

Vitamin D status and its related factors among healthy Adolescent and young adults in Eastern Province, Saudi Arabia

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ABSTRACT

Background: Vitamin D deficiency has become a significant and growing public health issue among young individuals globally. Its deficiency can adversely affect both the nervous and musculoskeletal systems, leading to conditions such as rickets, joint and muscle pain, neurological disorders, and changes in mood and behavior.

Objective: The purpose of this research is to evaluate how common vitamin D deficiency is among young adults residing in the Eastern Province of Saudi Arabia.

Methods: This study utilized a retrospective cross-sectional design, examining clinical records from 892 individuals between the ages of 15 and 40. Vitamin D levels in the blood were categorized into three groups: deficient (<20 ng/mL), insufficient (20–29 ng/mL), and sufficient (≥30 ng/mL). A structured and pre-tested questionnaire was employed to gather demographic and lifestyle data, including age, gender, skin tone, educational attainment, financial status, sun exposure, milk and soft drink consumption, exercise habits, and body mass index (BMI). The data were analyzed using IBM SPSS software, and logistic regression was applied to calculate adjusted odds ratios (OR) to identify risk factors. Statistical significance was set at $p < 0.05$.

Results: Among the 892 participants, 22.4% were found to have a vitamin D deficiency, and 37.8% had insufficient levels. Females, particularly those aged 25 or younger, were at a significantly greater risk than males (OR = 3.42, 95% CI: 2.51–4.66, $p < 0.001$). Other notable risk factors included lower economic status (OR = 2.01, $p = 0.001$), limited sun exposure (OR = 2.15, $p < 0.001$), lack of physical activity (OR = 1.62, $p < 0.001$), obesity (OR = 2.24, $p < 0.001$), and frequent intake of carbonated beverages (OR = 1.74, $p < 0.001$). No significant associations were observed with skin tone or the type of milk consumed ($p > 0.05$).

Conclusion: Vitamin D deficiency continues to be a major concern in Saudi Arabia, especially among women and those from lower socioeconomic backgrounds. Lifestyle-related factors such as inadequate sun exposure, physical inactivity, and obesity contribute significantly to the issue. Public health initiatives should target vulnerable groups, promote healthier lifestyles, and advocate for preventive measures. Further research is recommended to develop effective, targeted strategies for reducing vitamin D deficiency in this population.

KEYWORDS: Vitamin D, deficiency, risk factors, age, gender, sun exposure, Saudi Arabia.

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INTRODUCTION

Vitamin D deficiency is increasingly recognized as a widespread public health issue, particularly among children, adolescents, and women across various regions and cultural contexts. It is clinically defined by serum 25-hydroxyvitamin D [25(OH)D] levels below 50 nmol/L, with severe deficiency—below 30 nmol/L—linked to musculoskeletal pain, fatigue, mood disturbances, growth retardation, and even neurological symptoms [1,2]. In Saudi Arabia and neighboring countries, this health concern is notably severe, with some studies reporting prevalence rates exceeding 80% among younger populations, particularly females [3,4].

A combination of environmental, cultural, and behavioral factors contributes to this high prevalence. Cultural norms that limit sun exposure—especially among women due to clothing practices—and minimal outdoor activity are major contributors [5,6]. Dietary insufficiency and lack of fortified foods further exacerbate the issue, while sedentary lifestyles have become increasingly common [7,8].

Studies also emphasize significant gender-based disparities, with women consistently showing higher rates of deficiency. In some regions of Saudi Arabia, adolescent females exhibit vitamin D deficiency rates almost four times higher than males, largely due to sociocultural restrictions on sun exposure [9,10]. Similar trends have been observed among migrant populations and low-income households, indicating that socioeconomic status and migration-related stressors also play a role [6,10].

From a broader perspective, global data reflect similar challenges, including in countries like Iran, where adolescent girls have poor knowledge of vitamin D and often misuse sunscreen, further limiting synthesis from sunlight [7]. In Saudi Arabia, schoolchildren and adolescents from low-income families are especially vulnerable, and many are unaware of the health consequences of deficiency [8,4].

Recent evidence highlights the influence of genetic variability on vitamin D metabolism, underscoring the importance of personalized approaches in addressing this deficiency [11]. Furthermore, the relationship between vitamin D and obesity is gaining attention, as adiposity may interfere with vitamin D bioavailability and regulation [12]. Advances in diagnostic technologies, such as non-invasive assays for 25(OH)D levels, offer promising tools for improving surveillance and early detection [13].

