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Original Article

Factors contributing to vitamin D deficiency in Erbil, Iraq: A statistical investigation

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S U M M A R Y

Background & Aims: Scientific evidence supports vitamin D's ability to prevent and treat a wide range of diseases, and its physiological importance extends to calcium balance and bone health. This study aimed to find the factors associated with vitamin D deficiency in Erbil, Iraq.
Methods: For the study, data was gathered through a questionnaire in some private laboratories in Erbil, Iraq, between October 2020 and October 2021. Three sections make up the study: questions about demographics, questions regarding vitamin D, and questions about the effects of vitamin D insufficiency on the human body. Descriptive statistics, an independent sample test, a chi square test, a one-way ANOVA, and factor analysis were utilized to determine vitamin D deficiency using SPSS Version 28.
Results: The core findings demonstrated that while the mean vitamin D measurement for smokers was greater than for non-smokers, the mean vitamin D measurement for outside house sun exposure was higher than inside house sun exposure. People believe that low vitamin D levels are to blame for their tooth loss, Alzheimer's disease, weight gain, and dizziness, respectively.
Conclusion: This study highlights the significant role of vitamin D in maintaining overall health and well-being. It reveals that factors

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such as smoking and outdoor sun exposure are associated with varying vitamin D levels. Additionally, public perceptions link low vitamin D levels to conditions like tooth loss, Alzheimer's disease, weight gain, and dizziness. This underscores the importance of addressing vitamin D deficiency as a potential preventive measure against various health issues in the population of Erbil, Iraq.

Introduction

Vitamin D deficiency represents a widespread global health concern [1]. This fat-soluble vitamin, also known as calciferol, is obtainable through dietary supplements and occurs naturally in various food sources. Moreover, the human body synthesizes vitamin D when exposed to ultraviolet (UV) rays from sunlight. To become biologically active, vitamin D must undergo two hydroxylation processes. Initially, in the liver, it transforms into 25-hydroxyvitamin D [25(OH)D], or calcidiol. Subsequently, the second hydroxylation, predominantly occurring in the kidney, gives rise to the physiologically active form, 1,25-dihydroxyvitamin D [1,25(OH)2D], also known as calcitriol [2]. Vitamin D plays a crucial role in maintaining optimal serum calcium and phosphate levels, essential for proper bone mineralization, prevention of hypocalcemic tetany, and facilitation of nutrient absorption in the gastrointestinal tract. Insufficient vitamin D intake can result in bone thinning, brittleness, and deformities, as it is vital for bone growth and repair mediated by osteoblasts and osteoclasts. Adequate vitamin D intake prevents adult osteomalacia, childhood rickets, and helps stave off osteoporosis in older adults [2]. Furthermore, vitamin D modulates numerous genes, impacting cell growth, differentiation, and apoptosis [3]. Vitamin D receptors (VDRs) are present in various tissues, some of which convert 25(OH)D to 1.25(OH) 2D [2,3].

The acquisition of vitamin D can be achieved through dietary sources, sun exposure, and supplements [4]. Natural dietary sources of vitamin D are relatively limited, with fish liver oils and fatty fish like tuna, trout, salmon, meat, skeletal muscles, and mackerel being the richest sources [2,5–7]. Vitamin D content in animal tissues depends on their diet. Beef liver, cheese, and egg yolks contain trace amounts of vitamin D, primarily vitamin D3 and its metabolite, 25(OH)D3. Some mushrooms are also sources of vitamin D2, and UV-treated mushroom powder is approved by the FDA for use in food as a vitamin D2 supplement [8,9]. Bioavailability of vitamin D from dietary sources exhibits minimal variation [10].

