JOURNAL OF NUTRITION RESEARCH

RESEARCH ARTICLE

Vitamin D Deficiency and Related Factors among Healthcare Professionals. A Cross-Sectional Study in a Tertiary Hospital

Yuanling Wu[1], Dan Zhang[2], Pingzhi Wang[3], Junyan Zhang[4], Xiaolei Liu[5], Ruonan Duan[6], Gaiyan Du[7], Fang Gao[7]*

1 Department of Clinical Laboratory, Shanxi Bethune Hospital, Shanxi Academy of Medical Sciences, Tongji Shanxi Hospital, Third Hospital of Shanxi Medical University, Taiyuan, China
2 Department of Personnel, Shanxi Bethune Hospital, Shanxi Academy of Medical Sciences, Tongji Shanxi Hospital, Third Hospital of Shanxi Medical University, Taiyuan, China
3 Department of Rehabilitation Medicine, Shanxi Bethune Hospital, Shanxi Academy of Medical Sciences, Tongji Shanxi Hospital, Third Hospital of Shanxi Medical University, Taiyuan, China
4 Department of Clinical Epidemiology and Evidence-based Medicine, Shanxi Bethune Hospital, Shanxi Academy of Medical Sciences, Tongji Shanxi Hospital, Third Hospital of Shanxi Medical University, Taiyuan, China
5 Department of Neurology, The First Affiliated Hospital of Kunming Medical University, Kunming, Yunnan, China
6 Department of Clinical Nutrition, Shanxi Bethune Hospital, Shanxi Academy of Medical Sciences, Tongji Shanxi Hospital, Third Hospital of Shanxi Medical University, Taiyuan, China
7 Department of Prevention Care in Healthcare, Shanxi Bethune Hospital, Shanxi Academy of Medical Sciences, Tongji Shanxi Hospital, Third Hospital of Shanxi Medical University, Taiyuan, China

OPEN ACCESS

Received: 17.07.2024
Accepted: 10.12-2024
Published: 30.12.2024

Citation: Wu Y, Zhang D, Wang P, Zhang J, Liu X, Duan R, Du G, Gao F. (2024). Vitamin D Deficiency and Related Factors among Healthcare Professionals. A Cross-Sectional Study in a Tertiary Hospital. Journal of Nutrition Research. 12(2): 98-109. https://doi.org/10.55289/jnutres/v12i2.22

* **Corresponding author**.

gaofang0623@126.com

Funding: Details given in sources of support

Competing Interests: None

Published By India Association for Parenteral and Enteral Nutrition (IAPEN)

ISSN
Electronic: 2348-1064

Abstract

Vitamin D deficiency is a global health issue, affecting various populations including healthcare professionals. Despite their awareness and access to health resources, healthcare professionals are not immune to this deficiency. This study aims to investigate the prevalence and associated factors of vitamin D deficiency among licensed physicians and nurses in a tertiary hospital in Taiyuan, Shanxi Province. A cross-sectional study was conducted from January to March 2022, involving 1944 healthcare professionals (608 licensed physicians and 1336 nurses) at Shanxi Bethune Hospital. Serum 25-hydroxyvitamin D [25-(OH)D] levels were measured using the enzyme-linked immunosorbent assay (ELISA). Participants' demographic data, body mass index (BMI), and job-related factors were collected and analyzed. Significant differences were observed in age, gender distribution, and BMI between licensed physicians (LPs) and nurses. LPs were generally older, had a higher BMI, and a higher prevalence of hypertension. The median vitamin D level was slightly higher in LPs (9.4 ng/mL) compared to nurses (8.7 ng/mL). However, both groups exhibited a high prevalence of vitamin D deficiency, with 78.12% of LPs and 85.63% of nurses affected. Univariable and multivariable logistic regression analyses identified several factors associated with vitamin D deficiency. Age over 30 years was associated with a lower likelihood of deficiency (OR=0.68, 95% CI 0.50-0.92, P=0.013). Nurses were more likely to be deficient compared to LPs (OR=1.26, 95% CI 1.10-1.44, P=0.001). Lower-than-normal uric acid (UA) levels were associated with an increased risk of deficiency (OR=1.51, P=0.034). Vitamin D deficiency is prevalent among healthcare professionals, with nurses being more affected than licensed physicians. Factors such as age, job type, and UA levels significantly contribute to this deficiency. It is essential to implement multi-level interventions including increased sunlight exposure, work environment improvements, and regular health check-ups to enhance the vitamin D status of healthcare professionals.