This study aims to evaluate the prevalence and risk factors of vitamin D deficiency among young adults in Saudi Arabia, with a particular focus on lifestyle elements—sun exposure, dietary habits, BMI, and physical activity—as well as gender and socioeconomic disparities.

METHODOLOGY

Study Design and Setting:

This study employed a retrospective cross-sectional design and was carried out in the Eastern Province of Saudi Arabia. It involved the examination of both clinical and questionnaire-based data from 892 participants between the ages of 15 and 40. The primary objective was to determine the rate of vitamin D deficiency and explore its relationship with a range of sociodemographic, behavioral, and anthropometric variables in a representative cohort of the region's young adult population.

Sample size and recruitment

A total of 892 participants were included in the study. These individuals were selected from a community-based pool using an online self-administered questionnaire distributed through various social media platforms in both Arabic and English. The recruitment strategy enabled broad participation from different economic backgrounds, educational levels, and urban localities across the Eastern Province. Inclusion criteria comprised Saudi nationality, age between 15 and 40 years, and general good health. Individuals with known chronic conditions affecting vitamin D metabolism, such as liver, renal, or gastrointestinal diseases, or those on medications such as corticosteroids, anticonvulsants, or vitamin D supplements, were excluded.

Data collection

Data were collected using a standardized and pre-tested questionnaire, which captured information on participants' background characteristics and lifestyle habits. The questionnaire included items on age, gender, skin color, educational attainment, and self-perceived economic status. Behavioral data such as average daily sun exposure, physical activity, and consumption of milk and carbonated beverages were also recorded. In addition, participants reported their height and weight, from which body mass index (BMI) was calculated and categorized into normal weight ($<25 \text{ kg/m}^2$), overweight ($25\text{--}30 \text{ kg/m}^2$), and obesity ($>30 \text{ kg/m}^2$). Respondents were also asked about symptoms commonly associated with vitamin D deficiency, including fatigue, bone or muscle pain, mood changes, and sleep difficulties.

Vitamin D assessment

Serum vitamin D [25(OH)D] levels were retrieved from participant health records and categorized into three clinical groups based on international standards: deficient ($<20 \text{ ng/mL}$), insufficient ($20\text{--}29 \text{ ng/mL}$), and sufficient ($\geq 30 \text{ ng/mL}$). These thresholds were used to classify vitamin D status and to evaluate its associations with the participants' demographic and behavioral characteristics.

DATA ANALYSIS

The collected data were analyzed using IBM SPSS Statistics (Version 26; IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participant characteristics. Frequencies and percentages were calculated for categorical variables. To assess associations between vitamin D deficiency and potential risk factors, Chi-square tests were used for bivariate comparisons. Logistic regression analysis was performed to identify independent predictors of vitamin D deficiency. Adjusted odds ratios (OR) and 95% confidence intervals (CI) were reported, and a p-value of <0.05 was considered statistically significant.

ETHICAL CONSIDERATIONS

Ethical approval for the study was obtained from the Institutional Review Board at King Faisal

University in Al-Ahsa. Participation was voluntary, and informed consent was obtained electronically before data collection. All responses were anonymous, and participant confidentiality was maintained throughout the study. The data were securely stored on a password-protected database accessible only to the research team.

RESULTS

This study involved 892 Saudi participants and provides a detailed snapshot of vitamin D status with corresponding demographic and lifestyle profiles. The sample was nearly evenly split by gender (51.8% male and 48.2% female) and included a predominantly young population (48% ≤ 25 years and 33.1% aged 25–35 years) (see **Table 1**). Vitamin D deficiency was observed in 22.4% of the participants, while 37.8% had insufficient levels; only 39.8% reached sufficiency. These figures are in line with other regional research on widespread hypovitaminosis D.

The demographic profile shows that 62.1% of participants had light brown skin, and 50% held a bachelor's degree. Economically, 45.1% reported an intermediate income level, with only 10% falling into the low-income bracket. Lifestyle risk factors were notable: 35% had less than 2 hours of sun exposure daily, 70.1% consumed carbonated drinks, and physical inactivity was reported by 50% of the sample. Despite 65.7% reporting full-fat milk consumption—a potential source of dietary vitamin D—this did not offset the observed deficiency rates. Moreover, 20% of the participants were obese, while 30% were overweight, further raising metabolic concerns.

