Top Clin Nutr
Vol. 39, No. 4, pp. 288–297

ORIGINAL ARTICLE

Is There an Association Between Serum Levels of Vitamin D, Sleep Quantity, and Sleep Quality in Health Care Workers?

Data From the Azar Cohort Study

Seyed-Yaghob Moaddab, MD; Negar Bonyadi, MD; Elnaz Faramarzi, PhD; MohammadReza Bonyadi, MD; Mohammdhossein Somi, MD; Sarvin Sanaie, MD, PhD; Fatemeh Hamedi-Kalajahi, PhD(C); Roghayeh Molani-Gol, PhD(C)

The association between serum vitamin D levels and sleep quantity and quality was evaluated in this cross-sectional study, which was conducted on 1428 health care workers enrolled in the health care worker cohort study. Demographic characteristics, anthropometry, blood pressure, sleep quality using the Pittsburgh Sleep Questionnaire Inventory (PSQI), and serum levels of 25(OH) vitamin D were noted. The prevalence of vitamin D insufficiency and deficiency in

Author Affiliations: *Liver and Gastrointestinal Diseases Research Center, Tabriz University of Medical Sciences, Tabriz, Iran (Drs Moaddab, Faramarzi, and Somi); Student Research Committee, Tabriz University of Medical Sciences, Tabriz, Iran (Dr N. Bonyadi and Ms Molani-Gol); Immunology Research Center, Faculty of Medicine, Applied Research Center, Tabriz University of Medical Sciences, Tabriz, Iran (Dr Bonyadi); Research Center for Integrative Medicine in Aging, Aging Research Institute, Tabriz University of Medical Sciences, Tabriz, Iran (Dr Sanaie); and Student Research Committee, Department of Clinical Nutrition, Faculty of Nutrition and Food Sciences, Tabriz University of Medical Sciences, Tabriz, Iran (Ms Hamedi-Kalajahi).*

Seyed-Yaghob Moadab and Negar Bonyadi contributed equally as co-first authors.

Sarvin Sanaie and Fateme Hamedi-Kalajahi contributed equally as corresponding authors.

This study was supported by a grant from Liver and Gastrointestinal Diseases Research Center, Tabriz University of Medical Sciences.

The authors are grateful for the financial support from the Liver and Gastrointestinal Diseases Research Center, Tabriz University of Medical Sciences. The authors are deeply indebted to all subjects who participated in this study. We thank the Iranian Ministry of Health and Medical Education who has contributed to the funding used in the Health Care Worker cohort study. In addition, we would like to thank the Persian cohort study staff for their technical support. We would like to appreciate the cooperation of the Clinical Research Development Unit of Imam Reza General Hospital, Tabriz, Iran for conducting this research.

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Correspondence: *Sarvin Sanaie, MD, PhD, Research Center for integrative Medicine in Aging, Aging Research Institute, Tabriz University of Medical Sciences, Tabriz, Iran (Sarvin_so2000@yahoo.com); Fatemeh Hamedi-Kalajahi, PhD(C), Tabriz University of Medical Sciences, Tabriz, Iran (fatemehamedi2018@yahoo.com).*

DOI: 10.1097/TIN.0000000000000376

health care workers was 26.6% and 49.5%, respectively. Generally, 90.3% of the participants rated their sleep as fairly good or very good and the mean PSQI score was 4.69 ± 2.5. Only a small number of participants had sleep efficiency less than 65% (2.3%). There was no significant association between vitamin D levels and PSQI components ($P > .05$), possibly because most participants had good sleep quality. **Key words:** *cohort study*, *health care worker*, *Pittsburgh Sleep Questionnaire Inventory*, *sleep quality*, *sleep quantity*, *vitamin D*

VITAMIN D (25-hydroxy vitamin D [25(OH)D]) deficiency is relatively common in Europe, Canada, and the United States, with about 5.9% to 13% and 24% to 40% of individuals having 25(OH)D levels below 30 and 50 nmol/L, respectively.[1-3] In Iran, vitamin D deficiency rates vary from 30% to 90% among different age groups and regions.[4-6] Food sources of vitamin D are limited, but vitamin D can be synthesized endogenously in the skin by direct exposure to sunlight. Factors such as high latitude, dark skin pigments, old age, and sunscreen or protective clothing can affect the production of this vitamin.[7] Vitamin D as a fat-soluble vitamin plays a vital function in bone and calcium homeostasis and possibly plays a role in cancer, blood pressure, and blood glucose control, as well as may impart anti-inflammatory effects.[8,9]