Sun exposure remains a primary means of acquiring vitamin D globally, with the skin synthesizing vitamin D3 from 7-dehydrocholesterol when exposed to ultraviolet B (UVB) radiation within the 290–320 nanometer wavelength range. UVB exposure is influenced by various factors, including season, time of day, cloud cover, skin melanin levels, and sunscreen use. Windows block UVB rays, limiting indoor sunlight exposure [11]. Older adults and individuals with darker skin pigmentation produce less vitamin D through sun exposure [2,12–14]. Precisely determining the optimal sun exposure duration remains challenging due to variable UV radiation levels, individual responses, and uncertainties. Recommendations suggest exposing the face, arms, hands, and legs to sunlight without protection for 5–30 mins per day or at least twice a week between 10 a.m. and 4 p.m. This typically results in marked increase in serum 25(OH)D levels of 30 ng/mL or more [14,15]. Commercial tanning lamps emitting UVB radiation in the 2%–6% range are also effective [16]. Despite the importance of sunlight, caution is advised to limit skin exposure to UV radiation due to the risk of skin cancer [17].

UV radiation is a well-recognized carcinogen, and sunscreen with a sun protection factor (SPF) of 15 or higher is recommended to reduce skin cancer risk [17]. Sunscreens with SPF 8 or higher can inhibit the UV rays necessary for vitamin D synthesis. However, inadequate sunscreen application or reapplication may still permit vitamin D synthesis [2]. UV irradiation of yeast ergosterol produces vitamin D2, while UV irradiation of 7-dehydrocholesterol from lanolin and subsequent chemical conversion yield vitamin D3 [16]. Both forms effectively raise serum 25(OH)D levels and treat rickets. Vitamin D2 and D3 exhibit similar mechanisms and effects, with D3 being more potent in elevating and maintaining serum 25(OH)D levels [18].

Vitamin D, synthesized in the skin or obtained through diet, binds to vitamin D-binding protein (DBP) and travels to the liver [19]. Hydroxylation, mediated by cytochrome P450 (CYP) enzymes, converts vitamin D into 25(OH)D, which is then transported to the kidneys. DBP signals kidneys to perform the second hydroxylation, forming 1,25(OH)2D3, which interacts with the nuclear VDR, regulating gene expression through vitamin D response elements (VDRE) and retinoid X receptors (RXR) [16]. CYP enzymes play a crucial role in converting calcitriol into water-soluble derivatives for oral delivery [16]. The VDR also regulates CYP27B1 and CYP24A1, impacting vitamin D levels [16].

Vitamin D deficiency arises when individuals consistently consume less than recommended or lack adequate sunlight exposure and genetic factors [20–22], leading to insufficient active 25-hydroxyvitamin D synthesis or limited gastrointestinal absorption. This deficiency manifests in various illnesses, particularly among individuals with dairy sensitivity, lactose intolerance, vegetarian or vegan diets, or those who avoid sunlight [2]. Vitamin D deficiency can cause rickets, characterized by soft bones, skeletal deformities, and impaired bone mineralization. in addition, there is a correlation between vitamin D deficiency and hypothyroidism [42]. Severe rickets may result in cardiomyopathy, dental abnormalities, growth retardation, tetanic spasms, and hypocalcemia episodes [23]. Infants deprived of vitamin D are at risk, with higher prevalence among Black children in the United States [23]. Rickets incidence varies by region, with higher rates among racial and ethnic minority children, those breastfed for extended periods, and those with lower birth weight or below-average height [24]. Recent immigrants from sub-Saharan Africa, the Middle East, and Asia face increased rickets risk, influenced by genetic variations, dietary choices, and sun avoidance practices [24,25]. Osteomalacia, characterized by insufficient bone mineralization, affects both adults and adolescents [26], resulting in weakened bones, dental abnormalities, seizures, muscle contractions, and skeletal deformities [27].

The study aimed comprehensive statistical analysis investigates the relationships between Vitamin D levels, demographic variables, lifestyle factors, socioeconomic factors, and health behaviors.

Methods

The data utilized in this study were obtained between October 2020 and October 2021 from select private laboratories located in Erbil, Iraq, through the administration of a questionnaire. The Cobas e411 is utilized for conducting Vitamin D tests on all subjects. The dataset is partitioned into three distinct categories: demographic inquiries, inquiries pertaining to Vitamin D, and inquiries regarding the efficacy of Vitamin D on human physiology.

