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A retrospective cross-sectional study on vitamin D deficiency among residents in Aljabal Algharbi region of Libya

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ABSTRACT

Background: Vitamin D deficiency is estimated to affect 50% of the worldwide population of different civilizations and age groups.

Aim: This retrospective cross-sectional study aimed to determine the prevalence and associated risk factors of vitamin D deficiency among residents of the Aljabal Algharbi region in Libya.

Methods: A total of 657 laboratory test results were analyzed from patients in six cities: Gharian, Alasabaa, Alzintan, Jadu, Nalut, and Yafrin, covering the period from 2021 to 2024. Patient demographic data, including age and sex, were collected. All tests were conducted using the Elecsys Vitamin D III Total kit for quantifying serum 25-hydroxyvitamin D [25(OH)D] levels according to clinical records. Vitamin D deficiency was defined as a serum 25(OH)D level of <30 ng/mL, while levels between 30 and 100 ng/ml were considered sufficient.

Results: Overall, 506 (77%) patients were found to be vitamin D-deficient. The prevalence was significantly higher in women (80%, 366/460) than in men (71%, 140/197) ($p < 0.05$). The highest deficiency rate (85%) was observed in individuals aged 31 to 50 years ($p < 0.05$), while the lowest was recorded in children aged 0 to 5 years. Multivariate analysis revealed that females (OR: 1.162, 95% CI: 1.015–1.330) and individuals aged 31 to 50 years (OR: 3.004, 95% CI: 1.197–7.537) were at significantly higher risk of deficiency.

Conclusion: This study highlights the critical need for targeted public health interventions in the region. A coordinated effort involving health care providers, policymakers, and communities is essential to improve vitamin D status and mitigate associated health risks.

Keywords: Retrospective cross-sectional, Vitamin D deficiency, Risk factors, Epidemiology, Aljabal Algharbi region, Libya.

Introduction

Vitamin D is a group of fat-soluble secosteroids responsible for increasing the intestinal absorption of calcium, magnesium, and phosphate, as well as modulating innate and adaptive immune function, cardiovascular function, and proliferation and differentiation of normal and malignant keratinocytes (Holick, 2007). Vitamin D plays an important role in the proper functioning of the body, including bone health. It may also help prevent cancer and protect against many chronic conditions (Kennel *et al.*, 2010; Sobhi *et al.*, 2024).

Humans obtain vitamin D mainly from sunlight exposure. This occurs when ultraviolet rays from the sun penetrate the skin and convert 7-dehydrocholesterol to pre-vitamin D₃, an intermediate in the production of cholecalciferol (vitamin D₃) (Holick, 2006). However, vitamin D deficiency is common among people living in areas with year-round sunshine. The

other sources of vitamin D are food and nutritional supplements. Vitamin D is metabolized to its major circulating form (25(OH)D) in the liver, whereas its hormonal form (1,25(OH)₂D) occurs in the kidney (Bikle, 2014).

Vitamin D deficiency is estimated to affect 50% of the worldwide population of different civilizations and age groups (Nair and Maseeh, 2012). The main risk factors for this global deficiency included factors related to dietary intake, decreased outdoor activities, and decreased exposure to sunlight (Caccamo *et al.*, 2018). In Libya, many studies have reported the prevalence of vitamin D deficiency among citizens of almost all regions except Aljabal Algharbi. A study conducted on female patients at Seoul Hospital in Tripoli showed that the prevalence of vitamin D deficiency was 87.7% out of a total of 262 women who presented with nonspecific musculoskeletal and bone pain (Al-Graiw *et al.*, 2020). Another study conducted in Tripoli revealed a 45.42% prevalence of vitamin D deficiency in young adults

