INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print); 2222-5234 (Online)
Website: https://www.innspub.net
Email contact: info@innspub.net
Vol. 28, Issue: 2, p. 91-100, 2026

RESEARCH PAPER OPEN ACCESS

Illuminating the deficiency: Public awareness of vitamin- D in Lahore, Pakistan

Muhammad Zeeshan Arif*[1], Muhammad Arslan Shahid[2], Zeerak Laila[3], Ahmad Ali Shabbir[1], Farrukh Nadeem[1], M Muazzam Khan[1], Yousuf Shahjahan[1], Rajab Ali[3]

[1]Faculty of Medicine, Alatoo International University, Bishkek, Kyrgyzstan
[2]THQ Hospital Chunian, Punjab, Pakistan
[3]Saint Vincent's University Hospital, Dublin, Ireland; Faculty of International University of Kyrgyzstan, Bishkek, Kyrgyzstan

Key words: Vitamin D deficiency, Public awareness, Health literacy, Lahore Pakistan, Cross-sectional survey, Sunlight exposure

Received Date: January 25, 2026 **Published Date:** February 08, 2026

DOI: https://dx.doi.org/10.12692/ijb/28.2.91-100

ABSTRACT

Vitamin D plays a vital role in maintaining bone health, supporting immune function, and contributing to mental well-being. Despite its significance, public awareness and adequate intake remain suboptimal in many regions, including Pakistan. This cross-sectional study assessed awareness, sources of information, lifestyle practices, and perceptions related to vitamin D among residents of Lahore, Pakistan. Data were collected from 200 participants using a self-administered questionnaire covering sun exposure habits, dietary intake, supplement use, and perceived health effects of vitamin D. The results revealed that although the majority had heard of vitamin D, most reported insufficient sun exposure, infrequent consumption of vitamin D–rich foods, and limited knowledge of their own vitamin D status. A significant testing gap was identified; 48% of participants had never undergone screening for vitamin D deficiency. These findings underscore the urgent need for targeted public health campaigns, improved nutrition education, and routine screening initiatives to address vitamin D deficiency within the Pakistani population.

***Corresponding author:** Muhammad Zeeshan Arif ✉ malikmzeeshanarif@gmail.com

INTRODUCTION

Vitamin D is a fat-soluble prohormone that plays a fundamental role in maintaining calcium and phosphate homeostasis, thereby supporting optimal bone mineralization, skeletal integrity, and neuromuscular function (Holick, 2007; Bikle, 2014). Beyond its classical role in musculoskeletal health, vitamin D has increasingly been recognized for its broader biological functions, including immunomodulatory, cardioprotective, and neurocognitive effects (Chung *et al.*, 2009; Bouillon *et al.*, 2019). Deficiency of vitamin D has been associated with a wide spectrum of adverse health outcomes, such as rickets, osteomalacia, osteoporosis, increased susceptibility to infections, autoimmune disorders, cardiovascular disease, and mood disturbances (Pludowski *et al.*, 2013; Palacios and Gonzalez, 2014).

Over the past two decades, global research interest in vitamin D has intensified due to mounting evidence of its pleiotropic effects and the persistently high prevalence of deficiency worldwide. Vitamin D deficiency has been described as a "global health problem" and, in some populations, an emerging "epidemic," affecting both developed and developing countries (Holick and Chen, 2008). Notably, deficiency remains highly prevalent even in regions with abundant sunlight, including South Asia and the Middle East, where cultural, behavioral, and dietary factors limit effective ultraviolet B (UVB) exposure and endogenous synthesis (Lips *et al.*, 2019).

