International Journal of Drug Research in Clinics

Int J Drug Res Clin 2025;3:e23
doi:10.34172/ijdrc.2025.e23
http://ijdrug.com

Original Article

The Prevalence of Vitamin D Deficiency in the East Azarbaijan Province and its Relationship With Demographic Factors

Zahra Akrami[1], Hassan Soleimanpour[2], Mohammad Mianaji[3], Amir Reza Naseri[3], Zeinab Nikniaz[4], Leila Nikniaz[5*]

[1]Students Research Committee, School of Paramedical Sciences, Ardabil University of Medical Sciences, Ardabil, Iran
[2]Medical Philosophy and History Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[3]Student Research Committee, Tabriz University of Medical Sciences, Tabriz, Iran
[4]Liver and Gastrointestinal Diseases Research Center, Tabriz University of Medical Sciences, Tabriz, Iran
[5]Tabriz Health Services Management Research Center, Health Management and Safety Promotion Research Institute, Tabriz University of Medical Sciences, Tabriz, Iran

Article History:
Received: September 29, 2025
Revised: October 22, 2025
Accepted: November 21, 2025
ePublished: December 3, 2025

***Corresponding Author:**
Leila Nikniaz,
Email: nikniazleila@gmail.com

Abstract

Background: Vitamin D is a fat-soluble vitamin essential for various physiological functions. Its deficiency can lead to numerous health problems, making it a significant global health concern. However, limited data are available regarding its prevalence in East Azerbaijan province. This study aimed to assess the prevalence of vitamin D deficiency in this region and explore its association with demographic factors.

Methods: This cross-sectional study was conducted in the urban and rural areas of East Azarbaijan province in 2018. A total of 1500 households from Tabriz, Marand, Bonab, Osku, Varzeghan, and Khodaafarin were examined. The socio-demographic questionnaires were completed, and serum vitamin D levels were measured using the ELISA method. The relationship between vitamin D status and demographic factors was analyzed using SPSS. *P* values less than 0.05 were considered statistically significant.

Results: A total of 2816 individuals were investigated in the present study. Overall, more than 76.9% of the participants exhibited varying degrees of vitamin D deficiency, with a significantly higher prevalence in rural areas (64.6%) compared to Tabriz city (37.7%) ($P<0.001$). However, the age group between 35 and 45 years had the highest prevalence of vitamin D deficiency (84.2%). The prevalence of vitamin D deficiency in men and women was reported to be 40.6% and 61.9%, respectively ($P=0.01$). No significant differences were found between single and married individuals ($P>0.05$).

Conclusion: Vitamin D deficiency is significantly more prevalent in rural areas than in Tabriz city, with a higher incidence in women compared to men. Recognizing this issue is crucial for implementing preventive measures. Further studies are needed to confirm these findings and elucidate the underlying mechanisms.

Keywords: Vitamin D, Vitamin D deficiency, Demographic factors, East Azerbaijan

Please cite this article as follows: Akrami Z, Soleimanpour H, Mianaji M, Naseri AR, Nikniaz Z, Nikniaz L. The Prevalence of Vitamin D Deficiency in the East Azarbaijan Province and its Relationship With Demographic Factors. Int J Drug Res Clin 2025;3:e23. doi:10.34172/ijdrc.2025.e23

Introduction

Vitamin D is an essential fat-soluble vitamin that plays a crucial role in regulating the balance of calcium and phosphorus levels in the body. Additionally, it plays a significant role in numerous physiological processes beyond the skeletal-muscular system.[1,2] Vitamin D is predominantly obtained by the human body through the synthesis process that takes place when the skin is exposed to sunlight.[3] The two most prevalent forms of vitamin D are D2 (ergocalciferol) and D3 (cholecalciferol). In the liver, both forms are converted into 25-hydroxy vitamin D (25(OH)D), which is the main type of this vitamin present in the bloodstream. This form is utilized to evaluate the vitamin D status of individuals.[4]

Vitamin D deficiency can seriously affect different body systems and lead to numerous health problems. Vitamin D plays a crucial role in maintaining bone health by primarily supporting skeletal strength and regulating calcium balance. This essential function highlights its importance for overall bone health.[5] Low vitamin D levels can lead

to less calcium absorption, poor bone mineralization, and a high risk of bone disorders such as rickets in children and osteomalacia in adults.[6] Research shows that low vitamin D levels not only affect bone health but are also linked to various health issues encompassing bone metabolism, immune system function, cardiovascular diseases, metabolic processes, nervous functions, and even cancer treatment.[7,8] Low vitamin D levels can weaken the immune system, making individuals more susceptible to infections, autoimmune diseases, and inflammatory conditions.[9] Moreover, research underscores the crucial role of maintaining adequate vitamin D levels for optimal mental health and cognitive function. Insufficient levels of this essential vitamin are associated with various mental health issues, including mood disorders, Parkinson's disease, and Alzheimer's disease.[10] The findings suggest that vitamin D is essential for maintaining cellular health and inhibiting the proliferation of cancerous cells. Consequently, a deficiency in this nutrient may be linked to the development of certain types of cancer. This underscores the vital role of vitamin D in regulating cellular growth, promoting programmed cell death, and enhancing antitumor responses.[11]

