

# Awareness of Vitamin D Deficiency among the General Population in Taif City, Saudi Arabia

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## Abstract

Recently, vitamin D deficiency has been considered the most common nutritional deficiency all over the world that affects all age groups. The current study aimed to evaluate the level of awareness of the general population in Taif city, Saudi Arabia, toward vitamin D deficiency, vitamin D sources, and toxicity. A cross-sectional study was conducted. A validated questionnaire was distributed to the participants through social media platforms. The study included 431 participants. About half of the participants (46.6%) reported having a vitamin D deficiency history, and 13.5% of the participants were healthcare providers. Only 103 participants (23.9%) showed a good awareness level regarding vitamin D's role, sources, and toxicity. A better awareness regarding the benefits of vitamin D was indicated in females ( $p$ -value<0.001), participants with a university degree ( $p$ -value<0.001), and healthcare professionals (HCPs) ( $p$ -value<0.001). Respondents from the medical field, hold a university degree, and with a history of vitamin D deficiency had a significantly higher awareness level regarding the sources of vitamin D ( $p$ -value<0.001,  $p$ -value=0.028, and  $p$ -value=0.024, respectively). In addition, being one of the medical staff and holding a university degree were significant factors that had a favorable effect on the awareness level regarding the toxicity of vitamin D ( $p$ -value<0.001,  $p$ -value=0.009 respectively). The study demonstrated a low level of awareness among the general population toward vitamin D deficiency. Further studies are recommended to fill the awareness gap and to improve the awareness of vitamin D, its benefits, sources, and toxicity.

**Keywords:** Vitamin D, Deficiency, Awareness, Saudi Arabia

## INTRODUCTION

Major attention has been shown during the last few years on vitamin D status in health and multiple fields of biomedicine. Consequently, many studies have been established examining the benefits, use, and deficiency prevalence of vitamin D [1].

Vitamin D is a unique type of steroid pro-hormone that is synthesized through the skin after exposure to ultraviolet-B radiation. It is present in a few types of foods, such as oily fish, cod liver oil, egg yolk, and liver, so dermal synthesis is considered the primary source of vitamin D [2, 3].

Vitamin D is found in two inert forms: vitamin D<sub>2</sub> and vitamin D<sub>3</sub> [4]. Both forms come from diet and sun exposure. They are converted in the liver and kidney into the active form: 1, 25-dihydroxy vitamin D (calcitriol) [5, 6]. Additionally, vitamin D metabolism occurs in other tissues, and the active form serves an autocrine/paracrine function [7, 8]. Serum 1, 25-dihydroxy vitamin D should be higher than 30 ng/mL [9] to maintain a healthy and normal vitamin D level. Inadequate dietary intake or low sun exposure may lead to vitamin D deficiency [3].

Vitamin D plays a significantly vital role in bone metabolism, as well as phosphorus and calcium homeostasis. Moreover, inadequate levels of vitamin D may lead to several bad

consequences, including osteomalacia in adults and rickets in children [9]. Moreover, several studies illustrated a strong clear causality correlation between several adverse events and vitamin D deficiency, including autoimmune diseases, cancer, diabetes, cardiovascular diseases, depression, and mortality [10].

Vitamin D deficiency (hypovitaminosis D) is considered an undiagnosed disorder and was reported in 1 billion patients worldwide. Moreover, deficiency in vitamin D levels shows a widespread prevalence in all age groups, including children, adults, the elderly, as well as pregnant females and their

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neonates in rural and urban areas [11, 12]. Obese, elderly, and hospitalized patients are at increased vitamin D deficiency risk, where the prevalence is 35% higher in obese patients [13]. In addition, individuals with high skin melanin content and those who use excessive skin coverage, are at higher risk of vitamin D deficiency, as in the Middle East. Additionally, about 20-80% of healthy individuals were recognized to suffer from vitamin D deficiency [14].

