

**A Pilot Study of Vitamin D Inadequacy Among Hospital Staffs at Vachira Phuket Hospital:
Prevalence, Risk Factors and Response to Ergocalciferol Supplementation**

**การศึกษานำร่องภาวะวิตามินดีไม่เพียงพอในบุคลากรโรงพยาบาลวชิระภูเก็ต: ความชุก ปัจจัยเสี่ยง
และการตอบสนองต่อการเสริมเออร์โกแคลซิเฟอรอล**

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Abstract

Introduction: Vitamin D is vital for bone, immune, and overall health, yet deficiency persists even in tropical countries. Hospital staff are at particular risk due to indoor work and limited sun exposure.

Objective: To preliminarily assess vitamin D status, identify factors associated with vitamin D levels, and evaluate the response to Ergocalciferol (vitamin D₂) supplementation among healthcare personnel at Vachira Phuket Hospital.

Methods: A retrospective pilot cohort study was conducted among 66 healthcare personnel at Vachira Phuket Hospital between June and November 2024, with a 6-month follow-up. Serum 25(OH)D was measured and categorized as deficient (<20 ng/mL), insufficient (20–29 ng/mL), or sufficient (≥30 ng/mL). Participants with vitamin D deficiency or insufficiency received oral ergocalciferol (vitamin D₂) at a dose of 20,000 IU (1- 2 capsules per week).

Results: At baseline, 94.0% of participants had inadequate vitamin D status, with 57.6% classified as insufficient and 36.4% as deficient. Age ≥40 years was significantly associated with lower serum vitamin D levels ($p < 0.05$), whereas no significant associations were observed with other demographic or behavioral factors. After six months of vitamin D₂ supplementation, serum vitamin D status changed significantly within individuals ($p < 0.01$). Among participants who were vitamin D deficient at baseline, 45.8% showed improvement in vitamin D status, with 41.7% improving to the insufficient category and 4.1% achieving sufficient levels. However, 54.2% remained vitamin D deficient after supplementation.

Conclusions: Vitamin D insufficiency and deficiency were highly prevalent among hospital personnel, with age ≥40 years identified as a significant factor associated with lower vitamin D

levels. Findings from this pilot study suggest that weekly ergocalciferol supplementation of 20,000–40,000 IU may be insufficient to achieve adequate vitamin D status in many individuals. Further studies are warranted to determine the optimal vitamin D supplementation regimen for healthcare personnel.

Keywords: Vitamin D, Healthcare workers, Sun exposure, Ergocalciferol supplementation

บทคัดย่อ

บทนำ วิตามินดีมีความสำคัญต่อสุขภาพกระดูก ระบบภูมิคุ้มกัน และสุขภาพโดยรวม แม้ประเทศไทยจะมีแสงแดดตลอดปี แต่การขาดวิตามินดียังคงพบได้บ่อย โดยเฉพาะในบุคลากรโรงพยาบาลที่ทำงานในร่มและมีการรับแสงแดดจำกัด

วัตถุประสงค์ เพื่อประเมินระดับวิตามินดีในเลือด ศึกษาปัจจัยที่สัมพันธ์กับระดับวิตามินดี และประเมินประสิทธิผลของการเสริมเออร์โกแคลซิเฟอรอล (วิตามินดี₂) ในบุคลากรโรงพยาบาลวชิระภูเก็ต

วิธีการศึกษา ศึกษาสำรวจย้อนหลังแบบติดตามกลุ่มตัวอย่างในเจ้าหน้าที่โรงพยาบาลวชิระภูเก็ต จำนวน 66 คน ระหว่างเดือนมิถุนายน – พฤศจิกายน 2567 และติดตามผล 6 เดือน ระดับ 25(OH)D จำแนกเป็น ขาด (<20 ng/mL) ไม่เพียงพอ (20–29 ng/mL) และเพียงพอ (≥ 30 ng/mL) ผู้ที่มีระดับไม่เพียงพอหรือขาด ได้รับวิตามินดี₂ (20,000 IU) สัปดาห์ละ 1–2 แคปซูล

