Gender-specific differences in the awareness and intake of vitamin D among adult population in Qassim region

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ABSTRACT

Background
Despite the abundance of sunshine throughout the year, vitamin D deficiency is very prevalent among different Saudi populations.

Aims
The objective of the current study was to evaluate the awareness and intake of vitamin D rich sources and their associations among adults of both genders.

Methods
A cross-sectional study was performed between June 2016 and August 2016 among adult patients and their family members (>18 years) attending 6 primary care centres in Qassim region, Saudi Arabia.

Results
A total of 500 study participants were included in the current analysis. Approximately 54.6 per cent of the participants were males and the most frequent age was 26–50 years. The majority of the participants heard of vitamin D before (91.4 per cent), believed in its importance for health (92.8 per cent), were aware of the symptoms of vitamin D deficiency (72.6 per cent), and were able to identify sun exposure (81.4 per cent) and diet (70.4 per cent) as sources. The sources of vitamin D used by the participants were sun exposure (57.2 per cent), vitamin D rich foods (51.2 per cent) and supplements (18.8 per cent). There was a significant association between overall awareness of vitamin D and intake of at least 2 sources of vitamin D in males (p<0.001) but not females (p=0.920). Although females had better awareness than males, sun exposure was much lower among females than males.

Conclusion
As supplementation was very low in both gender and since cultural factors promoting limited sun exposure among females are not easily modifiable, the current findings further highlight the critical importance of vitamin D supplementation, especially among females in Saudi Arabia.

Key Words
Awareness, vitamin D deficiency, sun exposure, gender

What this study adds:

1. What is known about this subject?
Despite the abundance of sunshine throughout the year, vitamin D deficiency is very prevalent among different Saudi populations.

2. What new information is offered in this study?
Although females had better awareness than males, sun exposure was much lower among females than males.
Background

Vitamin D is a fat-soluble vitamin essential for the regulation of calcium and phosphorus that supports cellular processes, bone mineralization and neuromuscular function.\(^1\)\(^2\) It is also important for the functioning of several other body systems, including immune, cardiovascular, and reproductive systems.\(^3\)\(^4\) Vitamin D deficiency is a global public health problem affecting all regions of the world, specially the Middle East.\(^4\)\(^5\) In addition to skeletal and dental problems, vitamin D deficiency has been linked to a long list of diseases including some types of cancer, autoimmune diseases, allergic diseases, inflammatory bowel diseases, cardiovascular diseases, hypertension, diabetes, and several others.\(^6\)\(^6\) On the other hand, excess intake of vitamin D (hypervitaminosis D) can cause hypercalcemia and calcium deposition in a number of soft tissues in the body.\(^7\)

As very few food items are naturally rich in vitamin D and vitamin D fortified foods are often not adequately consumed, sun exposure remains the most important natural source for vitamin D.\(^8\) Milk in the Qassim region is a good source. Despite the abundant sunlight in Saudi Arabia, it was estimated that approximately 80 per cent of different Saudi populations have vitamin D deficiency (defined as 25-hydroxyvitamin D <50nmol/l).\(^8\) Additionally, vitamin D deficiency was notably much higher in female than male, probably due some cultural and religious reasons.\(^9\)\(^10\) These findings highlight the critical need to raise the public awareness of the problem and its prevention.\(^11\)\(^12\) In Saudi Arabia, a number of studies recently examined the awareness of vitamin D and its deficiency among children and adolescents,\(^13\)\(^14\) female college students,\(^15\) and hospital patients. Additionally, the awareness of vitamin D supplementation to infants has been examined among primary care physicians and mothers.\(^16\)\(^17\) However, none of the previous studies examined the awareness and intake of vitamin D rich sources among adults at primary care setting. Moreover, the association between awareness and intake of vitamin D rich sources has never been the focus of these studies. The objective of the current study was to evaluate the awareness and intake of vitamin D rich sources and their associations among adult males and females attending primary care centres in Qassim region.

Method

Study design

A cross-sectional study was performed between June 2016 and August 2016 among attendants of 6 primary care centres in Qassim region, Saudi Arabia. Ethical approval was obtained from the ethical committee of Qassim College of Medicine, Saudi Arabia.