Keywords: Vitamin D deficiency; Healthcare professionals; Cross-sectional study; Tertiary hospital; Risk factors; Nurses; Licensed physicians

1 Introduction

In recent years, there has been an exponential increase in vitamin D testing, and low vitamin D status is becoming a very common phenomenon worldwide. It is reported that the prevalence of vitamin D deficiency is 37% in Canada [1], 40% in Europe [2], and 24% in the United States [3]. As a fat-soluble vitamin, vitamin D receptors are present in most tissues and cells in the body. Therefore, In addition to causing rickets in children and osteomalacia or osteoporosis in adults [4], long-term deficiency of vitamin D is also strongly associated with non-skeletal diseases such as cancer, autoimmune diseases, cardiovascular diseases, and mental illnesses [5]. Especially, vitamin D deficiency with 25(OH)D concentrations below 30 nmol/L (or 12 ng/mL) significantly increases the risk of excess mortality [6]. Therefore, it is crucial to take steps to prevent vitamin D deficiency.

Under such circumstances, understanding the factors related to vitamin D deficiency becomes particularly important. Vitamin D is synthesized in the skin from 7-dehydrocholesterol upon exposure to ultraviolet B (UVB) radiation. As long as there is sufficient sunlight exposure, skin synthesis of vitamin D can meet 80-100% of the daily requirement [7], so exposure to sunlight is very important. In the absence of sufficient UVB availability/exposure for skin synthesis, dietary provision of vitamin D is crucial for meeting population needs and preventing vitamin D deficiency [8]. Apart from that, sleep disorders and poor sleep quality are also related to it, low levels of vitamin D are associated with shorter sleep duration [9,10]. Of course, there are other factors such as skin color, obesity, environmental pollution and gene [11,12].

Although vitamin D deficiency is common, it is rarely reported in healthcare professionals. In recent years, only one review has briefly mentioned the vitamin D deficiency among healthcare workers [13]. Furthermore, reports from India indicate that healthcare professionals have a greater deficiency of vitamin D compared to the general population [14]. The prevalence of vitamin D insufficiency or deficiency is high among anesthesiologists in South Asian countries and dentists in Nigeria [15,16]. Additionally, studies have shown that hospital residents have a higher risk of lower vitamin D levels compared to community physicians [17]. 89% of nurses of childbearing age also lack vitamin D [18]. Our previous study reported that the prevalence of vitamin D deficiency is more than 80% among hospital staff, while body mass index (BMI), age, (UA), and type of job are associated with vitamin D deficiency [19]. Although licensed physicians (LPs) and nurses share similar working conditions, comparisons of the prevalence of vitamin D deficiency between these two types of healthcare professionals are rare.

Therefore, this study aims to compare the serum 25-(OH)D levels among them at Shanxi Bethune Hospital, a tertiary healthcare facility located in Taiyuan, the capital city of Shanxi province [19].

2 Methods and Materials

2.1 Study Design

This study is a cross-sectional study that collected physical examination data of healthcare professionals at Shanxi Bethune Hospital from January to March 2022. The primary aim of this study is to compare the vitamin D deficiency status between doctors and nurses. All personal privacy information was removed before analysis.

2.2 Participants

All on-duty healthcare professionals without malignant diseases during the physical examination.

The inclusion criteria for hospital staff physical examination records were enrolled.

- Age $\geq$ 23 and $\leq$60
- LPs or nurses of Shanxi Bethune Hospital

The exclusion criteria for hospital staff physical examination records were enrolled.

- Third-party dispatched personnel
- ID number missing
- Duplicated records
- Staff with malignant neoplasms
- Retired employees

2.3 Ethical Approval and Consent to Participate

This study was approved by the Institutional Ethical Review Board of Shanxi Bethune Hospital (No. YXLL-2023-185, YXLL-SL-2022-221), according to the ethical guidelines of the Helsinki Declaration. All hospital staff signed Informed consent for clinical data use. As all data utilized in this study were anonymized, the requirement for informed consent was therefore waived.

2.4 Measurement Standards

Due to the stable nature of serum 25-hydroxyvitamin D (25-(OH)D), it is used as a marker for vitamin D status. Although there is controversy over using these cut-off values to define vitamin D deficiency, most agree that vitamin D levels <20 ng/mL (50 nmol/L) are considered deficient, 21 - 29 ng/mL (52 - 72 nmol/L) are considered insufficient, and >30 ng/mL (75 nmol/L) are considered sufficient [20]. The IOM DRI committee in the United States suggested that people are at risk of deficiency at serum 25(OH)D concentrations <12 ng/mL (30 nmol/L).At the same time, studies have used the most conservative serum 25(OH)D threshold of <10/12 ng/mL (25/30 nmol/L) [8]. This study used the enzyme-linked immunosorbent assay (ELISA) to measure [25(OH)D]. The range provided in the reagent instructions is <12.3 ng/mL (30.75 nmol/L) [19].