The demographic variables examined in this study encompass gender, age, marital status, place of residence, level of education, family income, and occupation. The subsequent section of this survey encompasses data pertaining to Vitamin D 25 (OH) examinations conducted on diverse patient cohorts, encompassing variables such as levels of vitamin D, consumption of vitamin D supplements, duration of sun exposure, frequency of fish consumption, and quality of sleep. The third section encompasses various physiological manifestations associated with vitamin D, including hair loss, dental loss, dry mouth, muscular fatigue, dizziness, and susceptibility to contracting COVID-19.

Subsequently, employ high-quality recording devices to capture the aforementioned data. The baseline measurement of serum vitamin D 25 (OH) was obtained, with a value of 310 for males and 480 for females.

In the analysis, various statistical methods were employed to examine the relationship between measures of vitamin D and demographic factors, as well as the impact of vitamin D deficiency on human body effectiveness. These methods included descriptive statistics, the independent sample test, the chi-square test, one-way ANOVA, and Factor Analysis. The findings pertaining to these associations were presented in the results section.

Results

Descriptive statistics for demographic questions

Table 1 presents the descriptive statistics pertaining to various demographic variables, including gender, age, marital status, residence, education, family income, and occupation. The proportion of female participants (60.8%) exceeds that of male participants (39.2%), with a majority of them being single (53.2%) and residing within urban areas (57%). The average age of the participants is 27. According to the data provided, the distribution of educational attainment among individuals can be categorized as follows: the highest proportion of individuals possessing a university degree (35.4%), followed by those with a primary education (29.1%). Individuals who are unable to read or write comprise 17.7% of the population, while those with a secondary education account for 16.5%. Finally, individuals with a master's or PhD degree represent a relatively small percentage at 1.3%. The findings indicate that a significant proportion of the participants possess a moderate level of income (87.3%), while a considerable portion of them is currently not engaged in any form of employment (36.7%).

Independent sample T *test*

An independent-samples *t*-test was conducted to compare the means of two separate groups on a continuous dependent variable [28]. The objective of this inquiry is to determine whether there exists a statistically significant disparity between the mean Vitamin D levels and various demographic factors, namely gender, marital status, place of residence, and level of education.

According to Table 2, there is a statistically significant difference in the mean values of the inside and outside responses, as evidenced by the *P*-value (0.03) being less than the predetermined significance level of α=0.05. As an illustration, the mean and standard deviation vitamin D level among individuals residing within urban areas (27±15 ng/mL) rises above that of individuals residing in suburban regions (20±12 ng/mL).

Furthermore, there is no statistically significant difference observed between the mean of the vitamin D measure and the respondents' gender, marital status, and educational level. This is indicated by the respective *P*-values (0.09, 0.06, and 0.21), which are greater than the predetermined significance level of 0.05.

Then, there is a statistically significant difference between the mean values of Sun Exposure responses (both indoors and outdoors) and the Vitamin D measure, as evidenced by the *P*-value (0.045)

Table 1
Descriptive Statistics for the personal information.

		Frequency	Percent (%)
Gender	Male	310	39.2%
	Female	480	60.8%
Age	(Mean ± SD)	(27 ± 13.3)	
Marital Status	Single	420	53.2%
	Married	370	46.8%
Residence	Inside City	450	57.0%
	Suburb City	340	43.0%
Level of Education	Illiterate	140	17.7%
	Primary	230	29.1%
	Secondary	130	16.5%
	University	280	35.4%
	Master/PHD	10	1.3%
Family Income	Low	70	8.9%
	Middle	690	87.3%
	High	30	3.8%
Occupation	Unemployment	290	36.7%
	Student	320	40.5%
	Employed	180	22.8%

Table 2
Compare between vitamin D (ng/mL) measure and (gender, marital status, place of residence, level of education, sun exposure, smoke cigarette, drink natural orange, family income and occupation).

