Prevalence and Determinants of Vitamin D Deficiency: A Comprehensive Analysis from the measured vitamin D level at Chemiluminescence Immunoassay (CLIA) laboratory of National Institute of Nuclear Medicine and Allied Sciences (NINMAS), Dhaka

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ABSTRACT

Vitamin D deficiency has emerged as a global health concern, affecting populations across various geographical and socioeconomic spectrums. This study, conducted at the National Institute of Nuclear Medicine and Allied Sciences (NINMAS) in Shahbag, Dhaka, investigates the prevalence and determinants of Vitamin D deficiency among 1,819 individuals who have visited for their regular health check-up. Utilizing retrospective data from the Laboratory Information System of the Chemiluminescence Immunoassay (CLIA) laboratory of In-vitro and Radiochemistry Division of NINMAS, we analyzed Vitamin D levels alongside demographic variables and seasonal fluctuations to elucidate patterns of deficiency within this cohort. Our findings reveal a widespread Vitamin D deficiency, with 62.1% of the studied population exhibiting levels below 20 ng/mL, indicative of deficiency. A gender disparity was evident, with females comprising 74.7% of those deficient, compared to 25.3% of males. The overall mean Vitamin D level was recorded at 19.73 ± 11.94 ng/mL, with a slight male predominance in Vitamin D concentrations (20.80 ± 11.48 ng/mL for males vs. 19.33 ± 12.11 ng/mL for females). Seasonal analysis further underscored higher Vitamin D levels during the summer months, pointing towards the impact of sun exposure on Vitamin D synthesis. Conclusively, the substantial prevalence of Vitamin D deficiency underscores an urgent need for comprehensive public health strategies aimed at addressing this issue within the Bangladeshi population. Strategies may include promoting dietary sources of Vitamin D, enhancing public awareness about the importance of sun exposure, and considering food fortification programs.

Keywords: Vitamin D, Deficiency, prevalence, Chemiluminescence Immunoassay.

Bangladesh J. Nucl. Med. Vol. 27 No. 1 January 2024

DOI : https://doi.org/10.3329/bjnm.v27i1.71523

INTRODUCTION

Vitamin D, a crucial component for maintaining bone health and supporting immunological function, has emerged as a focus topic in public health discussions due to the pervasive nature of its shortage. It is a fat-soluble vitamin that also acts as a prohormone. It is a chemical secosteroid in nature and maintains the balance of calcium and phosphate ions in our body by promoting their absorption (1). Vitamin D can be acquired in two ways. Most of which is synthesized in our skin (80–90%) due to the exposure of ultraviolet B sunrays. Another 10–20% is acquired nutritionally. The global prevalence of vitamin D deficiency is a concerning issue, particularly in regions where two primary sources of vitamin D are insufficient due to geographical, cultural, or socioeconomic factors including skin pigmentation, latitude, season, and the use of clothing or sunscreen that blocks UVB rays (3). Moreover, dietary sources of vitamin D, such as fatty fish, egg yolks, and fortified foods, play a crucial role in maintaining adequate levels, especially in populations with limited sun exposure (4). The challenge of achieving adequate vitamin D levels is particularly pronounced in South Asia, including Bangladesh, where cultural practices, urbanization, and dietary habits converge to create a unique set of barriers to vitamin D synthesis.

Urban living conditions, characterized by high-rise buildings and densely populated areas, significantly reduce direct sun exposure among city dwellers. Additionally, atmospheric pollution in metropolitan areas can further limit the penetration of UVB rays, essential for Vitamin D synthesis (5). Cultural practices in Bangladesh, such as the wearing of conservative clothing that covers most of the body and social norms that discourage sun exposure, especially among women, exacerbate the risk of Vitamin D deficiency. The desire among women for fairer skin, leading to the use of sunscreens and other sun-blocking measures, further compounds this issue. Moreover, the prevalence of vegetarian diets and economic barriers to accessing vitamin D-rich foods limit the dietary intake of this crucial nutrient (5,6,7). The implications of vitamin D deficiency are far-reaching, affecting bone health, immune function, and the risk of chronic diseases such as cardiovascular disease, diabetes, and certain cancers (8). Given the essential role of vitamin D in maintaining overall health, the high prevalence of deficiency observed globally and particularly in regions like Bangladesh calls for urgent attention and action. This study aims to address this gap by finding the vitamin D status among a cross-section of the urban population, exploring factors associated with deficiency and insufficiency, and assessing the impact of demographic variables such as age, gender, and seasonal variations on vitamin D levels.