Population

A total 500 primary care attendants were recruited using convenience sampling while waiting for primary care appointments. Both patients and their family members who agreed to join the study were included. Filling the questionnaire after explaining the objectives of the study was considered approval to join the study. Adult males and females, irrespective of the cause of attending the primary care centre were included. Exclusion criteria included age less than 18 years and having severe mental or sensory problems that affect convenient interactions.

Data collection

Data were collected using a self-answered study questionnaire covering the following sections; demographics, medical history, awareness of vitamin D, and intake of vitamin D. The questionnaire was developed after reviewing similar studies\(^13\)\(^18\). Data were collected using a self-answered study questionnaire covering the following sections; demographics, medical history, awareness of vitamin D, and intake of vitamin D. The questionnaire was developed after reviewing similar studies\(^13\)\(^18\). A pilot study was conducted on 10 volunteers to ensure clarity and convenience of the questions and to estimate the time needed to fill the questionnaire.

Study outcomes

Awareness of vitamin D was defined as the ability to positively answer 4 questions about ever hearing of vitamin D, awareness of the importance of vitamin D for health, awareness of the symptoms of vitamin D deficiency, and awareness of at least one vitamin D sources, including diet and sun exposure. Vitamin D intake was defined as actual intake of at least two sources of vitamin D, including sun exposure, vitamin D rich diet, and vitamin D supplements.

Statistical analysis

Data were presented as frequencies and percentages. Demographic characteristics and medical history were compared between groups defined by the study outcomes; overall awareness of vitamin D and intake of vitamin D. Chi-square or Fisher exact tests, as appropriate, was used to detect significant differences. The association of overall awareness and intake of vitamin D, overall and stratified by gender, were done using Chi-square and Mantel-Haenszel Chi-square. All P-values were two-tailed. P-value <0.05 was
Results
A total of 500 study participants were included in the current analysis. Demographic characteristics and medical history of the study participants are shown in Table 1. The most frequent age of the participants was between the age of 26 and 50 years (49.4 per cent), followed by ≤25 years (46.8 per cent) and very few >50 years (3.8 per cent). Approximately 54.6 per cent of the participants were males and 57.8 per cent were college graduates. Approximately 18.1 per cent of the female participants were either pregnant or breastfeeding. Approximately 41.8 per cent of the participants have been told before that they have vitamin D deficiency. History of vitamin D deficiency was more frequent in females than males (55.1 per cent and 30.8 per cent, \(p=0.001\)). Only 6.2 per cent of the participants had history of Crohn’s disease, ulcerative colitis, or celiac sprue. Approximately 27.2 per cent of the participants had history of diarrhoea in the last two weeks.

The awareness of vitamin D is shown in Table 2 and Figure 1. The majority of the participants heard of vitamin D before (91.4 per cent) and believed in its importance for health (92.8 per cent). Close to three-fourth (72.6 per cent) of the participants were aware of the symptoms of vitamin D deficiency such as tiredness, sadness, muscle and bone pain. Approximately 81.4 per cent and 70.4 per cent of the participants were able to identify sun exposure and diet (respectively) as sources of vitamin D, with approximately 64.0 per cent of them identified both sources and 87.8 per cent identified at least one source. Family and friends (28.8 per cent) as well as physicians (25.6 per cent) were the most common sources while school (9.4 per cent) and books (8.0 per cent) were the least common sources of information about vitamin D. Approximately 65.8 per cent of the participants had heard of vitamin D before, and were aware of its importance, aware of its deficiency symptoms, and aware of at least one vitamin D sources.