Besides basic information such as height, weight, gender, age, and blood pressure, we also collect other laboratory indicators from participants, including thyroid-stimulating hormone (TSH), Free triiodothyronine (FT3), Free thyroxine (FT4), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), UA, cholesterol (CHO), triglycerides (TG), and glucose (Glu). In addition, there are job-related factors such as involvement in surgical procedures and exposure to radiation.

3 Results

Totally, 1944 participants, with 608 LPs and 1336 nurses were recruited in this analysis (Figure 1).

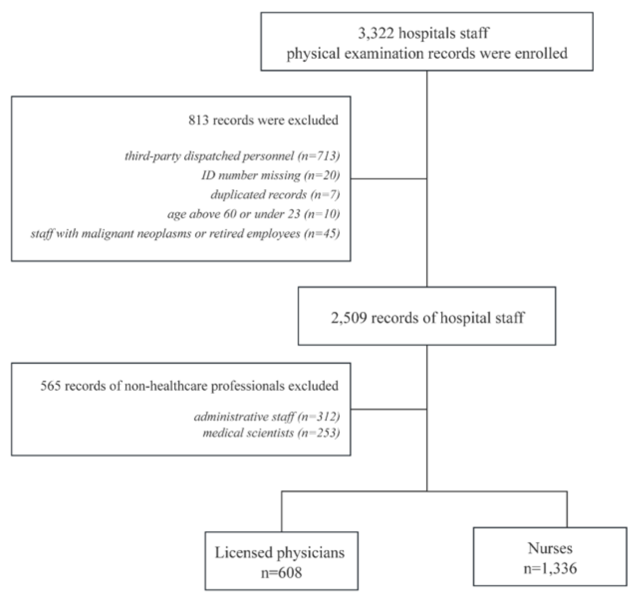

Fig 1. Flow Diagram

3.1 Demographic Information

The demographic informations of all participants are listed in Table 1. A significant disparity in sex is observed, with

39.14% of LPs being male compared to 6.59% among nurses (P<0.001). LPs tend to be older, with a mean age of 36.89 years, while nurses have a mean age of 33.33 years (P<0.001). The mean BMI is higher for LPs (23.97 kg/m^2) compared to nurses (22.64 kg/m^2) (P<0.001). A larger proportion of nurses fall within the normal BMI range (66.54%) compared to LPs (52.80%), whereas more LPs are classified as overweight or obese (44.74% vs. 29.27%) (P<0.001). The incidence of hypertension is greater among LPs (32.57%) compared to nurses (22.23%) (P<0.001). Additionally, nurses are more frequently involved in surgical-related work (48.73% vs. 41.45%) (P<0.001) but have less radiation exposure (3.44% vs. 19.74%) (P<0.001) compared to LPs.

3.2 Laboratory Testing Results

hows the laboratory testing results for health professionals. There are no significant differences in FT3 and FT4 levels between the groups, with both having a mean FT3 of 3.70pg/mL and FT4 of 0.86 ng/dL. However, the median TSH level is 2.24 μIU/mL for LPs and 2.38 μIU/mL for nurses which shows significant difference. (P=0.0165). LDL-C levels are higher in LPs (3.05 mmol/L) compared to nurses (2.81 mmol/L) (P<0.001), while HDL-C levels are lower in LPs (1.36 mmol/L) compared to nurses (1.41 mmol/L) (P<0.001). The median UA level is higher in LPs (291.9 μmol/L) than in nurses (255.5 μmol/L) (P<0.001). CHO levels are higher in LPs (4.75 mmol/L) compared to nurses (4.49 mmol/L) (P<0.001). Glc levels are also higher in LPs (4.99 mmol/L) compared to nurses (4.80 mmol/L) (P<0.001). TG levels are higher in LPs, with a median of 1.03 mmol/L compared to 0.82 mmol/L in nurses (P=0.0001). The median vitamin D level is slightly higher in LPs (9.4 ng/mL) compared to nurses (8.7 ng/mL) (P=0.0001), but both groups exhibit a high prevalence of vitamin D deficiency, with 78.12% of LPs and 85.63% of nurses affected (P<0.001) (Figure 2).

3.3 Primary Endpoint

Table 3 shows the results of logistic regression analysis of vitamin D deficiency.