Certain populations, including pregnant women and the elderly, are especially vulnerable to a lack of vitamin D. In pregnant women, insufficient vitamin D can lead to adverse pregnancy outcomes.[12] Among aging individuals, the lack of this vitamin can lead to various health complications, such as muscle weakness, an increased risk of falls, and fractures. Therefore, vitamin D deficiency has emerged as a critical public health challenge that affects populations worldwide.[13] Investigative studies focused on epidemiological aspects conducted across several Middle Eastern nations corroborate this trend, revealing a notable prevalence of insufficient vitamin D levels among diverse demographic groups, including children, adolescents, adults, and the elderly. Notably, studies conducted in Saudi Arabia, Iran, and Jordan reported a high rate of vitamin D deficiency, with prevalence ranging from 30% to 90% among these populations.[14,15]

This deficiency can arise from several factors such as insufficient exposure to sunlight, poor dietary habits, disorders that impair nutrient absorption, and specific population characteristics.[13] Various demographic factors, including age, gender, geographic location, seasonal variations, skin pigmentation, and socio-demographic status, can significantly influence vitamin D levels in individuals.[16,17]

Recent research indicates that age-related changes can impact vitamin D levels in the body.[18] Changes associated with aging affect the ability of the skin to synthesize vitamin D, making the elderly more susceptible to deficiency.[19] Previous investigations have also noted gender-based differences in vitamin D levels. Some studies reported a higher prevalence of vitamin D deficiency among females.[20] This difference may be due to factors such as clothing choices that limit sunlight exposure and hormonal influences on vitamin D metabolism.[21-23] Furthermore, the geographical latitude of an individual's residence significantly influences the production of this nutrient, primarily due to variations in the intensity of sunlight and duration of the exposure.[24]

Furthermore, vitamin D deficiency is often linked to socio-demographic factors, encompassing education, income, and access to healthcare.[25] Physiological factors, such as genetic variations and changes in vitamin D receptor genes, can influence the response of individuals to both sunlight exposure and dietary intake.[26]

Despite the importance of vitamin D, there is limited information about its deficiency in East Azerbaijan province. Therefore, the objective of this investigation was to evaluate the prevalence of various levels of vitamin D inadequacy in the population of East Azerbaijan province and to analyze its relationship with different demographic factors in 2018.

Methods

The present cross-sectional research was performed in 2018, focusing on Tabriz city and its surrounding small towns. The investigation included 1500 households residing in Tabriz, Marand, Bonab, Osku, Varzeghan, and Khodaafarin, which were organized into 150 clusters, each consisting of 10 households. Samples in each city were selected based on common socio-demographic characteristics, distance from the central district, population density, and accessibility to healthcare facilities. The clusters were selected using established and reliable frameworks, including postal codes, census records, and telecommunications data. Additionally, information from reputable organizations, such as health centers and governorates, was incorporated into the process.

The participants included individuals between the ages of 15 and 64 who resided in both urban and rural regions of East Azerbaijan province. This research employed a multistage stratified cluster sampling method based on probability proportional to size (PPS), which led to the identification of 150 distinct clusters. Each unit in this sampling method was selected based on its size, with larger units having a higher probability of being chosen. In this approach, the selection of clusters was systematically aligned with the postal code designations, which undergo annual updates, facilitating a structured method for sampling. Each address within the framework was distinctly represented by its corresponding 10-digit postal code, allowing for precise identification and categorization. Clusters within urban areas were commonly made up of multiple blocks or sections, where buildings were typically interconnected, forming a unified architectural space.

Following the identification of the starting locations for each cluster, the participant registration and data collection processes were initiated. At least two individuals (one female and one male) from the eligible members of

each household were randomly selected for examination. Iranian citizens within the age range of 16-65 years, who had been part of the household for at least six months, were included in the study. Moreover, individuals with low alertness, confirmed mental illnesses, cognitive disorders, blindness, deafness, or speech disorders were excluded from the study. The process of registration began by selecting the first household in the designated cluster and extended to nearby residences until the required number of individuals was reached. The selection of consecutive households was determined by the spatial orientation of the structures, with a specific emphasis on the right-hand side of each building.