ผลการศึกษา ณ จุดเริ่มต้นของการศึกษา พบว่าผู้เข้าร่วมร้อยละ 94.0 มีภาวะวิตามินดีไม่เพียงพอหรือขาด โดยร้อยละ 57.6 อยู่ในกลุ่ม insufficient และร้อยละ 36.4 อยู่ในกลุ่ม deficient อายุ ≥ 40 ปี มีความสัมพันธ์กับระดับวิตามินดีที่ต่ำลงอย่างมีนัยสำคัญทางสถิติ ($p < 0.05$) ขณะที่ปัจจัยด้านประชากรและพฤติกรรมอื่นไม่พบความสัมพันธ์อย่างมีนัยสำคัญ หลังได้รับการเสริมวิตามินดี₂ เป็นเวลา 6 เดือน พบว่าระดับวิตามินดีมีการเปลี่ยนแปลงภายในบุคคลอย่างมีนัยสำคัญทางสถิติ ($p < 0.01$) โดยผู้ที่มีภาวะ deficient ตั้งแต่เริ่มต้นมีระดับวิตามินดีสูงขึ้นร้อยละ 45.8 (ร้อยละ 41.7 เปลี่ยนเป็น insufficient และร้อยละ 4.1 เปลี่ยนเป็น sufficient) ขณะที่ร้อยละ 54.2 ยังคงอยู่ในกลุ่ม deficient

สรุป ภาวะวิตามินดีไม่เพียงพอในบุคลากรโรงพยาบาลมีความชุกสูง โดยอายุตั้งแต่ 40 ปีขึ้นไปเป็นปัจจัยที่สัมพันธ์กับระดับวิตามินดีต่ำ ผลการศึกษานำร่องชี้ว่าการเสริมวิตามินดี₂ (Ergocalciferol) ขนาด 20,000–40,000 IU ต่อสัปดาห์อาจยังไม่เพียงพอในการเพิ่มระดับวิตามินดี จึงควรมีการศึกษาเพิ่มเติมเพื่อกำหนดแนวทางการเสริมวิตามินดีที่เหมาะสมต่อไป

คำสำคัญ วิตามินดี, เจ้าหน้าที่โรงพยาบาล, การถูกแดด, เสริมวิตามินดี

Introduction

Vitamin D is a pleiotropic secosteroid hormone that exerts widespread biological effects well beyond its classical role in calcium homeostasis and bone metabolism. Upon activation into its hormonal form, 1,25-dihydroxyvitamin D [1,25(OH)₂D], it binds to the vitamin D receptor, which is expressed in almost all human tissues and immune cells. In the musculoskeletal system, vitamin D is paramount for maintaining bone mineral density and optimizing muscle contractility, thereby preventing sarcopenia and frailty (Płudowski, 2023). Beyond bone health, it plays a critical role in the cardiovascular system by modulating the renin-angiotensin-aldosterone system (RAAS), regulating blood pressure, and inhibiting vascular calcification. Furthermore, within metabolic homeostasis, vitamin D influences pancreatic beta-cell function and insulin sensitivity, establishing its significance in cardiometabolic health and the prevention of metabolic syndromes (Sangkaew et al., 2018). At the cellular and molecular levels, vitamin D acts as a potent immunomodulator that bridges innate and adaptive immunity. It enhances the antimicrobial activity of macrophages and monocytes while simultaneously suppressing overactive adaptive immune responses, thereby reducing the risk of respiratory tract infections and autoimmune diseases (Martineau et al., 2017). Additionally, vitamin D possesses substantial antineoplastic properties, regulating cell proliferation, differentiation, and apoptosis across various epithelial tissues. Emerging evidence also highlights its neuroprotective role; vitamin D influences neurotrophin production, neuromodulator synthesis, and antioxidant pathways within the central nervous system, which are essential for maintaining cognitive function and mitigating occupational fatigue (Anjum et al., 2018; Nowak et al., 2016). Given its multifaceted bioactivity, maintaining optimal serum vitamin D levels is critical for systemic resilience, making its deficiency a profound public health concern even in sun-abundant, tropical environments. The biosynthesis of vitamin D is a multi-step process initiated in the skin, where solar ultraviolet B (UVB) radiation (wavelengths 290–315 nm) photolyzes 7-dehydrocholesterol into previtamin D₃, which then undergoes thermal isomerization to become vitamin D₃ (cholecalciferol). Once synthesized or ingested via diet, vitamin D is biologically inert and requires two successive hydroxylations to achieve metabolic activation. The first step occurs predominantly in the liver, where the enzyme 25-hydroxylase (CYP2R1) converts vitamin D into 25-hydroxyvitamin D [25(OH)D], the major circulating form used clinically to determine overall vitamin D status. Subsequently, 25(OH)D is