3.4 Univariable Analysis Results

The univariable analysis identifies several factors associated with vitamin D deficiency among health professionals. Age over 30 years is linked to a lower likelihood of vitamin D deficiency (OR=0.61, 95% CI 0.45-0.82, P=0.001). Job category is also a significant factor, with nurses more likely to have vitamin D deficiency compared to LPs (OR=1.67, 95% CI 1.30-2.13, P<0.001). BMI within the normal range serves as the reference group, with underweight individuals (BMI <18) showing an OR of 1.97 (P=0.119) and overweight individuals (BMI >24) showing an OR of 0.72 (P=0.010). UA levels below the normal range are associated with an increased risk of vitamin D deficiency (OR=1.53, P=0.026), whereas UA levels above the normal range show a decreased risk (OR=0.53, P=0.009). CHO levels below (OR=0.68, P=0.221) and above (OR=0.72, P=0.025) the normal range are not significant. The other factors examined, TSH levels, FT3 levels, FT4 levels, LDL-C levels, TG levels, Glc levels, hypertension, engagement in surgery-related work, and radiation exposure did not exhibit a significant association with the prevalence of vitamin D deficiency.

3.5 Multivariable Analysis Results

The multivariable analysis further refines the associations between various factors and vitamin D deficiency. Age over 30 years continues to be associated with a lower likelihood of vitamin D deficiency (OR=0.68, 95% CI 0.50-0.92, P=0.013). Job category remains a significant factor, with nurses still more likely to have vitamin D deficiency compared to LPs (OR=1.26, 95% CI 1.10-1.44, P=0.001). UA levels below the normal range continue to show an increased risk of vitamin D deficiency (OR=1.51, P=0.034), while UA levels above the normal range show a decreased risk (OR=0.57, P=0.048).

The rest of other factors examined, including TSH levels, FT3 levels, FT4 levels, LDL-C levels, CHO levels, TG levels, BMI, Hypertension, engagement in surgical relevant work, and radiation exposure are also not significantly associated with vitamin D deficiency.

3.6 Sensitivity Analysis with IPTW Data Set

Table 4 presents the IPTW data set for health professionals, comparing LPs and nurses across various parameters and all the variables are well-balanced with SMD from 0.001 to 0.083, p-values from 0.152 to 0.983.

Table 5 compares the prevalence of vitamin D deficiency between LPs and nurses using the IPTW data set. The results indicate that vitamin D deficiency is prevalent in both groups but higher among nurses. Specifically, 78.02% of LPs are affected by vitamin D deficiency, compared to 83.41% of nurses (P=0.032). This statistically significant difference suggests that, even after adjusting for various confounding factors using IPTW, nurses are more likely to experience vitamin D deficiency compared to LPs.

Table 1. Demographic information of all health professionals

		Overall (n=1,944)	LP (n=608)	Nurse (n=1,336)	Statistics	P-value
Sex (male)		326 (16.77%)	238 (39.14%)	88 (6.59%)	χ^2=419.43	<0.001
Age	mean $\pm$ sd	34.44 $\pm$6.21	36.89 $\pm$6.03	33.33 $\pm$5.97	F=72.14	< 0.001
	median (q1-q3)	34 (30~38)	37 (32~41)	33 (29~36)		
	min-max	23~59	26~59	23~58		
BMI (kg/m^2)	mean $\pm$ sd	23.06 $\pm$3.36	23.97 $\pm$3.61	22.64 $\pm$3.16	F=31.04	< 0.001
	within normal range (18~24)	1210 (62.24%)	321 (52.80%)	889 (66.54%)	χ^2=58.19	<0.001
	Underweight (<18)	71 (3.65%)	15 (2.47%)	56 (4.19%)		
	overweight or obesity (>24)	663 (34.10%)	272 (44.74%)	391 (29.27%)		
Hypertension		495 (25.46%)	198 (32.57%)	297 (22.23%)	χ^2=50.94	<0.001
Surgical relevant work		903 (46.45%)	252 (41.45%)	651 (48.73%)	χ^2=381.22	< 0.001
Radiation exposure		166 (8.54%)	120 (19.74%)	46 (3.44%)	χ^2=204.88	< 0.001

LP: Licensed physicians; BMI: Body Mass Index, SBP: Systolic blood pressure, DBP: diastolic blood pressure