Vitamin D has also been associated with various aspects of quality of life, including sleep quality.[10] However, it was demonstrated that sleep quality can decrease with increasing vitamin D levels.[11] A systematic review has revealed mixed results on the effect of vitamin D on sleep.[12] The prevalence of poor sleep quality is high among adults, representing a paramount public health concern.[13-15] This issue is particularly prominent among health care workers.[16,17] Poor sleep quality can cause impaired physical and mental health, cognitive decline, low quality of life, and an increase in health care costs.[18,19] Moreover, increased risk of work injury and a negative correlation between anxiety and sleep problems in health care workers have been reported.[20,21] Several sleep quality-related problems like short sleep duration, sleep fragmentation, and lower sleep efficiency have been reported in association with low vitamin D status in different populations.[22-24] Currently, there are contradicting results of randomized controlled trials evaluating the effects of vitamin D supplementation on sleep quantity and quality.[25,26] Due to the high prevalence of vitamin D deficiency in Iran and worldwide, delineating an association between vitamin D and quantity and quality of sleep can be helpful in implementing clinical and preventive practices. This study aimed to evaluate the association between serum vitamin D with sleep quantity and quality using the validated Persian version of the Pittsburgh Sleep Questionnaire Inventory (PSQI)[27] for the first time among health care workers in Iran.

METHODS

Study design and population

This cross-sectional study used data from health care workers enrolled in the Health Care Worker Cohort study (AZAR cohort study), which is a part of the PERSIAN cohort.[28] The Liver and Gastrointestinal Diseases Research Center of Tabriz University of Medical Sciences, Tabriz, Iran, conducted this investigation.[29] The institutional ethics committee approved the study protocol (Ethical code: IR.TBZMED.REC.1400.619) and written informed consent was obtained from all participants.

This study was conducted on 1428 health care workers of the Tabriz University of Medical Sciences who were at the enrollment phase of a health care worker cohort study during 2019 to 2020. The participants were selected from different parts of the university, including schools, hospitals, health centers, etc. Data were collected to monitor the long-term health status of the participants in a cross-sectional manner. Under a unique protocol, all questionnaires were completed and

examinations were performed on the same day at the same place.

Participants included full-time and long-term contract employees aged 18 to 65 years who were not pregnant or breastfeeding and were not planning to retire within the next 5 years.

Demographic characteristics

Demographic characteristics were evaluated using a questionnaire that included the following items: age, gender, marital status, and education level.

Measure of sleep

The PSQI was used to assess sleep quality, which was translated and validated in Persian.[27] This subjective scale features 19 multiple-choice questions concerning the quality of sleep, the delay until falling asleep, sleep problems, use of hypnotic drugs, and interference with day-to-day activities due to daytime sleepiness. The total score ranges from 0 to 21 and is made up of 7 components (each scored between 0 and 3). Total scores above 5 indicate poor sleep quality.[30] The standard scoring system was used to calculate the PSQI scores.[30]

Anthropometry and blood pressure

Weight, height, and waist circumference of all participants were measured. Body mass index was calculated by dividing weight (kg) by height (m) squared. The details regarding the anthropometric measurements are reported on the AZAR cohort profile.[29] A trained nurse measured each participant's blood pressure twice for each arm during a 2-minute interval using a mercury sphygmomanometer (Rudolf Richter; DE-72417; Germany). The subjects rested for 10 minutes before the measurements. The mean values were taken as the systolic and diastolic blood pressures.

Assessment of 25(OH)D concentration

After overnight fasting for at least 12 hours, blood specimens were drawn from each subject to assess the serum 25(OH)D level with MONOBIND enzyme immunoassay kits (DIAsource KAP1921, Belgium).[31] In line with the standard ranges provided by the Endocrine Society, serum 25(OH)D levels below 20 ng/mL were considered as vitamin D deficiency, 20 to 30 ng/mL as insufficiency, and above 30 ng/mL as sufficiency.[32]