MATERIALS AND METHODS

This research was a retrospective cross-sectional analysis conducted at the Laboratory Information System of the In-vitro and Radiochemistry Division within NINMAS, Shahbag, Dhaka. The facility is equipped with advanced biochemistry and laboratory services, providing a comprehensive environment for conducting such analyses. The study included a total of 1,819 individuals who participated in regular health check-ups at NINMAS between January 2019 and December 2019. Inclusion criteria were based on the availability of complete health records, including 25-hydroxyvitamin D [25(OH) Vit D] levels, age, and sex, extracted from the hospital's Laboratory Information System (LIS). For each participant, data regarding serum levels of 25(OH) Vit D, along with demographic information such as age and sex, were retrieved from the LIS. The serum 25(OH) Vit D levels were determined using the chemiluminescence (CLIA) method, employing the ADVIA Centaur XPT Immunoassay System (Siemens Healthcare AG, Germany). This method is recognized for its precision and reliability in measuring vitamin D levels. Following the latest guidelines from the Endocrine Society, participants' vitamin D statuses were classified into three categories: deficient (less than 20 ng/mL), insufficient (20–30 ng/mL), and sufficient (greater than 30 ng/mL). This classification facilitated a nuanced analysis of vitamin D levels across different demographic groups within the study population. Participants were further categorized into four age groups: under 20 years, 21–40 years, 41–60 years, and over 60 years. This stratification allowed for an age-wise analysis of vitamin D status. Additionally, the study examined monthly variations in vitamin D levels over one year. This approach enabled an assessment of how monthly changes in sunlight exposure might affect vitamin D synthesis among the study population.

RESULT

This present study involved examining the health records of 1,819 individuals who underwent regular health check-up at the NINMAS, Shahbag, Dhaka, utilizing the Laboratory Information System of the In-vitro and Radiochemistry Division. The demographic breakdown showed that 27% of the participants were male and 73% were female, resulting in a gender ratio of approximately 1 male to 2.7 females. Analysis of vitamin D levels revealed an average concentration of 19.73 ± 11.94 ng/mL across the study group, with a median value of 17.35 ng/mL. When examining the data by gender, the average vitamin D concentration was slightly higher in males (20.80 ± 11.48 ng/mL, median 18.25 ng/mL) compared to females (19.33 ± 12.11 ng/mL, median 16.87 ng/mL). A closer look at the vitamin D status across the 1,819 participants indicated that 62.1% had vitamin D deficiency (below 20 ng/mL), including 25.3% of males and 74.7% of females. Vitamin D insufficiency (levels between 21 and 30 ng/mL) was found in 24.8% of the subjects, with a gender distribution of 28.5% male and 71.5% female. Conversely, only 13.17% of the participants had sufficient levels of vitamin D (30 ng/mL or higher), including 32.8% males and 67.2% females.

Table 1: Mean value of Vitamin D in male and female subjects

Sex	N (%)	Mean ± SD (ng/mL)	SEM	Median
Male	492 (27.0 %)	20.80 ± 11.48	0.517	18.25
Female	1327 (73.0 %)	19.33 ± 12.11	0.332	16.87
Total	1819 (100 %)	19.73 ± 11.94	0.280	17.35

Table 2: Distribution of Vitamin D in male and female subjects

Sex	Vitamin D Level				P-value
	VDD	VDI	VDS	Total	
Male	286 (25.3%)	129 (28.5%)	77 (32.8%)	492 (27%)	0.049
Female	843 (74.7%)	323 (71.5%)	161 (67.2%)	1327 (73%)	
Total	1129 (62.1%)	452 (24.8%)	238 (13.1%)	1819 (100%)	

In this analysis, the average vitamin D concentration within the Vitamin D Deficiency (VDD) group showed a slight difference between genders, with males displaying a level of 13.57 ± 3.97 ng/mL and females at 13.01 ± 4.14 ng/mL, suggesting marginally higher levels in males. Within the Vitamin D Insufficiency (VDI) cohort, the male participants had an average vitamin D level of 24.14 ± 2.69 ng/mL, which was slightly above the female average of 23.80 ± 2.82 ng/mL. On the other hand, in the Vitamin D Sufficiency (VDS) category, the average vitamin D concentration was lower for males at 42.05 ± 10.32 ng/mL, compared to females, who had a higher average of 43.46 ± 16.48 ng/mL.