Despite Saudi Arabia having a sunny climate, it locates at a higher latitude in which UV rays are less intense, making it difficult to obtain vitamin D from sun exposure [14]. Therefore, vitamin D deficiency is considered a severe issue in most regions [15]. Furthermore, several studies showed that the prevalence of vitamin D deficiency was about 40%-80% among Saudi adult populations [16-20].

Lack of awareness about vitamin D's importance in regulating body functions and non-adherence, as well as the outcome of its deficiency, can potentially increase the risk for the increasing prevalence of this concern [21]. Many studies revealed a lack of public knowledge and awareness toward vitamin D's role and sources in multiple countries such as Hong Kong, Saudi Arabia, the USA, and India [1, 6, 12, 14, 22]. Therefore, the current study was conducted to explore the awareness level of vitamin D benefits, sources, its deficiency consequences, and overdose toxicity among the adult population of Taif city, Saudi Arabia.

## MATERIALS AND METHODS

This was an observational, cross-sectional, survey-based study that was conducted in Taif city, Saudi Arabia, in the period from September to November 2022. The study included adult populations living in Saudi Arabia and older than 18 years old. The sample size calculation considered a 50% population proportion, a 95% confidence interval, and a 5% margin of error, and the minimum representative sample was 384 participants. We obtained ethical approval to conduct this research study from the Western region, Medical Services General Directorate.

The data collection tool was a validated self-administrated Arabic-version questionnaire adapted from a previous Saudi study [1]. The questionnaire was distributed via a Google form through social platforms to be filled out by participants. It consisted of 4 parts with 21 questions. Part 1 collected information on participants' demographics such as their age, gender, nationality, education level, marital status, occupation, and history of vitamin D deficiency). The remaining parts included questions about vitamin D's benefits, sources, and toxicity.

After data extraction, it was revised and coded. The statistical calculations were done using the computer program IBM SPSS (Statistical Package for Social Science) software last version. Data were statistically described in the median (IQR) for continuous data, and frequencies and valid percentages were used for categorical variables.

For calculating participants' awareness level, each correct statement was given a score of 1 point. A total score was calculated for each participant summing the individual scores for each question. The total score of the awareness of each participant was out of 14 points. Additionally, the total score was divided into three domains: benefit score, source score, and toxicity score. Each score was calculated individually for each participant. Afterward, the level of awareness was categorized into three groups: <50 % accounted for having a poor level, 50 - 70 % accounted for having a moderate level, and > 70 accounted for having a good level.

We compared individuals' awareness of vitamin D between the subgroups using the Mann–Whitney U test. P-values less than 0.05 were considered statistically significant.

Ethical approval was obtained from the research ethics committee of Taif University with letter number (2022-662).

## RESULTS AND DISCUSSION

A total of 431 participants took part in the study. Two-thirds of participants (64.3%) were aged 30 years or less. Most participants were Saudi (97.7%) with a university degree (74.9%) and were not healthcare professionals (86.5%). The larger proportions of the participants were females (57.8%) and single (58%). Additionally, about half of the participants (46.6%) reported having a vitamin D deficiency history. All data are illustrated in **Table 1**.

**Table 1.** Participants' characteristics

Parameters	Category	Count (n=431)	Percentage
Age	≤30 years	277	64.3
	> 30 years	154	35.7
Gender	Female	249	57.8
	Male	182	42.2
Nationality	Saudi	422	97.7
	Non-Saudi	9	2.1
Occupation	HCPs*	58	13.5
	Non-HCPs	373	86.5
	Elementary	8	1.9
Educational level	Intermediate	3	0.7
	High School	97	22.5
	University	323	74.9
Marital Status	Married	161	37.4
	Single	250	58
	Divorced	15	3.5
	Widowed	5	1.2
History of vitamin D deficiency	Yes	201	46.6
	No	84	19.5
	Don't know	146	33.9

\*HCPs: Healthcare professionals

The questions related to vitamin D deficiency are demonstrated in **Table 2**. For instance, most participants were aware of vitamin D's role in treating bone diseases, rickets (76.1%), immunity boosting (70.8%), as well as muscle strengthening (62.9%). Additionally, about 72.6% of participants recognized the importance of vitamin D in maintaining calcium and phosphate levels. Furthermore, 82.8% of respondents knew the benefits of vitamin D in maintaining bone and teeth.