Statistical analysis

SPSS version 11.5 (IBM, Chicago, Illinois) software was used for all statistical analyses. Quantitative variables were summarized using the mean ± standard deviation or median and checked for significant differences among the 3 study groups using the Kruskal-Walis and 1-way analysis of variance statistical tests. For categorical variables, frequencies and percentages were presented and the χ^2 and Kruskal-Walis statistical tests to determine significant differences among the groups where appropriate. Ordinal logistic regression was used to assess for any links between PSQI components and vitamin D status. Furthermore, crude and adjusted odds ratios, along with their 95% confidence intervals, were determined. Adjustments were made for confounding variables such as age, gender, education level, and marital status, chronic diseases (diabetes, hypertension, ischemic heart diseases, and depression) with vitamin D sufficiency (25(OH)D>30 ng/mL) being used as the reference group. Statistical significance was marked by P values below .05.

RESULTS

As indicated in Table 1, the prevalence of vitamin D deficiency and insufficiency in our participants was 49.5% and 26.6%, respectively. Vitamin D deficiency was significantly higher in males than in females (57.6% vs 41.5%) ($P < .001$). Generally, 90.3% of the participants rated their sleep as fairly good or very good. We found that the rate of fairly good or very good sleep quality among males and females was different, such that males had better sleep quality (92% vs 88.5%).

Of 1428 participants, nearly 96% did not use any sleep medications. Across all participants, the mean PSQI score was 4.69 ± 2.5.

Table 1. General Characteristics and Sleep Quality and Quantity of Participants Stratified by Gender

	Total n (%)	Male n (%)	Female n (%)	*P* Value[a]
Education level				<.001
Illiterate	29 (2)	23 (3.2)	6 (0.8)	
Primary school	84 (5.9)	70 (9.7)	13 (1.8)	
Diploma	256 (17.8)	166 (23.6)	90 (12.7)	
College	1060 (74.1)	460 (64)	600 (84.7)	
Marital status				<.001
Not married	168 (11.8)	42 (5.8)	126 (17.8)	
Married	1260 (88.2)	677 (94.2)	583 (82.2)	
Medical history				
Diabetes	50 (3.5)	32 (4.4)	18 (2.5)	.06
Hypertension	140 (9.8)	76 (10.6)	64 (9)	.37
Ischemic heart diseases	37 (2.6)	27 (3.8)	10 (1.4)	.007
Depression	115 (8.1)	40 (5.6)	75 (10.7)	.001
Vitamin D status				<.001
Deficient (<20ng/ml)	708 (49.5)	414 (57.6)	294 (41.5)	
Insufficient (20-29ng/ml)	380 (26.6)	177 (24.6)	203 (28.6)	
Sufficient (≥30 ng/ml)	340 (23.8)	128 (17.8)	212 (29.9)	
Subjective sleep quality (component 1)				.069
Very good	393 (27.5)	190 (26.4)	203 (28.6)	
Fairly good	897 (62.8)	472 (65.6)	425 (59.9)	
Fairly bad	112 (7.8)	47 (6.5)	65 (9.2)	
Very bad	26 (1.8)	10 (1.4)	16 (2.3)	
Sleep Latency score (component 2)				.014
0 (no difficulty)	691 (48.4)	369 (51.3)	322 (45.4)	
1	515 (36.1)	245 (34.1)	270 (38.1)	
2	161 (11.3)	84 (11.7)	77 (10.9)	
3 (sever difficulty)	61 (4.3)	21 (2.9)	40 (5.6)	
Sleep duration (hour) (component 3)				0.172
>7	210 (14.7)	106 (14.7)	104 (14.7)	
6-7	548 (38.4)	294 (40.9)	254 (35.8)	
5-6	542 (38)	262 (36.4)	280 (39.5)	
<5	128 (9)	57 (7.9)	71 (10)	
Habitual sleep efficiency (component 4)				.007
>85%	1299 (91)	668 (92.9)	631 (89)	
75-84%	72 (5)	35 (4.9)	37 (5.2)	
65-74%	24 (1.7)	6 (0.8)	18 (2.5)	
<65%	33 (2.3)	10 (1.4)	23 (3.2)	
Sleep disturbances score (component 5)				.023
0 (no difficulty)	340 (23.8)	183 (25.5)	157 (22.1)	
1	972 (68.1)	492 (68.4)	480 (67.7)	
2	111 (7.8)	43 (6)	68 (9.6)	
3 (severe difficulty)	5 (0.4)	1 (0.1)	4 (0.6)	

(*continues*)