transported via vitamin D-binding protein (DBP) to the kidneys, where the enzyme 1 α -hydroxylase (CYP27B1) performs the final, tightly regulated hydroxylation into 1,25-dihydroxyvitamin D [1,25(OH)₂D], the biologically active hormone. Notably, this metabolic pathway is heavily influenced by non-modifiable and modifiable factors, including advancing age which significantly depletes cutaneous 7-dehydrocholesterol concentrations and adiposity, which traps the lipophilic vitamin D molecule within adipose tissues, thereby compromising its systemic bioavailability and therapeutic repletion. Globally, serum 25(OH)D concentrations are governed by a complex interplay of these non-modifiable and modifiable risk factors. Age remains a primary non-modifiable determinant, as senescence compromises both cutaneous precursor efficiency and renal enzyme activity. Biological sex introduces variations often linked to hormonal profiles, where estrogen fluctuations during menopause can alter DBP kinetics and accelerate bone resorption. Furthermore, race and ethnicity heavily dictate synthesis efficiency; individuals with higher melanin concentrations require prolonged UV exposure to achieve equivalent vitamin D yields compared to fairer-skinned populations. Beyond these intrinsic traits, lifestyle and environmental variables act as major modifiable barriers. Inadequate sun exposure, driven by shift work and urbanization, sharply curtails natural production. This issue worsens because most natural foods contain very little vitamin D. Finally, underlying health conditions, such as malabsorption syndromes, liver disease, or progressive metabolic disorders, further destabilize the bioavailability and systemic equilibrium of the hormone. Epidemiological literature demonstrates that the prevalence of vitamin D inadequacy varies dramatically across these risk categories, reflecting distinct occupational and physiological baseline vulnerabilities. In terms of age, clinical registries consistently report that older populations (>65 years) exhibit deficiency rates exceeding 60–70% in many regions, though modern data show an alarming rise in younger indoor working cohorts as well. Regarding sex and hormonal profiles, postmenopausal women and individuals with metabolic syndrome experience a disproportionately high burden of deficiency, often clustering above 50% in cross-sectional surveys. In Southeast Asian nations, despite abundant ambient UV radiation, the prevalence of deficiency among indoor workers ranges from 40% to over 80%, demonstrating how occupational shade overrides geographic location (Divakar et al., 2019). Populations with prominent sun-avoidance behaviors, such as regular application of high-SPF

sunscreens or extended indoor hours, demonstrate nearly universal inadequacy in specific medical cohorts, sometimes reaching 100% (Rajatanavin et al., 2019).