The intake of vitamin D rich sources is shown in Table 3. Approximately half (51.2 per cent) of the participants reported eating vitamin D rich foods such as milk, oily fish, and eggs. The majority (83.5 per cent) of the participants were drinking one or two cups of milk every day. Only 18.8 per cent of the participants were taking vitamin D supplements and 19.6 per cent were taking multivitamins. More than half (57.2 per cent) of the participants reported exposing face, arms or legs (whenever possible) to sunlight within the last year. This was less than 5 minutes in 43.0 per cent of the participants and between 5 and 15 minutes in 30.4 per cent of the participants. Only 17.2 per cent of the participants were using sunscreen when exposed to the sunlight. As shown in Figure 2, out of the 3 common sources of vitamin D (diet, sun exposure, and supplements) 19.2 per cent of the participants were taking none of them. On the other hand, 80.8 per cent were taking at least one source, 41.2 per cent were taking at least 2 sources, and only 5.2 per cent were taking all the 3 sources.

The associations of patients’ characteristics with both awareness of vitamin D and its intake are shown in Table 4. The overall awareness (as shown in Figure 1) was significantly higher among the middle aged group compared to other age groups (76.9 per cent versus 54.9 per cent, \(p<0.001\)), females compared to males (78.9 per cent versus 54.9 per cent, \(p<0.001\)), graduates compared to non-graduates (71.3 per cent versus 58.3 per cent, \(p=0.003\)), and having compared to lack of previous history of vitamin D deficiency (83.7 per cent versus 52.9 per cent, \(p=0.001\)). The intake of at least 2 sources of vitamin D was significantly higher among males compared to females (85.7 per cent versus 74.9 per cent, \(p=0.002\)). As shown in Figure 3, this was caused by the lower sun exposure among females than males (41.9 per cent versus 70.0 per cent, \(p<0.001\)). Table 4 shows also marginally significant (\(p>0.05\) but <0.10) trends of higher vitamin D intake in pregnancy and breastfeeding (85.4 per cent versus 72.6 per cent, \(p=0.087\)) and in case of lack of previous history of vitamin D deficiency (83.5 per cent versus 77.0 per cent, \(p=0.070\)).

As shown in Figure 4, there was a significant association between overall awareness of vitamin D and intake of at least 2 sources of vitamin D for the all included participants, with aware participants having higher intake (45.0 per cent versus 33.9 per cent, \(p=0.012\)). However, when the same association is repeated by gender, it become stronger and more significant in males (57.3 per cent versus 33.3 per cent, \(p<0.001\)) but non-significant in females (34.6 per cent versus 35.4 per cent, \(p=0.920\)).

Discussion
The finding of the current study showed that approximately two-thirds of the participants have heard of vitamin D, and aware of its importance, aware of vitamin D deficiency symptoms, and aware of at least one vitamin D sources. Comparing the current finding to the data previously reported in Saudi Arabia is challenging due to the variability in the populations examined, and tools used in this and previous studies.\(^{13-15,18}\) Actually one of these studies used qualitative approach in studying the awareness.\(^{15}\)
Nevertheless, individual awareness items in the current study are better than seen in previous studies in Saudi Arabia. For example, those who heard of vitamin D were approximately 90 per cent in the current study compared with 70 per cent in adult patients attending different clinics in Western region and approximately 30–64 per cent among healthy children and adolescents in Riyadh. Similarly, those who were aware of sun exposure and/or diet as sources of vitamin D were 88 per cent in the current study compared with 51–76 per cent in previous studies. The better awareness of vitamin D observed in the current study may be related to the better educational level (more than half of our participants were graduates) and more health-oriented primary care population than populations examined in previous studies, including children and adolescents. As expected, the awareness in the current study was higher among more educated participants. The better awareness observed in the current study among those who had history of vitamin D deficiency may be related to more exposure to information while seeking medical advice. Similar to previous studies, relatives/friends and physicians were the main source of information about vitamin D. However, the finding also highlights the minor role played by the school and media in raising the public awareness of vitamin D.

Approximately 41.8 per cent of our participants reported a positive history of vitamin D deficiency. Unfortunately, we did not measure the vitamin D level in our participants to confirm the actual prevalence of vitamin D deficiency. As expected, the history of vitamin D deficiency was more frequent in females than males. A recent meta-analysis of 13 studies done over the last 10 years among more 24,000 Saudi adults, children, and pregnant women showed that the prevalence of vitamin D deficiency ranged between 50 per cent and 95 per cent with an average of 81 per cent. Interestingly, all the studies included in this meta-analysis and reported gender-specific prevalence showed much higher prevalence of vitamin D deficiency among females than males, even in childhood and adolescence.

