



Received August 02, 2025;
Revised September 13, 2025;
Accepted October 24, 2025;
Published October 30, 2025

Evaluation of Vitamin D Levels in the Municipality of Zillah

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ABSTRACT

Vitamin D, a fat-soluble prohormone, is essential for calcium homeostasis and bone metabolism. Its role, however, extends to a wide range of physiological processes, including immune regulation, cell proliferation, and cardiovascular health. Despite abundant sunlight in many regions, vitamin D deficiency is a global pandemic affecting all age groups. In Libya, lifestyle and cultural factors may contribute to a high prevalence of this deficiency, yet localized data, particularly from desert regions like Al-Jufra, remains scarce.

The study aimed to evaluate the prevalence of vitamin D deficiency and insufficiency among the adult population in the municipality of Zillah, and to investigate potential differences based on gender.

A cross-sectional study was conducted between June 2023 and June 2024. A total of 100 adult participants were recruited. Serum 25-hydroxyvitamin D [25(OH)D] levels were measured using a fluorescence immunoassay (FIA) analyzer. Vitamin D status was categorized as insufficient (40%), sufficient (35%), and deficient (25%). Data on demographics, sun exposure habits, and dietary intake were collected via a structured questionnaire. Data were analyzed using Microsoft Excel 2010 for descriptive statistics.

The study revealed a high prevalence of suboptimal vitamin D status. Only 35% of participants had sufficient vitamin D levels. A significant portion of the population was found to be insufficient and deficient. The analysis indicated that males (30.769%) had a higher rate of deficiency compared to females (18.75%). Conversely, females exhibited a higher prevalence of insufficiency compared to males (43.753%).

Vitamin D deficiency and insufficiency are highly prevalent in the municipality, representing a significant public health concern. The findings highlight the need for targeted public health strategies, including awareness campaigns about safe sun exposure, dietary counseling, and food fortification. Regular screening, particularly for at-risk populations, is crucial for early detection and intervention to mitigate the long-term health consequences associated with vitamin D deficiency.

Keywords: *Vitamin D Deficiency, 25-hydroxyvitamin D, Zillah, Public Health, Sun Exposure,*

1. Introduction

Vitamin D, often referred to as the "sunshine vitamin," is a unique nutrient that functions as a prohormone within the human body. Its primary and most well-understood role is the regulation of calcium and phosphorus metabolism, which is fundamental for the development and maintenance of a healthy skeleton [1,2]. However, research over the past two decades has unveiled a much broader spectrum of biological



functions. Receptors for vitamin D are present in nearly every cell and tissue in the body, from the brain to the immune system, indicating its involvement in a vast array of physiological processes beyond bone health [3,4]. These include modulating immune responses, regulating cell growth and differentiation, and influencing cardiovascular function.

Despite its critical importance, vitamin D deficiency has emerged as a global health pandemic, affecting many people worldwide of all ethnicities and age groups [5]. This high prevalence is paradoxical, especially in regions with abundant year-round sunlight, such as the Middle East and North Africa (MENA). In these areas, lifestyle factors, cultural practices (e.g., traditional clothing that limits skin exposure), and environmental conditions (e.g., high temperatures encouraging indoor lifestyles) often lead to inadequate synthesis of vitamin D in the skin, which is the primary source for most humans [6, 7].

In Libya, a sun-drenched country, this paradox is particularly relevant. However, there is a significant lack of research focused on specific communities, especially those in remote or desert regions like the Al-Jufra district. The population of Zillah, located within this district, presents a unique demographic for study due to its distinct environmental and lifestyle characteristics. Understanding the vitamin D status of this community is the first step toward identifying a potentially significant, yet overlooked, public health issue.

This study was therefore designed to conduct a preliminary assessment of vitamin D levels in the adult population of Zillah. The primary objectives were: 1) to determine the prevalence of vitamin D deficiency, insufficiency, and sufficiency; 2) to explore any significant differences in vitamin D status between males and females; and 3) to provide foundational data that can inform future public health policies and interventions aimed at addressing this nutritional deficiency in the region.

2. Scientific Background and Literature Review

2.1. Biochemistry and Metabolism of Vitamin D

Vitamin D is not a single compound but a group of fat-soluble secosteroids. The two major forms are vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol). Vitamin D2 is synthesized by plants and fungi, while vitamin D3 is synthesized in the skin of animals and humans upon exposure to ultraviolet B (UVB) radiation from sunlight. It can also be obtained from dietary sources like fatty fish, cod liver oil, and fortified foods [8,9].

