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Health risks and toxicological outcomes of excessive vitamin D intake

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ABSTRACT

Background: Vitamin D supplements are widely used to promote bone health and general wellness; however, excessive intake may lead to clinically significant toxicity, particularly when high doses are taken without medical supervision. Understanding public awareness and supplementation behavior is essential in reducing preventable health risks. This study aimed to assess knowledge, attitudes, and practices related to excessive vitamin D intake among adults in Saudi Arabia and to identify predictors of safe supplementation behavior.

Methods: A cross-sectional online survey was conducted among 523 adults using a validated questionnaire covering vitamin D knowledge, toxicity awareness, attitudes toward supplement safety, and supplementation practices. Safe supplementation practices were defined using a composite scoring system based on international recommendations. Descriptive statistics, correlations, and multiple linear regression were performed.

Results: While most participants recognized basic vitamin D benefits, misconceptions about toxicity were common. One-third believed supplements could not cause toxicity, and 38.8% were unaware of kidney-related risks. A total of 59.3% used vitamin D supplements, yet only 38.2% consulted a physician before taking high doses. Knowledge, attitudes, and practices were significantly correlated ($p < .001$). Regression analysis showed that attitudes ($\beta = 0.41$), knowledge ($\beta = 0.23$), and lower perceived community awareness ($\beta = -0.22$) predicted safe supplementation behavior.

Conclusion: Despite widespread use of vitamin D supplements, substantial gaps persist in understanding toxicity risks. Many adults engage in unsupervised high-dose supplementation that may increase the likelihood of harmful dosing. Strengthening public education, improving clinical guidance, and promoting medical consultation before high-dose use are essential to prevent vitamin D toxicity.

Keywords: cross-sectional study, hypercalcemia, supplementation, toxicity, Vitamin D.
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INTRODUCTION

Vitamin D is crucial for maintaining calcium balance, supporting bone health, and ensuring proper neuromuscular and metabolic functions. For years, public health initiatives have aimed to address the widespread deficiency of vitamin D, resulting in increased testing and supplement use among various populations.[1,2] As supplementation became more common, a new concern gradually emerged: the increasing number of individuals consuming excessive or prolonged high-dose vitamin D without medical oversight.[3]

Vitamin D toxicity occurs when elevated levels of 25-hydroxyvitamin D cause ongoing hypercalcemia, resulting in dehydration, nephrocalcinosis, acute kidney injury, neurological issues, and gastrointestinal problems.[4–7] While toxicity is usually linked to doses over 10,000 IU/day, some clinical reports document cases at lower doses, especially when individuals combine multiple supplements, take calcitriol without medical supervision, or maintain high-dose regimens for long durations.[8,9]

Despite known risks, many adults still view vitamin D as completely safe. International surveys reveal that some people regularly surpass the upper intake limit of 4,000 IU/day, often without seeking medical advice.[7,10–15] Trends on social media, online health

recommendations, and the availability of concentrated vitamin D formulations have contributed to this behavior. In addition, several toxicity cases have been linked to mislabeled supplements or manufacturing errors that resulted in doses far higher than those printed on product packaging.[16–22]

In Saudi Arabia, vitamin D deficiency has long been a public health concern, leading to widespread supplement use among the population. However, this trend toward self-supplementation raises the risk of unintentional overdoses. Few studies have explored how well Saudi adults grasp the dangers of high-dose vitamin D, recognize early signs of toxicity, or see the need for medical supervision. With reports of vitamin D overdose both worldwide and locally, understanding public awareness and practices has become more important.[6,18,23–25]

In this context, the study aimed to assess knowledge, attitudes, and practices related to excessive vitamin D intake among adults in Saudi Arabia and to identify factors that predict safe supplementation behaviors. These insights may support more effective public-health education and help reduce preventable cases of vitamin D toxicity.

METHODS

Study design and setting

This study employed a cross-sectional survey design to assess knowledge, attitudes, and behaviors related to excessive vitamin D intake. Data were collected between January and March 2025 from adults residing in Saudi Arabia. The survey was administered electronically to allow a wide geographic reach across the Central, Western, Eastern, Northern, and Southern regions.