Table 1. General Characteristics and Sleep Quality and Quantity of Participants Stratified by Gender (*Continued*)

	Total n (%)	Male n (%)	Female n (%)	*P* Value[a]
Use of hypnotic medication (component 6)				.085
Not during the past month	1383 (96.8)	700 (97.4)	683 (96.3)	
Less than once a week	15 (1.1)	9 (1.3)	6 (0.8)	
Once or twice or more times a week	30 (2.1)	10 (1.3)	20 (2.9)	
Day Time dysfunction score (component 7)				.009
0 (no difficulty)	688 (48.2)	325 (45.2)	363 (51.2)	
1	545 (38.2)	275 (38.2)	270 (38.1)	
2	181 (12.7)	111 (15.4)	70 (9.9)	
3 (severe difficulty)	14 (1)	8 (1.1)	6 (0.8)	
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	***P* value[b]**
Age (years)	42.50 ± 6.75	43.04 ± 7.33	41.95 ± 6.05	.003
Height (cm)	165.99 ± 9.52	172.85 ± 6.93	159.03 ± 6.16	<.001
Weight (kg)	76.79 ± 13.5	82.90 ± 13.16	70.57 ± 10.75	<.001
Waist circumference (cm)	95.48 ± 9.56	97.08 ± 9.12	93.85 ± 9.73	<.001
BMI (kg/m^2)	27.81 ± 3.96	27.71 ± 3.91	27.91 ± 4.02	.324
Systolic blood pressure (mmHg)	110.96 ± 14.48	116.84 ± 13.96	105.01 ± 12.45	<.001
Diastolic blood pressure (mmHg)	76.24 ± 9.26	79.19 ± 8.96	73.25 ± 8.58	<.001
Global Score	4.69 ± 2.50	4.55 ± 2.25	4.84 ± 2.73	.029

Abbreviations: BMI, body mass index; SD, standard deviation.
[a]*P* value: χ^2 test.
[b]*P* value: independent *t* test.

We observed that only a small number of participants had sleep efficiency less than 65% (2.3%).

Among the study participants, no significant difference between the vitamin D-deficient and non-deficient groups in terms of the total PSQI score or PSQI component scores ($P > .05$) was found. The related data are presented in Table 2. According to ordinal regression, there was no significant association between different vitamin D levels and PSQI components (Table 3).

DISCUSSION

The present study highlighted the high prevalence of vitamin D deficiency among health care workers; 49.5% of the participants were vitamin D deficient, and 26.6% had insufficient serum vitamin D levels. Vitamin D deficiency and its related complications and disorders are a global concern[33,34] that can lead to neurological disorders and affect brain development.[35,36] A previous study reported that restless leg syndrome (RLS) is strongly associated with vitamin D deficiency, and the prevalence of sleep problems is high in people with RLS.[37] The expression and activation of vitamin D receptors and vitamin D-related enzymes are regulated in the parts of the brain that are involved in regulating sleep.[38,39] Romano et al. postulate that vitamin D is most likely involved in the sleep-wake cycles.[40] Another suggested mechanism for the involvement of vitamin D in sleep regulation is its role in the conversion of tryptophan to 5-hydroxytryptophan, which is converted to serotonin to produce melatonin.[41]

Table 2. Comparison of Frequency, Mean, and Standard Deviation of Components of the PSQI by Vitamin D Status