Gender		N	Mean	Std. Deviation	t/F	*P*-value
Gender	Male	310	27	14	1.68	0.09
	Female	480	22	13		
Marital Status	Single	420	21	12	1.97	0.055
	Married	370	27	15		
Place of Residence	Inside City	450	27	15	2.15	0.030
	Suburb	340	20	12		
Level of Education	Illiterate	140	28	16	1.26	0.21
	Educator	650	23	13		
Place of sun exposure	Inside home	430	21	12	2.03	0.045
	Outside home	360	27	15		
Smoking cigarette	yes	110	31	13	2.03	0.045
	No	680	23	14		
Drinking natural orange daily	yes	560	26	14	2.04	0.046
	No	230	19	12		
Family Income	Low	70	15	9	1.90	0.15
	Middle	690	24	14		
	High	30	32	7		
	Total	790	24	14		
Occupation	Unemployment	290	26	15	5.65	0.005
	Student*	320	18	10		
	Employed*	180	30	15		
	Total	790	24	14		

*Notice, Depending on the LSD test, we found there is a significant difference between the mean of the employed and the student (12.077).

being below the predetermined significance level of α=0.05. As an illustration, the average and standard deviation value of patients' sun exposure outside their homes is (27±15 ng/mL), which exceeds the average value of patients' sun exposure indoors (21±12 ng/mL).

There exists a notable distinction between the mean values of responses regarding cigarette smoking (both yes and no) and the measurement of Vitamin D due to the fact that the *P*-value (0.045) is lower than the predetermined significance level of α=0.05. For instance, the average and standard deviation values of patients who engage in smoking is (31±13 ng/mL), which is greater than the average value of patients who do not smoke, which is (23±14 ng/mL).

There exists a notable distinction between the mean consumption of natural orange juice on a daily basis (both yes and no) and the measurement of Vitamin D, as evidenced by the *P*-value (0.04) being lower than the predetermined significance level of α=0.05. For instance, the average and standard deviation values of patients who consume orange on a daily basis is (26±14 ng/mL), which is greater than the average value of patients who do not consume orange daily, which is (19±12 ng/mL).

One-way ANOVA

This statistical method is employed to ascertain the equivalence of three or more population means. This is an extension of the t-test for two independent samples [28].

Is there a statistically significant correlation between three categories of family income and the levels of Vitamin D?

Is there a statistically significant association between three occupational groups and levels of Vitamin D?

Table 2 presents a statistically significant disparity among the mean values of occupation categories (unemployment, student, and employed) in relation to Vitamin D levels, as indicated by the *P*-value (0.005) being lower than the predetermined significance level of α=0.05. As an illustration, the average and standard deviation values of individuals who are employed (30±15 ng/mL) surpasses that of individuals who are unemployed (26±15 ng/mL), while the average value of individuals who are unemployed is higher than that of individuals who are students (18±10 ng/mL), among employed individuals is approximately 12 degrees higher than the average level of vitamin D among students. However, it is important to note that there is no statistically significant disparity observed in the mean family income (low, middle, and high) in relation to the Vitamin D outcome. This is due to the fact that the calculated *P*-value (0.156) exceeds the predetermined significance level of $\alpha=0.05$.

In addition, there is a statistically significant distinction between the mean values of students and employed individuals, as evidenced by the *P*-value (0.005) being below the predetermined significance level of $\alpha=0.05$. For instance, the average level of vitamin D among employed individuals is approximately 12 degrees higher than the average level of vitamin D among students.

Chi-square test

The Chi-square test statistic is frequently employed to analyze associations between two categorical variables [29]. The null hypothesis posits that there exists no significant association between the categorical variables within the population, indicating that they are all mutually independent. One potential research question that could be examined using a chi-square analysis is: Is there a statistically significant association between each individual component (daily sun exposure, sun exposure, smoking, and sun cream usage) and gender?