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compared to adults (Aljazzaf *et al.*, 2023). Younis (2024) also reported a 50.8% prevalence of severe vitamin D deficiency in Tripoli. In the middle region (Misrata), a high prevalence of inadequate vitamin D levels was reported in almost 80% of the participants. The women (25–64 years) were identified as the most vulnerable group, with 82% vitamin D inadequacy (Faid *et al.*, 2018). In Benghazi, the prevalence of vitamin D deficiency was also high (76%), which is almost similar to the prevalence in Sabha, the largest city of the Southern region (79%) (Younis, 2024). In another study, the prevalence of vitamin D deficiency was 54.2% in Sabha. Vitamin D levels were significantly lower among female (69.5%) patients than among male (24.5%) patients (Khames, 2024). In Qaminis, a town located in the Eastern region, the prevalence of vitamin D deficiency was 17.03%, which was 7.4% in the age group (1–26 years) and 9.63% in age group (26–80 years) (Al-jmali and Al-stail, 2024) In Zawia city, which is located in the western region, the mean value of vitamin D among females was significantly lower than that among males. The mean value of vitamin D was significantly lower in the age group of 41 to 64 years and >64 years compared to 1–40 years of age (Atia and Arhoma, 2022). In the whole country, the mean prevalence of vitamin D deficiency was 54.3% among males and 53.29% among females (Younis, 2024). To the best of our knowledge, the prevalence of vitamin D deficiency among the residents of Aljabal Algharbi region has not been previously studied. Therefore, a retrospective study was conducted to determine the prevalence of vitamin D deficiency and its associated factors, particularly sex and age groups, across the Aljabal Algharbi region, a large geographical area of Libya.

Materials and Methods

This retrospective cross-sectional study included records of the previous 25-OH vitamin D serum

quantification tests performed at public and private clinics in the Aljabal Algharbi region of Libya.

Study population and laboratory data

The study analyzed a total of 657 laboratory tests of patients from six cities of Aljabal Algharbi region, namely Gharian, Alasabaa, Alzintan, Jadu, Nalut, and Yafrin, from 2021 to 2024 (Table 1). Data about the sex and age of the patients were also collected. According to the clinics' records, all tests were performed using the Elecsys Vitamin D III Total Kit for 25-OH Vitamin D Serum Quantification (Roche Diagnostics Co., Ltd., Mannheim, Germany), following the American Society for Testing and Materials communication protocol on Cobas 411 Automatic Electrochemiluminescence Immunoassay Analyzer (Roche Diagnostics, Mannheim, Germany). Vitamin D serum level was classified according to cut-off values as deficient when the 25(OH)D level is <30 ng/ml and sufficient when the 25(OH)D level is from 30 to 100 ng/ml.

Statistical analysis

Descriptive statistics were used to summarize the percentage of categorical variables. Logistic regression analysis was also used to determine the associations between vitamin D levels categorized as sufficient and deficient, and independent variables such as sex and age groups. Odds ratios (OR) with their corresponding 95% confidence intervals (95% CI) were calculated and presented. Statistical significance was set at $p < 0.05$. Comparison between vitamin D levels of age groups is done by ANOVA with Tukey's test. Statistical analysis was performed using IBM SPSS 27.0 software (IBM Corp., Armonk, NY).

Ethical approval

The study was approved by the Bioethics subcommittee of the National Research Center for Tropical and Transboundary Diseases under number: NBC: 016.H.25.05.

Table 1. Number of sera collected and tested for vitamin D levels during years 2021 to 2024 from patients in some cities of the Aljabal Algharbi region of Libya during 2021 to 2024.

| City | Year | | | | | | | | Total |
|----------|------|-----|------|----|------|----|------|-----|-------|
| | 2021 | | 2022 | | 2023 | | 2024 | | |
| | M | F | M | F | M | F | M | F | |
| Ghanian | 21 | 82 | 2 | 24 | 9 | 35 | 0 | 0 | 173 |
| Alasabaa | 10 | 36 | 7 | 8 | 12 | 25 | 0 | 10 | 108 |
| Alzintan | 0 | 0 | 0 | 0 | 0 | 0 | 82 | 117 | 199 |
| Jadu | 9 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| Nalut | 5 | 16 | 0 | 0 | 0 | 0 | 16 | 21 | 58 |
| Yafrin | 11 | 36 | 0 | 0 | 0 | 0 | 13 | 34 | 94 |
| Total | 56 | 186 | 9 | 32 | 21 | 60 | 111 | 182 | 657 |

M = Male, F = Female.