The current study showed inadequate intake of vitamin D. The most common source of vitamin D in our participants was sun exposure (57.2 per cent), followed by vitamin D rich foods (51.2 per cent) and supplements (18.8 per cent). Actually only 5.2 per cent were taking the 3 sources and 41.2 per cent were taking at least 2 sources. The finding is not surprising given the high vitamin D deficiency and lower intake reported before in Saudi Arabia. However, some previous studies could not confirm the association between intake of some vitamin D sources (specially dietary sources) and the presence of vitamin D deficiency. As expected, the intake of vitamin D rich sources in the current study was lower in females than males. This was due to lower sun exposure rather than dietary sources or supplementations. The lower sun exposure among females in Saudi Arabia has been documented before, even among children. This has been linked to cultural, lifestyle, and religious reasons that limit female outdoor activities and demand wearing complete body cover usually of black colour when in public. Additionally, non-gender specific factors in Saudi Arabia such as very hot weather that limit outdoor activities and the generally dark skin colour that limit the penetration of sun light contribute to the problem of vitamin D deficiency in Saudi Arabia.

The current finding showed that awareness in associated with vitamin D intake in males but not females. The non-translation of awareness into action in females in the current study may be explained again by the same cultural, lifestyle, and religious reasons that limit sun exposure among females compared with males. Since these reasons are difficult to modify and since supplementation was very low in both gender, the current findings further highlight the critical importance of vitamin D supplementation specially among Saudi females and other at risk groups. Supporting this recommendation, less than 20 per cent of the participants in this study were receiving vitamin D supplementations or multivitamins. Additionally, more strict regulation demanding fortification of dairy products, cereals and orange juice may be also required in Saudi Arabia to counter the limited dietary intake of vitamin D.

To our knowledge, the current study is considered the first study to report gender-specific associations between awareness and intake of vitamin D. This was done among a relatively large sample size recruited from 6 primary care centres. Nevertheless, some limitations are acknowledged. For example, since the study design involved self-reported cross-sectional data collection, causation cannot be confirmed. Additionally, the convenience sampling used in recruitment of our participants may limit the generalization of findings. However, we believe that the current findings are good addition to the field of vitamin D research in Saudi Arabia and the above limitations are very minor and found in all previous awareness studies.

Conclusion

In conclusion, we are reporting a relatively good awareness but lower intake of vitamin D rich sources among a group of adult males and females at a primary care setting. The awareness was associated with vitamin D intake in males.
but not females, mainly due to lower sun exposure in females than males. As supplementation was very low in both gender and since cultural factors promoting limited sun exposure among females are not easily modifiable, the current findings further highlight the critical importance of vitamin D supplementation especially among females and other at risk groups in Saudi Arabia. Additionally, there is a need to promote the role played by the school and media in raising the public awareness of vitamin D.

