

# Relationship between serum vitamin D<sub>3</sub> levels and mental health in shift nurses

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## Research Article

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# Abstract

**Purpose:** The nurses work long hours and in various shifts, and often accompanied by depression, fatigue and sleep disorders. Many studies have found that vitamin D is related to mental health. We aimed to investigate the relationship between depression, sleep problems, fatigue, and serum vitamin D<sub>3</sub> levels in shift nurses as a basis for improving their mental health.

**Methods:** We recruited 34 day-shift, 30 evening-shift and 31 night-shift nurses. The questionnaires used are: The Beck Depression Inventory II (BDI-II), Numerical Rating Scale and General Sleep Disturbance Scale.

**Results:** Approximately 96.1% of shift nurses had deficient (<20 ng/ml) and inadequate (20–29 ng/ml) vitamin D<sub>3</sub> levels. Approximately 84.2% of shift nurses experienced fatigue. Night-shift nurses experienced significantly more severe sleep disturbance than day-shift and evening-shift nurses. However, no significant correlation was observed between vitamin D<sub>3</sub> levels and mental health when the vitamin D<sub>3</sub> level was categorized.

**Conclusion:** Vitamin D<sub>3</sub> deficiency, sleep disturbance, depression, and fatigue were common in shift nurses, but it was not possible to demonstrate the impact of vitamin D<sub>3</sub> deficiency on the mental health of shift nurses. However, the relationship between serum vitamin D<sub>3</sub> levels and mental health in shift nurses could not be ignored.

## Introduction

Nurses working on a shift system usually experience the following three main problems: disturbance in the circadian rhythm, including the waking and sleep cycles; poor physical and mental health; and chaotic social and family life (1). Physiological clock problems often encountered by shift nurses are often the biggest factors affecting personal health. Many studies have long confirmed that working at night increases the risk of melatonin secretion disorder, which indirectly leads to breast cancer and rectal cancer (2–5). Akerstedt et al. pointed out that the health problems most frequently complained by shift workers are sleep disorders and unrecoverable fatigue (6), and 80.2% of nurses have poor sleep quality (7). The lack of adequate sleep is the main reason for leaving work; compared with other medical staff in the hospital, the turnover rate of nursing staff is about 15–40%. The high turnover rate of nursing staff in hospitals seriously affects the quality of care. The care of patients is uninterrupted for 24 hours; hence, most nursing staff must work in shifts. The effect of shift work on the physical and mental health of nursing staff cannot be ignored. Scott et al. found the prevalence of depression among shift nurses is 15%. Some studies have reported the depression prevalence rate as high as 23%, and this rate is continuously increasing. In addition, 47% of nursing staff continue to experience depressive symptoms even after a shift work (8), which is also the most common symptom among this population. Shift work easily leads to mental health problems. Hence, improving the mental health of shift workers should be taken into consideration.

Several studies have investigated the prevalence of sleep problems, stress, and fatigue related with the concentration of tumour necrosis factor alpha (TNF- $\alpha$ ), and interleukin 6 (IL-6) (9); however, these markers can only be used to determine the presence or absence of sleep problems among shift nurses, but not as indicators of improvement in sleep quality; therefore, it is necessary to find objective indicators of physiological changes to prevent and reduce the prevalence of mental health disorders.

