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Vitamin D Level of Individuals Having Medical Service in a Tertiary Hospital

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ABSTRACT

OBJECTIVE: This study aimed to investigate the status of vitamin D level, rates of insufficiency and deficiency in individuals seeking medical services in a tertiary hospital.

METHODS: This retrospective study was conducted between October 1, 2022, and December 24, 2023. Inclusion criteria were individuals aged 18 years or older who had sought medical services in our hospital between August 2021 to May 2022. Information such as age, gender, ethnicity, and personal health data including vitamin D level, blood pressure, body mass index, and bone mineral density were collected. The percentages and risk features among the individuals with inadequate vitamin D levels were analyzed.

RESULTS: Among the 2,459 participants, the mean age was 52.0 years (interquartile range [IQR] 40, 67 years). Approximately one third had one or more health disorders (31.1%), with 29.7% being overweight, 10.8% being obese, and 57.3% having high blood pressure. Osteopenia or osteoporosis was found in 33.2%. The median vitamin D level was 26.3 ng/mL (IQR 19.4, 36.0 ng/mL), with 61.8% had inadequate vitamin D levels as insufficiency in 35.2% and deficiency in 26.6%. Univariable analysis revealed the following three features showing significant association with inadequate vitamin D levels: age younger than 60 years (odds ratio [OR] 2.3, p-value < 0.001), Thai ethnicity (OR 1.3, p-value = 0.014), and overweight/obesity (OR 1.3, p-value = 0.002). Multivariable analysis showed that all three features were independent risk factors for inadequate vitamin D levels.

CONCLUSION: This study showed a high percentage of inadequate vitamin D levels among the participants, with insufficiency in approximately one third and deficiency in one fourth. Older people, Thai people, and overweight/obese people were at risk of inadequate vitamin D levels.

KEYWORDS: calciferols, vitamin D, vitamin D deficiency, vitamin D insufficiency

INTRODUCTION

Vitamin D, or calciferol, exists as D2 and D3. It is obtained from sunlight, vitamin D-rich foods like fatty fish and fortified dairy, and supplements. Vitamin D is synthesized in the skin from 7-dehydrocholesterol upon UVB exposure, forming previtamin D3 and then active vitamin D3 (cholecalciferol). After binding to its receptor, vitamin D is transported to the liver, where it converts to calcifediol, and then to the active form, calcitriol, in the kidneys[1]. Calcitriol acts through the vitamin D receptor in various tissues to regulate physiological processes, including bone mineralization by managing calcium and

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phosphate levels, enhancing intestinal absorption, renal reabsorption, and osteoclast activity[2]. Additionally, vitamin D impacts the immune system, potentially affecting autoimmune diseases, infections, and cell growth, with implications for cancer prevention[3]. Inadequate vitamin D can reduce calcium absorption by 10%–15% and phosphorus absorption by 60%, causing bone issues like fractures, bone loss, muscle weakness, and falls. It can also lead to other health problems, including neurocognitive disorders, mental illness, cardiovascular disease, autoimmune diseases, infections, diabetes, cancer, infertility, and poor pregnancy outcomes[4,5].

The status of inadequate vitamin D, either insufficiency or deficiency, may be associated with many factors, such as environment or geographic location, socioeconomic status, season, culture, habitat, and individual features, including aging, dark skin color, gender, lifestyle, sunscreen usage, obesity, personal illness, and dietary intake of vitamin D-rich foods or supplements and medications that interfere with vitamin D metabolism[1,6-8].

Although the prevalence of vitamin D insufficiency slightly decreased from 2000–2010 to 2011–2022, it remained high among some populations, such as in the Eastern Mediterranean region and lower-middle income countries or living in high latitudes[9]. Several studies in Thailand conducted between 2009 and 2013 revealed the varying prevalences of 34%–78% for vitamin insufficiency[10-12] and 6% for vitamin D deficiency[13]. However, these previous studies were conducted in the community in non- or suburban areas of Thailand, which might not provide a situation in the hospital especially in urban area of the country. Our hospital, which is a tertiary hospital in a metropolitan city of the country, had many individuals who had medical services including vitamin D level determination. Data on the status of vitamin D and relevant information should be useful.

Our study aimed to investigate the status of vitamin D level, rates of insufficiency and deficiency in individuals seeking medical services in the hospital. The associated features, including the characteristics and their health status with vitamin D level, were also studied.