The metabolic activation of vitamin D involves a two-step hydroxylation process.

1. **First Hydroxylation:** Whether obtained from sun exposure or diet, vitamin D is transported to the liver, where it undergoes its first hydroxylation to become 25-hydroxyvitamin D [25(OH)D], also known as calcidiol. This is the major circulating form of vitamin D and is used to determine a person's vitamin D status.
2. **Second Hydroxylation:** 25(OH) D is then transported to the kidneys, where it undergoes a second hydroxylation to form the biologically active hormone, 1,25-dihydroxyvitamin D [1,25(OH)2D], also known as calcitriol. This step is tightly regulated by parathyroid hormone (PTH), serum calcium, and phosphorus levels [3, 10].

2.2. Biological Functions of Vitamin D

- **Skeletal Health:** The classic function of vitamin D is to maintain calcium and phosphorus homeostasis. Active vitamin D (calcitriol) enhances the absorption of these minerals from the intestine, promotes their reabsorption in the kidneys, and regulates their mobilization from bone, thereby ensuring proper bone mineralization. Severe deficiency leads to rickets in children and osteomalacia in adults [1].
- **Extra-Skeletal Health:** The discovery of the vitamin D receptor (VDR) in numerous non-skeletal tissues has broadened our understanding of its functions. Vitamin D plays a role in:



- **Immune Modulation:** It enhances the innate immune response against pathogens while regulating the adaptive immune response to prevent autoimmunity.
- **Cellular Regulation:** It controls the growth and differentiation of various cell types, suggesting a potential role in cancer prevention.
- **Cardiovascular Health:** It is involved in regulating blood pressure and may protect against heart disease.

2.3. Literature Review: Vitamin D Status

Studies from the MENA region consistently report high rates of vitamin D deficiency. A study in Saudi Arabia found that over 81.15% of healthy adults had suboptimal vitamin D levels [11]. Similarly, research in the United Arab Emirates and Qatar has shown a prevalence of deficiency exceeding 70%, even with ample sunlight [12]. The primary reasons cited are limited sun exposure due to cultural dress and avoidance of extreme heat, as well as low dietary intake of vitamin D.

The results of a study conducted in northern India indicated that vitamin D deficiency was present in approximately 84% of women in urban areas and approximately 83% in rural areas [13].

From another perspective, a study was conducted to assess the prevalence of 25-(OH)D(VDD) and 25-hydroxycholecalciferol (25-(OH)D) deficiency in different regions of Libya. The results indicated that approximately 80% of healthy individuals in the Middle East had a prevalence of VDD deficiency. In the Libyan capital, Tripoli, the prevalence of VDD deficiency reached approximately 50.80%, while in the second largest city, Benghazi, the prevalence reached approximately 76% [14]. There is a clear gap in the literature regarding the vitamin D status of populations in the southern and central desert regions, such as Al-Jufra. This study aims to begin filling that gap by providing data from Zillah, contributing to a more comprehensive understanding of the nutritional landscape in Libya.

3. Methodology

3.1. Study Design and Setting

A descriptive, cross-sectional study was conducted to assess the vitamin D status of the adult population in Zillah, a municipality within the Al-Jufra district in central Libya. The study was carried out over a 12-month period, from June 2023 to June 2024. Data and sample collection took place at the Al-Watan Polyclinic, which serves a significant portion of the local community.

3.2. Study Population and Sampling

A convenience sample of 100 adult participants (aged 18 years and older) was recruited for the study. The sample included both males and females who visited the polyclinic for routine check-ups or minor ailments and voluntarily agreed to participate.

- **Inclusion Criteria:** Adults aged 18 and above, residing in Zillah, and willing to provide written informed consent.
- **Exclusion Criteria:** Individuals with known metabolic bone diseases, chronic kidney or liver disease, malabsorption syndromes, or those taking medications known to interfere with vitamin D metabolism (e.g., anticonvulsants, glucocorticoids).

