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Knowledge, Attitudes, and Practices Towards Vitamin D Deficiency During the COVID-19 Pandemic in Saudi Arabia: A Cross-Sectional Study

Huda Wazzan [1], and Manal Malibary [1,2,3] *

[1]Department of Food and Nutrition, Faculty of Human Sciences and Designs, King Abdulaziz University, Jeddah, Saudi Arabia
[2] Food, Nutrition and Lifestyle Research Unit, King Fahd for Medical Research Centre, King Abdulaziz University, Jeddah, Saudi Arabia
[3]Saudi Diabetes Research Group, King Fahd Medical Research Center, King Abdulaziz University, Jeddah, Saudi Arabia
* Correspondence: mamalibary@kau.edu.sa

Abstract:

Vitamin D plays a crucial role in bone health and various physiological functions, yet deficiency remains a global public health concern. This study aimed to assess knowledge, attitudes, and practices (KAP) related to vitamin D among adults in Saudi Arabia, with a particular focus on gender differences and the impact of the COVID-19 pandemic. A cross-sectional survey was conducted among 449 participants. Knowledge was assessed through nine questions, with scores ranging from 0 to 26. Attitudes were measured using three questions. Participants were categorized into good or poor knowledge, attitude, and practice groups, and statistical analyses were conducted to examine associations with demographic factors. The mean knowledge score was 14.1 ± 3.9, while attitude and practice scores were low (1.2 ± 0.89 and 10.29 ± 3.86, respectively), indicating poor concern and behaviours related to vitamin D. Females showed greater knowledge and more health-related actions (e.g., supplement use, testing), whereas males reported better intake of vitamin D-rich foods ($p < 0.001$). Despite high knowledge, attitudes and practices need to improve across participants. most group differences in vitamin D-related KAP were not significant, except for citizenship, where non-Saudis showed better practices and slightly lower attitude scores than Saudis. The findings highlight the need for targeted public health initiatives to improve awareness of dietary sources, promote appropriate sun exposure, and encourage proactive vitamin D supplementation and testing, particularly among groups at higher risk of deficiency.

Keywords: Vitamin D deficiency, knowledge, attitude, practice, COVID-19, Saudi Arabia.

1. Introduction

Vitamin D is a fat-soluble vitamin that can be obtained from food and synthesized in the skin. It is essential for calcium and phosphorus metabolism and plays a crucial role in maintaining bone health, supporting immune function, and modulating inflammation [1, 2]. Beyond its physiological functions, Vitamin D deficiency has been linked to increased risks of chronic diseases, including osteoporosis, cardiovascular disorders, and immune dysregulation [3]. Despite the abundant sunlight in Saudi Arabia, Vitamin D deficiency remains highly prevalent across all age groups [4]. Studies indicate that approximately 80% of the Saudi population has insufficient Vitamin D levels, attributed to cultural practices limiting sun exposure, dietary patterns, and environmental factors [5].

The COVID-19 pandemic, declared in March 2020, led to prolonged lockdowns and mobility restrictions worldwide, including in Saudi Arabia. These public health measures, though necessary to limit viral spread, significantly reduced outdoor physical activity and sun exposure, potentially exacerbating existing Vitamin D

deficiency [6]. Evidence suggests that lockdowns disrupted dietary habits and health-seeking behaviors, further impacting Vitamin D status globally [7]. Moreover, research into COVID-19 risk factors highlighted Vitamin D's potential role in immune responses and infection outcomes, heightening public interest in the vitamin during the pandemic [8].

Understanding population-level knowledge, attitudes, and practices (KAP) related to Vitamin D is crucial for informing effective public health interventions. KAP studies assess individuals' understanding of a health issue, their perceptions and beliefs about its importance, and their practical behaviors [9]. Assessing KAP during the COVID-19 lockdown period can provide valuable insights into how pandemic-induced lifestyle changes influenced public awareness and behaviors concerning Vitamin D in Saudi Arabia. This study aims to evaluate the knowledge, attitudes, and practices regarding Vitamin D among adults in Saudi Arabia and assess the impact of the COVID-19 lockdown on these factors. The findings can inform targeted health promotion strategies to address Vitamin D deficiency in Saudi Arabia and similar populations.

2. Materials and Methods

2.1. Study design and population

This cross-sectional study was conducted using a structured, self-administrated questionnaire developed from different literature sources on knowledge, attitudes, and practices regarding vitamin D deficiency [10-13]. The questionnaire was distributed via social media (WhatsApp, Twitter, and Snapchat) in Arabic. The questionnaire was developed in Arabic, taking into account the cultural context of Saudi Arabia and drawing on relevant literature. The study sample included Saudi and non-Saudi individuals aged ≥18 years living in Saudi Arabia. A sample size for the Saudi population (estimated to be around 30 million people) with a confidence level of 95% and 5% margin of error was calculated at 385 participants. Ethical approval was obtained from the Faculty of Medicine Research Ethics Committee at King Abdul-Aziz University (Reference No 526-20).

2.2. Data collection

Data were collected from June to December 2020. An online consent form was presented on the first page of the online survey. In addition, the first page of survey provided information about the aim and objectives of the study, the duration of the survey, and its voluntary, confidential, and anonymous nature. The questionnaire consisted of four main parts with a total of 47 questions, covering demographic information, lifestyle and health behaviors, knowledge about Vitamin D, health practices, and dietary habits. The survey was administered online to allow for flexible completion by participants and to gather diverse responses from different regions in Saudi Arabia. The structured and culturally tailored format of the questionnaire ensured the acquisition of reliable data pertinent to the study's objectives.

2.3. Sociodemographic characteristics and physical characteristics

Participants were asked about their gender, age, height, weight, nationality, education level, marital status, and region of residence. Lifestyle and health inquiries included smoking status, physical activity levels, employment status, skin tone, and history of chronic diseases like diabetes, hypertension, or heart disease. Body mass index (BMI) (kg/m2) was calculated from self-reported heights and weights and presented according to National Center for Chronic Disease Prevention and Health Promotion (CDC) criteria: underweight (<18.5), normal weight (18.5 to 24.9), overweight (25 to 29.9), and obese (≥30) [14].