Table 1) Background characteristics of the sample

Variable	Category	Frequency	Percent
Gender	Male	462	51.80%
	Female	430	48.20%
Vitamin D Status	Deficient (<25 nmol/L)	200	22.40%
	Insufficient (25-50)	337	37.80%
	Sufficient (≥ 50)	355	39.80%
Age	≤ 25 years	428	48.00%
	25–35 years	295	33.10%
	≥ 35 years	169	18.90%
Skin Color	White	287	32.20%
	Light brown	554	62.10%
	Dark brown	46	5.20%
	Black	5	0.60%
Education	High school or below	268	30.00%
	Bachelor's degree	446	50.00%
	Master's or above	178	20.00%
Economic Level	Low	89	10.00%
	Intermediate	402	45.10%
	High	401	44.90%
Sun Exposure	<2 hours/day	312	35.00%
	2–4 hours/day	357	40.00%
	>4 hours/day	223	25.00%
Milk Consumption	Skimmed	44	4.90%
	Low fat	262	29.40%
	Full fat	586	65.70%
Carbonated Drinks	Yes	625	70.10%
	No	267	29.90%
Physical Activity	Yes	446	50.00%
	No	446	50.00%
BMI	Normal (<25 kg/m ²)	446	50.00%
	Overweight (25–30)	268	30.00%
	Obese (>30)	178	20.00%
Total		892	100.00%

Table 2 examines vitamin D status by gender. Among males ($n = 462$), 21.2% were deficient, 33.3% were insufficient, and 45.5% had sufficient levels. In contrast, among females ($n = 430$), 23.7% were deficient, 42.6% insufficient, while only 33.7% reached sufficiency. This significant difference indicates that females were more prone to suboptimal vitamin D levels (refer to **Table 2**).

Table 2 Vitamin D levels across gender

variable		vitamin D			Total
		Deficient	Insufficient	Sufficient	
gender	male	98	154	210	462
	female	102	183	145	430
Total		200	337	355	892

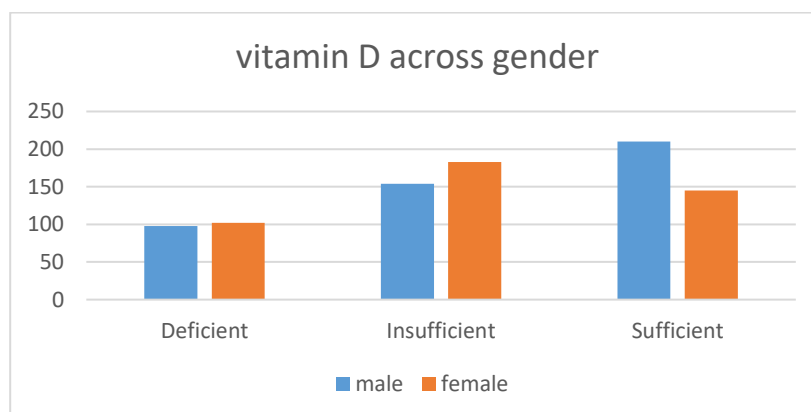
**Figure (1) Vitamin D deficiency across gender**

Table 3 further highlights the prevalence of vitamin D deficiency across various demographic and lifestyle factors for each gender. For example, among the vitamin D-deficient subjects, 55.4% of females were aged ≤ 25 years compared to 44.9% of males. Additionally, low economic status was linked with a higher deficiency rate in females (19.8% vs. 12.2%, $p = 0.008$). Limited sun exposure (< 2 hours/day) was experienced by 64.4% of deficient females versus 40.8% of males ($p < 0.001$), and physical inactivity and obesity were also more pronounced in females. These figures (highlighted in **Table 3**) suggest that females are at a higher risk for vitamin D deficiency due to a combination of age, socioeconomic, and lifestyle factors. Multiple figures (Figures 1–8) further illustrate the distribution of deficiency across age, education, economic level, sun exposure, carbonated drink consumption, physical activity, and BMI.