Results

This retrospective cross-sectional study included 657 patients from selected cities and towns in the Aljabal Algharbi region of Libya between 2021 and 2024. The results are presented in Table 2. Among the participants, 506 (77%) was found to be deficient in vitamin D across all locations. The prevalence of deficiency was significantly higher in women (80%; 366 out of 460) than in men (71%; 140 out of 197) ($p < 0.05$).

Analysis by age group revealed that individuals aged 31 to 50 years had the highest prevalence of vitamin D deficiency (85%) ($p < 0.05$), followed by those aged 13 to 18 years (80%), 51 to 70 years (79%), 19 to 30 years (78%), 6 to 12 years (73%), 71 and older (63%), and 0 to 5 years (53%). The lowest prevalence was observed in children aged 0 to 5 years.

Based on measured vitamin D levels, children aged 0 to 5 had the highest mean level (38.8 ng/ml), while adolescents (13–18 years) and adults aged 31 to 50 years had the lowest levels (Table 2, Fig. 1). Vitamin D sufficiency rates followed a similar trend, with the highest rates observed in the 0 to 5 age group (46.6%) and in the older adults aged 71 and older (39.1%). In contrast, the 31 to 50 age group had the lowest sufficiency rate at just 15.5% (Fig. 2). Figure 3 illustrates the distribution of vitamin D levels across age groups.

Risk factors for vitamin D deficiency were assessed using OR analysis. Logistic regression indicated that females had significantly lower odds of maintaining adequate vitamin D levels than males (OR: 1.162, 95% CI: 1.015–1.330). Additionally, individuals aged 31 to 50 years had a significantly higher OR for deficiency (OR: 3.004, 95% CI: 1.197–7.537; $p < 0.05$) than other age groups. These findings suggest that females and individuals aged 31–50 years are at increased risk of vitamin D deficiency.

Discussion

Vitamin D deficiency is a global health concern, particularly in low- and middle-income countries. A retrospective study involving 7.9 million participants from 81 countries reported that 15.7% (95% CI: 13.7–17.8) of individuals had serum 25-hydroxyvitamin D levels below 30 nmol/l between

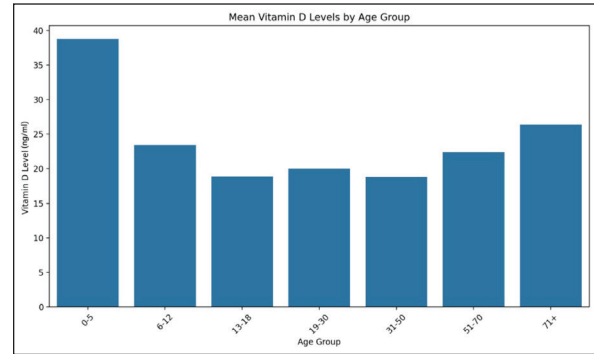


Figure 1. Mean vitamin D levels by age group.

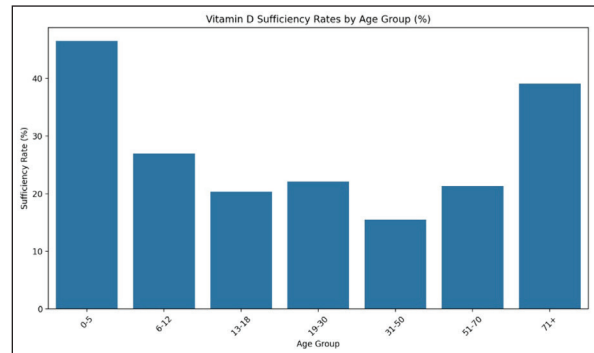


Figure 2. Vitamin D sufficiency rates according to age group.