To evaluate knowledge, respondents were asked about sources of vitamin D, dietary intake, recommended daily allowances, and factors affecting vitamin D synthesis. A knowledge quiz with a maximum score of 6 points was also included. Health-related questions explored the use of sunscreen, vitamin D testing, concerns about deficiency, and supplement intake practices. Questions on sun exposure covered frequency, duration, time of day, and exposed body parts without sunscreen. Dietary habits were assessed by examining the frequency of consumption of vitamin D-rich foods, such as fatty fish, milk, eggs, and fortified products.

2.4. Assessment of knowledge towards vitamin D

A total of nine questions were used to assess participants' knowledge about vitamin D, covering sources, health benefits, recommended intake, synthesis factors, deficiency-related diseases, and dietary sources. Responses were recorded as Yes/No for most questions, while multiple-choice options were provided for specific knowledge areas. A scoring sheet was developed to calculate each participant's total knowledge score, with a maximum possible score of 29. The knowledge scores ranged from 0 to 26, with a mean score of 14.1 ± 3.9. Participants scoring below the mean were classified as having poor knowledge, while those scoring at or above the mean were considered to have good knowledge. The proportion of participants in each category was analyzed, and associations with demographic factors were examined statistically.

2.5. Assessment of attitudes toward vitamin D

Participants' attitudes toward vitamin D during the COVID-19 pandemic were assessed using three questions. Those three questions were included to address factors relating to vitamin D level during the COVID-19 pandemic. Questions were as follows: 1) I'm concerned that my current vitamin D level might be too low; 2) Since the beginning of the Corona pandemic, have you increased your desire to eat foods rich in vitamin D.; 3) During the pandemic, were you more likely to consider taking supplements to get vitamin D? Possible responses to question 1 were "Agree" and "Disagree"; responses to questions 2 and 3 were "No" and "Yes". One point was given for each response of "Agree" or "Yes", and 0 points were given for each response of "Disagree" or "No. Responses were scored from 0 to 3, with one point assigned for each positive response. Attitude scores were categorized as good (≥2 points) or poor (<2 points). The proportion of participants with a good attitude was analyzed, and associations with demographic factors were examined using statistical tests.

2.6. Assessment of practices toward vitamin D

A total of 11 questions were included in the practices toward vitamin D section, as follows: 1) Do you use sunscreen? 2) Have you ever tested your vitamin D level? 3) Do you take vitamin D supplements? 4) Do you take calcium supplements with vitamin D? 5) Are you exposed to sunlight daily? 6) How often do you eat fatty fish? 7) How often do you drink milk? 8) How often do you eat butter? 9) How often do you eat eggs? 10) How often do you eat liver? 11) How often do you eat breakfast cereals fortified with vitamin D?
Possible responses to questions 1 to 5 were "No" and "Yes", which were coded as 0 and 1, respectively. Possible responses to questions 6 to 11 were "Never" = 0; "Once a week" = 1; "2–4 times a week" = 2; "5–6 times a week" = 3; and "Daily" = 4. The total score for the section was 29 points. The total practice score ranged from 0 to 29 points, with higher scores reflecting better vitamin D-related practices. Participants were classified as having good practice if they scored ≥50% of the total (≥15 points) and poor practice if they scored <15 points. The proportion of participants with good and poor practices was analyzed, and associations with demographic factors were examined statistically.

2.7. Statistical analysis

The extracted data were reviewed, encoded, and entered into SPSS version 22 (IBM, Inc., Chicago, IL) for analysis. Statistical tests were two-tailed, with a significance threshold of $P < 0.05$. For descriptive data, mean ± standard deviation (SD) was presented for continuous variables, while frequency (percent [%]) was presented for categorical variables. Cross-tabulation was performed to evaluate factors influencing knowledge and attitudes. The Pearson chi-square test was used to assess associations between variables, and the exact probability test was applied for small frequency distributions. Linear regression analyses were used to assess whether sociodemographic characteristics predicted scores on knowledge, attitudes, and practices. The assumptions of the linear regression analysis were evaluated and met.

3. Results

3.1. General characteristics of participants

The general characteristics of participants aged 16 to 73 are shown in table 1. The mean age of participants was 40 years, with a median age of 38 years. Approximately 94.2% of participants were Saudi, with the majority being females (82%) and males (17.8%). Most participants (73.1%) held a university degree or higher, while 24.9% had a high school diploma, and 2% had less than a high school education. Regarding BMI classification, 37.64% of participants were overweight, 27.67% were obese, 29.62% had a normal weight, and 4.9% were underweight. Married participants (75.3%) formed the majority, while 16% were single and 8.7% were widowed or divorced. Housing distribution showed that 47.7% lived in houses, 47.2% in apartments, and 5.1% in other types of housing. Employment status indicated that 44.1% were employed, while 55.9% were unemployed. Among employed participants, 36.5% worked inside a closed office, 6.7% worked outdoors, and 18.9% had a mixed work environment. Regarding skin color, 66.6% had light brown/medium/tanned skin, 32.3% had fair/light/pale skin, and 1.1% had dark brown/black skin. In terms of physical activity, 42.1% rarely or never engaged in exercise, 6.5% exercised daily, 28.5% exercised 1-2 times per week, 17.1% exercised 3-4 times per week, and 5.8% exercised 5-6 times per week.