Vitamin D<sub>3</sub> has gradually gained research attention in recent years. It is not only a vitamin but also a hormone that is associated with many diseases such as neurodegenerative diseases, cardiovascular diseases, chronic inflammatory diseases, cancer, diabetes, and autoimmunity. Some studies found that the vitamin D<sub>3</sub> receptor is present in many organs of the body (10). Vitamin D<sub>3</sub> binds to its receptors and regulates the cell cycle, thus affecting organ function. The level of vitamin D<sub>3</sub> was also negatively correlated with the incidence of colorectal and breast cancers (11). This evidence suggests that vitamin D<sub>3</sub> plays a protective role against various diseases. In other respects, many studies have pointed out that low vitamin D<sub>3</sub> levels increase the incidence of depression (12, 13), while higher vitamin D<sub>3</sub> levels can reduce the risk of depression (14). Previous studies conducted in older adults and young women indicated that the levels of vitamin D<sub>3</sub> can be used as an indicator of depression (15, 16). The lack of vitamin D<sub>3</sub>, which increases the inflammatory response, may be related to the occurrence of depression (17, 18). Some studies indicated that women with low levels of vitamin D<sub>3</sub> have higher serum IL-6 levels, and supplementation with vitamin D<sub>3</sub> can reduce the levels of inflammatory factors(19). This study aimed to explore the relationship between the levels of vitamin D<sub>3</sub> and depression in shift nurses, tendency to determine whether vitamin D<sub>3</sub> deficiency can be used as an indicator for predicting the risk of mental health disorder and to develop strategies for improving the physical and mental health of shift workers in the future.

## Methods

### Recruitment of participants

A total of 95 volunteer nurses working in Kuang-Tien General Hospital (Taichung County, Taiwan) in 2016 were recruited in the study. This study was approved by the Ethics in Human Research Committee (no. 10503), and all participants signed an informed consent prior to their inclusion in the study. Participants who had a history of alcohol abuse, smoking, pregnancy or lactation, supplement use in the previous month, chronic hepatitis B, chronic diseases such as diabetes mellitus, coronary heart disease, chronic respiratory inflammation, rheumatoid arthritis, systemic or local infection, liver cirrhosis or renal disease, and malignancy were excluded. A total of 95 volunteer nurses from the general ward, intensive care unit, and emergency room were included in the final analysis. These nurses have worked more than half a year and were assigned on a fixed shift (day, night, and evening shift) for more than 2 months. Of the 95 volunteer nurses, 34 were day-shift, 30 were evening-shift, and 31 were night-shift nurses. Each participant completed a questionnaire survey using a basic information questionnaire, Beck Depression

Inventory II (BDI-II) questionnaire, Numerical Rating Scale for Fatigue (NRS-F), and General Sleep Disturbance Scale (GSDS); blood samples were collected from each participant after a 3-day duty.

## Blood sample collection

Blood samples (20 mL) were collected under a fasting state. The serum was then separated from the cells by centrifugation, and the samples were stored at 80°C until analysis. The serum levels of aspartate aminotransferase (AST), alanine aminotransferase (ALT), high-sensitivity C-reactive protein (hs-CRP), total cholesterol, triglyceride, albumin, white blood cells (WBCs), lymphocytes, monocytes, neutrophils, eosinophils, basophils, total iron binding capacity (TIBC), red blood cells, platelets, hemoglobin, tumor necrosis factor alpha (TNF- $\alpha$ ), Interleukin (IL)-6, interferon gamma (IFN- $\gamma$ ), IL-8, and 25-hydroxyvitamin D (25(OH)D) were measured.

## Questionnaire

Four types of questionnaires were used in this study. The **basic information questionnaire** is used to collect more general information such as patient's name, height and weight, age, education level, marital status, work units, shifts (day, night, and graveyard shift), and the cumulative number of months in this shift. The **Beck Depression Inventory, second edition, (BDI-II)** is the Chinese version of the Beck Depression Inventory is translated from Beck Depression Inventory– second edition by Professor Huei-Chen Ko in 1978. The BDI-II scores is used to measure the severity of depressive symptoms: <10 points, normal; 10–18 points, mild depression; 19–29 points, moderate depression; 30–63 points, severe depression; and higher scores, more severe degree of depression. The **NRS-F** is a seven-item questionnaire, with each item rated from 0 (no fatigue) to 10 (very tired). This scale is used to rate the level of fatigue. Higher total scores and average scores indicate a more severe fatigue. An average score of 3.3 points or higher indicates a high level of fatigue (20). A previous Chinese study reported a Cronbach's  $\alpha$  reliability coefficient of 0.87–0.97. The **General Sleep Disturbance Scale (GSDS)** is a 15-item questionnaire used to rate the frequency of specific sleep problems in the last 7 days. Higher total and average scores indicate more sleep disorders (American Psychiatric Association, 1994). An average score of 3 or higher indicates clinically significant sleep disorder (20). The validity of the GSDS questionnaire was evaluated in 760 female shift nurses using the modified Stanford Sleep Questionnaire. The overall Cronbach's  $\alpha$  coefficient was 0.88.