	Vitamin D Status			
	Deficient (n = 708) (<20 ng/mL) n (%)	**Insufficient (n = 380) (20–29 ng/mL) n (%)**	**Sufficient (n = 340) (≥30 ng/mL) n (%)**	***P* Value[a]**
Subjective sleep quality (component 1)				.314
Very good	204 (28.8)	102 (2.68)	87 (25.6)	
Fairly good	441 (62.3)	243 (63.9)	213 (62.16)	
Fairly bad	49 (6.9)	30 (7.9)	33 (9.7)	
Very bad	14 (2)	5 (1.3)	7 (2.1)	
Sleep latency score (componet 2)				.333
0 (no difficulty)	355 (50.1)	173 (45.5)	163 (47.9)	
1	245 (34.6)	140 (36.8)	130 (38.2)	
2	77 (10.9)	52 (13.7)	32 (9.4)	
3 (sever difficulty)	31 (4.4)	15 (24.6)	15 (4.4)	
Sleep duration (hour) (component 3)				.167
>7	112 (15.8)	56 (14.7)	42 (12.4)	
6-7	262 (37)	157 (41.3)	129 (37.9)	
5-6	266 (37.6)	143 (37.6)	133 (39.1)	
<5	68 (9.6)	24 (6.3)	36 (10.6)	
Habitual sleep efficiency (component 4)				.428
>85%	647 (91.4)	348 (91.6)	304 (89.4)	
75-84	39 (5.5)	20 (5.3)	13 (3.8)	
65-74	7 (1)	9 (2.4)	8 (2.4)	
<65	15 (2.1)	3 (0.8)	15 (4.1)	
Sleep Disturbances score (component 6)				.475
0 (no difficulty)	173 (24.4)	87 (22.9)	80 (23.5)	
1	486 (68.6)	262 (68.9)	224 (65.9)	
2	45 (6.4)	31 (8.2)	35 (10.3)	
3 (sever difficulty)	4 (0.6)	0 (0)	1 (0.3)	
Use of hypnotic medication (Component 6)				.992
Not during the past month	686 (96.9)	368 (96.8)	329 (96.8)	
Less than once a week	7 (1)	5 (1.3)	3 (0.9)	
Once or twice or more times a week	15 (2.1)	7 (1.8)	8 (2.4)	
Daytime dysfunction score (component 7)				.057
0 (no difficulty)	317 (44.8)	198 (52.1)	173 (50.9)	
1	289 (40.8)	128 (33.7)	128 (37.6)	
2	93 (13.1)	52 (13.7)	36 (10.6)	
3 (Sever difficulty)	9 (1.3)	2 (0.5)	3 (0.9)	
	mean ± SD	**mean ± SD**	**mean ± SD**	
Subjective sleep quality	0.82 ± 0.63	0.83 ± 0.61	0.88 ± 0.65	.314
Median	1	1	1	
Sleep latency	0.69 ± 0.83	0.76 ± 0.83	0.70 ± 0.81	.333
Median	0	1	1	

(*continues*)

Table 2. Comparison of Frequency, Mean, and Standard Deviation of Components of the PSQI by Vitamin D Status (*Continued*)

	mean ± SD	mean ± SD	mean ± SD	
Sleep duration	1.40 ± 0.86	1.35 ± 0.80	1.47 ± 0.84	.167
Median	1	1	1	
Habitual sleep efficiency	0.13 ± 0.51	0.12 ± 0.45	0.21 ± 0.69	.420
Median	0	0	0	
Sleep disturbance	0.83 ± 0.54	0.85 ± 0.53	0.87 ± 0.57	.475
Median	1	1	1	
Use of sleep medication	0.06 ± 0.39	0.06 ± 0.38	0.07 ± 0.44	.992
Median	0	0	0	
Daytime dysfunction	0.70 ± 0.73	0.62 ± 0.73	0.61 ± 0.70	.057
Median	1	0	0	
Global score	4.66 ± 2.47	4.61 ± 2.40	4.84 ± 2.67	.430[b]

Abbreviations: PSQI, Pittsburgh Sleep Questionnaire Inventory; SD, standard deviation.
[a]*P* value: Kruskal-Walis test.
[b]*P* value: 1-way analysis of variance.

Table 3. The Association Between Components of the PSQI With Vitamin D Status

	Unadjusted OR (95% CI)	*P* Value	Adjusted OR[a] (95% CI)	*P* Value
Subjective sleep quality				
Deficient (< 20 ng/mL)	0.814 (0.62-1.06)	0.12	0.81 (0.62- 1.07)	.14
insufficient (20–29 ng/mL)	0.88 (0.65-1.18)	0.40	0.88 (0.65-1.19)	.43
Sufficient (≥ 30 ng/mL)		Reference		
Sleep latency				
Deficient (< 20 ng/mL)	0.95 (0.75-1.22)	0.728	1.01 (0.78-1.29)	.931
insufficient (20–29 ng/mL)	1.14 (0.86-1.50)	0.34	1.19 (0.90-1.58)	.203
Sufficient (≥ 30 ng/mL)		Reference		
Sleep duration				
Deficient (< 20 ng/mL)	0.86 (0.68-1.10)	0.23	0.91 (0.71- 1.16)	. 45
insufficient (20–29 ng/mL)	0.77 (0.59-1.01)	0.06	0.8 (0.59-1.02)	.07
Sufficient (≥ 30 ng/mL)		Reference		
Sleep disturbance				
Deficient (< 20 ng/mL)	0.85 (0.64-1.12)	0.24	0.90 (0.68-1.19)	.48
insufficient (20–29 ng/mL)	0.94 (0.68-1.28)	0.70	0.95 (0.69-1.53)	.79
Sufficient (≥ 30 ng/mL)		Reference		
Daytime dysfunction				
Deficient (< 20 ng/mL)	1.27 (0.99-1.63)	0.05	1.19 (0.930-1.541)	.16
insufficient (20–29 ng/mL)	1.00 (0.76-1.33)	0.96	0.97 (0.71-1.27)	.74
Sufficient (≥30 ng/mL)		Reference		