**References**

1. Deluca HF. Evolution of our understanding of vitamin D. Nutr Rev. 2008;66:573–87.
2. Valdivielso JM. The physiology of vitamin D receptor activation. Contrib Nephrol. 2009;163:206–212.
3. Prentice A, Goldberg GR, Schoenmakers I. Vitamin D across the lifecycle: physiology and biomarkers. Am J Clin Nutr. 2008;88(2):500S–506S.
4. Holick MF, Chen TC. Vitamin D deficiency: a worldwide problem with health consequences. Am J Clin Nutr. 2008;87(4):1085S–1086S.
5. Palacios C, Gonzalez L. Is vitamin D deficiency a major global public health problem? J Steroid Biochem Mol Biol. 2014;144:138–145.
6. Radiovic N, Mladenovic M, Simic D, et al. Vitamin D in the light of current knowledge. Srp Arh Celok Lek. 2012;140(1-2):110–114.
7. Razzaque MS. Can adverse effects of excessive vitamin D supplementation occur without developing hypervitaminosis D? J Steroid Biochem Mol Biol. 2017.
8. Al-Daghri NM. Vitamin D in Saudi Arabia: Prevalence, distribution and disease associations. J Steroid Biochem Mol Biol. 2016.
9. Alsuwadia AO, Farag YM, Al Sayyari AA, et al. Prevalence of vitamin D deficiency in Saudi adults. Saudi Med J. 2013;34(8):814–818.
10. Nabi G, Hobani Y, Sarwat M. High prevalence of vitamin D deficiency and cancer in Saudi Arabian populations: Can we hypothesize a link? Med Hypotheses. 2015;85(2):117–119.
11. Jefferson A. Vitamin D-raising awareness of low intakes. J Fam Health Care. 2014;24(4):36–37.
12. Hiom S. Public awareness regarding UV risks and vitamin D—the challenges for UK skin cancer prevention campaigns. Prog Biophys Mol Biol. 2006;92(1):161–166.
13. Al-Saleh Y, Al-Daghri NM, Khan N, et al. Vitamin D status in Saudi school children based on knowledge. BMC Pediatr. 2015;15:53.
14. Alshamsan FM, Bin-Abbas BS. Knowledge, awareness, attitudes and sources of vitamin D deficiency and sufficiency in Saudi children. Saudi Med J. 2016;37(5):579–583.
15. Christie FT, Mason L. Knowledge, attitude and practice regarding vitamin D deficiency among female students in Saudi Arabia: a qualitative exploration. Int J Rheum Dis. 2011;14(3):e22–e29.
16. Alramdhan AM, El-Zubair AG. Poor vitamin D supplementation in infants. Cross-sectional study of maternal practices and awareness of vitamin D supplementation in infants in Al-Ahsa, Eastern Saudi Arabia. Saudi Med J. 2014;35(1):67–71.
17. Babli AI, AlDawood KM, Khamis AH. Knowledge, attitude, and practice of general practitioners in Dammam, Saudi Arabia towards Vitamin D supplementation to infants. J Family Community Med. 2015;22(3):135–139.
18. Aljefree NM, Lee P, Ahmed F. Knowledge and attitudes about vitamin D, and behaviors related to vitamin D in adults with and without coronary heart disease in Saudi Arabia. BMC Public Health. 2017;17(1):266.
19. Vu LH, van der Pols JC, Whiteman DC, et al. Knowledge and attitudes about Vitamin D and impact on sun protection practices among urban office workers in Brisbane, Australia. Cancer Epidemiol Biomarkers Prev. 2010;19(7):1784–1789.
20. Elshafie DE, Al-Khashan HI, Mishriky AM. Comparison of vitamin D deficiency in Saudi married couples. Eur J Clin Nutr. 2012;66(6):742–745.
21. BinSaeed AA, Torchyan AA, AlOmair BN, et al. Determinants of vitamin D deficiency among undergraduate medical students in Saudi Arabia. Eur J Clin Nutr. 2015;69(10):1151–1155.
22. Al Shaikh AM, Abaalkhail B, Soliman A, et al. Prevalence of Vitamin D Deficiency and Calcium Homeostasis in Saudi Children. J Clin Res Pediatr Endocrinol. 2016;8(4):461–467.
23. Al-Daghri NM, Al-Saleh Y, Aljohani N, et al. Vitamin D status correction in Saudi Arabia: an experts’ consensus under the auspices of the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis, and Musculoskeletal Diseases (ESCEO). Arch Osteoporos. 2017;12(1):1.
24. Ardawi MS, Qari MH, Rouzi AA, et al. Vitamin D status in relation to obesity, bone mineral density, bone turnover markers and vitamin D receptor genotypes in healthy Saudi pre- and postmenopausal women. Osteoporos Int. 2011;22(2):463–475.
25. Sadat-Ali M, Al Elq A, Al-Farhan M, et al. Fortification with vitamin D: Comparative study in the Saudi Arabian and US markets. J Family Community Med. 2013;20(1):49–52.
ACKNOWLEDGEMENTS
The authors express their deep gratitude to the participant, who cooperated in the current research study.