Table 2. Laboratory testing results for all health professionals

		Overall (n=1,944)	LP (n=608)	Nurse (n=1,336)	Statistics	P-value
TSH (μIU/mL)	median (q1-q3)	2.34 (1.64~3.25)	2.24 (1.61~3.10)	2.38 (1.67~3.35)	χ^2=10.253	0.0165
FT3 (pg/mL)	mean $\pm$ sd	3.70 $\pm$0.46	3.70 $\pm$0.40	3.70 $\pm$0.49	F=2.45	0.062
FT4 (ng/dL)	mean $\pm$ sd	0.86 $\pm$0.15	0.87 $\pm$0.13	0.86 $\pm$0.16	F=0.52	0.670
LDL-C (mmol/L)	mean $\pm$ sd	2.89 $\pm$0.65	3.05 $\pm$0.65	2.81 $\pm$0.64	F=31.73	< 0.001
HDL-C (mmol/L)	mean $\pm$ sd	1.39 $\pm$0.29	1.36 $\pm$0.30	1.41 $\pm$0.29	F=12.14	< 0.001
UA (μmol/L)	median (q1-q3)	265 (225.9~318.3)	291.9 (236.3~369.7)	255.5 (219.9~298.6)	F=76.40	< 0.001
CHO (mmol/L)	mean $\pm$ sd	4.57 $\pm$0.84	4.75 $\pm$0.82	4.49 $\pm$0.84	F=21.40	< 0.001
TG (mmol/L)	median (q1-q3)	0.87 (0.65~1.27)	1.03 (0.76~1.54)	0.82 (0.62~1.15)	χ^2=137.839	0.0001
Glc (mmol/L)	mean $\pm$ sd	4.86 $\pm$0.72	4.99 $\pm$0.88	4.80 $\pm$0.63	F=10.07	< 0.001
Vitamin D (ng/ml)	median (q1-q3)	8.9 (7.40~11.00)	9.4 (7.70~11.62)	8.7 (7.30~10.60)	χ^2=-5.89	0.0001
	min-max	6.50 - 43.70	6.50 - 40.00	6.50 - 43.70		
Vitamin D deficiency		1619 (83.28%)	475 (78.12%)	1144 (85.63%)	χ^2=34.43	<0.001

LP: Licensed physicians; TSH: thyroid stimulating hormone; FT3: free thyroxine 3; FT4: free thyroxine 4; LDL-C: low-density lipoprotein cholesterol, HDL-C: high-density lipoprotein cholesterol; UA, uric acid; CHO: cholesterol; TG: triacylglycerol; Glc: glucose.