After consent was obtained from all participants, anthropometric measurements were recorded and socio-demographic data were collected. Additionally, a comprehensive questionnaire was utilized to gather essential data on variables such as age, gender, menopausal status, medical history, and medication use. Upon admission of the participants, fasting blood and urine samples were collected. Blood samples were centrifuged to obtain serum and stored at -20°C until analysis. The serum concentration of vitamin D was measured in 535 subjects by the ELISA method. The ELISA method involved coating a microtiter plate with antibodies targeting 25-hydroxyvitamin D. Serum samples were added to the wells to allow binding. After washing, a secondary antibody was introduced, followed by a substrate solution to produce a color change. The optical density was measured at 450 nm to quantify vitamin D levels. Vitamin D concentrations were calculated based on a standard curve, with results interpreted according to established cut-off values for deficiency. Controls were included to ensure accuracy. Serum vitamin levels above 30 nm/L were classified as normal, levels between 20 and 30 nm/L were considered insufficient, and levels below 20 nm/L were reported as deficient.

The data was analyzed using SPSS. In order to evaluate the distribution characteristics of the variables, various statistical methods were employed, including histograms, the Kolmogorov-Smirnov test, and the Chi-square test. Continuous variables were analyzed by calculating their means and standard deviations (SDs), while categorical variables were examined through the assessment of their proportions. Statistical comparisons between the groups were conducted utilizing either the independent *t*-test or the chi-square test. *P* values less than or equal to 0.05 ($P \leq 0.05$) were considered statistically significant.

Results

The demographic characteristics of the studied population are depicted in Table 1. A total of 2816 participants were included in the study. According to the findings of this investigation, 69.1% of individuals had obtained a diploma or an undergraduate degree. Moreover, 9.52% of participants were unemployed.

According to Table 2, about 76.9% of the participants displayed varying degrees of vitamin D insufficiency. Overall, the mean serum vitamin D level in our population was 24.4 ± 21.8 (min = 5, max = 222).

Table 1. Demographic Characteristics of the Studied Population

	Number (Total = 2816)	Percent
Age		
15-25	191	6.8
25-35	577	20.5
35-45	851	30.2
45-55	670	23.8
55-65	527	18.7
Gender		
Men	1367	48.5
Marital status		
Married	2458	87.3
Location		
Tabriz city	1369	48.6
Other cities	1447	51.4
Education		
Illiterate	366	13.0
Diploma or undergraduate	1947	69.1
College	503	17.8
Job		
Unemployed	1490	52.9
Employed	1152	40.9
Student	174	6.2

Table 2. Prevalence of Vitamin D Deficiency in Population of East Azarbaijan Province in 2018

Vitamin D Status	Prevalence (%)	Number
Normal serum 25(OH) D3	24.1	124
Insufficient serum 25(OH) D3	24.7	127
25(OH) D3 deficiency	51.2	284

Table 3 shows the prevalence of vitamin D deficiency in Tabriz city and rural areas. As can be seen, the prevalence of normal vitamin D levels in Tabriz city (34.2%) was significantly higher compared to rural areas (Marand, Benab, Esko, Varzeghan, Khodaafarin, and the suburbs that surround them) ($P = 0.001$).

As shown in Table 4, the prevalence of normal vitamin D levels in men was significantly higher than in women ($P = 0.02$).

According to Table 5, the age group of 35 and 45 years had the highest prevalence of vitamin D deficiency. In addition, as individuals approached the age of 45 years, a significant rise in the occurrence of vitamin D deficiency was observed, followed by a subsequent decrease. Moreover, no significant association was identified between marital status and vitamin D levels (Table 6).

Discussion

Vitamin D Overview

Vitamin D is an essential nutrient that plays a pivotal

Table 3. Prevalence of Vitamin D Deficiency in Tabriz City and Rural Areas in 2018

Vitamin D Status	Tabriz City	Other Cities	*P* Value*	95% Confidence Interval
Normal serum 25(OH) D3 (%, number)	34.2%, 91	14.2%, 31	0.001	0.000-0.005
Insufficient serum 25(OH) D3 (%, number)	28.1%, 69	21.1%, 58	0.12	0.099-0.151
25(OH) D3 deficiency (%, number)	37.7%, 97	64.6%, 186	0.001	0.000-0.005

* Chi-squared test

Table 4. Gender Distribution of Vitamin D Deficiency in East Azarbaijan Province in 2018

Vitamin D Status	Men	Women	*P* Value*	95% Confidence Interval
Normal serum 25(OH) D3 (%, number)	28.3%, 62	19.7%, 62	0.02	0.01-0.02
Insufficient serum 25(OH) D3 (%, number)	31.1%, 68	18.4%, 58	0.001	0.000-0.005
25(OH) D3 deficiency (%, number)	40.6%, 82	61.9%, 192	0.001	0.000-0.005