Pakistan, despite its favorable geographic location and year-round availability of sunlight, continues to report alarmingly high rates of vitamin D deficiency across diverse demographic groups (Riaz *et al.*, 2016). Factors contributing to this burden include limited outdoor activity in rapidly urbanizing populations, clothing practices that reduce skin exposure, inadequate dietary intake of vitamin D–rich foods, and minimal consumption of fortified products or supplements (Jadoon *et al.*, 2018). The problem is further exacerbated by the absence of large-scale public health initiatives, limited food fortification policies, and a lack of routine screening programs, resulting in underdiagnosis and untreated deficiency within the general population (Haroon *et al.*, 2019). Addressing vitamin D deficiency as a public health challenge requires a clear understanding of community-level awareness, perceptions, and practices related to vitamin D. Previous research has demonstrated that awareness alone does not necessarily translate into adequate sun exposure, dietary intake, or supplement use, highlighting the importance of contextual and behavioral factors (Arif *et al.*, 2025; van der Wielen *et al.*, 1995). In urban Pakistani settings, significant knowledge gaps regarding vitamin D deficiency and its clinical consequences remain a primary public health concern, highlighting the urgent need for localized research to inform effective health policies (Haroon *et al.*, 2019). Lahore, one of Pakistan's largest and most densely populated metropolitan cities, represents a critical setting for investigating these issues due to its rapid urbanization, lifestyle transitions, and cultural diversity. The present study aims to assess public knowledge of vitamin D, sources of information, sun exposure patterns, dietary behaviors, and supplement use among residents of Lahore. By identifying knowledge deficits and modifiable lifestyle factors, the findings of this study may inform targeted health education strategies and support the development of evidence-based national approaches for the prevention and management of vitamin D deficiency in Pakistan.

MATERIALS AND METHODS

Study design and population

This descriptive cross-sectional study was conducted among the general population of Lahore, Pakistan. The target population included males and females aged 16 to 35 years. To ensure a representative assessment of public knowledge, individuals with a professional or academic background in the medical field, including physicians, nurses, pharmacists, dentists, and medical students, were excluded from participation.

Sample size and sampling technique

The sample size was calculated using an estimated national population of approximately 240 million, with a 95% confidence level and a 5% margin of error, resulting in a minimum required sample of 192 participants. Convenience sampling was employed to recruit eligible individuals from various areas of Lahore.

Data collection tool

Data were collected through a pre-structured, self-administered questionnaire. The questionnaire was iteratively revised and refined, undergoing multiple rounds of review before finalization.

Questionnaire structure

The instrument consisted of two sections with a total of 20 items. Section one collected demographic information, including gender, height, weight, and educational level. Section two assessed knowledge and awareness related to vitamin D, covering its health benefits, deficiency-related consequences, dietary and environmental sources, and potential risks of excessive intake.

Data analysis

All responses were exported to Microsoft Excel for initial data handling and subsequently analyzed using IBM SPSS Statistics for Windows, Version 27.0. Descriptive statistics were applied, with frequencies and percentages computed for categorical variables to summarize participants' demographic profiles and responses.

RESULTS

To ensure internal consistency and validity, a pilot study was conducted among 20 randomly selected participants. Reliability analysis yielded a Cronbach's alpha coefficient of 0.78, indicating that the instrument was a reliable tool for assessing vitamin D awareness in this population.

Distribution of sociodemographic characteristics and vitamin D awareness

The demographic characteristics of the study participants are depicted in Figs 1a-1f. As shown in Fig. 1a, among the 200 respondents, males accounted for 52% and females for 48%, indicating an almost equal gender distribution. The age distribution illustrated in Fig. 1b shows that the majority of participants were young adults, with the highest representation in the 26-30-year age group (32%), followed by those aged 31-35 years (26.5%), while smaller proportions were observed in the 21-25-years (23%) and 16-20-years (18.5%) categories. Educational attainment, depicted in Fig. 1c, showed that nearly half of the respondents (47.5%) had a university-level education, 26.5% had completed primary education, 25% had completed secondary education, and 1% reported no formal education.

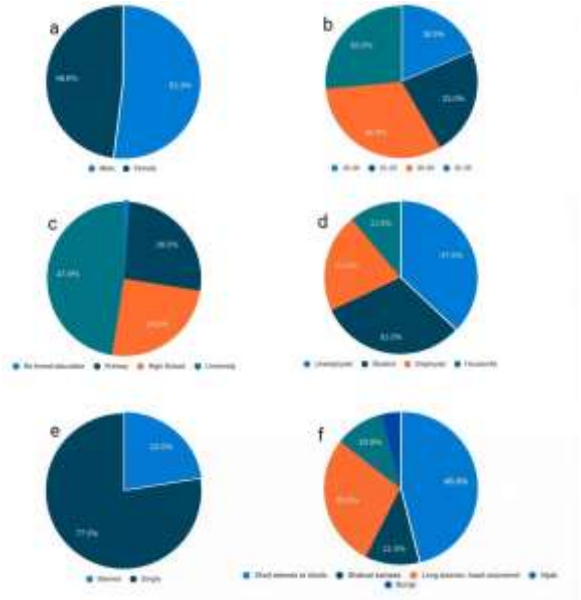

Fig. 1. Sociodemographic characteristics of participants: (a) Gender, (b) Age group, (c) Education level, (d) Occupation, (e) Marital status, and (f) Clothing style