The chi-square formula can be expressed as follows.

$$X^2 = \frac{\sum (O_i - E_i)^2}{E_i}$$

where; O_i = Value as observed (actual value).

E_i = Expected value (value anticipated).

Table 3 shows there is a significant difference between Gender and (daily sun, sun exposure, smoking, and sun cream) separately because their *P*-values (0.001) are less than $\alpha=0.05$. For example, the number of males who get daily sun (n=260) is higher than the number of females who get daily sun (n=130). Most of the males get sun exposure in suburbs (n=230), while most of the females get sun exposure inside their homes (n=350). Most of the male patients are smoking cigarettes (n=110) while

Table 3
Association between gender and (daily sun, sun exposure, smoking, and sun cream).

			Gender		Total	Chi square	*P*-value
			Male	Female			
Daily Sun	yes	Count	260	130	390	24.3	0.001
		Exp. Count	15.3	23.7	39		
	No	Count	50	350	400		
		Exp. Count	15.7	24.3	40		
Total		Count	310	480	790		
Sun Exposure	Inside home	Count	80	350	430	16.6	0.001
		Exp. Count	16.9	26.1	43		
	Outside home	Count	230	130	36		
		Exp. Count	14.1	21.9	36		
Total		Count	310	480	790		
Smoking	yes	Count	110	10	110	19.8	0.001
		Exp. Count	4.3	6.7	11.0		
	No	Count	200	480	680		
		Exp. Count	26.7	41.3	68		
Total		Count	310	480	790		
Sun cream (sunscreen)	yes	Count	20	190	210	10.6	0.001
		Exp. Count	8.2	12.8	21		
	No	Count	290	290	580		
		Exp. Count	22.8	35.2	58.0		
Total		Count	310	480	790		

none of the female patients smoke them (n=10). The number of females who take sunscreen (n=190) is higher than the number of males who take sunscreen (n=20).

Table 4 shows there is a significant difference between place of residence and sleeping hours daily and supplement separately because their *P*-values (0.001 and 0.01) are less than α=0.05. For example, most of the patients who live inside cities sleep 6–9 hours daily (n=350), while most of the patients who live in suburbs sleep more than 9 hours daily. The number of patients who live inside cities used supplements (n=220) more than those who live in suburbs (n=80).

Table 5 shows there is a statistically significant difference between level of education and eating fish because its *P*-value (0.02) is less than α=0.05. For example, most of the patients who are educated are eating fish daily (n=520), while most of the patients who are illiterate are not eating fish daily (n=70).

Factor analysis to identify the effect of deficiency in vitamin D

Factor analysis is a series of multivariate statistical methods whose primary purpose is to analyze and summarize data. It addresses the problem of investigating the relationships among the many different factors and then explaining such factors in terms of their essential, basic aspects. Since the results and interpretations of the techniques are alike but the mathematical models are different, this method can indeed be considered a summary of the principal component analysis (PCA) method. The correlations between a large number of quantitative variables are important to the FA technique. By calculating very few variables, known as factors, it lowers the number of primary variables. This reduction is achieved by grouping variables into factors, the variables of which are closely correlated with each other and less correlated with variables from other factors [30–32]. Communities, which is the variation in the original variables for which the factor solution considers. Each original variable's variability should be at least to some extent explained by the factor solution; thus, the communality value for each original variable should be at least 0.50, as it is in this study.

Table 4
Association between place of residence and (sleeping hours daily and supplement).

			Place of residence		Total	Chi square	*P*-value
			Inside city	Suburb			
Daily sleeping	<6	Count	60	20	80		
		Exp. Count	4.6	3.4	8		
	6–9	Count	350	150	500		
		Exp. Count	28.5	21.5	50	16.8	0.001
	10+	Count	40	170	210		
		Exp. Count	12.0	9.0	21		
Total		Count	450	340	790		
Using supplement	yes	Count	220	80	300		
		Exp. Count	17.1	12.9	30.0	5.3	0.019
	No	Count	230	260	490		
		Exp. Count	27.9	21.1	49		
Total		Count	450	340	790		

Table 5
Association between level of education and eating fish.