* Chi-squared test

Table 5. Age Distribution of Vitamin D Deficiency in East Azarbaijan Province in 2018

Age Groups (y)	Serum vitamin D3 Level Lower Than Normal Range (%, number)
15-25	76.0, 19
25-35	77.0, 57
35-45	84.2, 112
45-55	79.2, 118
55-65	69.4, 84

role in maintaining overall health and contributes to the proper functioning of various cells and tissues in the body. Vitamin D plays a crucial role in maintaining the health of bone, muscle, heart, brain, immune system, and other organs of the body.[27] Vitamin D functions as a hormone that regulates the activity of cells and tissues.[28] Numerous studies demonstrate the significant performance of vitamin D in facilitating the absorption of calcium and phosphorus, which are essential for optimal bone health.[29] Furthermore, recent studies have demonstrated that this essential nutrient possesses the ability to prevent several immune system-related disorders by modulating the activity of immune cells.[30] This vitamin can be obtained through dietary sources or synthesized by the body upon exposure to sunlight.[31] Insufficient levels of vitamin D can disrupt numerous health-related processes and increase the risk of both infectious and non-infectious diseases.[32]

The Widespread Occurrence of Vitamin D Deficiency

The outcomes of the present research showed that approximately 76.9% of the participants displayed various levels of vitamin D deficiency. The prevalence of vitamin D deficiency in other cities of the province was significantly higher than in Tabriz city.

Reports indicate that more than 1 billion individuals worldwide are affected by vitamin D deficiency.[33] In many countries, the prevalence of this deficiency is notably high among adults and children. A recent study conducted in the United States, which included a considerable sample size, indicated that more than 42% of adults in this country had deficient levels of vitamin D.[34]

According to reports, the prevalence of vitamin D deficiency among adults ranges from 14% to 59%, with higher rates observed in Asian countries.[35] El-Khateeb et al reported that 89.7% of the Jordanian population experienced this deficiency.[36] Duarte et al reported that 66.6% of the Portuguese population was affected by vitamin D deficiency.[37] Furthermore, studies assessing vitamin D deficiency in Saudi Arabia and Iraq reported prevalence rates of 60.2% and 74.3%, respectively.[38,39] Likewise, Siddiqee et al reported a deficiency rate of 68% in South Asia.[40] Additionally, research conducted in the provinces of Isfahan and Birjand, both known for their sunny weather in Iran, found prevalence rates of 50.8% and 26%, respectively.[35,41] Moreover, a multicenter study by Farhud et al revealed that West Azerbaijan province had the highest deficiency rate (33.24%), while North Khorasan province had the lowest rate (14.46%).[42]

Demographic Insights

Similar to the results of the present study, a recent multicenter cross-sectional study demonstrated that the prevalence of vitamin D deficiency among women in their reproductive age exceeded 85%.[43] Moreover, the meta-analysis conducted by Vatandost et al, which included 26042 patients, found that 64% of women and 44% of men suffered from vitamin D deficiency. This study highlights the necessity for further exploration of the causes and factors contributing to this deficiency, as well as appropriate compensatory measures.[20] The elevated prevalence of vitamin D insufficiency among women can be attributed to various factors, including the social laws, cultural beliefs, and traditional practices prevalent in the region.[44] Moreover, studies have indicated that the fear of skin cancer has led to the widespread use of sunscreen.[45] Living in apartments, driven by population growth and the desire to reside in urban areas, is another factor that restricts sun exposure in Iran and contributes to the high prevalence of vitamin D deficiency.[46]

Contrary to the results reported by Khalfa et al, which suggested that unmarried women exhibit notably reduced serum vitamin D concentrations compared to their married counterparts,[47] the present study revealed no

Table 6. Association between Vitamin D Levels and Marital Status in the Studied Population of East Azarbaijan Province in 2018

Vitamin D Status	Single	Married	*P* Value*	95% Confidence Interval
Normal serum 25(OH) D3 (%, number)	24.3%, 12	24%, 112	0.865	0.838-0.892
Insufficient serum 25(OH) D3 (%, number)	25.7%, 9	23.8%,118	0.478	0.438-0.518
25(OH) D3 deficiency (%, number)	49.2%, 27	52.5%, 257	0.660	0.622-0.698

* Chi-squared test

substantial association between these two variables.