Turning to the sources of vitamin D, most participants (91.6%) recognize that sun exposure induces the production of vitamin D in the skin. On the other hand, most individuals did not know that vitamin D was not found in vegetables and fruits (82.6%) and that a fat-free diet can cause vitamin D deficiency (66.1%). In addition, 61.7% of participants were unaware that vegetarian people have a high risk of vitamin D deficiency. Two-thirds of respondents believed that people in the cloudy area were more exposed to vitamin D deficiency (60.1%) and that frequent exposure to the sun can cause vitamin D poisoning (66.3%). In contrast, most respondents did not know that sunscreen creams could result in vitamin D deficiency (76.1%), and dark skin is associated with a higher vitamin D deficiency risk (81.2%). Finally, only one-third of participants (36.4%) were aware that vitamin D toxicity could result in hypercalcemia.

**Table 2.** Questions related to the level of awareness among participants (n=431) toward vitamin D deficiency

Questions	Yes	No	Don't know
<b>Benefits of vitamin D</b>			
1- Vitamin D is used to treat bone disease and rickets	328 (76.1%)	23 (5.3%)	80 (18.6)
2- Vitamin D is important to maintain calcium and phosphates	313 (72.6%)	24 (5.6%)	94 (21.8%)
3- Vitamin D is important for maintaining bone and teeth	357 (82.8%)	17 (3.9%)	57 (13.2%)
4- Vitamin D helps to strengthen immunity	305 (70.8%)	31 (7.2%)	95 (22%)
5- Vitamin D helps to strengthen muscles	271 (62.9%)	45 (10.4%)	115 (26.7%)
<b>Sources of vitamin D</b>			
6- Sun exposure enhances vitamin D production in the skin	395 (91.6%)	7 (1.6%)	29 (6.7%)
7- Vitamin D is found in animal meat but not in vegetables and fruits	75 (17.4%)	172 (39.9%)	184 (42.7%)
8- People living in cloudy areas are at higher risk of vitamin D deficiency	259 (60.1%)	52 (12.1%)	120 (27.8%)
9- Frequent sun exposure does not lead to vitamin D poisoning	145 (33.6%)	113 (26.2%)	173 (40.1%)

10- Use of sunscreen creams can result in vitamin D deficiency	103 (23.9%)	145 (33.6%)	183 (42.5%)
11- A fat-free diet may result in vitamin D deficiency	146 (33.9%)	94 (21.8%)	191 (44.3%)
12- Dark skin increases the risk of vitamin D deficiency than fairer skin	81 (18.8%)	152 (35.3%)	198 (45.9%)
13- Vegetarians are at higher risk of vitamin D deficiency	165 (38.3%)	78 (18.1%)	188 (43.6%)

**Toxicity of vitamin D**

14- Vitamin D toxicity can cause hypercalcemia	157 (36.4%)	40 (9.3%)	234 (54.3%)
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Regarding the awareness level of vitamin D deficiency, less than one-third of individuals (23.9%) were highly aware. Nevertheless, about 40.6% had poor awareness in this regard. The data are demonstrated in **Table 3**.

**Table 3.** Level of awareness among participants toward vitamin D deficiency

Awareness level	Count (n=431)	Percent
Poor (<50%)	175	40.6
Moderate (50-70%)	153	35.5
Good (>70%)	103	23.9

In **Table 4**, the current study evaluated the association between different factors and the level of awareness toward vitamin D benefits. For instance, respondents with a university degree and healthcare professionals (HCPs) had a significantly higher level of awareness toward vitamin D benefits (p-value<0.001). Additionally, females had a significantly higher awareness level regarding vitamin D benefits with a p-value<0.001. On the other hand, factors such as age, nationality, marital status, and history of vitamin D deficiency had no significant impact on the awareness level.