Table 1: General characteristics and lifestyle factors of participants

Variables	***n* (%)**
Gender	
Male	80 (17.8)
Female	369 (82)
Age (16 -73y)	
Mean	40 y
Median	38
BMI	
Underweight (<18.5 kg/m2)	22 (4.9)
Normal weight (18.5–24.9 kg/m2)	133 (29.62)
Overweight (25.0–29.9 kg/m2)	169 (37.64)
Obese (>30.0 kg/m2)	124 (27.67)
Citizenship	
Saudi	423 (94.2)
Non-Saudi	26 (5.8)
Marital status	
Single	72 (16)
Married	338 (75.3)
Widowed/divorced	39 (8.7)
Education level	
Less than high school	9 (2)
High school/diploma	112 (24.9)
University degree/ higher	328 (73.1)
Housing	
Apartment	212 (47.2)
House	214 (47.7)
Other	23 (5.1)
Employment status	
Employed	198 (44.1)

Unemployed	251 (55.9)
Nature of the job	
Inside a closed office	164 (36.5)
Outside/in the field	30 (6.7)
Mixed	85 (18.9)
Skin color	
Dark brown/black	5 (1.1)
Light brown/ medium/tanned	299 (66.6)
Fair/light/pale	145 (32.3)
Physical activity	
Never/rarely	189 (42.1)
Daily	29 (6.5)
1-2 times/week	128 (28.5)
3-4 times/week	77 (17.1)
5-6 times/week	26 (5.8)

3.2. Knowledge about vitamin D

A majority of participants, 96.3% of males and 98.9% of females, reported having heard or read about vitamin D, with females showing significantly higher awareness ($p < 0.001$). Sources of information varied notably between males and females. The internet was the most frequently reported source, with 56.3% of males and 50.7% of females citing it as their primary source ($p < 0.001$). Doctors or specialists were also commonly consulted, with slightly higher percentages among females (61.8%) compared to males (58.8%) ($p < 0.001$). Social media played a role for 46.3% of males and 52.8% of females ($p < 0.001$), while television and radio were more commonly cited by males (36.3%) than females (25.7%) ($p < 0.001$). Interestingly, family and friends were not a source of information for any participants, and school or university showed similar contributions for both genders. Newspapers and magazines were less frequently used, with 17.5% of males and 13.6% of females reporting these as sources ($p < 0.001$).

When asked about food as a source of vitamin D, only 10% of males and 9.2% of females responded positively, indicating a lack of awareness ($p < 0.001$). In contrast, knowledge of the recommended daily intake of vitamin D was high among both genders, with 92.5% of males and 92.4% of females answering correctly, showing no significant disparity between sexes. However, factors affecting vitamin D synthesis, such as skin pigmentation, sunscreen use, smoking, time of the day, skin cover, and obesity, were not widely recognized by participants of either sex.

Participants demonstrated a strong understanding of the role of vitamin D in bone health, with 93.8% of males and 89.7% of females acknowledging its importance, although this difference was not statistically significant ($p = 0.278$). Other health benefits, such as improved skin health, reduced risk of diabetes and cancer, improved mood, and immunity boosting, were less well recognized, with no significant differences between males and females. Awareness of the time required for sufficient sun exposure differed significantly, with 78.3% of females and 67.5% of males correctly identifying the appropriate duration ($p < 0.001$). Additionally, more males (86.3%) than females (79.4%) identified sun exposure as a key source of vitamin D ($p < 0.001$).

Knowledge of dietary sources of vitamin D varied. Fatty fish was recognized by 47.5% of males and 36.9% of females ($p < 0.001$), as was liver by 70% of males and 20.2% of females ($p < 0.001$). Other sources, including dairy products, red meat, mushrooms, fortified foods, cod liver oil, and egg yolks, were less commonly acknowledged, with females showing slightly higher awareness in certain categories. Moreover, 53.8% of

males and 55.6% of females associated vitamin D deficiency with diseases such as cardiovascular issues, diabetes, depression, hypercholesterolemia, and cancer ($p < 0.001$), Table 2.

The knowledge scores regarding vitamin D among participants ranged from 4 to 26, with a mean score of 13.69 ± 4.08. This suggests that, on average, participants had a moderate level of knowledge about vitamin D. Scores below the mean were classified as poor knowledge, indicating that a significant proportion of participants had limited awareness of vitamin D, its sources, and its health benefits. The observed standard deviation reflects variability in knowledge levels, suggesting disparities in understanding among the population.

Table 2: Participants' knowledge of vitamin D

Variables	Male (Frequency, %)	Female (Frequency, %)	P value
Have you ever heard/read about vitamin D?	77 (96.3)	365 (98.9)	< 0.001*
Yes	3 (3.8)	4 (1.1)	
No			
Sources of information about vitamin D?			
Internet			
Yes	45 (56.3)	187 (50.7)	< 0.001*
No	35 (43.8)	182 (49.3)	
Doctor/specialist			
Yes	47 (58.8)	228 (61.8)	< 0.001*
No	33 (41.3)	141 (38.2)	
Social media			
Yes	37 (46.3)	195 (52.8)	< 0.001*
No	43 (53.8)	174 (47.2)	
Family/friends			
Yes	0 (0.0)	0 (0.0)	< 0.001*
No	80 (100.0)	369 (100.0)	
Tv/radio			
Yes	29 (36.3)	95 (25.7)	< 0.001*
No	51 (63.7)	274 (74.3)	
School/university			
Yes	16 (20.0)	75 (20.3)	< 0.001*
No	64 (80.0)	294 (79.7)	
Newspaper/magazine			
Yes	14 (17.5)	50 (13.6)	< 0.001*
No	66 (82.5)	319 (86.6)	
Is food considered a good source of vitamin D?	8 (10.0)	34 (9.2)	< 0.001*
Yes	72 (90.0)	335 (90.8)	
No			