			Level of education		Total	Chi square	*P*-value
			Illiterate	Educator			
Eating fish	yes	Count	70	520	590		
		Exp. Count	10.5	48.5	59		
	No	Count	70	130	200	5.5	0.029
		Exp. Count	3.5	16.5	20		
Total		Count	140	650	790		

Table (6) presents the Kaiser-Meyer, Olkin, and Bartlett tests. For the set of variables included in the investigation, the overall Measure of Sampling Adequacy was 0.705. This indicates that such a test does not find the rate of correlation to be too weak for factor analysis and also exceeds the minimal condition of 0.50 for overall MSA. The 11 variables that are still being examined in the analysis meet the criteria for factor analysis's appropriateness.

H0. The model is inappropriate for factor analysis.

H1. The model is appropriate for factor analysis.

To use principal component analysis, the probability of Bartlett's Test of Sphericity should be less than the level of importance. The Bartlett test must have a probability of less than 0.001. The Bartlett test has a probability of 0.001, which meets this requirement.

Table 6 displays the variability's initial level of explanation by all factors and its final level of explanation by the components before and after rotation. As per the Kaiser Criteria that an Eigen Value be greater than 1, the result shows the three initial common factors, which explain 55.462% of the amount of variance. This percentage remains the same using the rotation technique, but it affects the percentage that accounts for each factor. These percentages have been modified, especially to reduce any mismatches post rotation.

We only utilize rotation sums of squared loadings in interpreting and analyzing the factor analysis result in Table 6. Here, it should also be noted that the first components, which included four variables (fearing dizzy, fearing Alzheimer's disease, fearing as if you're gaining weight, and fearing as if you're losing teeth), explained a large amount of variance (21.97% of the total variance). The second component, which consisted of the variables "Fearing dry lips," "Fearing lost fingernails," "Fearing lost hair," "Fearing delayed healing", and "Fearing tired muscles," respectively, explained 21.83% of the total variance. The final factor, which has been described by the variables "Fearing sweat" and "Fearing COVID-19," contributed 11.67% of the overall variance.

Discussion

Vitamin D is a fat-soluble vitamin that plays a crucial role in maintaining overall health. Its deficiency can lead to various health problems. There are several factors that can contribute to vitamin D deficiency, and it's important to understand these factors for better prevention and management. Data for this study were collected from some private laboratories in Erbil, Iraq using a questionnaire form. Findings from this study demonstrated that there is a statistically significant difference between the mean of the vitamin D measurement and place of residence (inside city and suburb), the same

Table 6
Rotated factor matrix and communalities.

	Component			Communalities
	1	2	3	
Fearing losing teeth	0.80			0.67
Fearing Alzheimer disease	0.67			0.54
Fearing weight gain	0.64			0.65
Fearing Dizzy	0.58			0.52
Fearing Dry lips		0.69		0.51
Fearing Losing fingernail		0.66		0.63
Fearing Losing hair		0.65		0.53
Fearing delayed recovery		0.61		0.68
Fearing tired muscles		0.58		0.58
Fearing sweat			0.76	0.58
Fearing COVID-19			0.63	0.57
% of Variance (Total)	21.96	21.82	11.66	(55.46)
KMO of Sampling Adequacy			0.70	
Bartlett Test			187.65	
			0.001	

result observed by Toqeer Ali butt *et al.* [33]. This is because the people who lived inside the city are more careful and have acknowledged the importance of vitamin D and those factors that can contribute to vitamin D deficiency more than the people who lived outside the city with 26.61. While the data analyzed in this study refuted widely accepted associations between the mean of the vitamin D measurement and (gender, marital status, and level of education).