Occupational status, shown in Fig. 1d, indicated that 37% of participants were unemployed and 31% were students, while 21% were employed and 11% were housewives. As presented in Fig. 1e, most respondents were single (77.5%), with married individuals comprising 22.5% of the sample. Clothing styles varied considerably, with 46% reporting the use of short sleeves or shorts, 28% wearing long sleeves with the head uncovered, 11.5% wearing shalwar kameez, 10.5% reporting the use of hijab, and 4% wearing a burqa.

Awareness and practices related to vitamin D

Overall awareness of vitamin D is shown in Fig. 2a, where a large majority of respondents (81%, n=162) reported having heard of vitamin D, while 19% (n= 38) had no prior knowledge. Sources of information are presented in Fig. 2b, indicating that television or radio were the most frequently reported sources (28%), followed by friends and family (22%) and social media (21%); fewer participants cited the internet (17%) or healthcare professionals (12%).

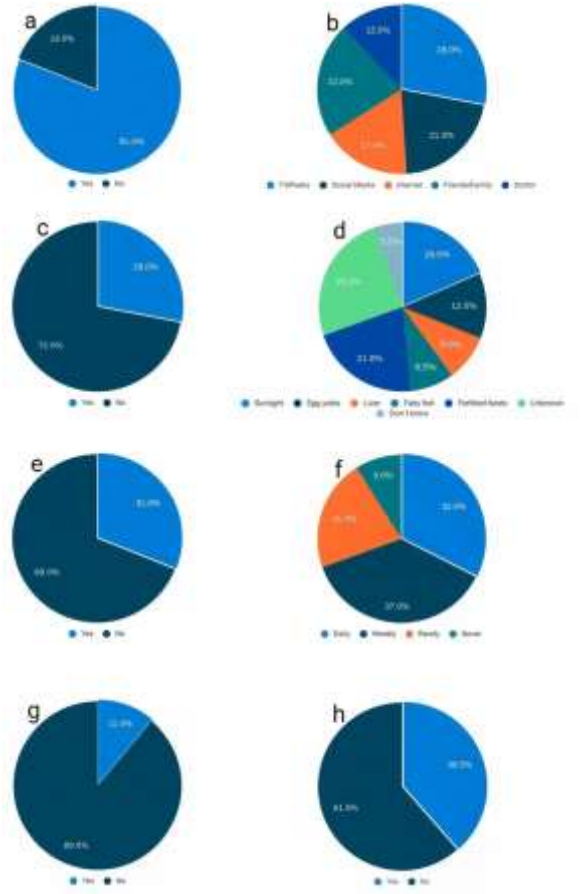

Fig. 2. Awareness and practices related to vitamin D among study participants: (a) Awareness of vitamin D, (b) Sources of information about vitamin D, (c) Knowledge of vitamin D deficiency symptoms, (d) Knowledge of vitamin D sources, (e) Awareness of recommended daily vitamin D requirements, (f) Frequency of sun exposure, (g) Use of sunscreen, and (h) Perceived effect of clothing style on sun exposure

Despite this general awareness, only 28% of participants reported knowledge of symptoms associated with vitamin D deficiency (Fig. 2c). Knowledge of vitamin D sources was limited (Fig. 2d), with only 18.5% correctly identifying sunlight as a source; fortified foods (21%), eggs (12.5%), liver (9%), and fatty fish (8.5%) were less frequently mentioned, while a notable proportion identified incorrect sources or reported no knowledge. Awareness of the recommended daily requirement of vitamin D was low, reported by only 31% of respondents (Fig. 2e). Sun exposure practices are shown in Fig. 2f, with 32.5% reporting daily exposure and 37% weekly exposure, whereas 21.5% reported rare exposure and 9% reported no sun exposure. Sunscreen use was uncommon, with only 11% reporting regular use (Fig. 2g). Perceptions regarding the effect of clothing on sun exposure are illustrated in Fig. 2h, where 38.5% believed their clothing style affected sun exposure, while 61.5% perceived no such effect.