Recommended daily intake of vitamin D for adults			
200 IU/400 IU/800 IU/1000 IU/Don't know	74 (92.5)	341 (92.4)	< 0.001*
600 IU	6 (7.5)	28 (7.6)	
Factors affecting synthesis of vitamin D			
Skin color (pigmentation)	25 (31.3)	94 (25.5)	0.261
Yes	55 (68.8)	275 (74.5)	
No			
Sunscreen use	7 (8.8)	34 (9.2)	0.921
Yes	73 (91.3)	335 (90.8)	
No			
Smoking	68 (85.0)	295 (79.9)	0.320
Yes	12 (15.0)	74 (20.1)	
No			
Time of the day and duration of sun exposure	57 (71.3)	293 (79.4)	0.098
Yes	23 (28.7)	76 (20.6)	
No			
Covered skin	9 (11.3)	22 (6.0)	0.085
Yes	71 (88.8)	347 (94.0)	
No			
Obesity	9 (11.3)	22 (6.0)	0.085
Yes	71(88.8)	347 (94.0)	
No			
<u>Health benefits of vitamin D</u>			
Bone health	75 (93.8)	331 (89.7)	0.278
Yes	5 (6.3)	38 (10.3)	
No			
Skin health	23 (28.7)	133 (36.0)	0.242
Yes	57 (71.3)	236 (64.0)	
No			
Prevent hair loss	40 (50.0)	191 (51.8)	0.700
Yes	40 (50.0)	178 (48.2)	
No			
Reduced risk of diabetes	20 (25.0)	62 (16.8)	0.076
Yes	60 (75.0)	307 (83.2)	
No			
Reduced risk of cancer			
Yes	22 (27.5)	85 (23.0)	0.364
No	58 (72.5)	284 (77.0)	

Improved mood and reduced risk of depression **Yes** **No**	63 (78.8) 17 (21.3)	269 (72.9) 100 (27.1)	0.208
Boosts immunity **Yes** **No**	47 (58.8) 33 (41.3)	236 (64.0) 133 (36.0)	0.457
How much time does a person need to spend in the sun to get enough vitamin D **> 10 minutes or I don't know** **10-20 minutes**	54 (67.5) 26 (32.6)	289 (78.3) 80 (21.7)	< 0.001*
Sources of vitamin D **Sun exposure** **Yes** **No**	69 (86.3) 11 (13.8)	293 (79.4) 76 (20.6)	< 0.001*
Food **Yes** **No**	55 (68.8) 25 (31.3)	251 (68.0) 118 (32.0)	< 0.001*
Supplements **Yes** **No**	42 (52.5) 38 (47.5)	174 (47.2) 195 (52.8)	< 0.001*
Is vitamin D deficiency related to other diseases, such as cardiovascular problems, diabetes, depression, hypercholesterolemia, and cancer? **Yes** **No**	43 (53.8) 37 (46.3)	205 (55.6) 164 (44.4)	< 0.001*
What types of food are good sources of vitamin D? **Vegetables & fruits** **Yes** **No**	51 (63.7) 29 (36.3)	232 (62.9) 137 (37.1)	< 0.001*
Dairy products **Yes** **No**	23 (28.7) 57 (71.3)	110 (29.8) 259 (70.2)	< 0.001*
Fatty fish **Yes** **No**	38 (47.5) 42 (52.5)	136 (36.9) 233 (63.1)	< 0.001*

Liver **Yes** **No**	56 (70.0) 24 (30.0)	222 (60.2) 147 (39.8)	< 0.001*
Red meat **Yes** **No**	24 (30.0) 56 (70.0)	121 (32.8) 248 (67.2)	< 0.001*
Mushrooms **Yes** **No**	20 (25.0) 60 (75.0)	93 (25.2) 276 (74.8)	< 0.001*
Food fortified with vitamin D **Yes** **No**	6 (7.5) 74 (92.5)	39 (10.6) 330 (89.4)	< 0.001*
Cod liver oil **Yes** **No**	3 (3.8) 77 (96.3)	44 (11.9) 325 (88.1)	< 0.001*
Egg yolks **Yes** **No**	8 (10) 72 (90.0)	63 (17.1) 306 (82.9)	< 0.001*
Knowledge total mean for both male and female ± SD score	13.69 ± 4.08		

3.3. Attitudes toward vitamin D

The results show that attitudes toward vitamin D differ by gender, with women showing a greater concern for dietary and supplementary intake and vitamin D status. The high awareness among women's may be a reflect more general health-seeking behaviors that have been previously confirmed in the previous studies, where women are frequently more proactive in maintaining their nutritional health and taking preventative action. Despite this concern, both genders' overall attitude scores were low, indicating a gap between awareness and practical actions.

Table 3 highlights attitudes toward vitamin D among male (n = 80, 17.8%) and female (n = 369, 82%) participants, revealing significant gender differences. More females (71.1%) were concerned about their current vitamin D levels than males (53.75%), a statistically significant difference (p = 0.003). Regarding the desire to increase consumption of vitamin D-rich foods during the pandemic, 77.8% of females and 68.8% of males reported an increased desire, although this difference was not statistically significant (p = 0.059). Similarly, 65.9% of females and 58.8% of males reported increased consideration of taking vitamin D supplements, with no significant gender difference (p = 0.304). The attitude scores regarding vitamin D during the COVID-19 pandemic ranged from 0 to 3, with a mean score of 1.2 ± 0.89. Based on the predefined cutoff, the majority of participants fell into the poor attitude category (<2 points).

Table 3: Participants' attitudes towards vitamin D

Variables	**Male** ***n*** **(%)**	**Female** ***n*** **(%)**	**P**

Concerned about their current vitamin D levels	43 (53.75)	262 (71.0)	0.003*
Agree	37 (46.25)	107 (29.0)	
Disagree			
Since the beginning of the Covid-19 pandemic, have you increased your desire to eat foods rich in vitamin D?	55(68.8)	287 (77.8)	0.059
Yes	25(31.3)	82 (22.2)	
No			
During the pandemic, did you more strongly consider taking supplements to get vitamin D?	47 (58.8)	243(65.9)	0.304
Yes	33 (41.3)	126 (34.1)	
No			
Attitude total mean for both male and female ± SD score	1.2 ± 0.89		

3.4. Practices towards vitamin D

The survey assessed participants' practices relating to vitamin D, revealing significant differences between males and females in various aspects, including sunscreen use, supplementation, sunlight exposure, and dietary habits. A higher proportion of females (50.4%) than males (41.3%) reported using sunscreen regularly, and this difference was statistically significant ($p < 0.001$). Testing for vitamin D levels was also more common among females (79.9%) than males (61.3%) ($p < 0.001$), indicating greater engagement among females in assessing their vitamin D status.