Participants (patients) who completed this study who were exposed to the sun outside their homes indicated lower vitamin D deficiency, and their mean vitamin D measure was 27.16 ng/mL, which is more than the mean of those patients who were exposed to the sun inside their homes. Zareef and Jackson [34] indicate that luck or low sun exposure cause vitamin D deficiency. This is regarding lack of sunlight exposure, especially in regions with limited sunshine or during the winter months, which can contribute to deficiency because vitamin D is often referred to as the "sunshine vitamin," and about 50%–90% of vitamin D is absorbed through the skin via sunlight while the rest comes from the diet.

This research includes participants (patients) who smoke cigarettes and those who do not smoke cigarettes. Smoking has been linked to lower levels of circulating vitamin D in the body and Smoking may affect the body's ability to metabolize and activate vitamin D, leading to lower levels of the active form of the vitamin. A meta-analysis by Yang L. *et al.* [35] indicates the negative effects of smoking on circulating vitamin D. So, our findings show that there is a significant difference between the average of smoking cigarette responses (yes and no) with the Vitamin D measure, and the mean of patients who are smoking 31.44 ng/mL is higher than those who are not smoking 22.55. Nwosu & Kum-Nji [36] revealed that tobacco smoke exposure is an independent predictor of vitamin D deficiency. In our study, many factors like sun exposure, dietary intake, gender, lifestyle, and socioeconomic status may play a role. Similarly, according to another factor that has an impact on vitamin D deficiency, drinking natural orange daily, data from this study show that there is a significant difference between the average of drinking natural orange daily (yes and no) with the vitamin D measure, with the mean of patients who are drinking orange daily at 25.64 ng/mL being higher than those who are not drinking orange daily at 19.29 ng/mL. This means that individuals may be at a lower risk for vitamin D deficiency due to their high consumption of healthy foods and beverages. According to Tangpricha *et al.* [37] fortification of orange juice with vitamin D is a novel approach for enhancing vitamin D nutritional health. Nevertheless, orange juice contains excessive amounts of sugar and lacks fiber, making it an unhealthy option.

Findings from this study demonstrated that there is a significant difference between the average of occupation (unemployment, student, and employed) and the vitamin D measure; the mean of employed, unemployed, and student is 30.26, 25.97, and 18.18 ng/mL, respectively. Sowah and Dannet *et al.* [38] in a systematic review compared vitamin D levels between indoor and outdoor workers; the mean vitamin D level was significantly lower in indoor and office workers compared to outdoor workers. This demonstrates that occupation can indeed impact an individual's vitamin D measurement. Occupations that involve significant outdoor exposure to sunlight tend to be associated with higher vitamin D levels, while indoor jobs may contribute to lower levels. While our result of the study shows that there is no statistically significant difference between the mean of family income (low, middle, and high) and the vitamin D measure.

Our study showed that there was is a significant relationship between gender and (daily sun, sun Exposure, smoking, and sun cream). Males had higher level of vitamin D than females, Gill *et al.* and Crowe *et al.* [5,39] confirmed the same result. Gender can influence daily sun exposure patterns; males tend to spend more time outdoors compared to females in some societies. With number of male (n=260) is higher than number of females who take daily sun (n=130). This can be due to differences in occupational choices, recreational activities, and cultural norms. Similarly, women are generally more likely to use protective measures like hats, sunglasses, and clothing that cover the skin when exposed to the sun with number (n=230) is lower than numbers of male (n=350). In contrast, men may engage in riskier sun exposure behaviours, such as not wearing protective clothing or sunscreen. Smoking rates have been higher among men, this study shows that most of the male's patients are smoking cigarettes (n=110) while a very little of the female smoke it (n=10). Lastly, gender can play a role in sunscreen use. This study shows that women are more likely to use sunscreen (n=190) regularly compared to men (n=20). This difference may be related to skincare practices, societal expectations, or perceptions of the importance of sun protection for maintaining youthful skin.