3.3. Data Collection

3.3.1. Questionnaire and Validation

A structured questionnaire was developed specifically for this study to collect relevant data. To ensure the tool's validity and reliability, a multi-step process was undertaken:

1. Content Validity: The initial questionnaire was reviewed by a panel of three experts, including two dermatologists and a clinical nutritionist. They assessed the relevance, clarity, and comprehensiveness of the questions. The Content Validity Index (CVI) was calculated, and items with a score below 0.78 were revised or discarded based on the experts' feedback.



2. Face Validity: A pilot study was conducted with 15 individuals (who were not part of the final sample) to assess the questionnaire's clarity, ease of understanding, and the time required for completion. Ambiguous questions were rephrased for better comprehension.

3. Reliability: The internal consistency of the multi-item scales within the questionnaire (e.g., scales measuring sun exposure habits or dietary frequency) was assessed using Cronbach's Alpha. A value of $\alpha > 0.7$ was considered acceptable, indicating good reliability.

The final questionnaire, administered in Arabic by trained researchers, collected the following information:

A: Demographic Data: Age and gender.

B: Sun Exposure Habits: Average daily time spent outdoors (in hours), frequency of sunscreen use (on a scale from "never" to "always"), and typical style of clothing (categorized as "fully covered," "mixed," or "uncovered").

C: Dietary Habits: Frequency of consumption of vitamin D-rich foods (e.g., fatty fish like tuna and salmon, eggs, fortified milk and yogurt) using a Likert scale (e.g., never, rarely, sometimes, often, daily).

D: Medical History: Presence of chronic diseases known to affect vitamin D metabolism (e.g., malabsorption syndromes, renal or liver disease) and current use of vitamin D or multivitamin supplements (including dosage and frequency).

3.3.2. Data Collection Procedure

Data collection took place at the National Medical Laboratory in Hun City. Participants who provided informed consent were interviewed in a private room by a trained researcher. The researcher read the questions aloud and recorded the responses to ensure consistency and minimize missing data. Each interview lasted approximately 15-20 minutes.

3.3.3. Blood Sample Collection and Analysis A 3 mL sample of venous blood was collected from each participant by a qualified phlebotomist into a plain tube. The samples were allowed to clot at room temperature and then centrifuged at 3000 rpm for 10 minutes to separate the serum. The serum was carefully transferred to a labeled Eppendorf tube and stored at -20°C until analysis.

Serum concentration of 25-hydroxyvitamin D [25(OH)D] was measured using a DrAccU FIA-6000 Fluorescence Immunoassay Analyzer. This quantitative method is based on a competitive immunoassay principle. The results were expressed in nanograms per milliliter (ng/mL).

3.4. Definition of Vitamin D Status

Based on the Endocrine Society's clinical practice guidelines, vitamin D status was categorized as follows:

- **Deficiency:** Serum 25(OH)D level < 20 ng/mL
- **Insufficiency:** Serum 25(OH)D level between 20 and 29.9 ng/mL
- **Sufficiency:** Serum 25(OH)D level ≥ 30 ng/mL

3.5. Statistical Analysis

The descriptive statistics were performed using Microsoft Excel 2010. Descriptive statistics, including frequencies and percentages, were used to summarize the demographic characteristics and the prevalence of different vitamin D status categories. The results were presented using tables.

3.6. Ethical Considerations

The study protocol was approved by the administration of the Al-Mahara Institute for Medical and Administrative Sciences 24/2023. Written informed consent was obtained from all participants after explaining the purpose and procedures of the study. All data were kept confidential and used solely for research purposes.



4. Results

4.1. Demographic Characteristics

A total of 100 participants were included in the final analysis. The sample consisted of both male and female adults from the Zillah municipality. The age of the participants ranged from 18 to 80 years.

4.2. Overall Prevalence of Vitamin D Status

The analysis of serum 25 (OH)D levels revealed that a majority of the participants (65%) had suboptimal vitamin D status. Only 35% of the study population had sufficient levels. The distribution across the different categories is shown in Table 1.

Table 1: Overall Distribution of Vitamin D Status

Vitamin D Status	Definition (ng/mL)	Number of cases	Percentage (%)
Deficiency	< 20	25	25.0%
Insufficiency	20 - 29.9	40	40.0%
Sufficiency	≥ 30	35	35.0%
Total		100	100.0%

4.3. Vitamin D Status by Gender

Table 2: Distribution of Vitamin D Status by Gender

Vitamin D Status	Males (n=52)	Females (n=48)
Deficiency (<20 ng/mL)	16 (30.769)	9 (18.75)
Insufficiency (20-29.9 ng/mL)	19 (36.538)	21 (43.753)
Sufficiency (≥30 ng/mL)	17 (32.692)	18 (37.50)
Total	52 (100%)	48 (100%)

When data were stratified by gender, notable differences were observed in the prevalence of deficiency and insufficiency. Males exhibited a higher rate of deficiency, while females showed a higher rate of insufficiency. The detailed breakdown is presented in Table 2.