This global phenomenon is closely mirrored in Thailand, where national data indicate an alarming prevalence of inadequacy, with insufficiency at 45.2% and deficiency at 5.7% (Chailurkit et al., 2011). While general population trends are well-documented (Siwamogsatham et al., 2014), hospital personnel represent a uniquely vulnerable cohort whose occupational demands create a compelling geographical paradox, particularly at Vachira Phuket Hospital. Phuket is globally renowned as a sun-drenched tropical island with high ambient UV radiation year-round, which theoretically should provide a natural safeguard against deficiency. However, the rigor of healthcare service often confines professionals to climate-controlled, indoor environments for extended periods. This discrepancy, where external environmental abundance fails to translate into internal biological sufficiency, underscores a critical occupational health gap and challenges the assumption that tropical residency confers innate protection against depletion. Furthermore, vitamin D deficiency in healthcare workers extends beyond biochemical markers to significant clinical and professional implications. Inadequate vitamin D status is increasingly linked to impaired innate immunity and chronic fatigue, conditions that directly jeopardize the performance and resilience of medical staff (Martineau et al., 2017; Nowak et al., 2016). In the high-stakes hospital environment, suboptimal immune function may increase susceptibility to healthcare-associated infections, while chronic fatigue can compromise cognitive precision and physical stamina during demanding clinical shifts (Anjum et al., 2018; Sowah et al., 2017). Addressing these risks is therefore paramount not only for individual health but also for maintaining the integrity of the healthcare system. While previous Thai studies have reported varying degrees of inadequacy among nurses (Hattapornsawan et al., 2011), office workers (Chaiyodsilp et al., 2015), and orthopedic surgeons (Phruetthiphat et al., 2021), there remains a paucity of longitudinal data evaluating the real-world efficacy of standard supplementation protocols in a sun-rich pilot setting. Consequently, this study aims to assess the prevalence of vitamin D inadequacy among personnel at Vachira Phuket Hospital, identify key determinants of vitamin D status, and evaluate the therapeutic response to the current hospital-based Ergocalciferol (Vitamin D2) protocol within this distinct professional cohort.

Objective

Primary Objective:

To preliminarily assess the status of vitamin D levels among hospital personnel at Vachira Phuket Hospital.

Secondary Objectives:

1. To explore demographic and behavioral factors associated with serum vitamin D levels to identify potential high-risk groups within the hospital setting.
2. To evaluate the response to current hospital practice of ergocalciferol (vitamin D₂) supplementation among those with vitamin D inadequacy.

Methods

Study Design

A pilot retrospective cohort study. Data were collected from medical records and physician-administered interviews conducted during a health screening and lifestyle modification program. COA number 00482025.

Setting

The study was conducted at Vachira Phuket Hospital, a tertiary care center in Phuket, Thailand. Baseline data were collected in June, with six months follow-up in November 2024. At both visits, participants received physician consultations as part of health promotion program.

Participants

Hospital staff who voluntarily enrolled in the hospital's health screening and lifestyle modification program were included. Eligibility required current employment at Vachira Phuket Hospital, voluntary participation, completion of both visits (baseline and follow-up), and available serum 25(OH)D results. All participants received routine care and counseling regardless of age, sex, or role. Because this was a retrospective study, information on medications that may influence vitamin D levels was not available.

Exclusion Criteria

To enhance internal validity and minimize confounding, specific exclusion criteria were applied. Electronic Medical Records (EMR) were reviewed to identify and exclude individuals with diagnosed malabsorption syndromes, primary hyperparathyroidism, or advanced chronic

kidney disease (Stage 4 or 5), as these conditions significantly alter vitamin D metabolism. Notably, while baseline serum levels were captured, information regarding pre-existing over-the-counter (OTC) vitamin D supplement use was not explicitly queried at enrollment; this factor is recognized as a study limitation regarding baseline dietary and supplemental intake.

Variables

The primary outcome was the prevalence of vitamin D inadequacy, defined by serum 25(OH)D levels classified as deficient (<20 ng/mL), insufficient (20–29 ng/mL), or sufficient (≥ 30 ng/mL).

Exposures and predictors included sun exposure habits, sunscreen use, and working hours. Potential confounders were age, sex, BMI, and baseline health status.