Dietary practices, supplement use, and testing related to vitamin D

Dietary practices and preventive behaviors related to vitamin D are illustrated in Figs 3a-f. As shown in Fig. 3a, consumption of vitamin D-rich foods varied among respondents, with nearly half reporting weekly intake (47%), while 27.5% consumed such foods daily and 20.5% only occasionally; a small proportion (5%) reported never consuming vitamin D-rich foods. The types of vitamin D-rich foods consumed are presented in Fig. 3b, where fish was the most commonly reported item (24%), followed by fortified foods (19.5%), eggs (19%), and cheese (17%); 15.5% reported consuming other sources, while 5% reported none.

Intentional use of fortified foods is shown in Fig. 3c, indicating that only 31.5% of participants consumed fortified products, whereas the majority (68.5%) did not. Vitamin D supplement use is illustrated in Fig. 3d, with only 23.5% of respondents reporting supplementation and 76.5% reporting no use. History of vitamin D testing is presented in Fig. 3e, showing that nearly half of the participants (48%) had never undergone testing, while 8% reported testing within the last month and 44% within the past year. Awareness of family history of vitamin D deficiency is

depicted in Fig. 3f, where only 18% reported a known family history, 34% reported none, and 48% were uncertain.

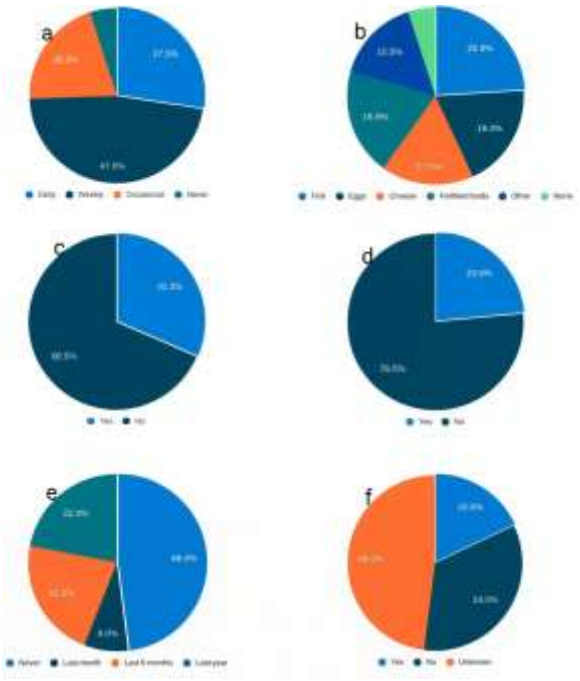

Fig. 3. Dietary practices and preventive behaviors related to vitamin D among study participants: (a) Frequency of consumption of vitamin D rich foods, (b) Common vitamin D rich foods consumed, (c) Use of fortified foods, (d) Use of vitamin D supplements, (e) History of vitamin D testing, and (f) Awareness of family history of vitamin D deficiency

Education level and awareness of vitamin D

In comparing education levels, there was a statistically significant difference in whether participants had heard of Vitamin D (χ^2= 14.59, df= 3, p= 0.002) (Table 1). Awareness was lowest among respondents with no formal education (50%) and highest among university graduates (90.5%). Primary school (66%) and high school (80%) participants showed moderate awareness.

Sun exposure frequency vs. symptoms of deficiency

The survey revealed a clear trend between reduced sun exposure and self-reported symptoms of vitamin D deficiency. Among participants with daily exposure to sunlight, only 12.3% (8 of 65) reported symptoms, compared to 27% (20 of 74) in the weekly group, 37.2% (16 of 43) in the rarely group, and a striking 66.7% (12 of 18) among those who reported never being exposed to sunlight. A Chi-square test of independence confirmed a highly significant association between sun exposure frequency and reported deficiency symptoms (χ^2 = 23.13, df= 3, p < 0.001) (Table 2). This suggests that reduced ultraviolet B (UVB) exposure, a primary driver of cutaneous vitamin D synthesis directly correlates with higher rates of symptomatic deficiency in the Lahore population surveyed.