**Table 4.** Factors potentially affecting the level of awareness towards vitamin D benefits

Factors	Benefits of Vitamin D			P-value
	Categories	Median	Interquartile Range	
Gender	Male	4	3	<0.001
	Female	4	2	
Age	≤to 30 years	4	2	0.85
	> 30 years	4	2	
Nationality	Saudi	4	2	0.187
	Non-Saudi	3	4	
Occupation	HCPs	5	1	<0.001
	Non-HCPs	4	2	

Educational level	Undergraduate	3	3	<b>&lt;0.001</b>
	Graduated	4	2	
Marital status	Married	4	2	0.109
	Non-married	4	2	
History of vitamin D deficiency	Yes	4	2	0.080
	No	4	2	

Regarding the awareness level of vitamin D sources, HCPs showed a significantly higher awareness level with a p-value<0.001. Additionally, respondents with a university degree (p-value=0.028) and those with a history of vitamin D deficiency (p-value=0.024) had a significant awareness regarding vitamin D sources. In contrast, gender, age, nationality, and marital status had no significant influence on awareness regarding vitamin D sources. All data are illustrated in **Table 5**.

**Table 5.** Factors potentially affecting the awareness level of vitamin D sources

Factors	Sources of Vitamin D			P-value
	Categories	Median	Interquartile Range	
Gender	Male	3	2	0.394
	Female	3	2	
Age	≤30 years	3	2	0.965
	> 30 years	3	2	
Nationality	Saudi	3	2	0.508
	Non-Saudi	2	4	
Occupation	HCPs	4	3	<b>&lt;0.001</b>
	Non-HCPs	3	2	
Educational level	Undergraduate	3	3	<b>0.028</b>
	Graduated	3	3	
Marital status	Married	3	2	0.946
	Non-married	3	2	
History of vitamin D deficiency	Yes	3	3	<b>0.024</b>
	No	3	2	

Comparing the associated factors with the level of awareness toward vitamin D toxicity (**Table 6**), there were no statistically significant differences except for education level and occupation. For instance, HCPs (p-values <0.001) and respondents with a university degree (p-value=0.009) had a higher significant awareness score of vitamin D toxicity.

**Table 6.** Factors potentially affecting the awareness level of vitamin D toxicity

Factors	Toxicity of Vitamin D			P-value
	Categories	Median	Interquartile Range	
Gender	Male	0	1	0.505

Age	Female	0	1	0.984
	≤30 years	0	1	
Nationality	> 30 years	0	1	0.111
	Saudi	0	1	
Occupation	Non-Saudi	0	0	<b>&lt;0.001</b>
	HCPs	1	1	
Educational level	Non-HCPs	0	1	0.009
	Undergraduate	0	1	
Marital status	Graduated	0	1	0.708
	Married	0	1	
History of vitamin D deficiency	Non-married	0	1	0.119
	Yes	0	1	
	No	0	1	

Furthermore, the present study demonstrated the association between different variables and the total awareness among respondents regarding vitamin D deficiency (**Table 7**). The study revealed that females (p-value=0.020) and respondents with vitamin D deficiency history (p-value=0.025) had a significantly higher awareness score. Additionally, HCPs (p-value<0.001) and participants with a university degree (p-value=0.001) had a significantly higher awareness of vitamin D deficiency. On the other hand, factors such as age, nationality, and marital status had no significant impact on the level of awareness.

**Table 7.** Factors potentially affecting the level of awareness regarding vitamin D deficiency

Factors	Total awareness regarding Vitamin D			p-value
	Categories	Median	Interquartile Range	
Gender	Male	7	5	<b>0.020</b>
	Female	7	3	
Age	≤to 30 years	7	4	0.597
	> 30 years	7	4	
Nationality	Saudi	7	3	0.241
	Non-Saudi	4	6	
Occupation	HCPs	9	4	<b>&lt;0.001</b>
	Non-HCPs	7	4	
Educational level	Undergraduate	6	4	<b>0.001</b>
	Graduated	7	4	
Marital status	Married	7	4	0.556
	Non-married	7	4	
History of vitamin D deficiency	Yes	7	4	<b>0.025</b>
	No	7	4	