Intervention and Adherence Monitoring

Participants with vitamin D inadequacy were prescribed 20,000–40,000 IU of ergocalciferol weekly, following current institutional protocols. In this retrospective setting, treatment adherence was assessed through verbal self-reports during routine clinical follow-up. While objective measures such as pill counts were not available, attending physicians verified dosing consistency to ensure basic treatment compliance.

Data Sources and Measurement

Biochemical data were obtained from hospital records. Serum 25(OH)D was measured by Chemiluminescent Microparticle immunoassay (CMIA). Lifestyle and behavioral data were collected through structured physician interviews, with all assessments performed by the same physician.

Bias

Information bias reduced by standardized interviews and consistent lab protocols.

Study Size

A convenience sample of 66 staff members was included, exceeding the minimum threshold of 30 participants recommended for pilot exploratory research to estimate variance and effect sizes (Daniel & Cross, 2018; Johanson & Brooks, 2010).

Statistical Methods

Descriptive statistics summarized participant characteristics and vitamin D status. Associations between categorical variables were tested using chi-square analysis. Subgroup analyses by role, gender, and baseline vitamin D status were performed. Missing data were minimal and addressed by

list wise deletion. Since this was a convenience sample, no formal sampling strategy was applied. A sensitivity analysis reclassified borderline vitamin D values to test robustness.

Results

Vitamin D Status

At baseline, most participants had vitamin D insufficiency (57.6%) or deficiency (36.4%), while only 6% were sufficient. After receiving vitamin D₂ supplementation at 20,000–40,000 IU per week, serum 25(OH)D levels showed a statistically significant overall change at 6-month follow-up ($p < 0.01$).

Among those initially deficient ($n = 24$), 41.7% improved to insufficiency and 4.1% achieved sufficiency, while 54.2% remained deficient. Of the 38 participants who were initially insufficient, 44.7% deteriorated to deficiency and 2.6% reached sufficiency. All four participants who were sufficient at baseline maintained sufficient levels at follow-up. (Table 1).

Table 1. Vitamin D status of participants ($n = 66$)

Vitamin D status (n%)	First time (n%)	Follow-up at 6 months (n%)			Sig.
		Deficient	Insufficient	Sufficient	
Deficient	24 (36.4)	13 (54.2)	10 (41.7)	1 (4.1)	< 0.01
Insufficient	38 (57.6)	17 (44.7)	20 (52.6)	1 (2.6)	
Sufficient	4 (6.0)	0 (0.0)	0 (0.0)	4 (100.0)	

General Characteristics of the Participants

Most participants were female (84.8%) with a mean age of 46.7 years. Based on the Asian BMI classification, 4.5% were underweight, 37.9% normal, 18.2% overweight, and 39.4% obese. Over half had medium skin tone according to the cosmetic skin tone chart (56.1%). Nurses represented the largest occupational group (31.8%), followed by public health officers (18.2%). The majority reported working ≤ 50 hours per week (62.1%). Thailand Nursing Council's April 17, 2017 Announcement mandates a 40-hour work week as the international standard for nurse staffing to ensure patient safety. The policy provides guidelines for shift scheduling and

compensation for Registered Nurses, Licensed Practical Nurses, and Nursing Assistants under the Ministry of Public Health (MoPH). Citing MoPH directives (No. ST0202.3.7/ว 79), which stress the need to avoid work weeks exceeding 60 hours or consecutive 12-hour shifts over three days, a 50-hour work week was adopted for assessment in this research. Details are presented in Table 2.