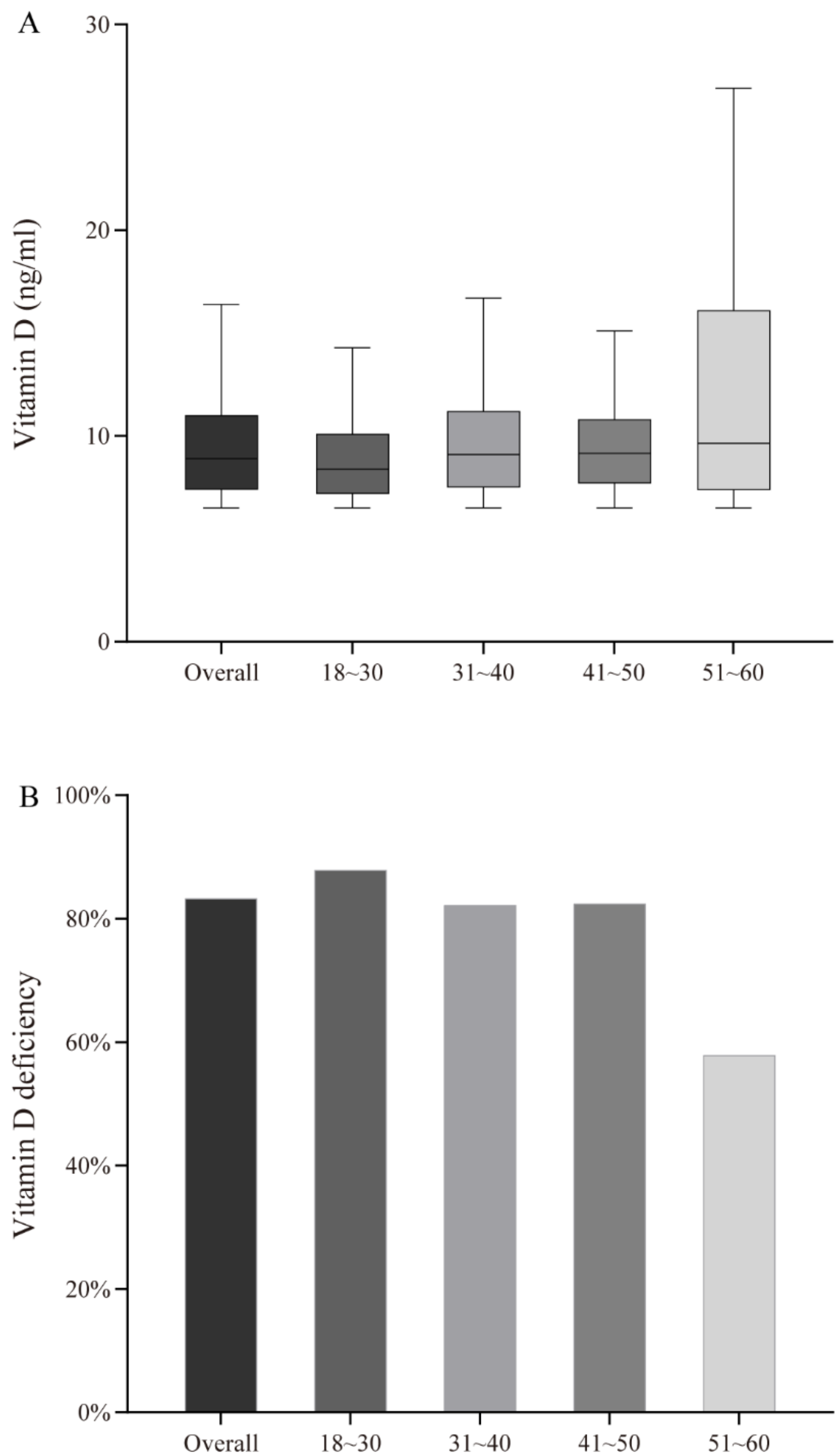

Fig 2. Vitamin D Levels and Deficiency Across Different Age Stratifications. A. The lines within the boxes represent the median levels of Vitamin D (ng/ml). The bottom and top edges of the boxes correspond to the 1st and 3rd quartiles, respectively. The whiskers (bottom and top lines) indicate the minimum and maximum levels. B. The prevalence of Vitamin D deficiency across different age stratifications

Table 3. Uni- and multivariable logistic regression for the vitamin D deficiency among all health professionals

			Univariable analysis		Multivariable analysis	
		Number (%)	OR (95%CI)	P-value	OR (95%CI)	P-value
Sex	female	1618 (83.23%)	1.27 (0.94, 1.72)	0.123	0.72 (0.49, 1.07)	0.101
Age	>30	1416 (72.84%)	0.61 (0.45, 0.82)	0.001	0.68 (0.50, 0.92)	0.013
Job category	LP	608 (31.28%)	1			
	Nurse	1336 (68.72%)	1.67 (1.30, 2.13)	<0.001	1.26 (1.10, 1.44)	0.001
TSH (μIU/mL)	within normal range (0.56-5.91)	1809 (93.06%)	1.0			
	subpar to normal range (≤0.56)	54 (2.78%)	0.63 (0.33, 1.19)	0.154		
	superior to normal range (≥5.91)	81 (4.17%)	1.27 (0.66, 2.43)	0.469		
FT3 (pg/mL)	within normal range (2.30-4.80)	1913 (98.41%)	1.0			
	superior to normal range (≥4.80)	31 (1.59%)	1.04 (0.40, 2.74)	0.929		
FT4 (ng/dL)	within normal range (0.59-1.25)	1897 (97.58%)	1			
	subpar to normal range (≤0.59)	32 (1.65%)	0.71 (0.30, 1.66)	0.430		
	superior to normal range (≥1.25)	15 (0.77%)	0.80 (0.22, 2.84)	0.726		
BMI (kg/m^2)	18-24	1210 (62.24%)	1			
	<18	71 (3.65%)	1.97 (0.84, 4.61)	0.119	1.62 (0.68, 3.83)	0.276
	>24	663 (34.10%)	0.72 (0.57, 0.93)	0.010	0.84 (0.64, 1.10)	0.213
Hypertension		495 (25.46%)	0.82 (0.63, 1.07)	0.153		
LDL-C (mmol/L)	within normal range (<3.37)	1531 (78.76%)	1			
	superior to normal range (≥3.37)	413 (21.24%)	0.76 (0.58, 1.01)	0.055	1.10 (0.68, 1.77)	0.705
HDL-C (mmol/L)	within normal range (1.03-1.55)	1249 (64.25%)	1			
	subpar to normal range (≤1.03)	164 (8.44%)	1.14 (0.72, 1.78)	0.578		

Continued on next page

Table 3 continued

	superior to normal range (≥1.55)	531 (27.31%)	1.03 (0.78, 1.35)	0.836		
UA (μmol/L)	within normal range (208-428)	1551 (79.78%)	1			
	subpar to normal range (≤208)	304 (15.64%)	1.53 (1.05, 2.22)	0.026	1.51 (1.03, 2.22)	0.034
	superior to normal range (≥428)	89 (4.58%)	0.53 (0.32, 0.85)	0.009	0.57 (0.33, 0.99)	0.048
CHO (mmol/L)	within normal range (3.25-5.2)	1484 (76.34%)	1			
	subpar to normal range (≤3.25)	66 (3.40%)	0.68 (0.37, 1.26)	0.221	0.61 (0.33, 1.13)	0.115
	superior to normal range (≥5.2)	394 (20.27%)	0.72 (0.55, 0.96)	0.025	0.80 (0.50, 1.28)	0.354
TG (mmol/L)	within normal range (≤1.7)	1680 (86.42%)	1			
	superior to normal range (1.7)	264 (13.58%)	1.07 (0.75, 1.53)	0.705		
Glc (mmol/L)	within normal range (3.9-6-1)	1875 (96.45%)	1			
	subpar to normal range (≤3.9)	28 (1.44%)	1.19 (0.41, 3.46)	0.745		
	superior to normal range (≥6.1)	41 (2.11%)	0.62 (0.30, 1.27)	0.190		
Surgical relevant work		903 (46.45%)	1.16 (0.91, 1.48)	0.225		
Radiation exposure		166 (8.54%)	0.79 (0.53, 1.18)	0.255		