Study population and sampling

Adults aged 18 years or older, living in Saudi Arabia during the study period, and able to complete the questionnaire in Arabic or English were eligible to participate. A convenience sampling strategy was used, with the survey distributed via social media platforms (WhatsApp, X/Twitter, Telegram) and university networks. Only one submission per device was permitted to reduce duplicate responses.

Instrument development

The questionnaire was developed following a review of current literature on vitamin D supplementation, toxicity, recommended intake limits, and clinical indicators of hypervitaminosis D.[1–7] Items covered four domains, which are (1) sociodemographic characteristics; (2) knowledge about vitamin D sources, safety thresholds, and toxicity risks; (3) attitudes toward supplement safety and medical consultation; and (4) supplementation practices, including dose, frequency, and physician involvement.

Operational definitions

To ensure consistency with international recommendations, key variables were defined as follows:

- High-dose vitamin D: ≥10,000 IU/day of cholecalciferol (vitamin D_3) OR any use of calcitriol without medical indication.
- Safe supplementation practices (composite score): engaging in behaviors such as testing vitamin D levels before supplementation, consulting a physician prior to high-dose use, avoiding doses above 4,000 IU/day unless prescribed, and not combining multiple vitamin D products or high-dose calcium supplements.
- Awareness of toxicity: recognition that excessive vitamin D can cause hypercalcemia, kidney injury, neurological symptoms, and gastrointestinal disturbances.

Validation and pilot testing

Two experts in clinical nutrition and public health reviewed the questionnaire for content validity and relevance. Items were refined to ensure alignment with vitamin D–specific constructs and to remove unrelated antibiotic content. A pilot test with 20 adults evaluated clarity, skip logic, and completion time. Minor linguistic and formatting adjustments were made based on participant feedback.

Data collection procedure

The final questionnaire was hosted on Google Forms. Before participation, respondents were informed about the study's purpose, their voluntary involvement, and anonymity. Electronic consent was required to proceed. No identifiable personal data was collected.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 29. Descriptive statistics (frequencies, percentages, means, and standard deviations) summarized participant characteristics and responses. Before selecting the main regression model, the distribution of the composite practice score was examined. The outcome demonstrated an approximately continuous distribution suitable for linear analysis; assumptions of linear regression, including normality, linearity, and homoscedasticity, were checked and met. Robust standard errors were applied to account for any minor deviations. The analytical plan included (1) Pearson correlation coefficients to examine relationships among knowledge, attitudes, practices, and perceived community awareness, and (2) Multiple linear regression to identify predictors of safe supplementation practices. Independent variables included knowledge, attitude score, awareness of toxicity, gender, and education level. Statistical significance was set at $p < 0.05$.

RESULTS

A total of 523 participants completed the survey. Sociodemographic characteristics are presented in **Table 1**. Most respondents were aged 18–29 years (44.6%), followed by those aged 30–39 years (29.1%). Nearly two-thirds of the sample were female (62.1%). Almost half held a bachelor's degree (48.4%), and participants were distributed across all regions of Saudi Arabia, with the Central region representing the largest proportion (28.3%). Only 21.6% of the respondents reported working in the health sector.

Knowledge scores varied across items, as shown in **Table 2**. The majority correctly identified that vitamin D is essential for bone health (87.4%) and can be obtained from sunlight (82.9%). However, awareness of toxicity was markedly lower. Only 58.4% recognized that excessive vitamin D intake may cause serious health problems, while 33.2% incorrectly

believed that toxicity cannot occur from supplements. Additionally, 38.8% were unaware that very high vitamin D levels may affect kidney function.

Supplementation behaviors are summarized in Table 3. More than half of the participants (59.3%) reported taking vitamin D supplements. Among supplement users, 41.9% consumed vitamin D 5–7 times per week, and 41.1% took supplements without a medical prescription. Only 56.8% had previously tested their vitamin D blood levels.

Figure 1 illustrates participants' consultation behaviors before taking high-dose vitamin D supplements. As shown, only 38.2% (n = 118) of respondents reported consulting a doctor prior to using high doses, while a considerably larger proportion, 61.8% (n = 192), indicated that they do not seek medical advice.