## Determining inflammatory parameters

The serum levels of AST, ALT, hs-CRP, and uric acid were measured using an automated clinical chemistry analyzer (FUJI DRI-CHEM 4000i). The serum levels of ferritin, cortisol, IL-6, and TNF- $\alpha$  were measured using enzyme-linked immunosorbent assay (Biosense Laboratories, Norway). Ferritin levels were measured using a human ferritin enzyme immunoassay test kit (IBL-Hamburg kit, Germany) according to the manufacturer's instructions. The cortisol levels were measured using a human cortisol enzyme immunoassay kit (Cayman, USA).

## Statistical analysis

Statistical analysis was performed using the Chinese version of SPSS version 22 (IBM SPSS statistics). Continuous variables with a normal distribution were analysed using analysis of variance. Values were expressed as mean  $\pm$  standard deviation. For variables with non-normal distribution, the Kruskal–Wallis test was used. Categorical variables were analysed using a chi-square test. If the total number of fines in each of the fines less than five is more than 20%, the Fisher's exact test was used. Values were expressed as percentages (%). A P value of  $< 0.05$  was considered significant.

## Results

### Clinical characteristics

The characteristics and clinical data of shift nurses are shown in Tables 1 and 2. A total of 95 shift nurses were included in the study (day shift, 34; evening shift, 30; and night shift, 31). The day-shift nurses were significantly older than the evening-shift and night-shift nurses ( $P < 0.001$ ). In terms of marital status, the proportion of single participants assigned in the evening shift (90%) and night shift (90.4%) was significantly greater than that in the day shift (26.5%)(Tables 1). Meanwhile, a significant difference was observed in the WBC count between day-shift nurses and evening-shift nurses (Tables 2).

### Correlation between inflammatory data and 25(OH)D in shift nurses

After dividing the vitamin D<sub>3</sub> levels into  $< 20$  ng/ml ( $n = 46$ ),  $20\text{--}29$  ng/ml ( $n = 41$ ), and  $\geq 30$  ng/ml ( $n = 8$ ), no significant difference was observed in the levels of vitamin D<sub>3</sub> among the shift nurses from all three categories (Tables 3). No significant difference was also observed in the levels of inflammatory markers, including hs-CRP, IL-6, TNF- $\alpha$ , IL-8, and IFN- $\gamma$  (Table 4).

### Correlation between questionnaire scores and 25(OH)D

We used three types of questionnaires (Beck BDI-II, NRS-F, and GSDS) to obtain and analyze the data of all nurses. Night-shift nurses obtained higher total and average GSDS scores than evening-shift and day-shift nurses (Table 5). After dividing the vitamin D<sub>3</sub> levels into three groups, the scores of the three questionnaires were compared and results showed that each level of vitamin D<sub>3</sub> did not show a significant difference (Table 6). In a cross-tabulation analysis, the Beck BDI-II scores were categorized as mild, moderate, and severe depression; the NRS-F scores were categorized as absence or presence of fatigue; and GSDS scores were categorized as absence or presence of sleep disorder. None of the results showed a significant difference in each level of vitamin D<sub>3</sub>.