5. Discussion

The findings of this study provide crucial, albeit preliminary, insight into the vitamin D status of the adult population in Zillah, Libya, revealing a significant public health concern. The high prevalence of suboptimal vitamin D levels, with 65% of participants being either deficient (25%) or insufficient (40%), is alarming and aligns with the growing body of evidence that designates hypovitaminosis D as a silent global pandemic [1,8].

5.1. Interpretation of High Prevalence

The most striking finding is the high prevalence of deficiency in a region characterized by intense, year-round sunlight. This paradox is a hallmark of vitamin D deficiency in the MENA region [15,16]. Several factors likely contribute to this phenomenon in Zillah:

- **Sun Avoidance and Lifestyle:** The extremely high temperatures in this desert region for a large part of the year encourage an indoor lifestyle. People tend to remain indoors during peak sun hours (10 a.m. to 4 p.m.) [17], when UVB radiation, necessary for vitamin D synthesis, is most intense.
- **Cultural and Clothing Habits:** Traditional clothing for both men and women in the region often covers most of the body surface, severely limiting the skin's exposure to UVB rays. Even minimal clothing can significantly reduce vitamin D production.



- **Dietary Factors:** The typical Libyan diet may not be naturally rich in vitamin D. Consumption of fatty fish, a primary natural source, is not as common as in other regions. Furthermore, the availability and consumption of vitamin D-fortified foods, such as milk and cereals, may be limited or inconsistent. The questionnaire data from this study could be further analyzed to establish a stronger correlation between specific dietary patterns and low vitamin D levels.

5.2. Gender Disparities

The study revealed an interesting gender-based pattern. While men had a higher rate of deficiency (30.769% vs. 18.75%), women had a higher rate of insufficiency (43.753% vs. 36.538%). This complex observation could be multifactorial:

- **Hormonal Influences:** Hormonal differences, particularly the role of estrogen in females, can influence vitamin D metabolism and bone health. Estrogen is known to impact the enzymes involved in vitamin D activation [18].
- **Behavioral Differences:** Men in the region might engage in occupations or activities that require more time outdoors, but perhaps during early morning or late afternoon hours when UVB intensity is lower. Women, while potentially spending more time indoors, might have different dietary habits or a higher body fat percentage, which can sequester vitamin D, making it less available in the circulation. The higher rate of insufficiency in women places them in a high-risk category, on the verge of deficiency, making them a critical target for preventative health measures.

5.3. Public Health Implications

The long-term health consequences of such a highly prevalent deficiency are considerable, with the potential to impact multiple physiological systems over time. Chronic vitamin D deficiency is a well-established risk factor for osteoporosis and fractures. Moreover, emerging evidence links it to an increased risk of various non-skeletal diseases, including cardiovascular diseases; type 2 diabetes, certain cancers, and autoimmune disorders [6,19]. The high prevalence found in Zillah suggests that the community may be bearing a hidden burden of these chronic conditions, which could be mitigated through effective public health interventions.

5.4. Limitations of the Study

This study has several limitations that should be acknowledged. First, the use of a convenience sample from a single polyclinic may not be fully representative of the entire Zillah population. Second, the cross-sectional design captures data at a single point in time and cannot establish causality or account for seasonal variations in vitamin D levels, which are known to occur. A longitudinal study would be beneficial to track these changes. Finally, the study did not measure PTH levels, which would have provided a more complete picture of calcium homeostasis.

6. Conclusion

This study provides the documented evidence of the high prevalence of vitamin D deficiency and insufficiency among the adult population of Zillah, Libya. With nearly two-thirds (66 cases) of the participants exhibiting suboptimal levels, this issue constitutes a significant and previously unaddressed public health problem. The findings underscore a pressing need for prompt action to mitigate the long-term health consequences of vitamin D deficiency. The observed differences in prevalence rates between genders also emphasize the importance of designing tailored interventions that consider the unique physiological and behavioral factors affecting men and women.



7. Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. **Public Health Awareness Campaigns:** Launching community-wide educational programs through local media, clinics, and community centers to raise awareness about the importance of vitamin D, the risks of deficiency, and practical ways to improve vitamin D status.
2. **Promotion of Safe Sun Exposure:** Educating the public on how to obtain sensible and safe sun exposure (e.g., 10-15 minutes of exposure for arms and legs during mid-day hours, 2-3 times a week, 11am-3pm) while avoiding the risks of sunburn and skin cancer [20].
3. **Dietary Counseling and Food Fortification:**
 1. Encouraging the consumption of vitamin D-rich foods.
 2. Advocating for a national policy for the fortification of staple foods like flour, bread, and dairy products with vitamin D, a strategy that has proven effective in other countries.
4. **Clinical Screening and Supplementation:**
 1. Recommending routine screening for vitamin D deficiency for individuals at high risk (e.g., the elderly, pregnant women, individuals with limited sun exposure).
 2. Developing clear clinical guidelines for healthcare providers on vitamin D supplementation protocols.
5. **Further Research:** Conducting larger, population-based studies with random sampling to confirm these findings. Future research should also explore seasonal variations, the impact of deficiency on specific health outcomes in the region, and the effectiveness of intervention programs.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ETHICAL STATEMENT

The study protocol was approved by the administration of the Al-Mahara Institute for Medical and Administrative Sciences 24/2023. Written informed consent was obtained from all participants after explaining the purpose and procedures of the study. All data were kept confidential and used solely for research purposes.

AUTHORS' CONTRIBUTIONS:

- Nabel Ahmed A Mansour: Conceptualization, Methodology, Investigation, Writing – Original Draft, Project Administration.
- Seraj M. Ali Elwan: Validation, Resources, Data Curation, Formal Analysis, Writing – Review & Editing, Supervision.

CONFLICT OF INTEREST

The authors declare that there are no known financial or personal conflicts of interest that could have influenced the work presented in this paper.

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Appendix: Questionnaire Form

A. Personal Information:

1. ID Code: _____
2. Gender: ☐ Male ☐ Female
3. Age Group: _____

B. Health Information:

1. Are you regularly exposed to the sun? ☐ Yes ☐ No
2. Do you drink milk daily? ☐ Yes ☐ No



3. Do you frequently eat fast food? ☐ Yes ☐ No
4. Are you following a specific diet? ☐ Yes ☐ No
5. Do you smoke? ☐ Yes ☐ No
6. Are you pregnant? ☐ Yes ☐ No
7. Are you breastfeeding? ☐ Yes ☐ No
8. Do you exercise? ☐ Yes ☐ No
9. Do you take multivitamins? ☐ Yes ☐ No
10. Do you suffer from a chronic disease? ☐ Yes ☐ No

When was your last vitamin D test? _____

What is your vitamin D level? a) <20 ng/mL b) 20-29 ng/mL c) 30-69 ng/mL d) I don't know

Do you suffer from hair loss? ☐ Yes ☐ No

Do you have muscle pain? ☐ Yes ☐ No

Do you feel tired and fatigued most of the time? ☐ Yes ☐ No

Do you suffer from obesity? ☐ Yes ☐ No

Do you suffer from headaches and nausea most of the time? ☐ Yes ☐ No

Do you consume caffeine frequently in your daily diet? ☐ Yes ☐ No

Do you have insomnia or sleep disturbances? ☐ Yes ☐ No

Do you suffer from anxiety and stress at times? ☐ Yes ☐ No

Have you taken pills for vitamin D deficiency? ☐ Yes ☐ No

Have you taken an injection for vitamin D deficiency? ☐ Yes ☐ No

Do you eat a balanced diet fortified with vitamin D? ☐ Yes ☐ No

Have you read or heard about vitamin D? ☐ Yes ☐ No

Do you know the sources of vitamin D? ☐ Yes ☐ No

Do you think vitamin D deficiency is linked to other diseases like depression? ☐ Yes ☐ No

In your opinion, what are the possible causes of vitamin D deficiency? a) Lack of sun exposure b) Diet c) Nutritional deficiency in pregnant women and the elderly d) Economic status

It is known that vitamin D deficiency reduces immunity. Do you suffer from a lack of immunity? ☐ Yes ☐ No