Table 2. General Characteristics of the Participants (n = 66)

Characteristics	n	percent
Gender		
male	10	15.2
female	56	84.8
Age		
Mean ($\pm$ SD)	46.7 ($\pm$ 10.2)	Min =25, Max =65
Body mass index (BMI) WHO Asian BMI classification		
Underweight	3	4.5
Normal	25	37.9
Overweight	12	18.2
Obesity	26	39.4
Mean ($\pm$ SD)	24.80 ($\pm$ 4.55)	Min =17.27, Max =36.09
Skin tone		
medium skin tone	37	56.1
fair skin	23	34.8
dark skin tone	6	9.1
Occupation		
Nurse	21	31.8
Public health officers	12	18.2
Pharmacist	11	16.7
Doctor	9	13.6
Dentist	5	7.6
Supporting staff	5	7.6
Rehabilitation	3	4.5

Characteristics	n	percent
Working hours per week		
≤ 50 hours per week	41	62.1
> 50 hours per week	25	37.9

Sun Exposure Behaviors

The majority of participants reported ≤20 minutes of daily sun exposure (60.6%), mainly in the morning before 10:00 AM (74.2%). The leading barrier was an unfavorable work environment (56.1%). Regarding sun protection, 48.5% of participants applied sunscreen regularly, with 72.7% choosing a high-protection formula (SPF >30). It is noted that routinely applying high SPF sunscreen results in lower serum 25(OH)D concentrations compared with discretionary use (van der Mei et al., 2024). Hats or umbrellas were used occasionally by 53.0%. A history of osteoporosis or fractures was noted in 13.6%, while none had prior gastric or intestinal surgery. Details are shown in Table 3.

Table 3. Behaviors of participants and history of any diagnosed disease (n = 66)

Sun exposure behaviors	n	percent
Mean duration of daily sun exposure		
≤ 20 minutes (HealthLink BC, 2025)	40	60.6
> 20 minutes	26	39.4
Time of sun exposure		
Morning (before 10:00 AM) (n%)	49	74.2
Midday (10:00 AM – 3:00 PM) (n%)	14	21.2
Afternoon (after 3:00 PM) (n%)	25	37.9
No sun exposure (n%)	3	4.5
Reasons for limited sun exposure		
Lack of time to go outdoors (n%)	25	37.9
Work environment not conducive to sun exposure (n%)	37	56.1
Consistent sun protection (n%)	24	36.4
Frequency of sunscreen use during sun exposure		

Sun exposure behaviors	n	percent
Always (before sun exposure)	32	48.5
Sometimes (before sun exposure)	24	36.4
Rarely	10	15.2
SPF value of sunscreen used		
≤ 30	18	27.3
> 30	48	72.7

Table 3. Behaviors of participants and history of any diagnosed disease (n = 66) (continued)

Sun exposure behaviors	n	percent
Use of hat/umbrella use during sun exposure		
Always	8	12.1
Sometimes	35	53.0
Rarely	23	34.9
History of osteoporosis or bone fractures		
None	57	86.4
Yes	9	13.6
Had undergone gastric or intestinal surgery		
None	66	100

Association between Various Factors and Vitamin D Levels

Univariate analysis showed that age was significantly associated with vitamin D levels ($p < 0.05$) with the prevalence of insufficiency and deficiency being notably higher in participants aged 40 years and older compared with the younger cohort. No other demographic or behavioral factors demonstrated significant associations (Table 4). However, a notable clinical trend was observed regarding workload; participants with extreme working hours (>80 hours/week) showed a 100% prevalence of vitamin D inadequacy, suggesting that the clinical environment acts as a primary barrier to UV synthesis. Similarly, while not statistically significant, the prevalent use of high-SPF sunscreen (72.7%) aligns with documented risks of limited UVB-induced vitamin D production among healthcare staff (Tran et al., 2025).