Aging and Vitamin D Deficiency

Based on the results of this study, the age group of 35-45 years had the highest prevalence of vitamin D deficiency. In a similar manner, the findings of investigations conducted in diverse regions of Iran and among different age groups demonstrated a considerable rate of vitamin D insufficiency. As individuals grow older, the ability of their body to produce and absorb vitamin D diminishes. Therefore, this situation creates major concerns regarding vitamin D deficiency among the aging population.[48] Indeed, the natural process of aging results in alterations in the synthesis and metabolism of vitamin D, which are significantly affected by factors including limited access to sunlight and a diminished capacity of the skin to produce the vitamin. Consequently, these age-related changes can have detrimental effects on skeletal health, resulting in issues such as reduced bone density, osteomalacia, and an increased susceptibility to fractures.[49]

According to the research conducted by Hovsepian et al, adults residing in Isfahan, despite being located in central Iran, grapple with significant vitamin D deficiency (50.8% for deficiency and 19.6% for insufficiency). Furthermore, it has been observed that these rates are even higher among younger individuals. It is important to highlight that the prevalence of vitamin D deficiency in this study showed no significant variation between genders, which contrasts with the results of our study.[35] Moreover, the results of a study conducted in Tehran by Hashemipour et al indicated that the rates of severe, moderate, and mild vitamin D deficiency among individuals aged 20 to 64 years were 9.5%, 57.6%, and 14.2%, respectively.[50]

Dietary Habits and Deficiency

The most natural way to get enough vitamin D is sunlight exposure. Additionally, numerous food sources (especially animal-derived foods) also contain this vital nutrient. Studies show that poor dietary habits can lead to vitamin D deficiency in many societies.[51] For instance, the avoidance of fish and other vitamin D-rich foods is common among many individuals worldwide.[52] Various dietary choices can affect the risk of insufficient vitamin D levels in the population of East Azarbaijan. The traditional dietary practices in this region often lack sufficient vitamin D-rich foods, such as fatty fish and fortified dairy products. This situation has led to a decrease in the serum concentration of this vitamin among residents. Furthermore, the geographical location also contributes to limited sunlight exposure, particularly during the winter months, which exacerbates the deficiency.[53] Therefore, improving dietary habits through education and encouraging the consumption of vitamin D-rich foods are vital steps in addressing vitamin D deficiency in East Azarbaijan.[54]

Socio-demographic Factors

The present research indicated that 52.9% (1490 individuals) of the examined population was unemployed. Studies showed that unemployed individuals generally had significantly lower serum levels of vitamin D compared to their employed counterparts, primarily due to reduced exposure to sunlight.[36] Bazzano et al found that 65.5% of their study population was unemployed.[55] Furthermore, another study revealed that among employed individuals, those working in indoor environments tended to have lower serum vitamin D levels than those who worked outdoors.[56]

Study Limitations and Strength

First, because of its cross-sectional design, we cannot conclude cause and effect relationships. Second, the single measurement of 25(OH) D does not necessarily indicate the vitamin D status of the population for the entire year. The strength of this study is the use of a large representative sample of participants.

Conclusion

The findings of the current research indicate that around 76.9% of the population in urban and rural areas of East Azarbaijan province suffer from varying degrees of vitamin D deficiency. Moreover, the prevalence of vitamin D deficiency in rural areas was significantly higher than in Tabriz city. Furthermore, women demonstrated a significantly higher prevalence of vitamin D deficiency compared to men. Additional prospective studies are needed to confirm the findings of this study and also elucidate the underlying mechanisms.

Ethics statement

This study was approved by the Ethics Committee of Tabriz University of Medical Sciences (TBZMED.REC.1394.383). In this study, the privacy and confidentiality of the participants' personal data were ensured and the results of the study were reported honestly. Furthermore, the project guaranteed that individuals participated willingly, without any financial constraints imposed at any stage.

Disclosure of funding source

This research received no specific grant from any funding agency.

Conflict of interests declaration
The authors declare no conflict of interests.

Acknowledgements
We would like to appreciate the cooperation of the Clinical Research Development Unit, Imam Reza General Hospital, Tabriz, Iran, and Tabriz Health Services Management Research Center in conducting this research.

Data availability statement
If requested, data will be available at https://hsri-en.tbzmed.ac.ir/

Author contributions
Conceptualization: Hassan Soleimanpour, Zeinab Nikniaz & Leila Nikniaz
Investigation: Mohammad Mianaji & Zahra Akrami
Methodology: Hassan Soleimanpour, Zeinab Nikniaz & Leila Nikniaz
Writing–original draft: Zahra Akrami, Mohammad Mianaji, Amir Reza Naseri & Leila Nikniaz
Writing–review & editing: Zahra Akrami & Leila Nikniaz, Amir Reza Naseri
Supervision: Hassan Soleimanpour, Zeinab Nikniaz & Leila Nikniaz

Consent for publication
Not applicable.