PEER REVIEW
Not commissioned. Externally peer reviewed.

CONFLICTS OF INTEREST
The authors declare that they have no competing interests.

Table 1: Demographic characteristics and medical history of the study participants

|                                      | Number | Percentage |
|--------------------------------------|--------|------------|
| Age (years)                          |        |            |
| 18-25                                | 234    | 46.80%     |
| 26-50                                | 247    | 49.40%     |
| >50                                  | 19     | 3.80%      |
| Gender                               |        |            |
| Male                                 | 273    | 54.60%     |
| Female                               | 227    | 45.40%     |
| Education level                      |        |            |
| High school or less                  | 211    | 42.20%     |
| Graduate                             | 289    | 57.80%     |
| Pregnancy or breastfeeding           |        |            |
| No                                   | 186    | 81.90%     |
| Yes                                  | 41     | 18.10%     |
| History of vitamin D deficiency      |        |            |
| No                                   | 273    | 54.60%     |
| Yes                                  | 209    | 41.80%     |
| Don’t know                           | 18     | 3.60%      |
| History of Crohn’s disease, ulcerative colitis, or celiac sprue | | |
| No                                   | 469    | 93.80%     |
| Yes                                  | 31     | 6.20%      |
| History of diarrhea in the last two weeks | | |
| No                                   | 364    | 72.80%     |
| Yes                                  | 136    | 27.20%     |
### Table 2: Awareness of vitamin D among the study participants

| Question                                                                 | Number | Percentage |
|--------------------------------------------------------------------------|--------|------------|
| Have you heard of vitamin D?                                             |        |            |
| No                                                                       | 43     | 8.60%      |
| Yes                                                                      | 457    | 91.40%     |
| Do you think Vitamin D is important for your health?                     |        |            |
| No                                                                       | 16     | 3.20%      |
| Yes                                                                      | 464    | 92.80%     |
| Don’t know                                                               | 20     | 4.00%      |
| Do you know that vitamin D deficiency causes tiredness, sadness as well as muscle and bone pain? |        |            |
| No                                                                       | 117    | 23.40%     |
| Yes                                                                      | 363    | 72.60%     |
| Don’t know                                                               | 20     | 4.00%      |
| What are the main sources of Vitamin D?*                                 |        |            |
| Diet                                                                     | 352    | 70.40%     |
| Sun exposure                                                             | 407    | 81.40%     |
| Others                                                                   | 58     | 11.60%     |
| Don’t know                                                               | 3      | 0.60%      |
| From where have you heard about Vitamin D?                               |        |            |
| Family and friends                                                       | 144    | 28.80%     |
| Physician                                                                | 128    | 25.60%     |
| School                                                                   | 47     | 9.40%      |
| Books                                                                    | 40     | 8.00%      |
| Others                                                                   | 120    | 24.00%     |
| Don’t know                                                               | 21     | 4.20%      |

* Multiple choices were allowed

### Table 3: Intake of vitamin D rich sources among the study participants

| Question                                                                 | Number | Percentage |
|--------------------------------------------------------------------------|--------|------------|
| Do you include vitamin D rich foods such as milk, oily fish or eggs in your meal? | 226    | 45.20%     |
| No                                                                       | 256    | 51.20%     |
| Don’t know                                                               | 18     | 3.60%      |
| On average, how many servings of milk do you get daily?                   |        |            |
| 1 cup                                                                    | 206    | 41.20%     |
| 2 cups                                                                   | 212    | 42.40%     |
| 3 cups                                                                   | 69     | 13.80%     |
| > 3 cups                                                                 | 13     | 2.60%      |
| Do you take vitamin D supplements (tablets)?                             |        |            |
| No                                                                       | 388    | 77.60%     |
| Yes                                                                      | 94     | 18.80%     |
| Don’t know                                                               | 18     | 3.60%      |
| Do you take multivitamins?                                               |        |            |
| No                                                                       | 402    | 80.40%     |
| Yes | 98 | 19.60% |
|-----|----|--------|
| **Have you been out in the sun within the last year with exposed face, arms or legs whenever possible?** |
| No  | 214| 42.80% |
| Yes | 286| 57.20% |
| **On average, how much sun exposures have you had in the past week?** |
| less than 5 min | 215 | 43.00% |
| 5-15 min        | 152 | 30.40% |
| 15-30 min       | 76  | 15.20% |
| >30 min         | 57  | 11.40% |
| **Do you use sunscreen?** |
| No  | 414| 82.80% |
| Yes | 86 | 17.20% |