Attitudes toward vitamin D safety are presented in Table 4. Participants generally acknowledged the importance of caution, with a high mean score for the statement "Consulting a doctor before supplements is important" (M = 4.31, SD = 0.91). Concerns about toxicity were moderately recognized; participants agreed that excessive vitamin D can cause hypercalcemia (M = 3.89, SD = 1.10) and kidney problems (M = 4.02, SD = 1.03). However, misconceptions remained evident. A notable portion still perceived high doses as safe, reflected in a low mean score for the item "High doses of vitamin D are always safe" (M = 2.44, SD = 1.18). Participants also believed that the broader community lacks adequate awareness of overdose risks (M = 2.68, SD = 1.12).

Associations among knowledge, attitudes, practices, and perceived community awareness are shown in Table 5. Knowledge was positively correlated with attitudes ($r = 0.56$, $p < 0.001$) and supplementation practices ($r = 0.49$, $p < 0.001$), indicating that higher knowledge is associated with safer behaviors and more cautious perspectives. Attitude scores were strongly correlated with practices ($r = 0.63$, $p < 0.001$), suggesting that beliefs about safety strongly influence actual supplementation behaviors. Awareness of community risk was negatively correlated with knowledge ($r = -0.27$, $p < 0.001$), attitudes ($r = -0.34$, $p < 0.001$), and practices ($r = -0.41$, $p < 0.001$), reflecting

Table 1. Sociodemographic characteristics of participants

Variable	Category	n	%
Age	18–29 years	233	44.6
	30–39 years	152	29.1
	40–49 years	87	16.6
	50+ years	51	9.7
Gender	Male	198	37.9
	Female	325	62.1
Education Level	High school or below	121	23.1
	Diploma	149	28.5
	Bachelor's degree	253	48.4
Region of Residence	Central	148	28.3
	Western	117	22.4
	Eastern	94	18
	Northern	81	15.5
	Southern	83	15.9
Health Sector Employment	Yes	113	21.6
	No	410	78.4

Table 2. Knowledge about vitamin D and toxicity

Knowledge Item	Correct n (%)	Incorrect n (%)	I Don't Know n (%)
Vitamin D is important for bone health.	457 (87.4)	28 (5.4)	38 (7.3)
Sunlight is a source of vitamin D.	434 (82.9)	45 (8.6)	44 (8.4)
Excessive vitamin D causes serious health problems.	305 (58.4)	92 (17.6)	126 (24.1)
Toxicity cannot occur from supplements.	175 (33.2)	248 (47.4)	100 (19.1)
Very high vitamin D levels may affect kidney function.	320 (61.2)	80 (15.3)	123 (23.5)

Table 3. Vitamin D supplementation practices

Item	Category	n	%
Do you take vitamin D supplements?	Yes	310	59.3
	No	213	40.7
If yes, frequency per week	1–2 times	92	29.7
(Only supplement users; n = 310)	3–4 times	88	28.4
	5–7 times	130	41.9
Prescription-based use?	Yes	183	58.9
(Only supplement users)	No	127	41.1
Tested vitamin D level before?	Yes	176	56.8
	No	134	43.2

that individuals with better personal understanding perceive public awareness as insufficient.

A multiple linear regression was conducted to identify predictors of safe supplementation practices (Table 6). The model was statistically significant, $F(5, 517) = 42.7$, $p < 0.001$, with an adjusted R^2 of 0.39, indicating that 39% of the variance in supplementation behavior was explained by the predictors. Attitude toward vitamin D safety was the strongest predictor ($\beta = 0.41$, $p < 0.001$), followed by knowledge ($\beta = 0.23$, $p < 0.001$). Lower perceived community awareness predicted riskier behaviors ($\beta = -0.22$, $p < 0.001$). Gender showed a small but significant effect, with females engaging in safer practices ($\beta = 0.09$, $p = .009$). Higher education level also predicted safer behaviors ($\beta = 0.08$, $p = .045$).