Table 3 Prevalence of vitamin D deficiency among Saudi males and females across different variables

Variable	Category	Male (n=98)	p-value	Female (n=102)	p-value
Age	≤ 25 years	44 (44.9%)	0.369	56 (55.4%)	0.041*
	25–35 years	34 (34.7%)		24 (23.8%)	
	≥ 35 years	20 (20.4%)		21 (20.8%)	
Skin Color	White	25 (25.5%)	0.512	30 (29.7%)	0.218
	Light brown	65 (66.3%)		60 (59.4%)	
	Dark brown/Black	8 (8.2%)		12 (11.9%)	
Education	High school or below	35 (35.7%)	0.087	42 (41.6%)	0.016*
	Bachelor's degree	48 (49.0%)		45 (44.5%)	
	Master's or above	15 (15.3%)		15 (14.9%)	
Economic Level	Low	12 (12.2%)	0.254	20 (19.8%)	0.008*
	Intermediate	45 (45.9%)		55 (54.5%)	
	High	41 (41.8%)		27 (26.7%)	
Sun Exposure	< 2 hours/day	40 (40.8%)	0.023*	65 (64.4%)	$< 0.001^*$
	2–4 hours/day	45 (45.9%)		30 (29.7%)	
	> 4 hours/day	13 (13.3%)		7 (6.9%)	
Milk Consumption	Skimmed	5 (5.1%)	0.332	8 (7.9%)	0.105
	Low fat	30 (30.6%)		40 (39.6%)	
	Full fat	63 (64.3%)		54 (53.5%)	
Carbonated Drinks	Yes	75 (76.5%)	0.002*	85 (84.2%)	0.001*

	No	23 (23.5%)		17 (15.8%)	
Physical Activity	Yes	60 (61.2%)	0.038*	35 (34.7%)	<0.001*
	No	38 (38.8%)		67 (65.3%)	
BMI	Normal (<25 kg/m ²)	45 (45.9%)	0.010*	30 (29.7%)	<0.001*
	Overweight (25–30)	35 (35.7%)		40 (39.6%)	
	Obese (>30)	18 (18.4%)		32 (31.7%)	

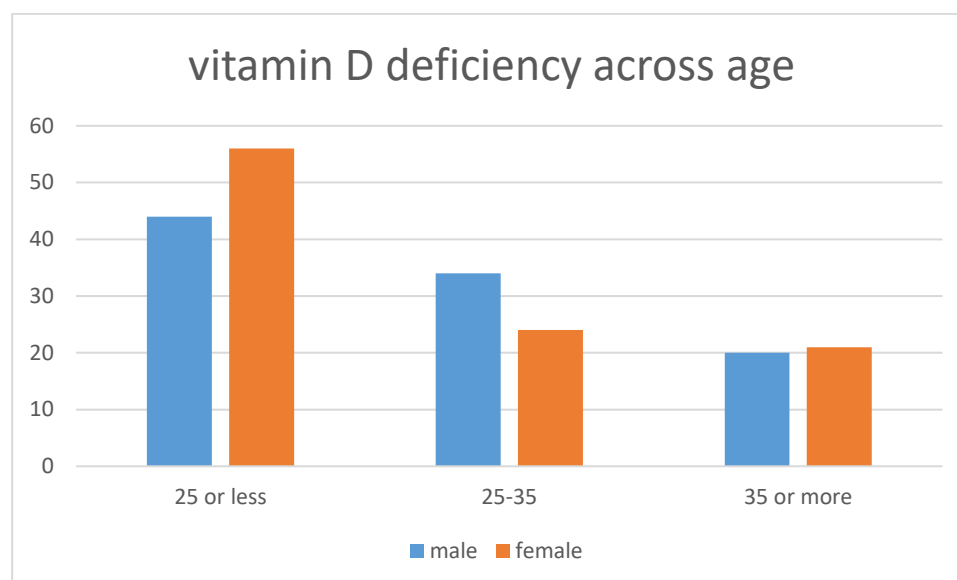


Figure (2): vitamin D deficiency across age

Table 4 presents the logistic regression analysis identifying independent predictors of vitamin D deficiency. Females had a 3.42-fold higher risk (95% CI: 2.51–4.66, $p < 0.001$) compared to males. Additionally, low economic status, limited sun exposure (<2 hours/day), physical inactivity, obesity, and carbonated drink consumption were significant predictors. These findings underscore the importance of addressing modifiable lifestyle factors and socioeconomic constructs, with a focus on gender-specific public health strategies.