Table 1. Awareness of vitamin D by education level

Education level	Total (N)	Heard of vit. D N (%)	Not Heard N (%)	*p*-value
No formal education	2	1 (50.0)	1 (50.0)	0.002
Primary	53	35 (66.0)	18 (34.0)	
High School	50	40 (80.0)	10 (20.0)	
University	95	86 (90.5)	9 (9.5)	

Table 2. Sun exposure frequency vs. symptoms of deficiency

Exposure frequency	Yes (n)	No (n)	*p*-value
Daily	8(12.3%)	57(87.7%)	< 0.001
Weekly	20(27.0%)	54(73.0%)	
Rarely	16(37.2%)	27(62.8%)	
Never	12(66.7%)	6(33.3%)	

Table 3. Supplement use vs. last vitamin D test

	Never	Last month	Last 6 months	Last year	*p*-value
Yes	10(5.0%)	8(4.0%)	15(7.5%)	14(7.0%)	<0.001
No	86(43.0%)	8(4.0%)	29(14.5%)	30(15.0%)	

Supplement use vs. last vitamin D test

Analysis of supplement use and recency of vitamin D testing revealed a statistically significant relationship. Among respondents who reported using supplements, 37% had undergone testing in the last 6 months or last month, compared to only 21% of non-users. Specifically, 10 supplement users had never been tested, while 8 were tested in the last month, 15 in the last 6 months, and 14 in the last year. In contrast, the majority of non-users (86 respondents) had never been tested, with smaller proportions having been tested in the last month (8), last 6 months (29), or last year (30). A Chi-square test confirmed a significant association between supplement use and testing frequency ($\chi^2 = 19.83$, df = 3, $p < 0.001$) (Table 3), indicating that supplement users are more likely to monitor their vitamin D status.

DISCUSSION

This study provides a detailed snapshot of vitamin D awareness, knowledge, and related practices among 200 respondents from Lahore. Overall awareness ("have you heard of vitamin D") was relatively high, with 81% of participants reporting familiarity. However, more specific knowledge was substantially lower: only 28% could name deficiency symptoms, 18.5% cited sunlight as a source and 21% cited fortified foods, and just 31% knew the recommended daily requirement. Taken together, these results demonstrate the common pattern seen worldwide, broad recognition of vitamin D as an important nutrient but limited understanding of how to obtain and maintain adequate status (Tariq *et al.*, 2020).

Comparison with local and international studies

The findings of the present study are consistent with a growing body of literature from Pakistan and other low- and middle-income countries demonstrating that vitamin D deficiency persists despite favorable climatic conditions. Previous studies from Lahore and other Pakistani urban centers have reported a high prevalence of biochemical vitamin D deficiency and identified reduced sun exposure, indoor lifestyles, limited health literacy, and cultural clothing practices as major contributing factors (Junaid *et al.*, 2015; Riaz *et al.*, 2016). Our results similarly show that although general awareness of vitamin D is widespread, detailed knowledge regarding sources, optimal sun exposure, recommended intake, and preventive behaviors remains inadequate, reinforcing the ongoing public-health relevance of vitamin D deficiency in Pakistan.

Comparable patterns have been observed across the Middle East and Gulf region. Studies from Saudi Arabia, including Najran, Riyadh, and Jeddah, consistently report high awareness levels often exceeding 80% yet markedly lower knowledge of primary vitamin D sources, effective sun-exposure practices, and supplementation guidelines (Alshamsan *et al.*, 2016).

Similar findings have been documented in Qatar, the United Arab Emirates, and Kuwait, where cultural sun avoidance, conservative dress, and reliance on indoor lifestyles contribute to persistent deficiency despite abundant sunlight (Bener *et al.*, 2009; Lips *et al.*, 2019). The pattern observed in our Lahore-based sample closely mirrors these regional trends, suggesting shared sociocultural and behavioral determinants across South Asia and the Middle East.