Table 4. Demographic Factors and behaviors associated with Serum Vitamin D Levels (n=66)

Factors	Vitamin D level (n, %)			P-value
	Deficient (n=24)	Insufficient (n=38)	Sufficient (n=4)	
Gender				0.077
Male	1 (4.2)	9 (23.7)	0 (0.0)	
Female	23 (95.8)	29 (76.3)	4 (100.0)	
Age				0.021*
< 40	12 (50.0)	8 (21.1)	0 (0.0)	
≥ 40	12 (50.0)	30 (78.9)	4 (100.0)	
BMI				0.134
Underweight	0 (0.0)	3 (7.9)	0 (0.0)	
Normal	10 (41.7)	11 (38.9)	4 (100.0)	
Overweight	4 (16.6)	8 (21.1)	0 (0.0)	
Obese	10 (41.7)	16 (42.1)	0 (0.0)	
Skin tone				0.703
Fair	9 (37.5)	12 (31.6)	2 (50.0)	
Medium	14 (58.3)	21 (55.3)	2 (50.0)	
Dark	1 (4.2)	5 (13.1)	0 (0.0)	
History of osteoporosis or fracture				0.662
Yes	4 (16.7)	5 (13.2)	0 (0.0)	
No	20 (83.3)	33 (86.8)	4 (100.0)	
Working hours per week				0.800
≤ 50 hours/week	14 (58.3)	24 (63.2)	3 (75.0)	
> 50 hours/week	10 (41.7)	14 (36.8)	1 (25.0)	

* P-value <0.05

After receiving their vitamin D test results, some participants reported making lifestyle adjustments. Approximately 40.3% of participants increased their sun exposure and 43.5% modified their diet or consumed more vitamin D-rich foods and supplements (Table 5).

Table 5. Behavioral Changes after Receiving Vitamin D Test Results among Inadequacy Participants (n = 62)

Behavior modification	n	percent
Increased sun exposure		
No	37	59.7
Yes	25	40.3
Modified diet or intake of vitamin D-rich foods/supplements		
No	35	56.5
Yes	27	43.5

Discussion

The prevalence of vitamin D inadequacy among hospital staff in this study (94%) was markedly higher than in the general Thai population (insufficiency 45.2%, deficiency 5.7%). This mirrors findings in other medical cohorts, such as Thai dermatologists (100% inadequacy), highlighting a significant occupational risk driven by indoor-centric duties and sun-avoidance behaviors (Rajatanavin et al., 2019). Intriguingly, despite the uniform indoor environment shared by the cohort, age 40 years emerged as the sole variable significantly associated with lower vitamin D levels ($p < 0.05$). This can be explained through two primary physiological mechanisms of senescence. First, aging significantly depletes the cutaneous concentration of 7-dehydrocholesterol, sharply diminishing the skin's capacity to synthesize vitamin D from solar UVB radiation regardless of sun exposure duration. Second, advancing age is naturally accompanied by a decline in renal function, specifically a reduction in the activity of the enzyme 1α -hydroxylase within the kidneys. This enzymatic compromise hinders the final, critical step of converting circulating 25-hydroxyvitamin D [25(OH)D] into its biologically active hormonal form, 1,25-dihydroxyvitamin D [1,25(OH)₂D], thereby compounding baseline depletion in older personnel.

A critical finding was the deterioration of vitamin D status in 44.7% of the initially insufficient group, despite six months of continuous supplementation. This highlights that the current hospital practice, utilizing a low-dose regimen (20,000–40,000 IU/week) without an initial high-dose loading phase, is insufficient to meet the Thai Endocrine Society's recommendation of 40,000–60,000 IU per week for 8–12 weeks. Without this loading phase, individuals with significant baseline depletion may