References
1. Girgis CM, Clifton-Bligh RJ, Hamrick MW, Holick MF, Gunton JE. The roles of vitamin D in skeletal muscle: form, function, and metabolism. Endocr Rev. 2013;34(1):33-83. doi:10.1210/er.2012-1012
2. Makariou S, Liberopoulos EN, Elisaf M, Challa A. Novel roles of vitamin D in disease: what is new in 2011? Eur J Intern Med. 2011;22(4):355-62. doi:10.1016/j.ejim.2011.04.012
3. Grant WB. Ecological studies of the UVB-vitamin D-cancer hypothesis. Anticancer Res. 2012;32(1):223-36.
4. Anderson PH, May BK, Morris HA. Vitamin D metabolism: new concepts and clinical implications. Clin Biochem Rev. 2003;24(1):13-26.
5. Charoenngam N, Shirvani A, Holick MF. Vitamin D for skeletal and non-skeletal health: what we should know. J Clin Orthop Trauma. 2019;10(6):1082-93. doi:10.1016/j.jcot.2019.07.004
6. Chang SW, Lee HC. Vitamin D and health - the missing vitamin in humans. Pediatr Neonatol. 2019;60(3):237-44. doi:10.1016/j.pedneo.2019.04.007
7. Melamed ML, Manson JE. Vitamin D and cardiovascular disease and cancer: not too much and not too little? The need for clinical trials. Womens Health (Lond). 2011;7(4):419-24. doi:10.2217/whe.11.18
8. Aranow C. Vitamin D and the immune system. J Investig Med. 2011;59(6):881-6. doi:10.2310/JIM.0b013e31821b8755
9. Sîrbe C, Rednic S, Grama A, Pop TL. An update on the effects of vitamin D on the immune system and autoimmune diseases. Int J Mol Sci. 2022;23(17):9784. doi:10.3390/ijms23179784
10. Lasoń W, Jantas D, Leśkiewicz M, Regulska M, Basta-Kaim A. The vitamin D receptor as a potential target for the treatment of age-related neurodegenerative diseases such as Alzheimer's and Parkinson's diseases: a narrative review. Cells. 2023;12(4):660. doi:10.3390/cells12040660
11. Krishnan AV, Trump DL, Johnson CS, Feldman D. The role of vitamin D in cancer prevention and treatment. Rheum Dis Clin. 2012;38(1):161-78.
12. Urrutia-Pereira M, Solé D. [Vitamin D deficiency in pregnancy and its impact on the fetus, the newborn and in childhood]. Rev Paul Pediatr. 2015;33(1):104-13. doi:10.1016/j.rpped.2014.05.004 [Portuguese].
13. Scully H, Laird E, Healy M, Walsh JB, Crowley V, McCarroll K. Geomapping vitamin D status in a large city and surrounding population-exploring the impact of location and demographics. Nutrients. 2020;12(9):2663. doi:10.3390/nu12092663.
14. Chakhtoura M, Rahme M, Chamoun N, El-Hajj Fuleihan G. Vitamin D in the Middle East and North Africa. Bone Rep. 2018;8:135-46. doi:10.1016/j.bonr.2018.03.004.
15. Bassil D, Rahme M, Hoteit M, Fuleihan Gel H. Hypovitaminosis D in the Middle East and North Africa: prevalence, risk factors and impact on outcomes. Dermatoendocrinol. 2013;5(2):274-98. doi:10.4161/derm.25111
16. Mitchell DM, Henao MP, Finkelstein JS, Burnett-Bowie SA. Prevalence and predictors of vitamin D deficiency in healthy adults. Endocr Pract. 2012;18(6):914-23. doi:10.4158/ep12072.or