Evidence from South and Southeast Asia further supports these observations. Studies from India, Bangladesh, Malaysia, and Indonesia report moderate to high awareness of vitamin D but low levels of consistent dietary intake, limited use of fortified foods, and poor understanding of recommended dosages. These findings highlight that awareness alone is insufficient to translate into effective preventive practices in the absence of structured public-health messaging and accessible nutritional interventions.

Importantly, the present results align closely with our previously published study among university students in Bishkek, Kyrgyzstan, which demonstrated a similar disconnect between high awareness of vitamin D and inadequate practical knowledge, sun-exposure

behaviors, and supplement use. Despite differences in geography, ethnicity, and sunlight availability, both studies underscore the central role of educational quality, behavioral norms, and health-system engagement in shaping vitamin D–related practices. This cross-contextual consistency strengthens the argument that vitamin D deficiency is driven less by environmental availability and more by modifiable lifestyle and informational factors.

High-income countries also report comparable challenges, though often to a lesser degree. Studies from Europe and North America indicate that while public recognition of vitamin D's health importance is relatively high, adherence to dietary recommendations and supplementation guidelines remains inconsistent, particularly among younger adults and ethnic minorities (Spiro and Buttriss, 2014; Cashman *et al.*, 2016; van der Wielen *et al.*, 1995).

Notably, countries such as the United Kingdom and Finland have demonstrated that coordinated national strategies—including food fortification, updated intake recommendations, and targeted public-health campaigns—can significantly improve population vitamin D status and knowledge (Scientific Advisory Committee on Nutrition- SACN, 2017). These international experiences provide a strong policy framework that may be adapted to the Pakistani context, particularly in urban centers such as Lahore.

Key pattern explanations from our data

Several interconnected factors help explain the observed gaps in vitamin D awareness and practices among respondents. Although nearly one-third of participants reported daily sun exposure, a substantial proportion experienced only weekly, rare, or no exposure, and clothing styles that limit skin exposure such as long sleeves, hijab, or burqa were associated with reduced actual and perceived sunlight exposure. This pattern aligns with well-documented cultural drivers of vitamin D deficiency and helps explain why biochemical deficiency remains prevalent even in sun-rich regions, where sun avoidance and skin shielding rather than lack of sunlight are the primary contributing factors. Furthermore, our findings regarding symptom prevalence align with international research by Binkley *et al.* (2010), who reported that vitamin D deficiency symptoms were most common among individuals with limited outdoor activity, regardless of dietary intake. This is further supported by local research from Lahore, particularly among office workers, students, and women with restricted outdoor mobility.

Educational level also influenced awareness, as university-educated respondents demonstrated higher overall awareness, though knowledge of vitamin D sources and recommended intake remained incomplete. This pattern matches trends in international studies (Cashman *et al.*, 2016) and local Lahore data (Junaid *et al.*, 2015), which consistently show that higher educational attainment is linked to better nutritional awareness. Information was obtained predominantly through television, radio, and social media, whereas healthcare professionals played a relatively minor role, with only about 12% of respondents citing doctors as an information source, highlighting mass and social media as critical channels for public health interventions in Lahore.

Despite general awareness, a clear behavioral gap was evident, as only 31.5% of participants reported consuming fortified foods, 23.5% used vitamin D supplements, and nearly half had never undergone vitamin D testing. This pattern reflects findings from U.S. and European cohort studies (Holick *et al.*, 2011), which consistently show that supplement users engage in more preventive health behaviors, including regular blood tests. Similarly, this pattern aligns with large-scale international data which indicates that supplement users are significantly more likely to engage in other preventive health behaviors, suggesting that supplementation often serves as a proxy for a broader health-conscious lifestyle (Reider *et al.*, 2020). This disconnect between awareness and practice likely reflects barriers such as cost, limited access, beliefs regarding supplementation, and insufficient engagement with healthcare providers, a pattern commonly observed in low- and middle-income settings.