Regarding supplementation, 48.8% of males and 52.3% of females reported taking vitamin D supplements, a statistically significant difference ($p < 0.001$). Calcium supplementation alongside vitamin D was less common, with only 23.8% of males and 31.7% of females reporting this practice ($p < 0.001$). Daily sunlight exposure was limited in both genders, with only 31.3% of males and 30.0% of females reporting regular exposure, and no significant difference ($p < 0.001$).

Dietary practices varied significantly between genders. Consumption of fatty fish, an important source of vitamin D, was reported daily by 2.5% of males and 0.8% of females, while 62.0% of males and 64.0% of females consumed it once a week ($p < 0.001$). Milk consumption showed more pronounced differences, with 28.7% of males drinking daily compared to 25.5% of females. However, females reported higher consumption frequencies across other categories ($p < 0.001$). Butter consumption was more common among males, with 41.3% consuming it daily compared to only 2.7% of females ($p < 0.001$).

Dietary practices varied significantly between genders, with distinct consumption patterns observed for various food items. For fatty fish, the most common intake frequency among both males and females was once a week, reported by 61.2% and 64.0%, respectively ($p < 0.001$). Similarly, egg consumption was predominantly once a week, with 47.5% of males and 40.1% of females reporting this frequency, while a substantial proportion of females (40.4%) indicated that they never consumed eggs ($p < 0.001$). In contrast, liver consumption differed markedly, as 55.0% of males consumed it daily, whereas 62.6% of females reported consuming it 5–6 times per week ($p < 0.001$). A similar trend was observed for breakfast cereals fortified with vitamin D,

where the highest intake frequency among both genders was never consuming it, reported by 62.5% of males and 66.2% of females ($p < 0.001$).

Regarding milk consumption, males most commonly consumed it once a week (40.0%), whereas among females, the highest proportion (26.3%) reported 5–6 times per week consumption ($p < 0.001$). Conversely, butter consumption exhibited a stark contrast, as 41.3% of males reported daily intake, while 44.2% of females consumed it 5–6 times per week, highlighting a significant gender-based difference ($p < 0.001$). These findings underscore notable variations in dietary habits between males and females, which may have implications for vitamin D intake and overall nutritional status, the p value indicating a gender-based difference in overall intake patterns. The total practice score ranged from 1 to 22, with a mean score of 10.29 ± 3.86, indicating that most participants had poor vitamin D-related practices (<15 points) (Table 4 & 5).

Table 4: Practices towards vitamin D

Variables	Male *n* (%)	Female *n* (%)	P value
Do you use sunscreen?			
Yes	30 (41.3)	186 (50.4)	<
No	50 (62.5)	183 (49.6)	0.001*
Did you ever test your vitamin D levels?			
Yes	49 (61.3)	295 (79.9)	<
No	31 (38.8)	74 (20.1)	0.001*
Do you take vitamin D supplements?			
Yes	39 (48.8)	201 (54.4)	<
No	41 (51.2)	167 (47.7)	0.001*
Do you take calcium supplements with vitamin D?			
Yes	19 (23.8)	117 (31.7)	<
No	61 (76.3)	252 (68.3)	0.001*
Are you exposed to sunlight daily?			
Yes	25	107 (29.99)	<
No	(31.25)	262 (71.0)	0.001*
	55 (68.7)		
How often do you eat fatty fish (salmon, sardines, tuna)?			
Daily	2 (2.5)	3 (0.8)	<
Once a week	49 (61.2)	236 (64.0)	0.001*
2–4 times a week	15 (18.7)	33 (8.9)	
5–6 times a week	1 (1.3)	5 (1.4)	
Never	13 (16.3)	92 (24.9)	

Table 5: Sun exposure and practices relating to vitamin D

How often do you drink milk?			
Daily	23 (28.7)	94 (25.5)	< 0.001*
Once a week	32 (40.0)	87 (23.6)	
Never	13 (16.3)	81 (22)	
٢–4 times a week	10 (12.5)	10 (2.7)	
5–6 times a week	2 (2.5)	97 (26.3)	
How often do you eat butter?			
Daily	33 (41.3)	10 (2.7)	< 0.001*
Once a week	10(12.5)	136 (36.9)	
Never	30 (37.5)	51 (13.8)	
٢–4 times a week	5 (6.3)	9 (2.4)	
5–6 times a week	2 (2.5)	163 (44.2)	
How often do you eat eggs?			
Daily	21 (26.3)	33 (8.9)	< 0.001*
Once a week	38 (47.5)	148 (40.1)	
Never	5 (6.3)	149 (40.4)	
٢–4 times a week	11 (13.8)	15 (4.1)	
5–6 times a week	5(6.3)	24 (6.5)	
How often do you eat liver?			
Daily	44 (55.0)	3 (0.8)	< 0.001*
Once a week	0 (0)	124 (33.8)	
Never	34(42.5)	5 (1.4)	
٢–4 times a week	0 (0)	6 (1.6)	
5–6 times a week	2 (2.5)	231 (62.6)	
How often do you eat breakfast cereals fortified with vitamin D?			
Daily	19 (23.8)	46 (12.5)	< 0.001*
Once a week	8 (10.0)	37 (10.0)	
Never	50 (62.5)	244 (66.2)	
٢–4 times a week	3 (3.8)	27 (7.3)	
5–6 times a week	0 (0)	15 (4.0)	
Practice total Mean for both male and female ± SD score	**10.29 ± 3.86**		