The current study demonstrates gaps in public awareness in regard to vitamin D deficiency, sources, benefits, and toxicity among the population in Taif city, Saudi Arabia. The present study showed that nearly half of the participants (40.6%) had

poor awareness of vitamin D. Similar to the present study, several studies illustrated the inadequate awareness of vitamin D. For instance, Salmanpour *et al.* reported that most participants showed an inadequate awareness level in general toward vitamin D deficiency among adult population in Al-Sharjah, UAE [23]. Another study conducted in Kuwait illustrated the poor awareness of vitamin D among patients in primary care centers [24]. In Saudi Arabia, Alamoudi *et al.* illustrated inadequate awareness among the adult population in Jeddah (39.3%) toward vitamin D [1]. Additionally, a study demonstrated that about 40% of mothers had insufficient awareness about using vitamin D supplements for their kids in Al-Ahsa, Saudi Arabia [25]. Moreover, Abukhelaif *et al.* illustrated that awareness among public residents toward vitamin D deficiency was low in the Al-Baha region, Saudi Arabia [15].

Out of Gulf countries, several studies revealed the same results. In particular, an Indian study illustrated that more than one-half of the antenatal mothers had poor awareness in regard to vitamin D deficiency [26]. Moreover, Tariq *et al.* showed limited awareness of vitamin D among health university students in Pakistan [27]. Furthermore, a British study illustrated that about 54% of at-risk patients showed inadequate awareness in regard to vitamin D deficiency symptoms [28].

Furthermore, the current study demonstrated that most participants (91.6%) confirmed that sun exposure encourages dermal production of vitamin D. Similarly, the Saudi study conducted in Jeddah illustrated that about 86.2% of respondents approved of sun exposure's main role in producing vitamin D [1]. In addition, Khan *et al.* illustrated that about 90% of female university students in Oman were aware that sunlight is the primary source of vitamin D [29]. On the other hand, a study on university students in Pakistan showed that only 36% of respondents were aware that exposure to the sunlight can induce the production of vitamin D [27]. Moreover, our study illustrated that most participants were unaware that the use of sunscreen may be associated with a higher risk of vitamin D deficiency. In the same way, the study conducted in Jeddah showed that about 82.5% of participants did not know the association between sunscreen use and the high risk of vitamin D deficiency [1]. A report from Saudi Arabia also demonstrated a high rate of sunscreen use, especially among females [30].

Furthermore, the present study illustrated that majority of participants had a good knowledge of the importance of vitamin D and its benefits. Similarly, in the study in Jeddah where about two-thirds of participants were aware of the role of vitamin D in bone health, immune health, and teeth health [1]. In addition, the study in the Al-Baha region showed that more than one-half of the respondents were aware of vitamin D benefits [15]. In contrast, the study in Pakistan illustrated that only 33% of respondents were aware of the vitamin D benefits in bone health [27]. Moreover, our study demonstrated that approximately two-thirds of participants

were unaware of the toxicity of vitamin D. On the other hand, a study among public residents in the Al-Baha region showed that about 40.5% were not aware of the vitamin D toxicity [15].

In the current study, a high educational level was significantly associated with a good level of awareness. In the same way, the study conducted in Jeddah showed a significant positive association between the level of education and awareness of vitamin D [1]. Our study demonstrated that HCPs were significantly associated with good awareness of vitamin D. Our results were the same as the results of the study conducted in the Al-Baha region, where employment status was significantly associated with the knowledge of vitamin D [15].

Furthermore, the present study illustrated that females have a better awareness level of vitamin D and its benefits. Similarly, the study carried out in the Al-Baha region confirmed that result [15]. In contrast, the study conducted in Jeddah demonstrated that gender had no significant impact on the level of awareness of vitamin D [1]. In our study, marital status and age had no significant impact on the level of awareness. On the other hand, a study conducted by Abukhelaif *et al.* illustrated that age and marital status had a significant influence on the awareness of vitamin D [15]. Moreover, our study showed that participants with a Vitamin D deficiency history have higher awareness levels. To our knowledge, there were no studies in Saudi Arabia comparing the awareness level among those individuals to the general population.