Implications for public health policy and practice

The combined evidence from this survey and prior studies supports a multi-pronged public health approach to addressing vitamin D deficiency. Given the prominence of television, radio, and social media as primary information sources in this population, targeted education campaigns delivered through these channels could rapidly improve specific knowledge, including optimal timing for sun exposure, culturally appropriate guidance, and identification of locally available fortified foods. Evidence from pilot social-media–based interventions in low- and middle-income countries has demonstrated the effectiveness of such approaches in improving micronutrient awareness and behaviors (Blebil *et al.*, 2019). Incorporating vitamin D–related content into school and university curricula may further strengthen baseline nutritional literacy, as the education-level gradients observed in this study suggest that structured learning at secondary and tertiary levels can promote preventive behaviors; similar curriculum-based interventions have been successfully evaluated in university settings (Buttriss *et al.*, 2022). In addition, expanding access to fortified foods and improving product labeling could help address the low uptake observed in this study, particularly among lower-income households, by increasing visibility and consumer understanding of fortified products. Finally, encouraging opportunistic screening and physician-led counseling is essential, as the observed association between recent vitamin D testing and supplement use indicates that clinical engagement can prompt protective action. Training primary-care providers to identify at-risk groups, including women, indoor workers, and individuals wearing clothing that limits sun exposure, and to provide practical advice on safe sun exposure and supplementation, may substantially improve vitamin D-related health outcomes.

CONCLUSION

This cross-sectional analysis demonstrates that there is lack of knowledge and awareness in people regarding vitamin- D. Despite University and school studying students lack significant knowledge. Education level must be closely linked in awareness, indicating that more and more educational campaigns are crucial. We suggest that non-governmental organizations and social workers work together with government health agencies to inform parents and children about the uses and benefits of vitamin D. Moreover, there is a need for additional interventions and qualitative research to evaluate awareness levels and uncover the reasons for the existing knowledge gaps. By tackling these challenges, we can improve vitamin D status and reduce health issues associated with its deficiency or toxicity in the Pakistani population.

STRENGTHS AND LIMITATIONS

Our study explored various health aspects of vitamin D, including its benefits, sources, and potential awareness in Lahore, Pakistan, and we included a relatively fair sample size. While several other studies have looked into vitamin D awareness, we identified a gap in this area and conducted a study. We, too, believe there is a lot of room for improvement in this area.

REFERENCES

Alshamsan F, Bin-Abbas B. 2016. Knowledge, awareness, attitudes and sources of vitamin- D deficiency and sufficiency in Saudi children. Saudi Medical Journal **37**, 579–583. https://doi.org/10.15537/smj.2016.5.14951

Arif MZ, Qasim J, Pathak D, Beg MMA. 2025. Shadows on the sunshine vitamin: assessment of vitamin- D knowledge among Bishkek's university students. International Journal of Biosciences **27**(4), 191–202. https://doi.org/10.12692/ijb/27.4.191-202

Bener A, Al-Ali M, Hoffmann GF. 2009. High prevalence of vitamin D deficiency in young children in a highly sunny humid country. Public Health Nutrition **12**(9), 1–7.

Bikle DD. 2014. Vitamin- D metabolism, mechanism of action, and clinical applications. Chemistry and Biology **21**(3), 319–329. https://doi.org/10.1016/j.chembiol.2013.12.016

Binkley N, Ramamurthy R, Krueger D. 2010. Low vitamin- D status: Definition, prevalence, consequences, and correction. Endocrinology and Metabolism Clinics of North America **39**(2), 287–301. https://doi.org/10.1016/j.ecl.2010.02.008

Blebil A, Dujaili J, Teoh E, Wong PS, Kc B. 2019. Assessment of awareness, knowledge, attitude, and the practice of vitamin- D among the general public in Malaysia. Journal of Karnali Academy of Health Sciences **2**, 171–180. https://doi.org/10.3126/jkahs.v2i3.26646

Bouillon R, Marcocci C, Carmeliet G, Bikle D, White JH, Dawson-Hughes B, Lips P. 2019. Skeletal and extraskeletal actions of vitamin- D: current evidence and outstanding questions. Endocrine Reviews **40**(4), 1109–1151. https://doi.org/10.1210/er.2018-00126

Buttriss JL, Lanham-New SA, Steenson S. 2022. Implementation strategies for improving vitamin- D status and increasing vitamin- D intake in the UK: Current controversies and future perspectives. British Journal of Nutrition **127**(10), 1567–1587. https://doi.org/10.1017/S0007114521002555

Cashman KD, Dowling KG, Škrabáková Z, Gonzalez-Gross M, Valtueña J, De Henauw S, Kiely M. 2016. Vitamin- D deficiency in Europe: pandemic. The American Journal of Clinical Nutrition **103**(4), 1033–1044. https://doi.org/10.3945/ajcn.115.120873

Chung M, Balk EM, Brendel M, Ip S, Lau J, Lee J, Trikalinos TA. 2009. Vitamin- D and calcium: A systematic review of health outcomes. Agency for Healthcare Research and Quality, evidence report no. 183.