Table 4. Logistic Regression Analysis of Factors Associated with Vitamin D Deficiency

Variable	Category	Adjusted OR	95% CI	p-value
Gender	Male	Ref.	—	—
	Female	3.42	2.51–4.66	<0.001
Age	≤25 years	Ref.	—	—
	25–35 years	1.12	0.82–1.53	0.47
	≥35 years	1.05	0.72–1.54	0.79
Skin Color	White	Ref.	—	—
	Light brown	1.18	0.89–1.56	0.251
	Dark brown/Black	1.32	0.85–2.05	0.214
Economic Level	High	Ref.	—	—
	Intermediate	1.47	1.09–1.98	0.012
	Low	2.01	1.32–3.06	0.001
Sun Exposure	>4 hours/day	Ref.	—	—
	2–4 hours/day	1.28	0.88–1.86	0.201
	<2 hours/day	2.15	1.49–3.10	<0.001
Physical Activity	Yes	Ref.	—	—
	No	1.62	1.25–2.10	<0.001
Milk Consumption	Full fat	Ref.	—	—
	Low fat	1.23	0.93–1.63	0.148

	Skimmed	1.41	0.89–2.23	0.141
Carbonated Drinks	No	Ref.	—	—
	Yes	1.74	1.30–2.33	<0.001
BMI	Normal (<25 kg/m ²)	Ref.	—	—
	Overweight (25–30)	1.38	1.02–1.87	0.038
	Obese (>30)	2.24	1.61–3.12	<0.001

DISCUSSION

Our results demonstrate that vitamin D deficiency remains a significant public health issue in Saudi Arabia. Among healthy young adults from the Eastern Province, 22.4% were vitamin D deficient, and 37.8% had insufficient levels. Logistic regression analysis identified several significant predictors of deficiency, including female gender, lower economic status, limited sun exposure (less than 2 hours/day), physical inactivity, high intake of carbonated drinks, and elevated body mass index (BMI). These findings are consistent with earlier studies conducted both regionally and internationally, which have reported similar prevalence rates and risk factors [14–16].

A particularly notable observation is the gender disparity in vitamin D deficiency. Female participants had a significantly higher risk (OR = 3.42, 95% CI [2.51, 4.66], $p < 0.001$) compared to males. This finding aligns with previous studies that observed higher prevalence rates among females, potentially due to cultural and behavioral factors limiting sun exposure [14,16]. Kaddam et al. [14] reported that 69.2% of female school students in Saudi Arabia were deficient, reinforcing the need to explore gender-specific determinants further.

Economic status also emerged as a critical determinant. Participants from lower-income households were nearly twice as likely to be deficient (OR = 2.01, $p = 0.001$), a finding supported by dos Santos et al. [17] and Scully et al. [18], who found that lower socioeconomic groups had reduced sun exposure and limited access to vitamin D-rich diets or supplementation.

Sunlight remains essential for endogenous vitamin D synthesis. In our study, individuals with less than 2 hours of daily sun exposure had more than double the risk of deficiency (OR = 2.15, $p < 0.001$), supporting results from Karamizadeh et al. [16]. Although Kaddam et al. [14] found variable associations in adjusted models, our findings reinforce the importance of adequate sun exposure in Saudi populations.

Lifestyle factors were also influential. Physical inactivity raised the risk of deficiency by 62% (OR = 1.62, $p < 0.001$), and high consumption of carbonated drinks increased the risk by 74% (OR = 1.74, $p < 0.001$). Similar associations were reported by Kaddam et al. [14] and Bindayel [19], emphasizing the need for public health strategies that encourage active lifestyles and healthier dietary choices.

BMI was another significant variable. Overweight individuals had a 38% increased risk, while those classified as obese had more than double the risk compared to individuals with normal BMI. These findings are consistent with previous literature, which suggests that vitamin D is sequestered in adipose tissue, reducing its bioavailability [20,14]. However, the significance of BMI varied across subgroups, warranting further investigation.

Interestingly, the type of milk consumed (skimmed/low-fat vs. full-fat) did not significantly impact vitamin D status, echoing findings from Kaddam et al. [14] and Morales-Villarreal et al. [15]. This supports the broader view that behavioral and environmental factors outweigh dietary vitamin D sources in this population.