17. Carpenter TO, Herreros F, Zhang JH, Ellis BK, Simpson C, Torrealba-Fox E, et al. Demographic, dietary, and biochemical determinants of vitamin D status in inner-city children. Am J Clin Nutr. 2012;95(1):137-46. doi:10.3945/ajcn.111.018721.
18. Mouodi S, Delbari S, Hosseini SR, Ghadimi R, Bijani A. Serum vitamin D status in older adults: a cohort study. Iran J Med Sci. 2023;48(3):277-85. doi:10.30476/ijms.2022.94269.2550
19. Wyskida M, Wieczorowska-Tobis K, Chudek J. Prevalence and factors promoting the occurrence of vitamin D deficiency in the elderly. Postepy Hig Med Dosw (Online). 2017;71(0):198-204. doi:10.5604/01.3001.0010.3804
20. Vatandost S, Jahani M, Afshari A, Amiri MR, Heidarimoghadam R, Mohammadi Y. Prevalence of vitamin D deficiency in Iran: a systematic review and meta-analysis. Nutr Health. 2018;24(4):269-78. doi:10.1177/0260106018802968
21. Al-Yatama FI, AlOtaibi F, Al-Bader MD, Al-Shoumer KA. The effect of clothing on vitamin D status, bone turnover markers, and bone mineral density in young Kuwaiti females. Int J Endocrinol. 2019;2019:6794837. doi:10.1155/2019/6794837
22. Tsiaras WG, Weinstock MA. Factors influencing vitamin D status. Acta Derm Venereol. 2011;91(2):115-24. doi:10.2340/00015555-0980
23. LeBlanc ES, Desai M, Perrin N, Wactawski-Wende J, Manson JE, Cauley JA, et al. Vitamin D levels and menopause-related symptoms. Menopause. 2014;21(11):1197-203. doi:10.1097/gme.0000000000000238
24. Yeum KJ, Song BC, Joo NS. Impact of geographic location on vitamin D status and bone mineral density. Int J Environ Res Public Health. 2016;13(2):184. doi:10.3390/ijerph13020184
25. Wang TY, Wang HW, Jiang MY. Prevalence of vitamin D deficiency and associated risk of all-cause and cause-specific mortality among middle-aged and older adults in the United States. Front Nutr. 2023;10:1163737. doi:10.3389/fnut.2023.1163737
26. Voltan G, Cannito M, Ferrarese M, Ceccato F, Camozzi V. Vitamin D: an overview of gene regulation, ranging from metabolism to genomic effects. Genes (Basel). 2023;14(9):1691. doi:10.3390/genes14091691
27. Wacker M, Holick MF. Vitamin D - effects on skeletal and extraskeletal health and the need for supplementation. Nutrients. 2013;5(1):111-48. doi:10.3390/nu5010111
28. Pike JW, Christakos S. Biology and mechanisms of action of the vitamin D hormone. Endocrinol Metab Clin North Am. 2017;46(4):815-43. doi:10.1016/j.ecl.2017.07.001
29. Reid IR, Bolland MJ. Calcium and/or vitamin D supplementation for the prevention of fragility fractures: who needs it? Nutrients. 2020;12(4):1011. doi:10.3390/nu12041011
30. Ghaseminejad-Raeini A, Ghaderi A, Sharafi A, Nematollahi-Sani B, Moossavi M, Derakhshani A, et al. Immunomodulatory actions of vitamin D in various immune-related disorders: a comprehensive review. Front Immunol. 2023;14:950465. doi:10.3389/fimmu.2023.950465.