METHODS

This retrospective cross-sectional study received ethical approval from the Institutional Review Board of MedPark Hospital, Thailand (COA 001/2022 E) and was conducted between October 1, 2022, and December 24, 2023. Inclusion criteria were adult patients aged 18 years or older who had sought medical services in our hospital between August 2021 to May 2022. The participants must have had serum vitamin D level testing as a part of either health surveillance program or medical care for any abnormal health condition. Pregnant women and individuals whose basic characteristic data were unavailable were excluded. Based on a 65% prevalence of vitamin D insufficiency in central Thailand[8], the sample size of at least 350 participants was required with the significant level was 0.05, and the $Z_{\alpha/2} = 1.96$.

The electronic database of the hospital was used to collect basic characteristics of age, gender, ethnicity, serum 25(OH)D level, and personal health data, such as health history and findings when vitamin D level was determined, including blood pressure, body mass index (BMI), and bone mineral density (BMD). The first value of determined vitamin D in our hospital was used for the analysis.

Serum 25(OH)D levels were measured in the hospital laboratory by electrochemiluminescence immunoassay (Cobas e801 immunoassay analyzer; Roche Diagnostics, Basel, Switzerland) using Cobas e801 analyzer, and the results were correlated with those using the CDC Vitamin D Reference Laboratory by LC-MS/MS (r = 0.980). The detection limit of total 25(OH)D was 3–100 ng/mL or 7.5–250 nmol/L. Internal quality controls were performed daily, and external quality assessment was conducted monthly by Randox Laboratories Ltd., RIQAS program (ISO 17043: 2010).

All statistical analyses were conducted using IBM SPSS Statistics for Windows,

Version 28.0 (IBM Corporation, Armonk, NY, USA). Descriptive data were presented as frequencies and percentages for categorical variables and mean ± standard deviation or median and ranges for continuous data. For comparison, the data were grouped as follows: age (< or ≥ 60 years), gender (male vs. female), ethnicity (Thai vs. others), health status (normal vs. abnormal), BMI (normal vs. overweight/obese), BMD (normal, abnormal), and vitamin D status (sufficiency, insufficiency, and deficiency). Overweight/obesity was defined with BMI ≥ 25 kg/m^2. Abnormal BMD was defined as osteopenia and osteoporosis according to the BMD report. Vitamin D status was defined in accordance with the Institute of Medicine guidelines: deficiency with serum 25(OH)D level < 20 ng/mL (< 50 nmol/L), insufficiency with a level between 20 and 29.9 ng/mL (50–72.5 nmol/L), and sufficiency with a level > 30 ng/mL (75 nmol/L)[14]. Chi-square or Fisher's exact tests were employed to explore the associations between vitamin D status and findings of health outcomes of interest. Multivariable logistic regression analyses were conducted for factors that were significant as determined by univariable analysis. A p-value < 0.05 was considered statistically significant.

RESULTS

Among the 2,727 individuals who sought health services and underwent vitamin D measurement in our hospital, 268 were excluded because of having an age lower than 18 years old (n = 223) or lacking available data on their vitamin D levels (n = 45).

A total of 2,459 individuals who underwent vitamin D measurement and had available characteristic data were included in this study. The median age was 52.0 years (interquartile range [IQR] 40, 67 years), with females accounting for slightly more than half (55.6%). The majority was Asian (94.4%; being Thai in 82.9%). Table 1 shows the basic characteristics of the participants.

Table 2 shows the health history or findings of the participants. Nearly one third (31.1%) reported or were found to have one or more health disorders. Basic physical examination revealed that 29.7% were overweight and 10.8% were obese. More than half (57.3%) had high blood pressure. Among the 696 participants who underwent BMD examination, approximately one third (33.2%) showed abnormalities of either osteopenia or osteoporosis.

Table 1 Basic characteristic features of the participants (n = 2,459)

Basic characteristics features	n	%
Age, years		
< 40	570	23.2
≥ 40 to 49	530	21.6
≥ 50 to 59	398	16.2
≥ 60	961	39.1
Gender		
Male	1,093	44.4
Female	1,366	55.6
Ethnic		
Asian	2,320	94.4
Thai	2,038	82.9
Others*	282	11.5
Western	139	5.6

Abbreviation: n, number
*Other ethnics included people from 26 countries from the 5 different regions in Asia

Table 2 Health history or findings of the participants

Health features	n	%
Health history & finding* (n = 2,459)		
Normal	1,694	68.9
Abnormal*	765	31.1
Cardiovascular	135	15.1
Respiratory	286	31.9
Neurological	22	2.5
Gastrointestinal	51	5.7
Musculoskeletal	147	16.4
Skin	54	6.0
Endocrine	201	22.4
Blood pressure level (n = 1,922)		
Normal	821	42.7
High	1,101	57.3
Body mass index (n = 2,389)		
Underweight	157	6.6
Normal	1,264	52.9
Overweight	709	29.7
Obesity	259	10.8
Bone mineral density (n = 696)		
Normal	465	66.8
Abnormal	231	33.2

Abbreviation: n, number
*One may have one or more health disorders

Among the 2,459 participants, the median vitamin D level was 26.3 ng/mL (IQR 19.4, 36.0 ng/mL). We found that 61.8% had inadequate levels, with insufficiency in 35.2% and deficiency in 26.6%. Table 3 lists the vitamin D status and levels of the participants.