DISCUSSION

The findings of this study provide a detailed view of how adults in Saudi Arabia understand and use vitamin D supplements. Although most participants recognized the basic benefits of vitamin D, the results show that important misconceptions remain, particularly regarding toxicity. A considerable portion either underestimated the risks associated with excessive intake or believed that supplements could not cause harm. These observations are consistent with reports from other countries where supplement use has become routine and where the risks of high-dose intake are often overlooked.[1–4]

The high prevalence of self-directed supplementation in this study is notable. Nearly sixty percent of participants reported using vitamin D supplements, and many did so without prior medical consultation. This pattern mirrors international findings linking the rise of unsupervised supplementation to online health content, increased availability of high-dose formulations, and the broad perception that vitamins are inherently safe.[5,6] The low rate of medical consultation before taking high doses is particularly concerning, as toxicity has been reported in individuals who exceeded recommended limits or combined multiple vitamin D products unintentionally.[7–9]

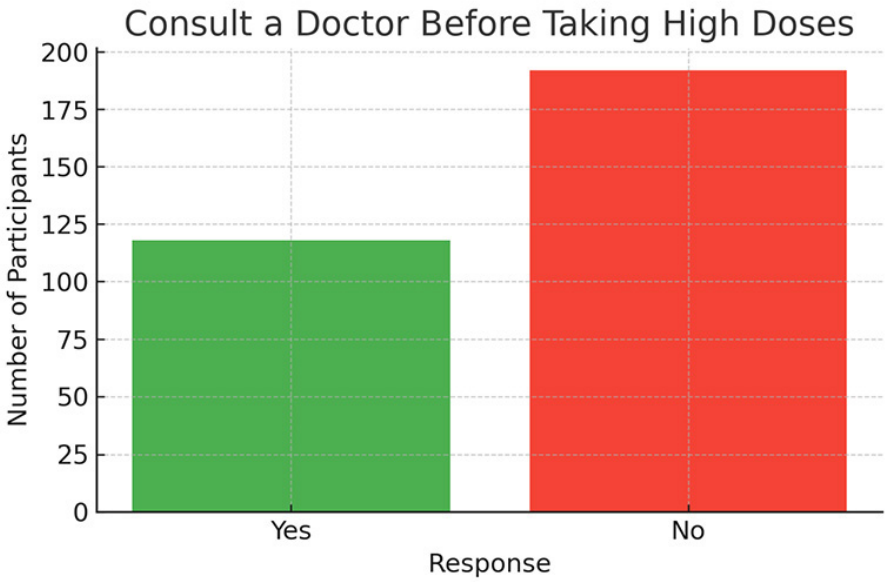

Figure 1. Consultation with a doctor before taking high-dose vitamin D supplements

Table 4. Attitudes toward vitamin D safety

Attitude Item	Mean	SD
Excess vitamin D can cause high calcium levels.	3.89	1.1
High doses of vitamin D are always safe.	2.44	1.18
Consulting a doctor before taking supplements is important.	4.31	0.91
Vitamin D toxicity may lead to kidney problems.	4.02	1.03
The community is aware of overdose risks.	2.68	1.12

Table 5. Correlation matrix among key study domains

Variable	1	2	3	4
1. Knowledge	—			
2. Attitude	0.56***	—		
3. Practice	0.49***	0.63***	—	
4. Awareness of Risk	−0.27***	−0.34***	−0.41***	—

Note: *p < 0.001

Table 6. Multiple linear regression predicting safe supplementation practices

Predictor	B	SE B	β	t	p
Knowledge score	0.24	0.05	0.23	4.88	< 0.001
Attitude score	0.39	0.06	0.41	6.52	< 0.001
Awareness of risk	−0.21	0.04	−0.22	−4.90	< 0.001
Gender (Female = 1)	0.08	0.03	0.09	2.64	0.009
Education level	0.07	0.03	0.08	2.01	0.045

The relationship between knowledge, attitudes, and behavior was clear. Higher knowledge and a cautious attitude toward supplement safety were strongly associated with safer supplementation practices. This supports prior evidence that awareness of risk plays a central role in shaping health behaviors and may serve as an important

target for future interventions.[10,11] Participants who demonstrated better understanding of toxicity were also more likely to perceive gaps in community awareness, suggesting that those who are informed recognize the need for broader public education.