31. Bendik I, Friedel A, Roos FF, Weber P, Eggersdorfer M. Vitamin D: a critical and essential micronutrient for human health. Front Physiol. 2014;5:248. doi:10.3389/fphys.2014.00248
32. Rehan M, Aslam A, Umber J, Khan MR, Azeem W, Aftab H, et al. Immunomodulatory role of vitamin D in infectious and non-infectious diseases. Hosts Viruses. 2019;6(5):115-29. doi:10.17582/journal.hv/2019/6.5.115.129
33. Naeem Z. Vitamin d deficiency-an ignored epidemic. Int J Health Sci (Qassim). 2010;4(1):V-VI.
34. Cui A, Xiao P, Ma Y, Fan Z, Zhou F, Zheng J, et al. Prevalence, trend, and predictor analyses of vitamin D deficiency in the US population, 2001-2018. Front Nutr. 2022;9:965376. doi:10.3389/fnut.2022.965376
35. Hovsepian S, Amini M, Aminorroaya A, Amini P, Iraj B. Prevalence of vitamin D deficiency among adult population of Isfahan city, Iran. J Health Popul Nutr. 2011;29(2):149-55. doi:10.3329/jhpn.v29i2.7857
36. El-Khateeb M, Khader Y, Batieha A, Jaddou H, Hyassat D, Khawaja N, et al. Vitamin D deficiency and associated factors in Jordan. SAGE Open Med. 2019;7:2050312119876151. doi:10.1177/2050312119876151.
37. Duarte C, Carvalheiro H, Rodrigues AM, Dias SS, Marques A, Santiago T, et al. Prevalence of vitamin D deficiency and its predictors in the Portuguese population: a nationwide population-based study. Arch Osteoporos. 2020;15(1):36. doi:10.1007/s11657-020-0695-x
38. AlFaris NA, AlKehayez NM, AlMushawah FI, AlNaeem AN, AlAmri ND, AlMudawah ES. Vitamin D deficiency and associated risk factors in women from Riyadh, Saudi Arabia. Sci Rep. 2019;9(1):20371. doi:10.1038/s41598-019-56830-z
39. Hussein DA, Ahmed GS, Ahmed SF, Salih RQ, Kakamad FH, Salih AM, et al. Pattern of vitamin D deficiency in a Middle Eastern population: a cross-sectional study. Int J Funct Nutr. 2022;3(5):7. doi:10.3892/ijfn.2022.30
40. Siddiqee MH, Bhattacharjee B, Siddiqi UR, MeshbahurRahman M. High prevalence of vitamin D deficiency among the South Asian adults: a systematic review and meta-analysis. BMC Public Health. 2021;21(1):1823. doi:10.1186/s12889-021-11888-1
41. Nakhaee S, Yaghoubi MA, Zarban A, Amirabadizadeh A, Faghihi V, Yoosef Javadmoosavi S, et al. Vitamin D deficiency and its associated risk factors in normal adult population of Birjand, Iran. Clin Nutr ESPEN. 2019;32:113-7. doi:10.1016/j.clnesp.2019.04.002
42. Farhud DD, Mehrabi A, Sarafnejad A, Sadeghipour HR, Rahimiforoushani A, Rokni MB, et al. A comprehensive, epidemiological and ecological descriptive study on vitamin D status in Iran (308005 people, from 2009-2018). Iran J Public Health. 2019;48(4):644-54.
43. Emdadi R, Chaichian S, Mahboubi M, Moradi Y, Akhlaghdoust M, Basharkhah A. Prevalence of vitamin D deficiency among women of reproductive age: a multi centric study in Tehran. Shiraz E Med J. 2016;17(11):e40745. doi:10.17795/semj40745
44. Ojah RC, Welch JM. Vitamin D and musculoskeletal status in Nova Scotian women who wear concealing clothing. Nutrients. 2012;4(5):399-412. doi:10.3390/nu4050399
45. Neale RE, Khan SR, Lucas RM, Waterhouse M, Whiteman DC, Olsen CM. The effect of sunscreen on vitamin D: a review. Br J Dermatol. 2019;181(5):907-15. doi:10.1111/bjd.17980
46. Marzban M, Kalantarhormozi M, Mahmudpour M, Ostovar A, Keshmiri S, Darabi AH, et al. Prevalence of vitamin D deficiency and its associated risk factors among rural population of the northern part of the Persian Gulf. BMC Endocr Disord. 2021;21(1):219. doi:10.1186/s12902-021-00877-5
47. Khalfa HM, Al-Msaid HL, Alsahlanee R. Relationship between vitamin D3 levels and marital status: a random study in females suffering from bone disorders in Al-Najaf province. J Med Life Sci. 2019;1(3):65-70. doi:10.21608/jmals.2019.110859
48. Giustina A, Bouillon R, Dawson-Hughes B, Ebeling PR, Lazaretti-Castro M, Lips P, et al. Vitamin D in the older population: a consensus statement. Endocrine. 2023;79(1):31-44. doi:10.1007/s12020-022-03208-3
49. Hill TR, Aspray TJ. The role of vitamin D in maintaining bone health in older people. Ther Adv Musculoskelet Dis. 2017;9(4):89-95. doi:10.1177/1759720x17692502
50. Hashemipour S, Larijani B, Adibi H, Javadi E, Sedaghat M, Pajouhi M, et al. Vitamin D deficiency and causative factors in the population of Tehran. BMC Public Health. 2004;4:38. doi:10.1186/1471-2458-4-38
51. Fikri B, Juliaty A, Engels S, Putera AM, Hikmah Z, Febriani AD, et al. Primary source of vitamin D: sunlight or nutrition? Bali Med J. 2024;13(1):458-62. doi:10.15562/bmj.v13i1.4958
52. Schmid A, Walther B. Natural vitamin D content in animal products. Adv Nutr. 2013;4(4):453-62. doi:10.3945/an.113.003780
53. Holick MF. Environmental factors that influence the cutaneous production of vitamin D. Am J Clin Nutr. 1995;61(3 Suppl):638S-45S. doi:10.1093/ajcn/61.3.638S
54. Masood SH, Iqbal MP. Prevalence of vitamin D deficiency in South Asia. Pak J Med Sci. 2008;24(6):891-7.
55. Bazzano AN, Littrell L, Lambert S, Roi C. Factors associated with vitamin D status of low-income, hospitalized psychiatric patients: results of a retrospective study. Neuropsychiatr Dis Treat. 2016;12:2973-80. doi:10.2147/ndt.S122979
56. Sowah D, Fan X, Dennett L, Hagtvedt R, Straube S. Vitamin D levels and deficiency with different occupations: a systematic review. BMC Public Health. 2017;17(1):519. doi:10.1186/s12889-017-4436-z