Abbreviations: CI, confidence interval; OR, odds ratio; PSQI, Pittsburgh Sleep Questionnaire Inventory.
[a]Adjusted for age, gender, marital status, education level, and chronic diseases (diabetes, hypertension, ischemic heart diseases, and depression).

The findings of the current study about the association between vitamin D with sleep quantity and quality among health care workers demonstrated that approximately 90% of participants rated their sleep as fairly good or very good. However, sleep problems are common among health care workers and shift workers.[42] The results of regression indicated no significant association between different vitamin D levels and PSQI components, possibly because most participants had good sleep quality. Similarly, Kim et al[43] demonstrated that vitamin D level change was not a significantly associated factor with sleep quality among shift workers in a medical center. Another study also did not reveal a significant association between serum 25(OH)D levels and sleep quality.[44] In addition, there was no association between vitamin D and measured sleep parameters in Asian and Caucasian postmenopausal women.[23] Another cross-sectional study conducted in 2021 found no association between vitamin D and sleep quality among the general population.[25] Nevertheless, in a study performed by Bertisch et al[22] among the general population, people with vitamin D deficiency had shorter sleep durations than people with sufficient vitamin D status. Moreover, a study reported a significant association between low levels of serum 25(OH)D and poor sleep quality (short sleep duration and low sleep efficiency) among older men; sleep parameters were measured using an actigraph.[24] Therefore, concerning the association between vitamin D and sleep quality, the results are contradictory. Huiberts and Smolders[12] found inconsistent and even negative relationships between serum vitamin D levels and sleep indicators. However, our study did not show any association between vitamin D and sleep quality. This result may be because health care workers are likely to fall asleep faster and deeper due to fatigue from consecutive shifts, which is probably why they report good sleep quality; however, it should be confirmed in future studies. It is noteworthy that in a clinical trial, vitamin D supplementation did not play a significant role in sleep improvement in a vitamin D-insufficient population.[25]

To the best of our knowledge, this is the first study that evaluated the association between serum vitamin D levels and sleep quality among health care workers in Iran, and the large sample size is a strength of this study. Nonetheless, this study is limited by its cross-sectional nature and reliance on self-reported data on sleep quality, which may be affected by the literacy and information retrieval of the subjects. Also, all of the possible confounding factors that might have influenced an association between vitamin D and sleep were not controlled. Due to contradictory results in the literature, further studies with larger sample sizes can help elucidate the relationship between vitamin D and sleep quality and quantity among health care workers. Accordingly, policies can be implemented in the field of educational and therapeutic measures to improve the quality of sleep and thus increase the efficiency and effectiveness of services provided by health care workers. Future studies are warranted to establish these findings and reveal their contributing factors.

CONCLUSION

The results of this study indicated a high prevalence of vitamin D deficiency among health care workers of Tabriz University of Medical Sciences; however, there was no significant association between serum vitamin D levels with sleep quantity and quality. Our findings may guide subsequent randomized clinical trials and assist in prioritizing vitamin D interventions to increase its general health effects in the population. Moreover, because some studies have found an association with sleep and vitamin D, it may be beneficial to assess vitamin D levels in those who report problems sleeping.