The regression model further emphasized the importance of knowledge and attitudes as predictors of behavior. Both variables independently contributed to safer supplementation practices, even after adjusting for gender and education. This indicates that educational strategies—if delivered clearly and consistently—have the potential to reduce unsafe dosing patterns and encourage appropriate medical consultation. Previous studies have also highlighted that public-health campaigns focusing only on deficiency may unintentionally shift attention away from toxicity, underscoring the need for a more balanced approach.[12,13]

At the same time, the findings show that many participants were unaware of early symptoms of toxicity or kidney-related complications. This highlights an important gap, as early recognition is critical for preventing severe outcomes. Public-health messaging may therefore benefit from including practical examples, such as how to interpret supplement labels, the risks of combining multiple vitamin D preparations, and when medical testing is necessary. Clearer pharmacy counseling and standardized supplement labeling could also help guide consumers toward safer practices.

Strengths of the Study

This study has several strengths. First, it included a large and diverse sample from different regions of Saudi Arabia, allowing for broad insights into public knowledge and behavior. Second, the questionnaire was developed using current evidence related to vitamin D toxicity and underwent expert review and pilot testing, improving the relevance and clarity of the items. Third, the study examined multiple related domains—knowledge, attitudes, practices, and perceived community awareness—enabling a more complete understanding of the factors influencing supplementation behavior.

Limitations

Despite these strengths, several limitations should be noted. The cross-sectional design prevents establishing causal relationships between the measured variables. The survey relied on self-reported data, which may be influenced by recall error or social desirability. The practices reported were not verified through clinical or laboratory measures such as serum 25(OH)D levels, which would have provided objective confirmation of supplementation patterns. In addition, although the sample was geographically diverse, convenience sampling may limit generalizability to the entire population.

Future Research Recommendations

Future studies could benefit from combining behavioral data with laboratory measurements to explore how knowledge and practices relate to actual vitamin D status. Qualitative studies may also help uncover deeper beliefs, cultural influences, and social-media trends that shape supplement use. Longitudinal designs could track changes over time and assess the impact of educational interventions. Finally, examining physician prescribing patterns and pharmacist counseling practices may provide further insight into how healthcare professionals influence public behavior.

CONCLUSION

This study shows that although awareness of the general benefits of vitamin D is high, important gaps persist in understanding the risks linked to excessive intake. Many participants reported using supplements without medical advice, and misconceptions about toxicity were common. Knowledge and attitudes were closely tied to safer supplementation behaviors, highlighting the importance of clear public-health communication. Educational efforts that explain safe dosing, warning signs of toxicity, and when to seek medical evaluation may help reduce preventable harm. Stronger clinical guidance and consistent messaging from healthcare providers can further support the safe and responsible use of vitamin D supplements.

ETHICAL CONSIDERATIONS

The study adhered to the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Saudi Ministry of Health Ethics Committee (approval number: *MOH-REC-2025-011*). Participation was voluntary, and the survey included an electronic consent statement that explained the study purpose, confidentiality measures, and the right to withdraw at any time. No identifiable personal information was collected, ensuring full anonymity of respondents.

CONFLICT OF INTEREST

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

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AUTHORS' CONTRIBUTIONS

AA: Conceptualization, methodology, data collection, data analysis, and manuscript drafting. FH: Literature review, data interpretation, and manuscript editing. EO: Data collection, validation, and clinical content review. AG: Data entry, quality control, and reviewing of nutritional sections. RA: Review of methods and statistical consistency. FS: Data collection and technical support. AbA: Data acquisition and questionnaire distribution. DA: Review of discussion and interpretation of findings. GA: Literature review support and referencing. AdA: Data management and documentation. HG: Review of manuscript structure and coherence. SK: Editing support and final manuscript preparation. LA: Formatting, reference management, and proofreading. LK: Tables, figures, and supplementary materials assistance. AAA: Study design, supervision, data interpretation, critical revision, and final approval. All authors have read and agreed to the published version of the manuscript.

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