The present study had some limitations as the knowledge of the appropriate timing of sun exposure was not assessed, which can significantly affect the level of vitamin D production. In addition, the data was collected from the population in a single city in Saudi Arabia, which could limit the generalization of the results to the whole population.

## CONCLUSION

Our study showed an inadequate awareness among the adult population in Taif city toward vitamin D deficiency. The study also illustrated a significant association between the educational level and the level of awareness in regard to vitamin D deficiency. For that reason, more educational campaigns are recommended to increase awareness of vitamin D. Additionally; further studies are needed to identify the reasons for poor awareness among the general population and to fill the awareness gap.

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## REFERENCES

1. Alamoudi LH, Almuteeri RZ, Al-Otaibi ME, Alshaer DA, Fatani SK, Alghamdi MM, et al. Awareness of Vitamin D Deficiency among the General Population in Jeddah, Saudi Arabia. *J Nutr Metab*. 2019;2019:4138187.
2. Chang SW, Lee HC. Vitamin D and health - The missing vitamin in humans. *Pediatr Neonatol*. 2019;60(3):237-44.
3. Antonucci R, Locci C, Clemente MG, Chicconi E, Antonucci L. Vitamin D deficiency in childhood: old lessons and current challenges. *J Pediatr Endocrinol Metab*. 2018;31(3):247-60.
4. Hamhoum AS, Aljefree NM. Knowledge and Attitudes towards Vitamin D among Health Educators in Public Schools in Jeddah, Saudi Arabia: A Cross-Sectional Study. *Healthcare (Basel)*. 2022;10(12):2358. doi:10.3390/healthcare10122358
5. Salman S, Khouzami M, Harb M, Saleh B, Boushnak MO, Moussa MK, et al. Prevalence and Predictors of Vitamin D Inadequacy: A Sample of 2,547 Patients in a Mediterranean Country. *Cureus*. 2021;13(5):e14881.
6. Lhamo Y, Chugh PK, Gautam SR, Tripathi CD. Epidemic of Vitamin D Deficiency and Its Management: Awareness among Indian Medical Undergraduates. *J Environ Public Health*. 2017;2017:2517207.
7. Delahunty I, Li J, Jiang W, Lee C, Yang X, Kumar A, et al. 7-Dehydrocholesterol Encapsulated Polymeric Nanoparticles As a Radiation-Responsive Sensitizer for Enhancing Radiation Therapy. *Small*. 2022;18(17):e2200710. doi:10.1002/smll.202200710
8. Makke A. Vitamin D Supplementation for Prevention of Dental Implant Failure: A Systematic Review. *Int J Dent*. 2022;2022:2845902. doi:10.1155/2022/2845902
9. Sizar O, Khare S, Goyal A, Bansal P, Givler A. Vitamin D deficiency. *InStatPearls [Internet]* 2021 Jul 21. StatPearls Publishing.
10. Alfaqih MA, Araidah A, Amarin Z, Saadeh R, Al-Shboul O, Khanfar M, et al. Association of vitamin D levels and polymorphisms in vitamin D receptor with type 2 diabetes mellitus. *Biomed Rep*. 2022;18(1):3. doi:10.3892/br.2022.1585
11. Charoengam 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
12. Lamberg-Allardt C. Vitamin D in foods and as supplements. *Prog Biophys Mol Biol*. 2006;92(1):33-8. doi:10.1016/j.pbiomolbio.2006.02.017
13. Pereira-Santos M, Costa PR, Assis AM, Santos CA, Santos DB. Obesity and vitamin D deficiency: a systematic review and meta-analysis. *Obes Rev*. 2015;16(4):341-9.
14. Christie FT, Mason L. Knowledge, attitude and practice regarding vitamin D deficiency among female students in Saudi Arabia: a qualitative exploration. *Int J Rheum Dis*. 2011;14(3):e22-9.