Table 3: Sex distribution of the subjects of all age group in accordance to their vitamin D status

Sex	VDD				VDI				VDS			
	N	Mean ± SD (ng/mL)	SEM	Median	N	Mean ± SD (ng/mL)	SEM	Median	N	Mean ± SD (ng/mL)	SEM	Median
Male	286	13.57 ± 3.97	0.23	13.99	129	24.14 ± 2.69	0.24	23.88	77	42.05 ± 10.32	1.18	40.44
Female	843	13.01 ± 4.14	0.14	13.32	323	23.80 ± 2.82	0.16	23.34	161	43.46 ± 16.48	1.29	37.63

Table 4 presents the average levels of vitamin D across various age groups for both male and female participants. In the under-20 years category, 24.2% of males had an average vitamin D level of 20.43 ± 10.95 ng/mL, while the female participants constituted 11% of this group, with an average level of 20.52 ± 15.00 ng/mL. For those aged between 21 and 40 years, a significant proportion was observed, comprising 41.7% of males and 49.4% of females, with their mean vitamin D levels recorded at 20.55 ± 12.25 ng/mL for males and 18.63 ± 11.21 ng/mL for females, respectively. Participants aged 41 to 60 years made up 26.8% of the male and 33.5% of the female groups, showing average vitamin D concentrations of 20.93 ± 10.43 ng/mL for males and 19.59 ± 11.13 ng/mL for females. The oldest age group included 7.3% of males and 6.1% of females, with their vitamin D levels averaging 22.91 ± 12.52 ng/mL for males and 21.51 ± 17.08 ng/mL for females.

Table 4: Age and sex-wise distribution of the subjects

Age (years)	Male			Female		
	N (%)	Mean ± SD (ng/mL)	Median (SEM)	N (%)	Mean ± SD (ng/mL)	Median (SEM)
<20	119 (24.2 %)	20.43 ± 10.95	17.94 (1.00)	146 (11.0 %)	20.52 ± 15.04	17.59 (1.24)
21–40	205 (41.7 %)	20.55 ± 12.25	17.99 (0.86)	655 (49.4 %)	18.63 ± 11.21	16.25 (0.44)
41–60	132 (26.8 %)	20.93 ± 10.43	18.56 (0.91)	445 (33.5 %)	19.59 ± 11.13	17.69 (0.53)
>60	36 (7.3 %)	22.91 ± 12.52	20.04 (2.09)	81 (6.1 %)	21.51 ± 17.08	16.31 (1.90)