Reasons for not taking vitamin D supplements			
	26 (32.9)	37 (10.0)	< 0.001*
I think I get enough vitamin D through diet and sunlight.	8 (10.1)	30 (8.1)	0.512
I prefer not to take supplements and vitamins.	14 (17.7)	58 (15.7)	0.617
I don't know what kind to take.	4 (5.1)	18 (4.9)	1.000
Expensive	20 (25.3)	165 (44.7)	0.002
Laziness / preoccupation / forgetfulness	10 (12.7)	18 (4.9)	0.018
Unaware of its benefits			
How many times are you exposed to sunlight during the week?			
Daily	35 (43.75)	35 (9.48)	< 0.001*
I don't get exposed to the sun.	6 (7.5)	124 (33.60)	
1–2 times a week	18 (22.5)	134 (36.31)	
3–4 times a week	14 (17.5)	36 (9.75)	
5–6 times a week	6 (7.5)	12 (3.25)	
What time are you usually exposed to the sun?			
8–10 am	23 (28.7)	136 (36.9)	< 0.001*
11–1 pm	30 (3.75)	146 (39.3)	
2–4 pm	27(33.8)	88 (23.5)	
5–6 pm	0 (0)	0 (0)	
I am never exposed to the sun	0 (0)	0 (0)	
For how long are you usually exposed to the sun?			
Less than 10 minutes	23 (28.75)	123 (33.33)	< 0.001*
10–20 minutes	26(32.5)	113 (30.62)	
More than 10 minutes	24(30)	63 (17.1)	
I am never exposed to the sun	3(3.75)	70 (18.9)	
What part of your body is exposed to the sun without a cover?			
Face, hands and feet	51 (63.7)	247 (66.9)	< 0.001*
Most of my body is exposed to the sun.	25 (31.3)	104 (28.2)	0.572
None, I am fully covered	4 (5)	18 (4.9)	0.028

Table 6: Association between knowledge, attitudes and practices toward vitamin D and characteristics of participants

Category	Subgroup	Knowledge Score (Mean ± SD, p-value)	Attitude Score (Mean ± SD, p-value)	Practice Score (Mean ± SD, p-value)
Gender	**Male**	13.71 ± 3.77 (p = 0.936)	1.24 ± 0.75 (p = 0.633)	9.76 ± 3.98 (p = 0.176)
	Female	13.67 ± 4.15	1.29 ± 0.92	10.41 ± 3.82
Citizenship	**Saudi**	13.66 ± 3.96 (p = 0.470)	1.28 ± 0.87 (p = 0.044)	10.23 ± 3.83 (p = 0.013)
	Non-Saudi	14.24 ± 4.98	1.01 ± 0.84	11.13 ± 3.96
Employment Status	**Employed**	1.58 ± 0.50 (p = 0.891)	–	–
	Unemployed	1.59 ± 0.49	–	–
BMI	**Underweight**	12.74 ± 3.77 (p = 0.304)	1.47 ± 0.96 (p = 0.499)	10.79 ± 3.66 (p = 0.142)
	Normal Weight	13.57 ± 4.23	1.35 ± 0.89	10.20 ± 3.58
	Overweight	14.20 ± 4.32	1.21 ± 0.97	10.83 ± 3.94
	Obese	13.20 ± 3.82	1.30 ± 0.86	9.97 ± 3.97
Education	**Less than High School**	12.50 ± 3.80 (p = 0.509)	1.10 ± 0.70 (p = 0.969)	9.50 ± 4.30 (p = 0.840)
	High School/Diploma	13.80 ± 4.00	1.30 ± 0.80	10.10 ± 3.90
	University Degree/Higher	14.20 ± 4.20	1.40 ± 0.90	10.60 ± 4.00
Marital Status	**Single**	13.71 ± 3.79 (p = 0.935)	1.36 ± 0.95 (p = 0.703)	10.56 ± 3.89 (p = 0.819)
	Married	13.65 ± 4.15	1.27 ± 0.92	10.24 ± 3.78
	Divorced/Widowed	13.90 ± 3.55	1.26 ± 0.83	10.31 ± 4.11
Physical Activity	**Never/Rarely**	13.06 ± 4.10 (p = 0.337)	1.31 ± 0.74 (p = 0.812)	9.63 ± 4.46 (p = 0.235)
	1–4 Times/Week	14.48 ± 3.06	1.29 ± 0.85	10.05 ± 3.92
	>5 Times/Week	13.33 ± 3.57	1.33 ± 0.87	9.22 ± 3.53

The scores of vitamin D-related attitudes were slightly higher among females (1.29 ± 0.92) than males (1.24 ± 0.75), but this difference was not statistically significant (p = 0.633). Similarly, the scores of vitamin D-related practices were also higher among females (10.41 ± 3.82) compared to males (9.76 ± 3.98), but this difference did not reach statistical significance (p = 0.176). In terms of knowledge, participants with education at a high school/diploma level (13.80 ± 4.00) had lower mean scores compared to those with lower than high school education (12.50 ± 3.80) and those holding university degrees or higher (14.20 ± 4.20), although the differences were not statistically significant (p = 0.509).

Unemployed participants had slightly higher mean scores for vitamin D-related knowledge (1.59 ± 0.49) compared to employed participants (1.58 ± 0.50), but the difference was not statistically significant (p = 0.891).

Attitude scores were similar among participants who engaged in physical activity five or more times per week (1.33 ± 0.87), those who practiced one to four times per week (1.29 ± 0.85), and those who never practiced (1.31 ± 0.74), with no significant difference (p = 0.812). On the other hand, practice scores were lower among participants who did not engage in any physical activity (9.63 ± 4.46) compared to those with moderate or frequent activity, but this difference was not statistically significant (p = 0.235).

The scores of vitamin D-related knowledge were slightly higher among non-Saudi participants (14.24 ± 4.98) than Saudi participants (13.66 ± 3.96), though this difference was not significant (p = 0.470). However, attitudes (p = 0.044) and practice scores (p = 0.013) differed significantly by citizenship, with non-Saudi participants showing more favourable practices and slightly lower attitude scores. These findings highlight several demographic and behavioural factors associated with participants' knowledge, attitudes, and practices related to vitamin D (Table 6).