15. Abukhelaif AE, Alzahrani SA, Al-Thobaiti LY, Alharbi AA, Al KM, Shumrani YS. Assessment level of awareness of Vitamin D deficiency among the public residents of Al-Baha region; Saudi Arabia. *Med Sci*. 2021;25(116):2728-36.
16. Hussain AN, Alkhenizan AH, El Shaker M, Raef H, Gabr A. Increasing trends and significance of hypovitaminosis D: a population-based study in the Kingdom of Saudi Arabia. *Arch Osteoporos*. 2014;9(1):1-5.
17. Ardawi MS, Qari MH, Rouzi AA, Maimani AA, Raddadi RM. Vitamin D status in relation to obesity, bone mineral density, bone turnover markers and vitamin D receptor genotypes in healthy Saudi pre- and postmenopausal women. *Osteoporos Int*. 2011;22(2):463-75.
18. Ardawi MS, Sibiany AM, Bakhsh TM, Qari MH, Maimani AA. High prevalence of vitamin D deficiency among healthy Saudi Arabian men: relationship to bone mineral density, parathyroid hormone, bone turnover markers, and lifestyle factors. *Osteoporos Int*. 2012;23(2):675-86.
19. Alsuwadia AO, Farag YM, Al Sayyari AA, Mousa DH, Alhejaili FF, Al-Harbi AS, et al. Prevalence of vitamin D deficiency in Saudi adults. *Saudi Med J*. 2013;34(8):814-8.
20. Alfawaz H, Tamim H, Alharbi S, Aljaser S, Tamimi W. Vitamin D status among patients visiting a tertiary care center in Riyadh, Saudi Arabia: a retrospective review of 3475 cases. *BMC Public Health*. 2014;14(1):1-6.
21. Al-Agha AE, Alorabi SH, NoorSaeed SM, Shalabi NM. Awareness of vitamin D and its deficiency in Jeddah population, Saudi Arabia. *J Community Public Health Nurs*. 2016;2(2):1-5.
22. SaeidiFard N, Haeri-Mehrizi AA, Akbarzadeh Z, Janbozorgi N, Montazeri A, Yaseri M, et al. Association of health literacy and nutritional literacy with sun exposure in adults using structural equation modelling. *BMC Public Health*. 2022;22(1):1162. doi:10.1186/s12889-022-13465-6
23. Salmanpour VA, Ibrahim HS, Salameh AG, Yahya AM, Debal BK. Vitamin D deficiency: knowledge and practices among the adult population in Sharjah, United Arab Emirates. *Arch Osteoporos*. 2016;11(1):1-7.
24. Al Bathi BA, Al Zayed KE, Al Qenai M, Makboul G, El-Shazly MK. Knowledge, attitude and practice of patients attending primary care centers toward vitamin D in Kuwait. *Alexandria J Med*. 2012;48(3):277-82.
25. Alramdhan AM, El-Zubair AG. Poor vitamin D supplementation in infants. Cross-sectional study of maternal practices and awareness of vitamin D supplementation in infants in Al-Ahsa, Eastern Saudi Arabia. *Saudi Med J*. 2014;35(1):67-71.
26. Kavitha D. Knowledge, attitudes and practice regarding Vitamin D deficiency among antenatal mothers. *Int J Pharma Bio Sci*. 2015;6(4):486-97.
27. Tariq A, Khan SR, Basharat A. Assessment of knowledge, attitudes and practice towards Vitamin D among university students in Pakistan. *BMC Public Health*. 2020;20(1):1-0.
28. Alemu E, Varnam R. Awareness of vitamin D deficiency among at-risk patients. *BMC Res Notes*. 2012;5(1):1-6.
29. Khan N, Hussain S, Bashar S, Hasan S, Palis EA, Iqbal S. Attitudes and behavior towards sunlight exposure and knowledge about vitamin D among Omani female university students. *EC Nutr*. 2017;8(2):35-42.
30. AlGhamdi KM, AlAklabi AS, AlQahtani AZ. Knowledge, attitudes and practices of the general public toward sun exposure and protection: A national survey in Saudi Arabia. *Saudi Pharm J*. 2016;24(6):652-7.