REFERENCES

1. Schleicher RL, Sternberg MR, Looker AC, et al. National estimates of serum total 25-hydroxyvitamin D and metabolite concentrations measured by liquid chromatography-tandem mass spectrometry in the US population during 2007-2010. *J Nutr*. 2016; 146(5):1051-1061.
2. Sarafin K, Durazo-Arvizu R, Tian L, et al. Standardizing 25-hydroxyvitamin D values from the Canadian Health Measures Survey. *Am J Clin Nutr*. 2015; 102(5):1044-1050.
3. Cashman KD, Dowling KG, Škrabáková Z, et al. Vitamin D deficiency in Europe: pandemic? *Am J Clin Nutr*. 2016;103(4):1033-1044.
4. Olang B, Naghavi M, Bastani D, Strandvik B, Yngve A. Optimal vitamin A and suboptimal vitamin D status are common in Iranian infants. *Acta Paediatr*. 2011; 100(3):439-444.
5. Alipour S, Saberi A, Seifollahi A, Shirzad N, Hosseini L. Risk factors and prevalence of vitamin D deficiency among Iranian women attending two university hospitals. *Iran Red Crescent Med J*. 2014; 16(10):e15461.
6. Khashayar P, Meybodi HR, Homami MR, et al. The discriminative value of various biochemical parameters in detecting varying degrees of vitamin D deficiency in the Iranian population. *Clin Lab*. 2011; 57(3-4):163-170.
7. Stipanuk MH, Caudill MA. *Biochemical, Physiological, and Molecular Aspects of human Nutrition–E-book*. Elsevier Health Sciences; 2018.
8. Yin K, Agrawal DK. Vitamin D and inflammatory diseases. *J Inflamm Res*. 2014;7:69-87.
9. Zhang R, Naughton DP. Vitamin D in health and disease: current perspectives. *Nutr J*. 2010;9:65.
10. Mirzaei-Azandaryani Z, Abdolalipour S, Mirghafourvand M. The effect of vitamin D on sleep quality: a systematic review and meta-analysis. *Nutr Health*. 2022;28(4):515-526.
11. Mason C, de Dieu Tapsoba J, Duggan C, Wang CY, Korde L, McTiernan A. Repletion of vitamin D associated with deterioration of sleep quality among postmenopausal women. *Prev Med*. 2016;93:166-170.
12. Huiberts LM, Smolders KCHJ. Effects of vitamin D on mood and sleep in the healthy population: Interpretations from the serotonergic pathway. *Sleep Med Rev*. 2021;55:101379.
13. Berhanu H, Mossie A, Tadesse S, Geleta D. Prevalence and associated factors of sleep quality among adults in Jimma Town, Southwest Ethiopia: a community-based cross-sectional study. *Sleep Disord*. 2018; 2018:8342328.
14. Aydin Guclu O, Karadag M, Akkoyunlu ME, et al. Association between burnout, anxiety and insomnia in healthcare workers: a cross-sectional study. *Psychol Health Med*. 2022;27(5):1117-1130.
15. Madrid-Valero JJ, Martínez-Selva JM, Ribeiro do Couto B, Sánchez-Romera JF, Ordoñana JR. Age and gender effects on the prevalence of poor sleep quality in the adult population. *Gac Sanit*. 2017;31(1): 18-22.
16. Ghalichi L, Pournik O, Ghaffari M, Vingard E. Sleep quality among health care workers. *Arch Iran Med*. 2013;16(2):100-103.
17. Liu H, Liu J, Chen M, et al. Sleep problems of healthcare workers in tertiary hospital and influencing factors identified through a multilevel analysis: a cross-sectional study in China. *BMJ Open*. 2019; 9(12):e032239.
18. Matsui K, Yoshiike T, Nagao K, et al. Association of subjective quality and quantity of sleep with quality of life among a general population. *Int J Environ Res Public Health*. 2021;18(23):12835.
19. Garbarino S, Lanteri P, Durando P, Magnavita N, Sannita WG. Co-morbidity, mortality, quality of life and the healthcare/welfare/social costs of disordered sleep: a rapid review. *Int J Environ Res Public Health*. 2016;13(8):831.
20. Sun W, Fu J, Chang Y, Wang L. Epidemiological study on risk factors for anxiety disorder among Chinese doctors. *J Occup Health*. 2012;54(1):1-8.
21. Kling RN, McLeod CB, Koehoorn M. Sleep problems and workplace injuries in Canada. *Sleep*. 2010;33(5): 611-618.
22. Bertisch SM, Sillau S, de Boer IH, Szklo M, Redline S. 25-Hydroxyvitamin D concentration and sleep duration and continuity: multi-ethnic study of atherosclerosis. *Sleep*. 2015;38(8):1305-1311.
23. Darling AL, Hart KH, Arber S, et al. 25-Hydroxyvitamin D status, light exposure and sleep quality in UK dwelling South Asian and Caucasian postmenopausal women. *J Steroid Biochem Mol Biol*. 2019;189:265-273.
24. Massa J, Stone KL, Wei EK, et al. Vitamin D and actigraphic sleep outcomes in older community-dwelling men: the MrOS sleep study. *Sleep*. 2015; 38(2):251-257.
25. Larsen AU, Hopstock LA, Jorde R, Grimnes G. No improvement of sleep from vitamin D supplementation: insights from a randomized controlled trial. *Sleep Med X*. 2021;3:100040.
26. Song EK, Wu JR. Associations of vitamin D intake and sleep quality with cognitive dysfunction in older adults with heart failure. *J Cardiovasc Nurs*. 2018; 33(4):392-399.
27. Farrahi Moghaddam J, Nakhaee N, Sheibani V, Garrusi B, Amirkafi A. Reliability and validity of the Persian version of the Pittsburgh Sleep Quality Index (PSQI-P). *Sleep Breath*. 2012;16(1):79-82.