Haroon M, Alam MA, Baig M 2019. Vitamin D deficiency: A public health issue in Pakistan. Journal of the Pakistan Medical Association **69**(1), 1–2.

Holick MF. 2007. Vitamin- D deficiency. The New England Journal of Medicine **357**(3), 266–281. https://doi.org/10.1056/NEJMra070553

Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP, Weaver CM. 2011. Evaluation, treatment and prevention of vitamin- D deficiency: An endocrine society clinical practice guideline. Journal of Clinical Endocrinology and Metabolism **96**(7), 1911–1930. https://doi.org/10.1210/jc.2011-0385

Holick MF, Chen TC. 2008. Vitamin-D deficiency: A worldwide problem with health consequences. The American Journal of Clinical Nutrition **87**(4), 1080S–1086S. https://doi.org/10.1093/ajcn/87.4.1080S

Jadoon SA, Ahmed A, Alam MA. 2018. Vitamin- D deficiency in Pakistan: tip of iceberg. Journal of Ayub Medical College Abbottabad **30**(1), 78–80.

Junaid K, Rehman A, Jolliffe DA, Wood K, Martineau AR. 2015. Prevalence and determinants of vitamin- D deficiency in women in Lahore, Pakistan. BMC Women's Health **15**, Article 83. https://doi.org/10.1186/s12905-015-0242-x

Lips P, Cashman KD, Lamberg-Allardt C, Bischoff-Ferrari HA, Terwee CB, Lorenc RS. 2019. Current vitamin- D status in European and Middle Eastern countries and strategies to prevent deficiency. European Journal of Endocrinology **180**(4), P23–P54. https://doi.org/10.1530/EJE-18-0736

Mithal A, Wahl DA, Bonjour JP, Burckhardt P, Dawson-Hughes B, Eisman JA, Lips P. 2009. Global vitamin- D status and determinants of hypovitaminosis D. Osteoporosis International **20**(11), 1807–1820. https://doi.org/10.1007/s00198-009-0954-6

Palacios C, Gonzalez L. 2014. Is vitamin- D deficiency a major global public health problem? Journal of Steroid Biochemistry and Molecular Biology **144**, 138–145. https://doi.org/10.1016/j.jsbmb.2013.11.003

Reider CA, Chung RY, Devarshi PP, Grant RW, Hazels Mitmesser S. 2020. Inadequacy of immune health nutrients: Intakes in US adults, the 2005–2016 NHANES. Nutrients **12**(6), 1735. https://doi.org/10.3390/nu12061735

Riaz H, Finlayson AE, Bashir S, Hussain S, Mahmood S, Malik F, Godman B. 2016. Prevalence of vitamin- D deficiency in Pakistan and implications for the future. BMJ Open **6**, e012595. https://doi.org/10.1586/17512433.2016.1122519

Scientific Advisory Committee on Nutrition (SACN). 2017. Fortifying foods and drinks with vitamin D: A SACN rapid review. Public Health England, London. https://www.gov.uk/government/publications/fortifying-food-and-drink-with-vitamin-d-a-sacn-rapid-review

Spiro A, Buttriss JL. 2014. Vitamin- D: An overview of vitamin- D status and intake in Europe. Nutrition Bulletin **39**(4), 322–350. https://doi.org/10.1111/nbu.12108

Tariq A, Khan SR, Basharat A. 2020. Assessment of knowledge, attitudes and practice towards vitamin-D among university students in Pakistan. BMC Public Health **20**(1), 355. https://doi.org/10.1186/s12889-020-8453-y

Van der Wielen RPJ, Löwik MRH, van den Berg H, de Groot LCPGM, Haller J, Moreiras O, van Staveren WA. 1995. Serum vitamin- D concentrations among elderly people in Europe. The Lancet **346**(8969), 207–210. https://doi.org/10.1016/S0140-6736(95)91266-5