We also explored the association between vitamin D status and the characteristics and health features of the participants with inadequate vitamin D levels (table 4). Univariable analysis showed the following significant features associated with inadequate vitamin D levels: age younger than 60 years, Thai ethnicity, and overweight/obesity. Multivariable analysis revealed that all of these features were independent factors associated with inadequate vitamin D status. The frequency of inadequate vitamin D level was higher in individuals with a history of illnesses or abnormal health findings than in normal individuals (40.1% vs. 37.3%). However, the difference was not statistically different.

Vitamin D status was also studied among the 696 participants who had available data of BMD. A significantly higher rate of osteopenia/osteoporosis was found among the individuals who had adequate vitamin D levels (41.9%, 106 out of 253 participants) compared with those with inadequate vitamin D status (28.3%, 125 out of 442 participants).

Table 3 Vitamin D status and level (n = 2,459)

Vitamin D status	Vitamin D level, mean ± SD (ng/mL)	n	%
Sufficient	46.46 ± 19.10	939	38.2
Inadequate	20.70 ± 5.62	1,520	61.8
Insufficient	24.85 ± 2.80	867	35.2
Deficient	15.18 ± 3.13	653	26.6

Abbreviations: n, number; ng, nanograms; mL, milliliter; SD, standard deviation

Table 4 Features associated with inadequate vitamin D

Features	n	Vitamin D level		Crude OR (95% CI)	P-value	Adjusted OR (95% CI)	P-value
		Inadequate	Sufficient				
Age (years), n = 2,459							
< 60	1,498	1,043 (69.6)	455 (30.4)	2.3 (1.97–2.75)	< 0.001	2.4 (2.02–2.85)	< 0.001
≥ 60	961	477 (49.6)	484 (50.4)				
Gender, n = 2,459							
Female	1,366	846 (61.9)	520 (38.1)	1.0 (0.86–1.19)	0.892	-	-
Male	1,093	674 (61.7)	419 (38.3)				
Ethnic, n = 2,459							
Thai	2,038	1,282 (62.9)	756 (37.1)	1.3 (1.05–1.61)	0.014	1.6 (1.28–2.00)	< 0.001
Others	421	238 (56.5)	183 (43.5)				
Health status, n = 2,459							
Abnormal	765	307 (40.1)	458 (59.9)	0.9 (0.75–1.06)	0.182	-	-
Normal	1,694	632 (37.3)	1,062 (62.7)				
Body mass index, n = 2,389							
Overweight/Obesity	968	635 (65.6)	333 (34.4)	1.3 (1.10–1.54)	0.002	1.4 (1.20–1.70)	< 0.001
Normal	1,421	845 (59.5)	576 (40.5)				

Abbreviations: CI, confidence interval; n, number; OR, odds ratio
*Abnormal health status referred to history of personal illnesses and/or presence of abnormal health findings

DISCUSSION

Our study found 61.8% of the individuals having medical service in the hospital had inadequate vitamin D level: insufficiency in 35.2% and deficiency in 26.6%. The prevalence of vitamin D status in various populations has been widely reported. The different prevalences of vitamin D insufficiency or deficiency across studies may lie on many factors, especially the characteristics of the participants in each study, e.g., ethnic or geographic area, altitude, age group, gender, and other personal features of BMI, skin color, living conditions or residence, use of sunscreen, and illnesses. The features of Thai ethnicity, age younger than 60 years, and overweight/obesity, which were found to be significantly associated with inadequate vitamin D in our study, had also been previously reported as influencing factors.

Regarding the ethnic or geographic impact on vitamin D status, people from areas with high sun exposure, such as Asia, should have a lower prevalence of inadequate vitamin D levels than those who live in Western countries[15]. However, the 35.2% of vitamin D insufficiency in our study, 34% to 39% in other reports from Thailand[10-12], and 36% to 43% in other reports from Asia[16,17] were not much different from 34% to 41% in the reports from the Western country (US)[9,18,19]. This was also the situation for vitamin D deficiency which was found 26.6% in our study compared to 21% to 23% in Asia[16,17], and 20% to 25% in the US reports[18,19]. The exceptions were high rates of vitamin D deficiency from one study which reported 58% among 982 Indian participants aged 45 years and over[20] and 68% from one systematic review including 65 studies from South Asia[21]. We wanted to focus on finding of vitamin D levels of Thai population in our study compared with the other ethnics altogether. Although not representing the overall population of the country, a higher rate of inadequate vitamin D among Thai was revealed compared to the other ethnic population in the study (adjusted OR 1.6). Many other factors, aside from ethnicity, may play certain roles in the relationship with vitamin D levels, e.g., characteristics of the participants, attitudes and lifestyle behaviors toward sun exposure, use of sunscreen, or diets[13,17,19,22].