28. Poustchi H, Eghtesad S, Kamangar F, et al. Prospective epidemiological research studies in Iran (the PERSIAN cohort study): rationale, objectives, and design. *Am J Epidemiol*. 2018;187(4):647-655.
29. Farhang S, Faramarzi E, Amini Sani N, et al. Cohort profile: the AZAR cohort, a health-oriented research model in areas of major environmental change in Central Asia. *Int J Epidemiol*. 2019;48(2):382-382h.
30. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193-213.
31. Hollis BW, Horst RL. The assessment of circulating 25(OH)D and 1,25(OH)2D: where we are and where we are going. *J Steroid Biochem Mol Biol*. 2007;103(3-5):473-476.
32. Holick MF. Vitamin D deficiency. *N Engl J Med*. 2007;357(3):266-281.
33. Lips P, de Jongh RT, van Schoor NM. Trends in vitamin D status around the world. *JBMR Plus*. 2021;5(12):e10585.
34. Palacios C, Gonzalez L. Is vitamin D deficiency a major global public health problem? *J Steroid Biochem Mol Biol*. 2014;144(pt A):138-145.
35. Moretti R, Morelli ME, Caruso P. Vitamin D in neurological diseases: a rationale for a pathogenic impact. *Int J Mol Sci*. 2018;19(8):2245.
36. Bivona G, Gambino CM, Iacolino G, Ciaccio M. Vitamin D and the nervous system. *Neurol Res*. 2019;41(9):827-835.
37. Çakır T, Doğan G, Subaşı V, et al. An evaluation of sleep quality and the prevalence of restless leg syndrome in vitamin D deficiency. *Acta Neurol Belg*. 2015;115(4):623-627.
38. Stumpf WE, O'Brien LP. 1,25 (OH)2 vitamin D3 sites of action in the brain. An autoradiographic study. *Histochemistry*. 1987;87(5):393-406.
39. Mizoguchi A, Eguchi N, Kimura K, et al. Dominant localization of prostaglandin D receptors on arachnoid trabecular cells in mouse basal forebrain and their involvement in the regulation of non-rapid eye movement sleep. *Proc Natl Acad Sci U S A*. 2001;98(20):11674-11679.
40. Romano F, Muscogiuri G, Di Benedetto E, et al. Vitamin D and sleep regulation: is there a role for vitamin D? *Curr Pharm Des*. 2020;26(21):2492-2496.
41. Kaneko I, Sabir MS, Dussik CM, et al. 1,25-Dihydroxyvitamin D regulates expression of the tryptophan hydroxylase 2 and leptin genes: implication for behavioral influences of vitamin D. *FASEB J*. 2015;29(9):4023-4035.
42. Tian H, Di Y, Song JJC. Investigation of sleep quality and influencing factors of medical workers in a grade—a tertiary hospitals. *Chin J of Soci Med*. 2015;32:48-51.
43. Kim S, Choi J, Min J, et al. Association between serum vitamin D level and sleep quality in shift-workers. *Korean J Fam Pract*. 2022;12(1):41-47.
44. Winegar RJT. Investigating vitamin D and sleep quality. *J Nurse Pract*. 2021;17(8):935-940.