LP: Licensed physicians; TSH: thyroid stimulating hormone; FT3: free thyroxine 3; FT4: free thyroxine 4; LDL-C: low-density lipoprotein cholesterol, HDL-C: high-density lipoprotein cholesterol; UA, uric acid; CHO: cholesterol; TG: triacylglycerol; Glc: glucose; OR: odds ratio; CI: confidence interval.

Table 4. IPTW data set for all health professionals

		LP (n = 1900.24)	Nurse (n = 1948.66)	P - value	SMD
Sex (male)		324.98 (17.10)	319.57 (16.40)	0.750	0.019
Age	mean ± sd	34.74 (5.60)	34.24 (6.43)	0.152	0.083
BMI (kg/m^2)	mean ± sd	23.16 (3.29)	22.95 (3.22)	0.249	0.065
Hypertension		466.31 (24.54)	471.14 (24.18)	0.888	0.008
Surgical relevant work		895.00 (47.10)	889.57 (45.65)	0.642	0.029
Radiation exposure		176.76 (9.30)	195.60 (10.04)	0.691	0.025
TSH (μIU/mL)	median (q1-q3)	2.32 (1.64, 3.19)	2.34 (1.60, 3.28)	0.745	0.083
FT3 (pg/mL)	mean ± sd	3.69 (0.40)	3.70 (0.46)	0.673	0.025
FT4 (ng/dL)	mean ± sd	0.86 (0.12)	0.86 (0.15)	0.96	0.003
LDL-C (mmol/L)	mean ± sd	2.90 (0.61)	2.88 (0.66)	0.533	0.038
HDL-C (mmol/L)	mean ± sd	1.40 (0.29)	1.40 (0.29)	0.983	0.001
UA (μmol/L)	median (q1-q3)	262.81 (217.35, 315.45)	265.31 (226.40, 313.96)	0.424	0.009
CHO (mmol/L)	mean ± sd	4.58 (0.79)	4.55 (0.85)	0.567	0.035
TG (mmol/L)	median (q1-q3)	0.87 (0.68, 1.26)	0.85 (0.64, 1.25)	0.265	0.025
Glc (mmol/L)	mean ± sd	4.84 (0.69)	4.84 (0.68)	0.934	0.005

LP: Licensed physicians; TSH: thyroid stimulating hormone; FT3: free thyroxine 3; FT4: free thyroxine 4; LDL-C: low-density lipoprotein cholesterol, HDL-C: high-density lipoprotein cholesterol; UA, uric acid; CHO: cholesterol; TG: triacylglycerol; Glc: glucose; OR: odds ratio; CI: confidence interval; IPTW, Inverse probability of treatment weighting; SMD: standard mean difference.

Table 5. Vitamin D deficiency for IPTW data set

		LP (n=1900.24)	Nurse (n=1948.66)	P-value
Vitamin D deficiency	n (%)	1482.53 (78.02)	1625.36 (83.41)	0.032

IPTW: Inverse probability of treatment weighting; LP: Licensed physicians

4 Discussion

Despite the widespread prevalence of vitamin D deficiency, certain groups such as healthcare professionals face a higher risk. In this study, factors related to vitamin D deficiency among them in a tertiary hospital were significantly associated with age, job type, and UA levels.

This study indicates that age is a factor associated with vitamin D deficiency in healthcare professionals. Individuals over 30 years old are less likely to develop this condition. A study conducted in the United States shows older age is a protective factor for vitamin D deficiency[21]. A study in South Korea shows that nurses in their 30s have higher vitamin D levels compared to nurses in their 20s[18]. This may be because young people prefer ordering food delivery[22]. Such as quick and convenient food choices, these foods lack natural sources of vitamin D such as fatty fish, egg yolks, and fortified dairy products[23]. Therefore, an unbalanced diet can significantly reduce the efficiency of vitamin D absorption, leading to lower vitamin D levels in the body[24].