International comparisons further underscore the global burden of vitamin D deficiency. In Mexico City, only 3.2% of participants had sufficient levels [15], while studies in Iran and China emphasized the roles of sun exposure and age, respectively [16,20]. Collectively, these findings confirm that vitamin D deficiency is a multifaceted issue influenced by diverse environmental, behavioral, and biological factors.

Studies in other populations provide additional insight. For example, in Turkey, vitamin D deficiency in children was linked with increased neurological symptoms [1], while in high-altitude Saudi regions, younger individuals were disproportionately affected [21]. In the UK, Julies et al. [22] reported a significant burden of nutritional rickets, highlighting the global challenge of vitamin D insufficiency across various age groups and regions.

CLINICAL IMPLICATIONS

The findings of this study highlight critical clinical implications for primary care and public health systems in Saudi Arabia. The high prevalence of vitamin D deficiency and insufficiency, especially among females and individuals with low socioeconomic status, calls for routine screening of at-risk populations during general health checkups. Family physicians and clinicians should consider incorporating vitamin D status evaluation into regular assessments, particularly for young adults presenting with non-specific symptoms such as fatigue, musculoskeletal pain, and mood disturbances. Additionally, given the strong association between vitamin D levels and modifiable lifestyle factors—such as sun exposure, physical activity, and dietary habits—clinical interventions should adopt a holistic, preventive approach. Education on safe sun exposure practices and lifestyle counseling should be part of health promotion programs, especially targeting women and adolescents.

STRENGTH POINTS

One of the key strengths of this study is its large and diverse sample size ($n = 892$), which enhances the statistical power and generalizability of the findings to the young adult population in Eastern Saudi Arabia. The study also used a rigorously developed and pre-tested questionnaire, enabling the collection of detailed demographic, behavioral, and anthropometric data. By analyzing both clinical vitamin D data and lifestyle variables, the study provides a multifactorial view of the determinants of deficiency. Furthermore, logistic regression was employed to identify independent predictors, offering robust insights into the risk profile of individuals more susceptible to vitamin D deficiency. The gender-based breakdown of data adds a valuable layer of analysis, making the results highly actionable for targeted interventions.

LIMITATIONS

Despite its contributions, this study has several limitations. The retrospective cross-sectional design limits the ability to establish causal relationships between the risk factors and vitamin D deficiency. Additionally, self-reported measures—such as sun exposure, dietary intake, and physical activity—are prone to recall bias and may not fully capture actual behavior. The use of electronic health records for serum vitamin D levels could have introduced inconsistencies in lab testing methods. Moreover, the exclusion of individuals with chronic diseases may limit the applicability of results to populations with comorbidities. Lastly, seasonal variations in sun exposure and vitamin D synthesis were not accounted for, which may influence the interpretation of deficiency rates.

CONCLUSION

In conclusion, vitamin D deficiency remains highly prevalent among young Saudi adults in the Eastern Province. Female gender, low economic status, limited sun exposure, physical inactivity, high carbonated drink consumption, and elevated BMI independently contribute to a higher risk of deficiency. These findings emphasize the need for comprehensive public health strategies that prioritize at-risk groups by promoting safe sun exposure, encouraging physical activity, and improving lifestyle behaviors. Future research should aim to develop and evaluate targeted interventions that address the complex interplay of behavioral, socioeconomic, and environmental determinants of vitamin D deficiency.

LIST OF ABBREVIATIONS

- **BMI** – Body Mass Index
- **CI** – Confidence Interval
- **OR** – Odds Ratio
- **SPSS** – Statistical Package for the Social Sciences
- **25(OH)D** – 25-hydroxyvitamin D
- **ng/mL** – Nanograms per Milliliter

Ethical Considerations

Ethical approval for this study was obtained from the Institutional Review Board at King Faisal University in Al-Ahsa, Saudi Arabia. Participants gave informed electronic consent before inclusion in the study. Data collection was anonymous, and all participants' information was handled with strict confidentiality. The study adhered to the principles outlined in the Declaration of Helsinki.

Acknowledgment

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Conflicts of Interest

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

Confidentiality of Data

All data collected were stored on a secure, password-protected platform accessible only to the research team. No identifying information was collected, and all responses remained anonymous.

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