Inconsistent data have been reported regarding the relationship between age and vitamin D status. Only a few investigations focused on this relationship, including one study from Thailand that found a positive association between older age and high vitamin D levels[18,19,23]. By contrast, one previous report[24] and our study found younger age was

a risk factor for low vitamin D (adjusted OR 2.4 in our study). Theoretically, the elderly should have low vitamin D levels due to the decreased production and metabolism of vitamin D caused by the physiological changes of aging. In addition, factors such as limited physical activity and concerns about skin cancer may lead to reduced sun exposure and subsequently low cutaneous vitamin D synthesis in older individuals[25]. However, older individuals, who are often more health-conscious than younger age groups, are highly likely to take vitamin D supplements, which could impact the findings.

Another risk factor for inadequate vitamin D levels identified in this study was overweight/obesity. This finding was consistent with previous reports that also found a direct association between overweight or high BMI and low or inadequate vitamin D levels[18,19,24,26]. The causes of poor vitamin D level in overweight/obese people are complex and may involve multiple pathways, e.g., reduced vitamin D synthesis in adipose tissues and the liver, gene expression dysregulation, parathyroid hormone modulation, and decreased 25-OH-vit D availability in most obese individuals, resulting in decreased levels of the active form, 1,25-dihydroxyvitamin D[27-29].

One contradictory finding of our study was the significant association between inadequate vitamin D levels and normal BMD, which was contradictory to the established understanding that low vitamin D levels or vitamin D deficiency have detrimental effects on bone health[17,30,31]. Considering that data on vitamin D supplementation were not available in this study, we simply proposed that individuals with abnormal bone conditions might have already taken vitamin D supplements, potentially explaining this unexpected result.

Although our study did not find a significant impact of gender or history of illnesses or abnormal health findings on vitamin D status, this relationship merited some discussion. Data regarding the impact of gender are inconsistent: some studies reported that males are associated with inadequate vitamin D levels[18], and others found that females have a high risk[19,23]. Various personal characteristics of the participants across studies may contribute to the different impacts of gender on vitamin D level. Regarding illnesses, many studies found a direct association between low vitamin D level or vitamin D deficiency and various illnesses[24,20,32-34]. Focusing on one hospital-based study, their study found lower vitamin D level in the patients with high blood pressure compared to those with normal pressure[34]. Although our study found a slightly higher percentage of inadequate vitamin D in individuals with who had abnormal health status than healthy individuals (table 4: 40.1% vs 37.3%), the difference was not statistically significant which may be attributed to a heterogeneous illness or findings, especially when most of them were not confirmed or had longitudinal follow-up data for verification.

Our study have some limitations. First, it was a retrospective design, so data which have an impact on vitamin D status such as prior vitamin D levels and diet or sun-exposure habits and/or vitamin D-containing supplements were not available. Second, some participants simply sought a health check-up without requiring specific medical care for health problems, so the health history and findings from various investigations were heterogeneous. With a lack of complete data and longitudinal follow-up, their association with vitamin D status should be interpreted cautiously. Third, the association between vitamin D status and bone health measured with BMD was against all odds. With the unavailability of data on vitamin supplements, this finding could not represent a genuine association. Lastly, this study was conducted as one hospital-based study which may not represent all Thai ethnic across the country.

Nevertheless, our study had some strengths. The number of individuals who underwent vitamin D measurement was quite large, and these people had various characteristics, including ethnicity. Our findings may be informative for specific groups with abnormal vitamin D levels. Further research should focus on these specific groups with vitamin D insufficiency or deficiency and associated illnesses. The genuine causal relationship between characteristic features and vitamin D inadequacy should be confirmed, especially among the Thai population. Moreover, longitudinal studies are necessary to gain additional insight into the direction of the associations.

CONCLUSION

This study demonstrated a high percentage of inadequate vitamin D levels, with insufficiency in approximately one third and deficiency in one fourth of the participants. Age younger than 60 years, Thai ethnicity, and overweight/obesity were found to be independent risk factors.

CONFLICT OF INTEREST

The authors have declared no competing interests exist.

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DATA AVAILABILITY STATEMENT

Please contact the corresponding author for data availability.

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