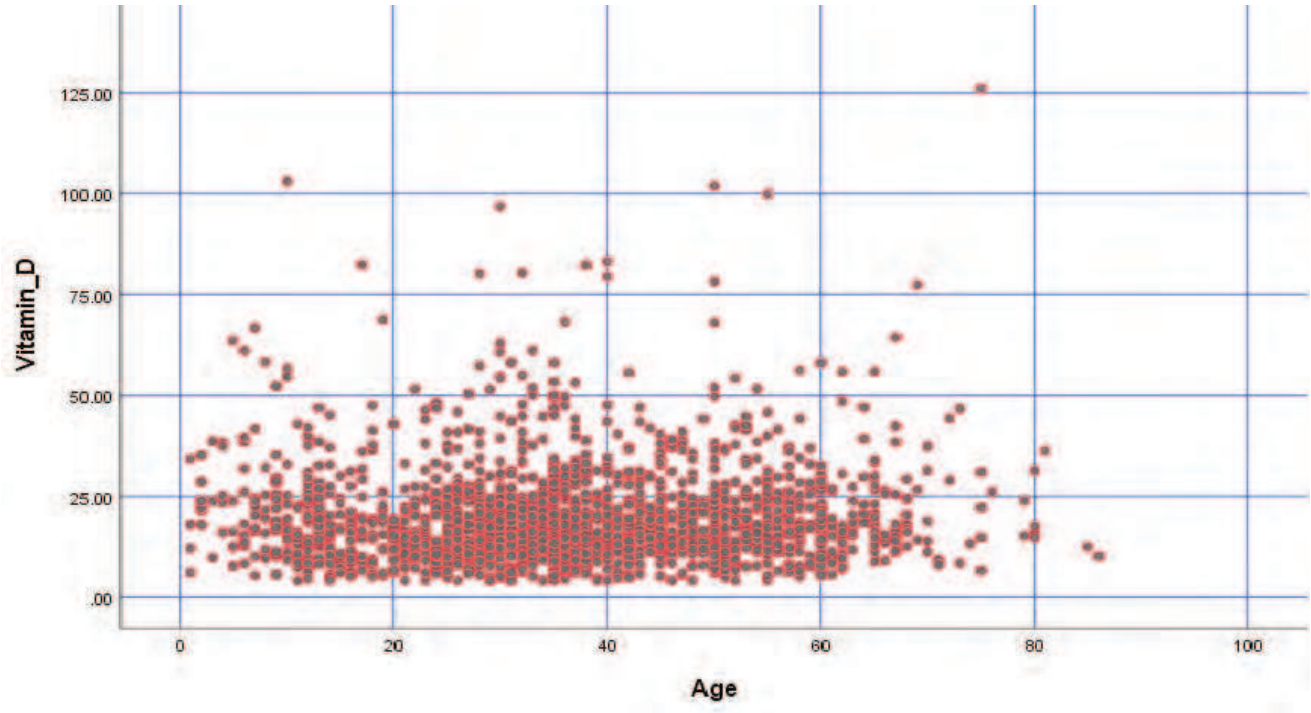

Figure 2: Age distribution of Vitamin D

The highest level of Vitamin D is found in August (Male: 31.12±17.65 ng/mL, Female: 30.56±18.94 ng/mL) where lowest level is seen in September (Male: 14.27±8.65 ng/mL, Female: 14.26±8.65 ng/mL) indicating a significant drop as seasons change.

Table 05: Monthly sex wise distribution of Vitamin D

Month	Male			Female		
	Mean ± SD (ng/mL)	Median (ng/mL)	SEM (ng/mL)	Mean ± SD (ng/mL)	Median (ng/mL)	SEM (ng/mL)
January	21.33±12.07	19.75	1.64	16.96±7.33	15.58	0.66
February	18.16±6.70	17.68	1.04	19.64±13.49	16.69	1.32
March	16.27±9.43	12.94	1.59	17.31±13.45	14.49	1.19
April	18.15±11.57	14.79	1.74	17.62±8.86	16.37	0.75
May	18.05±10.81	13.89	2.21	18.12±6.78	17.61	0.73
June	20.99±8.17	20.29	1.19	18.19±5.78	18.29	0.59
July	20.05±7.68	18.01	0.96	18.77±8.99	17.18	0.72
August	31.12±17.65	27.08	2.94	30.56±18.94	25.78	1.91
September	14.27±8.65	12.89	1.70	14.26±8.65	12.17	0.68
October	18.62±13.85	17.58	1.10	18.62±13.85	15.68	1.85
November	25.62±12.21	23.38	1.73	23.41±12.29	20.24	1.30
December	23.58±11.83	21.74	1.99	24.43±16.01	20.1	1.68