In summary, although most differences in mean KAP scores across gender, education, employment, and physical activity levels were not statistically significant, citizenship showed a significant association with both attitudes (p = 0.044) and practices (p = 0.013). Non-Saudi participants demonstrated more favourable practices and slightly lower attitude scores compared to Saudi participants. Overall, these findings suggest limited but notable group differences in vitamin D-related KAP.

4. Discussion

The results highlight significance gender differences in vitamin D knowledge, information sources, and knowledge about its synthesis, health benefits, and dietary sources. The survey indicates that high percentage of females and males have heard or read about vitamin D suggesting great knowledge about vitamin D. However, previous study conducted among health educators in Jeddah, Saudi Arabia, where male educators demonstrated better knowledge of vitamin D compared to their female counterparts. Specifically, 58.7% of males had good knowledge versus a lower percentage in females, highlighting gender disparities in vitamin D knowledge even among health professionals [15].

Regarding information sources, the internet was the most frequently cited medium by both genders, followed by social media, television, and radio, as well as physicians or specialists. Interestingly, none of the participants reported family or friends as sources. These was consistent with rsults from a study in Jazan University, Saudi Arabia, where the internet and healthcare professionals were primary sources of vitamin D information among female students [16]. Results showed a general lack of knowledge regarding factors affecting vitamin D synthesis. This is concerning since managing vitamin D effectively requires an understanding of these aspects. Similarly, a study conducted among Omani university students revealed that they had a moderate general grasp of vitamin D but a poor comprehension of its synthesis and sources [17].

A small proportion of participants correctly identified food as a source of vitamin D in relation to dietary sources, indicating a lack of knowledge. On the other hand, both genders had a high level of knowledge regarding their required daily intake of vitamin D. Particular information regarding dietary sources varied; for example, liver was identified by 70% of males and only 20.2% of females, but fatty fish was recognized by 47.5% of males and 36.9% of females. These reflected the need for better awareness of, which are in line with study from the Qassim city of Saudi Arabia, where women showed greater awareness of vitamin D but less sun exposure than men. Professionals were primary sources of vitamin D information among female students [18]. This highlights the need for targeted educational interventions to improve vitamin D awareness and

practices among population regarding vitamin D sources and synthesis. A good understanding of vitamin D's role in bone health was shown among participants. However, other health benefits, such as improved skin health, reduced risk of diabetes and cancer, enhanced mood, and boosted immunity, were less recognized, with no significant gender differences. Awareness of the time required for sufficient sun exposure was differed significantly between male and female. Additionally, more males than females identified sun exposure as a key source of vitamin D. This is consistent with findings from a study among Saudi children, where only 28% were aware of vitamin D sources, highlighting a widespread lack of knowledge across different demographics [19].

Moreover, results highlight a critical gap in the participants' understanding of the factors influencing vitamin D synthesis, such as skin pigmentation, sunscreen use, clothing coverage, smoking, obesity, and time of day. Despite the noticed general awareness of vitamin D, the lack of recognition of these variables suggests that participants possess only a basic understanding of how vitamin D is produced and regulated in the body. This agreed with previous study conducted in the Gulf region, which have similarly reported limited knowledge about non-dietary factors affecting vitamin D status [20].

Additionally, participants in this study showed a well-established link between vitamin D and bone health, however, their limited awareness of vitamin D's roles in immune function, mood regulation, and disease prevention—reflects a limited understanding influenced by commonly shared public health messages that primarily focus on bone health [21]. Moreover, BinSaeed et al. (2015) observed that while many people were familiar with vitamin D's role in bone health, they knew far less about its other important benefits—highlighting the need for education efforts to go beyond just skeletal health [22].

These findings align with earlier research carried out in Saudi Arabia. For example, Kambal et al. (2023) showed that while female students shown more knowledge, real behaviors like sun exposure were still insufficient, possibly as a result of social or lifestyle factors [16]. Similarly, previous study found that although many participants acknowledged the significance of vitamin D, there was a lack of practical implementation, such as increasing sun exposure or regularly taking supplements [23].

Perhaps the importance of vitamin D in immune function is probably the reason for the minor increase in interest in vitamin D-rich foods and supplements during the COVID-19 pandemic. However, the fact that many individuals' behavior did not significantly change could point to enduring obstacles including poor knowledge, and problems with accessibility [24-26].

Regarding the practices related vitamin D, results demonstrate a notable difference between males and females, with females generally showing greater attention in health-related behaviours, such as supplement use and testing for vitamin D levels. This aligns with previous research shown women are more proactive in health maintenance, including nutrition and preventive care. Despite both genders exhibited low overall practice scores, highlighting a lack of effective behaviours necessary to maintain adequate vitamin D levels.

In addition, one of the most concerning patterns was the limited exposure to sunlight across both genders, despite high awareness levels reported in earlier studies. This suggests a disconnect between knowledge and behavioural implementation. Cultural factors, such as clothing practices and indoor lifestyles—especially prevalent in some regions of Saudi Arabia—may contribute to this issue. These barriers have been previously

identified in studies such as Kambal et al. (2023), which also reported low sun exposure among female university students, despite good awareness [16, 18].

Dietary habits further reflected gendered patterns in food choices, possibly influenced by cultural preferences and social norms. For instance, while males reported more frequent consumption of certain traditional vitamin D-rich foods like liver and butter, females appeared to consume a wider variety of food sources in moderation. These variations in intake frequencies, though statistically significant, were insufficient to ensure optimal vitamin D levels, as indicated by the low overall practice scores [27, 28].

This gap between awareness and effective practice has also been documented in previously, which emphasised that increased knowledge alone does not necessarily reflect healthy practice. The low consuming of fortified foods and the unsufficient calcium intake in combination with vitamin D suggest that public health strategies should include targeted educational and behavioural change programs, along with easier access to vitamin D-rich options.