According to our findings, there is a significant difference between place of residence and sleeping hours daily and supplement. The place of residence, whether inside a city or suburb, can affect sleeping patterns. Inside cities tend to have more noise and artificial light, which may disrupt sleep for some individuals. In contrast, a suburb may offer a quieter and darker environment, potentially promoting longer and more restful sleep for some residents. That is why most of the patients who live inside the city are sleeping 6–9 hours daily (n=350), while most of the patients who live in a suburb are sleeping more than 9 hours daily. Similarly, the number of patients who live inside cities used supplements (n=220) more than those who live in suburbs (n=80). Choi, Lee *et al.* [40] found that low serum vitamin D status was associated with excessive sleep duration in individuals with low sun exposure.

The data that was analyzed in this research study showed that there is a statistically significant association between level of education and eating fish, with most of the patients who have been educated eating fish daily (n=520), while most of the patients who are illiterate are not eating fish daily (n=70). In fact, individuals with higher levels of education often have greater access to health information and are more likely to be aware of the nutritional benefits of foods like fish, which is a source of vitamin D, and they may be more inclined to make informed dietary choices based on this knowledge. Lehmann *et al.* [41] in a meta-analysis of randomized controlled trials conclude that fish are an important food source of vitamin D.

Lastly, our research study showed three main components that caused a deficiency of vitamin D. The first component included these factors (fearing dizzy, fearing Alzheimer's disease, fearing as if you're gaining weight, and fearing as if you're losing teeth), which explain a large amount of variance (21.97% of the total variance), which indicates the first level of effective factors. The second component included these factors: “fearing dry lips,” “fearing losing fingernail,” “fearing losing hair,” “fearing delayed healing,” and “fearing tired muscles,” respectively, which explained 21.83% of the total variance, and “feeling COVID-19" contributed 11.67% of the overall variance. The third component included these factors (fearing sweat and fearing COVID-19), which contributed 11.67% of the overall variance.

Conclusion

Statistically significant differences were observed across various factors in relation to Vitamin D measurements. Firstly, the mean Vitamin D measurement responses exhibited a significant higher Vitamin D level among an individual's residing inside the city than rural. Additionally, there was a notable disparity between responses based on sun exposure locations (inside and outside the home), where patients with outside home sun exposure showed a higher mean Vitamin D compared to those with inside sun exposure. Similarly, cigarette smoking displayed a significant impact, as patients who smoked had a higher mean Vitamin D comparison to non-smokers. Moreover, a distinct correlation was established between daily consumption of natural orange and Vitamin D levels, as patients consuming orange daily exhibited a higher mean Vitamin D. In terms of occupation, the mean Vitamin D measurement responses also varied significantly, with employed individuals displaying the highest average, followed by unemployed, and students. Furthermore, associations between gender and specific factors such as daily sun exposure, sun exposure locations, smoking habits, and sun cream usage were statistically significant. Similarly, associations were identified between place of residence and variables like daily sleep hours and supplement intake, as well as between level of education and fish consumption.

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Availability of data and materials

The data used to support the findings of this study are available from corresponding author on a reasonable request.

Authors contribution

Hazhar Talaat Abubaker Blbas: Conceptualization; data curation; investigation; methodology; writing—original draft; writing—review and editing. **Sirwan Khalid Ahmed**: Investigation; data curation; methodology; resources; writing—original draft; writing—review and editing. **Wasfi Taher Saalih Kahwachi**: Conceptualization; methodology; writing—original draft; writing—review and editing. **Khanda Gharib Aziz**: Data curation; methodology; writing—original draft; and writing—review. **Shahen Mohammed Faraj**: Conceptualization; data curation; formal analysis; methodology; supervision; writing—original draft; and writing—review. **Mohammed Subhan Mohammed**: Conceptualization; data curation; methodology; supervision; writing—original draft; and writing—review.

Ethics approval and consent to participate

All of the participants provided written informed consent for their involvement in the study after the Ethics Committee approved the research procedure at Salahaddin University.

Patient consent for publication

Not applicable.

Declaration of competing interest

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

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