This study shows that the prevalence of vitamin deviancy is higher among nurses than that of LPs. An important factor is significantly related to the work environment and nature of their jobs. Although both participate in shift work, nurses' rotating shifts are more common[25]. Nurses' work content is usually more intensive and varied, including 24-hour continuous bedside care, medication management, and emotional support for patients. In contrast, licensed physicians focus more on diagnosis and treatment and do not engage in 24-hour direct care, resulting in a lower frequency of shift work[26]. A study in Korea exploring environmental and occupational factors associated with vitamin D deficiency found that shift work was significantly related to vitamin D deficiency[27]. A systematic review by Luca Coppeta et al. also mentioned that shift workers have consistently been reported as the occupational group most likely to be deficient in vitamin D3[28]. Shift work including early mornings, partial nights, or overnight shifts, thus it can lead to significantly reduced outdoor activities and daytime sunlight exposure, affecting vitamin D synthesis[29]. Furthermore, the night shift conditions for licensed physicians differ from those for nurses. Licensed physicians on night duty in the wards can sleep, whereas nurses on duty cannot, resulting in different sleep conditions. Research shows that lack of sleep and disruption of circadian rhythms affect the secretion of various hormones in the body, including those that influence vitamin

D metabolism[30].

Based on our published study, nurses often experience shorter sleeping hours and longer working hours per day compared to LPs[31]. Nurses not only work long hours but also handle a large number of direct patient care tasks that demand high physical and mental investment[32]. Studies have shown that high stress and long working hours can lead to irregular eating, further reducing vitamin D intake and can easily result in a suboptimal health status[33,34].

This presented study also found that lower-than-normal UA levels were associated with an increased risk of vitamin D deficiency. Vitamin D is transported in the blood (bound to vitamin D-binding protein) to the liver, where it is hydroxylated to 25-hydroxyvitamin D (25-(OH)D), which is further converted to 1α,25-dihydroxyvitamin D (1α,25-(OH)2D)[35]. High uric acid inhibits 1 alpha-hydroxylase, leading to a decrease in 1,25-dihydroxyvitamin D (1,25(OH)2D), which in turn causes a relative increase in 25-(OH) D concentration[36–38]. Another possible reason is UA is a potent antioxidant, and higher UA levels can reduce oxidative stress, thereby reducing the consumption of vitamin D[39]. High uric acid levels are generally associated with the consumption of seafood and meat, which are also sources of dietary vitamin D[40,41].

In this cross-sectional study, we compared the vitamin D status of healthcare professionals during the same physical examination period, and it was indeed found that there is a high prevalence of vitamin D deficiency. Meanwhile, nurses are more likely to experience vitamin D deficiency due to various factors related to their work environment, job nature, and lifestyle. To improve the health status of nurses, it is recommended to adopt multi-level intervention measures, such as increasing sunlight exposure, improving the work environment, providing psychological support, enhancing health education, and conducting regular health check-ups. It is also recommended to strengthen monitoring of vitamin D deficiency and use reasonable supplementation measures to increase their vitamin D levels. This not only helps to improve the health of nurses but also enhances the overall quality of healthcare services.

Our study has several limitations. First, we do not know the frequency of night shifts for each individual before the physical examination, nor do we know their rest conditions during the night shifts. Additionally, we are not aware of each person's specific dietary habits or whether they took vitamin supplements before the examination. Hope further studies can be implemented to answer such questions.

5 Conclusion

Healthcare professionals generally lack vitamin D, and nurses are more deficient than licensed physicians.

Acknowledgment

We extend our gratitude to Cuiqin Liu and Jingfang He from Bothwin Clinical Study Consultants for their valuable assistance and dedication to data analysis.

Sources of Support

- Yunnan Science and Technology Leading Talents Project, Young and Middle-aged Academic and Technical Leaders Reserve Talents Project (No. 202405AC350046 to X.L.)
- Technology Innovation Team of Kunming Medical University (No. CXTD202104 to X.L.)
- Yunnan Clinical Research Center for Neurological Diseases (No. ZX20190305 to X.L.)
- Shanxi Provincial Science and Technology Department Basic Research Program Project (No.202203021212093 to R.D.)
- Research Start-up Fund Project for Talent Introduction at Shanxi Bethune Hospital (No. 2021RC031 to R.D.)

Author Contributions

Y.W. contributed to the conceptualization and writing original draft. D.Z. handled data curation and writing. P.W. was involved in data curation and investigation. J.Z. focused on formal analysis and methodology. X.L. contributed to funding acquisition and methodology. R.D. was responsible for funding acquisition, resources, and validation. G.D. was involved in data curation and investigation. F.G. was responsible for the conceptualization, project administration, and supervision. All authors reviewed and edited this manuscript.

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