Moreover, the majority of female participants reported having previously measured their vitamin D blood levels, reflecting heightened health concerns and more proactive attitudes toward vitamin D. In contrast, most male participants had never undergone vitamin D testing. These findings are consistent with those of BinSaeed et al. (2015), where a female-majority sample (62.3%) showed significantly better knowledge and more positive attitudes toward vitamin D, with 86.3% achieving a good knowledge score (mean 6.33 out of 9) [22]. Similar trends have been reported in studies from China [12] and Australia [29], where only about half of participants expressed concern about their vitamin D status . In Jordan, Al-Qerem et al. (2015) found that 44.6% of university students had never tested their vitamin D levels [14]. Such limited awareness and concern likely contribute to poor vitamin D status; however, the willingness of individuals to learn presents an opportunity for targeted education and intervention [30].

5. Conclusions

The current study revealed a low level of knowledge regarding vitamin D among the Saudi Arabian population, which may negatively impact their health. However, participants demonstrated positive attitudes and good practices related to vitamin D, suggesting that behavioral change initiatives may be effective in improving vitamin D intake. Overall, there appears to be considerable misunderstanding and confusion about the role of sunlight in vitamin D production, its health benefits, and the sources and functions of vitamin D. Educational programs should place greater emphasis on enhancing knowledge of dietary sources of vitamin D and the importance of sun exposure. Additionally, information should be provided on the optimal time of day for adequate sun exposure, particularly during winter.

6. Limitations & Future Research

The main limitation of this study was its reliance on an online survey format, which may not effectively reach older individuals with limited access to digital media. Additionally, information regarding supplement use and the specific types of supplements taken should be explored in greater detail. Certain subgroups—including nutrition students and graduates, pregnant or breastfeeding women, menopausal women, and individuals over 65 years of age—were underrepresented, limiting the ability to draw conclusions about these populations. Future studies should specifically target these groups. A valuable enhancement would be the inclusion of

serum 25-hydroxyvitamin D [25(OH)D] measurements to allow correlations between this objective biomarker and participants' knowledge, attitudes, and practices regarding vitamin D.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Authors Contribution: Conceptualization, H.W.; methodology, M.M.; validation, M.M., H.W.; formal analysis, M.M.; investigation, H.W., M.M.; data curation, H.W.; writing—original draft preparation, M.M., H.W.; writing—review and editing, M.M., H.W.; visualization, M.M. All authors have read and agreed to the published version of the

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Data availavility

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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المعارف والاتجاهات والممارسات تجاه نقص فيتامين (د) خلال جائحة كوفيد-١٩ في المملكة العربية السعودية: دراسة مقطعية

هدى وازن[1]، ومنال مليباري[3،2،1]*

[1] قسم الغذاء والتغذية، كلية علوم الإنسان والتصاميم، جامعة الملك عبدالعزيز، جدة، المملكة العربية السعودية

[2] وحدة أبحاث الغذاء والتغذية ونمط الحياة، مركز الملك فهد للبحوث الطبية، جامعة الملك عبدالعزيز، جدة، المملكة العربية السعودية

[3] مجموعة أبحاث السكري السعودية، مركز الملك فهد للبحوث الطبية، جامعة الملك عبدالعزيز، جدة، المملكة العربية السعودية

للمراسلةmamalibary@kau.edu.sa

الملخص :

يلعب فيتامين (د) دورًا جوهريًا في صحة العظام والوظائف الفسيولوجية المتعددة، ومع ذلك فإن نقصه ما يزال يمثل قضية صحية عامة عالمية. هدفت هذه الدراسة إلى تقييم المعارف والاتجاهات والممارسات (KAP) المتعلقة بفيتامين (د) لدى البالغين في المملكة العربية السعودية، مع التركيز على الفروق بين الجنسين وتأثير جائحة كوفيد-١٩. أُجري مسح مقطعي شمل ٤٤٩ مشاركًا. تم تقييم المعرفة من خلال تسعة أسئلة، حيث تراوحت الدرجات بين ٠ و٢٦. أما الاتجاهات فقُيّمت باستخدام ثلاثة أسئلة. وصُنّف المشاركون إلى مجموعات ذات معرفة جيدة أو ضعيفة، واتجاهات وممارسات جيدة أو ضعيفة، وأُجريت التحليلات الإحصائية لفحص الارتباط بالعوامل الديموغرافية. بلغ متوسط درجة المعرفة ١٤,١ ± ٣,٩، بينما كانت درجات الاتجاهات والممارسات منخفضة (١,٢ ± ٠,٨٩ و١٠,٢٩ ± ٣,٨٦ على التوالي)، مما يشير إلى ضعف الاهتمام والسلوكيات المرتبطة بفيتامين (د). أظهرت الإناث مستوى معرفة أعلى وإجراءات صحية أكثر (مثل استخدام المكملات وإجراء الفحوصات)، في حين أفاد الذكور بتناول أفضل للأطعمة الغنية بفيتامين (د) ($p < 0.001$). وعلى الرغم من ارتفاع مستوى المعرفة، فإن الاتجاهات والممارسات تحتاج إلى تحسين لدى جميع المشاركين. معظم الفروق بين المجموعات في المعارف والاتجاهات والممارسات المتعلقة بفيتامين (د) لم تكن ذات دلالة إحصائية، باستثناء الجنسية، حيث أظهر غير السعوديين ممارسات أفضل ودرجات اتجاهات أقل قليلًا مقارنة بالسعوديين. تؤكد النتائج الحاجة إلى مبادرات صحية عامة موجّهة لتحسين الوعي بمصادر الغذاء، وتعزيز التعرض المناسب لأشعة الشمس، وتشجيع المكملات والفحوصات الاستباقية لفيتامين (د)، خصوصًا بين الفئات الأكثر عرضة للنقص .

الكلمات المفتاحية:

نقص فيتامين (د)، المعرفة، الاتجاه، الممارسة، كوفيد-١٩، المملكة العربية السعودية.