**Figure 1:** Overall awareness of vitamin D among the study participants

**Figure 2:** The number of vitamin D sources taken among the study participants
Table 4: Associations of demographic and medical characteristics with overall awareness of vitamin D and intake of at least 2 sources of vitamin D among the study participants

|                                    | Overall awareness of vitamin D | Intake of ≥2 sources of vitamin D |
|------------------------------------|--------------------------------|----------------------------------|
|                                    | No (N=171 [34%]) | Yes (N=329 [66%]) | p.-value | No (N=294 [565]) | Yes (N=206 [41%]) | p.-value |
| **Age (years)**                    |                  |                     |          |                  |                     |          |
| 18-25                              | 103 (44.0%)      | 131 (56.0%)         | <0.001   | 43 (18.4%)       | 191 (81.6%)         | 0.811    |
| 26-50                              | 57 (23.1%)       | 190 (76.9%)         |          | 50 (20.2%)       | 197 (79.8%)         |          |
| >50                                | 11 (57.9%)       | 8 (42.1%)           |          | 3 (15.8%)        | 16 (84.2%)          |          |
| **Gender**                         |                  |                     |          |                  |                     |          |
| Male                               | 123 (45.1%)      | 150 (54.9%)         | <0.001   | 39 (14.3%)       | 234 (85.7%)         | 0.002    |
| Female                             | 48 (21.1%)       | 179 (78.9%)         |          | 57 (25.1%)       | 170 (74.9%)         |          |
| **Education level**                |                  |                     |          |                  |                     |          |
| High school or less                | 88 (41.7%)       | 123 (58.3%)         | 0.003    | 40 (19.0%)       | 171 (81.0%)         | 0.906    |
| College Graduate                   | 83 (28.7%)       | 206 (71.3%)         |          | 56 (19.4%)       | 233 (80.6%)         |          |
| **Pregnancy or breastfeeding**     |                  |                     |          |                  |                     |          |
| No                                 | 42 (22.6%)       | 144 (77.4%)         | 0.259    | 51 (27.4%)       | 135 (72.6%)         | 0.087    |
| Yes                                | 6 (14.6%)        | 35 (85.4%)          |          | 6 (14.6%)        | 35 (85.4%)          |          |
| **History of Vitamin D deficiency**|                  |                     |          |                  |                     |          |
| No/don’t know                      | 137 (47.1%)      | 154 (52.9%)         | <0.001   | 48 (16.5%)       | 243 (83.5%)         | 0.07     |
| Yes                                | 34 (16.3%)       | 175 (83.7%)         |          | 48 (23.0%)       | 161 (77.0%)         |          |
| **History of Crohn’s disease, ulcerative colitis, or celiac sprue** |                  |                     |          |                  |                     |          |
| No                                 | 162 (34.5%)      | 307 (65.5%)         | 0.531    | 88 (18.8%)       | 381 (81.2%)         | 0.335    |
| Yes                                | 9 (29.0%)        | 22 (71.0%)          |          | 8 (25.8%)        | 23 (74.2%)          |          |
| **History of diarrhea in the last two weeks** |                  |                     |          |                  |                     |          |
| No                                 | 118 (32.4%)      | 246 (67.6%)         | 0.169    | 71 (19.5%)       | 293 (80.5%)         | 0.777    |
| Yes                                | 53 (39.0%)       | 83 (61.0%)          |          | 25 (18.4%)       | 111 (81.6%)         |          |

Figure 3: Gender-specific differences in the intake of at least 2 sources of vitamin D
Figure 4: Gender-specific associations between overall awareness of vitamin D and intake of at least 2 sources of vitamin D