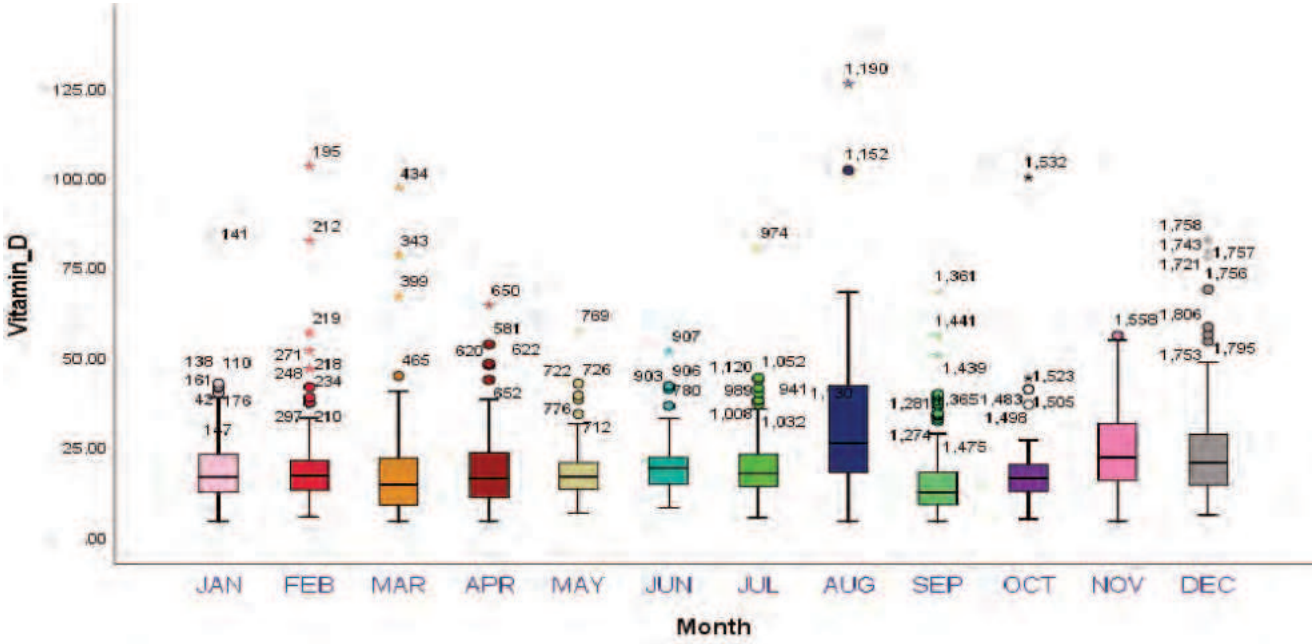

Figure 3: Monthly distribution of Vitamin D

DISCUSSION

Addressing the vitamin D deficiency requires a nuanced understanding of the interplay between geographical, cultural, and socioeconomic factors that inhibit adequate vitamin D synthesis. Despite the abundance of sunlight in countries like Bangladesh (9), the prevalence of vitamin D deficiency remains high due to a constellation of lifestyle and environmental factors. The critical role of sunlight in vitamin D synthesis is well documented, yet urban living conditions in Dhaka, characterized by densely populated areas and high-rise buildings, significantly reduce direct sun exposure among the city's inhabitants (4). Furthermore, cultural practices, such as the prevalent use of conservative clothing that covers most of the body, particularly among women, and the pursuit of fairer skin through the use of sunscreens, further diminish vitamin D synthesis (4,6). This analysis of 1,819 participants revealed insightful trends regarding vitamin D deficiency and insufficiency among different demographics. The findings underscore the pervasive issue of vitamin D deficiency, with 62.1% of participants falling below the 20 ng/mL threshold, aligning with global concerns about vitamin D status in various populations [10]. Our analysis revealed a slight male predominance in vitamin D levels, with males averaging 20.80 ± 11.48 ng/mL compared to females at 19.33 ± 12.11 ng/mL. This is consistent with existing literature indicating gender differences in vitamin D metabolism and absorption, possibly attributed to lifestyle differences, hormonal factors, or genetic predispositions (10,11,12). The sex ratio of participants (approximately 1 male to 2.7 females) further emphasizes the importance of considering gender-specific health strategies in addressing vitamin D deficiency. The stratification of vitamin D levels by age groups in this study revealed that the youngest (<20 years) and oldest (>60 years) age brackets had marginally higher vitamin D levels compared to the middle-aged groups. This pattern suggests a potential lifestyle or physiological factor influencing vitamin D synthesis or intake across different life stages. Previous research has highlighted that age can significantly impact vitamin D status, with older adults often at higher risk for vitamin D deficiency due to decreased skin synthesis capability and dietary intake (13,14). However, our findings suggest a short understanding of age-related differences, potentially reflecting increased outdoor activity in younger individuals or dietary supplementation in older adults. Notably, our study observed the highest mean vitamin D levels in August for both males and females, with a sharp decline in September. This seasonal fluctuation aligns with known variations in sun exposure and vitamin D synthesis, with peaks typically occurring in late summer due to higher UVB radiation levels (15). The significant drop in

September might also reflect changes in weather patterns, clothing, or behavior as individuals transition from summer to autumn, reducing their sun exposure and, consequently, vitamin D synthesis (15,16). The high prevalence of vitamin D deficiency and insufficiency among the study's participants indicates a significant public health concern. Vitamin D plays a crucial role in bone health, immune function, and chronic disease prevention (4,6). The findings underscore the need for public health initiatives to improve vitamin D status, such as promoting dietary supplementation, fortifying foods, and encouraging safe sun exposure practices.

CONCLUSION

This study underscored a pervasive issue of Vitamin D deficiency across various demographics. Notably, 62.1% of the studied population exhibited Vitamin D deficiency, with a higher prevalence observed among females (74.7%) compared to males (25.3%). Furthermore, the study highlighted a modest difference in Vitamin D levels between genders, with males averaging slightly higher levels. Seasonal variations also played a significant role, with Vitamin D levels peaking during the summer months.

LIMITATIONS

The cross-sectional design limits causal inferences, and the study's geographical focus on Dhaka may restrict the generalizability of findings to other regions with different sunlight exposure, dietary habits, and genetic backgrounds. Future research should consider longitudinal designs to explore causal relationships and interventions to enhance vitamin D status.

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