never reach the therapeutic threshold within a standard window. The limited response is likely multifactorial. First, Vitamin D2 (Ergocalciferol) exhibits lower affinity for vitamin D-binding protein (DBP) and a shorter half-life than Vitamin D3, resulting in less stable serum elevations (Van den Heuvel et al., 2023). Adherence may also have played a role, as once- or twice-weekly dosing can be easily missed. In this regard, recent evidence suggests that higher-dose regimens administered less frequently (e.g., monthly) may offer better adherence and effectiveness in maintaining long-term levels compared to frequent low-dose therapy (Pludowski et al., 2023). Second, the high prevalence of obesity (39.4%) in our cohort likely hindered treatment success. According to the VITAL randomized clinical trial analysis by Tobias et al. (2023), higher body weight and BMI are significantly associated with a diminished response to vitamin D supplementation. This "sequestration effect," where vitamin D is trapped in adipose tissue, reduces its bioavailability and underscores the necessity for BMI-adjusted dosing protocols (Walsh et al., 2017). Third, molecular determinants—specifically Vitamin D Receptor (VDR) polymorphisms—prevalent in Thai populations may further contribute to a "non-responder" phenotype (Sangkaew et al., 2018; Usategui-Martín et al., 2022). Occupational factors, such as extended indoor hours and consistent high-SPF sunscreen use (72.7%), further compound these biological barriers. While the pilot nature of this study (n = 66) may limit the detection of subtle associations, the longitudinal paired measurements provide robust real-world insights. These findings offer actionable evidence to reform hospital wellness policies, moving toward Vitamin D3-based regimens, BMI-adjusted dosing, and mandatory high-dose loading strategies to effectively protect the health of medical personnel.

Conclusions

This study reveals a critical occupational health gap at Vachira Phuket Hospital, with over 90% of staff exhibiting vitamin D inadequacy, a rate significantly higher than the general Thai population. Age 40 years and older was the only factor significantly associated with lower vitamin D levels. Crucially, the current hospital-based repletion protocol utilizing oral Vitamin D2 (Ergocalciferol) at 20,000–40,000 IU/week for six months yielded suboptimal real-world efficacy, with 44.7% of initially insufficient individuals deteriorating into a deficient state. These findings underscore that a uniform, low-dose regimen without a mandatory high-dose loading phase fails to counteract systemic sequestration in a cohort with high obesity rates (39.4%) and universal sun-avoidance behaviors.

Recommendations

Based on the actionable evidence generated from this longitudinal study and aligned with established Thai clinical frameworks, the following strategic policy reforms are recommended for hospital wellness programs:

Implementation of a Stratified Loading Phase: Hospital personnel presenting with baseline vitamin D insufficiency or deficiency should not be placed immediately on a maintenance dose. Instead, they should undergo an aggressive loading phase of 40,000–60,000 IU per week for 8–12 weeks using Vitamin D2, or ideally Vitamin D3, as recommended by the Thai Endocrine Society to rapidly saturate tissue stores before stepping down to maintenance therapy.

Transition to Vitamin D3 Regimens: In alignment with extensive metabolic and clinical evidence from Thai cohorts, including the foundational work by Suntrapa et al. Vitamin D3 (Cholecalciferol) should be prioritized over Vitamin D2 for institutional repletion due to its superior bioavailability, stronger affinity for DBP, and prolonged half-life, which ensure more stable and sustained serum 25(OH)D elevations.

BMI-Adjusted and Age-Targeted Dosing: Future screening and therapeutic interventions must transition away from a "one-size-fits-all" approach. Given the high prevalence of obesity and the significant impact of advanced age identified in this cohort, dosing protocols must be personalized. Personnel with a BMI ≥ 25 kg/m² require a 2- to 3-fold higher loading dose to overcome adipocyte sequestration, while staff aged ≥ 40 years should be placed under active surveillance with routine bi-annual serum 25(OH)D monitoring.

Proactive Adherence and Absorption Surveillance: Institutional management should establish systematic screening for compliance barriers and actively investigate underlying gastrointestinal or molecular factors in individuals identified as clinical "non-responders."

Institutional Wellness Policies: Vachira Phuket Hospital should spearhead shift-work scheduling adjustments that permit safe, brief sun exposure during off-peak hours and introduce structured clinical adherence monitoring (such as digital reminders or monthly high-dose alternatives) to prevent missed weekly doses among high-fatigue medical staff.

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