Table 2. Logistic regression for two variables (gender and age groups) on vitamin D deficiency status among study participants belonging to cities of Aljabal Algharbi region of Libya from 2021 to 2024 ($p \leq 0.05$).

| Gender | Mean vitamin D level (ng/ml) | Deficient (n/%) | Sufficient (n/%) | Odds Ratio | 95 percent CI | p-value |
|----------------------------|------------------------------|-----------------|------------------|--------------|---------------|--------------|
| Male (n = 197) | 24.45 | 140 (71%) | 57 (29%) | 0.631 | 0.430–0.925 | – |
| Female (n = 460) | 21.09 | 366 (80%) | 94 (20%) | 1.162 | 1.015–1.330 | 0.018 |
| Age groups (years) | | | | | | |
| 0-5 (n = 58) | 38.80 | 31 (53%) | 27 (47%) | 0.570 | 0.211–1.542 | 0.269 |
| 6-12 (n = 63) | 23.45 | 46 (73%) | 17 (27%) | 1.387 | 0.503–3.829 | 0.528 |
| 13-18 (n = 54) | 18.85 | 43 (80%) | 11 (20%) | 2.365 | 0.808–6.924 | 0.116 |
| 19-30 (n = 149) | 20.01 | 116 (78%) | 33 (22%) | 1.810 | 0.717–4.568 | 0.209 |
| 31-50 (n = 206) | 18.81 | 174 (85%) | 32 (15%) | 3.004 | 1.197–7.537 | 0.019 |
| 51-70 (n = 103) | 22.40 | 81 (79%) | 22 (21%) | 1.893 | 0.720–4.979 | 0.196 |
| Seventy one years (n = 24) | 25.43 | 15 (63%) | 9 (37%) | – | – | – |

The bolded numbers refer to significant p values less than 0.05.

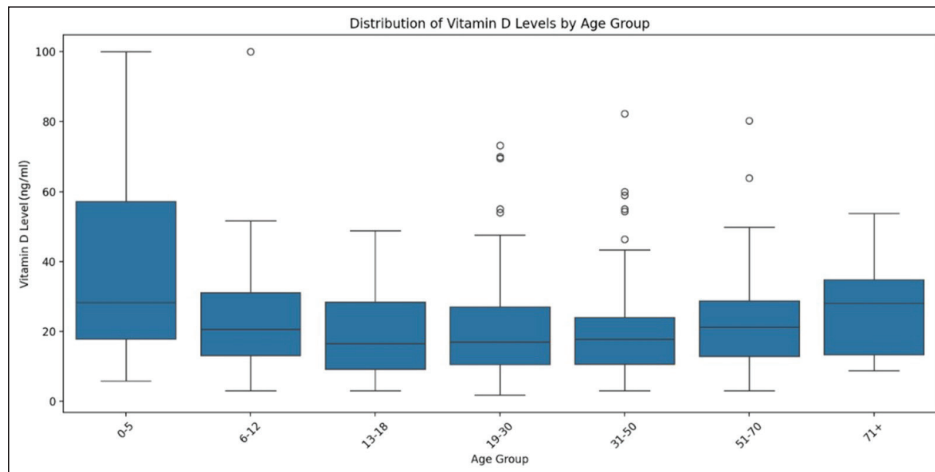


Figure 3. Distribution of vitamin D levels according to age group.

2000 and 2022 (Cui *et al.*, 2023). Similarly, a systematic review including 1,693 studies—130 of which involved 21,676 participants from 23 African countries—found a pooled prevalence of vitamin D deficiency of 17.31% (95% CI: 9.86–26.27), using the same cutoff (Reagan *et al.*, 2020).

In the current study, the prevalence of vitamin D deficiency was 77% (506 out of 657 participants) in selected cities in the Aljabal Algharbi region of Libya. This rate is notably higher than the national average reported in a recent study, where vitamin D deficiency affected 54.3% of men and 53.29% of women across Libya (Younis, 2024). However, the prevalence in Aljabal Algharbi is consistent with the figures reported in other Libyan regions: 80% in Misrata (central region), 76% in Benghazi (east), and 79% in Sabha (south) (Younis, 2024).

Deficiency rates have been reported across North Africa. Sherief *et al.* (2021) reported a prevalence of 94.8% among healthy adolescents in Egypt. Tunisia showed a lower prevalence of 47.6% in a healthy population (Afef *et al.*, 2022). In Algeria, 25(OH) D insufficiency (<50 nmol/l) was common in 435 healthy children aged 5 to 15 years, particularly during winter. This deficiency was associated with increased parathyroid hormone (PTH) levels and leg deformities (Djennane *et al.*, 2014). In Morocco, vitamin D deficiency was more common in women (29.33%) than in men (18.78%) (El-houcine and Mohammed, 2023), with another study reporting an overall prevalence of 91% (Fadoua *et al.*, 2009).

Vitamin D deficiency was significantly more prevalent among females (80%) than males (71%). This is consistent with a study at the Seoul Hospital in Tripoli, which reported a prevalence of 87.7% among women presenting with nonspecific musculoskeletal and bone pain (Al-Graiw *et al.*, 2020). Faïd *et al.* (2018) also found that women aged 25 to 64 years were particularly vulnerable, with an 82% prevalence. In contrast,

Afef *et al.* (2022) reported no significant association between sex and vitamin D deficiency in Tunisia. However, other studies on Libya support the observed sex disparity. For instance, Khames (2024) found that vitamin D deficiency was significantly higher in Sabha females (69.5%) than in males (24.5%). In Zawia, a cross-sectional study found that the mean serum vitamin D level among females (19.8 ± 2 nmol/l) was significantly lower than in males (25.7 ± 3 nmol/l), with the lowest levels recorded in individuals aged 41–64 years and above (Atia and Arhoma, 2022). Other studies in neighboring countries corroborate these findings. Raif *et al.* (2015) found vitamin D deficiency in 72.6% of nurses, 54% of pregnant women, 72% of women of childbearing age, 39.5% of elderly women, and 77.2% of geriatric Egyptian women. Sherief *et al.* (2021) reported a higher prevalence among girls than boys, with significant associations to physical inactivity, limited sun exposure, and poor dietary intake. Factors contributing to higher deficiency rates among women include cultural clothing practices that limit sun exposure, obesity, low vitamin D dietary intake, and reduced outdoor activity (Al-Graiw *et al.*, 2020).

The highest deficiency rate (85%) was observed in the 31 to 50-year age group ($p < 0.05$). This contrasts with the findings of Aljazzaf *et al.* (2023) who reported that lower vitamin D levels in younger adults in Libya were linked to certain health conditions. In Tunisia, 40.9% of children were vitamin D-deficient, attributed to low intake of vitamin D-rich foods, although no significant correlations were found with maturation status, adiposity, or insulin resistance (Ikram *et al.*, 2016). A study of 102 mother-newborn pairs in Morocco found that 90.1% of the mothers had hypovitaminosis D. However, maternal age, BMI, season, birth interval, or neonatal birth weight were not significantly correlated (Loudyi *et al.*, 2016).

Encouragingly, the current study found the lowest prevalence of vitamin D deficiency in children aged 5 years. This could be attributed to the use of fortified milk formulas and multiple micronutrient powders during early childhood. Vitamin D deficiency is highly prevalent among neonates in South Asia, with rates of up to 85%, and remains a major concern in Tunisia and Egypt (Nimmathota *et al.*, 2024).

Conclusion

Vitamin D deficiency remains a widespread public health issue that affects populations across all age groups and geographical regions, particularly in low- and middle-income countries. Despite the abundance of sunlight in many of these areas, including North Africa, persistently low vitamin D levels are attributed to cultural practices, dietary insufficiencies, and limited public health initiatives. In Libya, available studies highlight the prevalence of vitamin D deficiency among both the general population and high-risk groups, such as women. These findings underscore the urgent need for targeted public health strategies to address the growing burden of vitamin D deficiency, including awareness campaigns, food fortification, supplementation programs, and routine screening.

Recommendation

A collaborative approach involving health care providers, policymakers, and communities is essential to improve vitamin D status and reduce associated health risks across Libya and similar regions. Food fortification and awareness campaigns are highly recommended.

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Author's contribution

Aljetlawi collected the data, and Kammon analyzed and wrote the manuscript.

Conflict of interest

No conflicts of interest are available.

Data availability

Sufficient information was available.

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