## Discussion

According to the 2005–2008 National Nutrition Survey conducted in Taiwan, the average 25 (OH)D concentration of 2,596 adults aged 19 years and older was 18.1. In this study, the vitamin D levels of the three groups of shift nurses were as follows:  $21.1 \pm 6.2$  ng/ml for day shifts,  $21.3 \pm 6.9$  ng/ml for evening

shifts, and  $20.1 \pm 4.7$  ng/ml for night shifts; these results were like those of the National Health Survey. In Iran, Thailand, and India, studies conducted in nursing staff showed that 89%, 95.4%, and 94% of nurses had vitamin D deficiency ( $< 30$  ng/ml) (21–23). These findings are consistent with those of the present study. In another study conducted in female nurses in Iran, the serum vitamin D levels in young nurses ( $< 50$  years) was lower than that in older nurses ( $> 50$  years) (24). The participants in this study were younger female nurses, and age possibly contributed to the lower vitamin D levels in this group.

The other study in China, the incidence of depression among nurses was 61.7%, and 74.9% of them had mild depression (25). Our results showed that all three groups of nurses had mild depression. This study found no significant differences in the vitamin D levels and depression incidence, although many studies have shown an inverse relationship between vitamin D and depression, probably due to the small sample size. However, results of previous studies are consistent with the findings of this study. In the 2005–2006 United States National Health and Nutrition Survey, the results did not show a significant correlation between vitamin D levels and mild depression, moderate-to-severe depression, and severe depression in American adults (26). The study conducted by Pan et al. also found that vitamin D level was not associated with depression incidence. They also pointed out that due to poor eating habits and lack of outdoor activities, the relationship between vitamin D and depression incidence could not be verified (27). This factor can also be used to explain the results of this study.

Our study results show that nurses experience a high degree of fatigue (average score:  $\geq 3.3$ ), but it is not related to level of vitamin D. Other research in Taiwan also pointed out that 37.1% of nurses experience fatigue (28). In our study, the nurses with a vitamin D level of  $\geq 30$  ng/ml had trend lower fatigue score than the other two groups, but the difference was not significant. The results of our study could be due to the small sample size. In a double-blind placebo-controlled clinical trial (29), 120 patients with fatigue and vitamin D deficiency (serum 25(OH)D  $< 20$   $\mu$ g/L) were recruited and randomly assigned to receive an oral dose of 100,000 units of vitamin D or placebo. After 4 weeks, the fatigue of patients with vitamin D deficiency who received vitamin D supplementation significantly improved. However, the frequency of sun exposure and physical activity in each study population were not taken into account.

A previous study (30) showed no difference in the degree of fatigue between night-shift and day-shift nurses; however, night-shift nurses had worse sleep quality than day-shift nurses, which is consistent with our study results; despite the presence of fatigue and sleep disturbance, the scores of nursing staff in the night shift were significantly higher than those in the evening shift and day shift, but the level of fatigue of the three groups of nurses did not show a significant difference. Another study has pointed out that young nursing staff with 1–2 years of experience are more likely to have a shift work disorder (31). This result is consistent with that of our study. When comparing the night-shift and day-shift nurses, results showed that night-shift nurses are 20 years younger and have higher incidence of sleep disorders than day-shift nurses. A previous study examined the relationship between the daytime sleepiness (assessed using the Epworth sleepiness scale) and vitamin D concentration in white and black patients. No significant correlation was observed between daytime sleepiness and vitamin D in the white group (32).

In our study, no significant difference was found between vitamin D levels and sleep disturbance after grouping the nurses according to vitamin D levels.

In our study, none of the inflammatory factors any significant differences. In other studies (33), only the concentration of TNF- $\alpha$  in shift nurses was significantly higher than that in day-shift nurses, while IL-6 and IFN- $\gamma$  were not significantly different. A possible reason is that the number of samples was too small, and the blood samples were not obtained at the end of night shift, which may have affected the results.

This study has several limitations. In the future, it may be possible to use objective testing methods, such as cortisol, to detect depression symptoms, and an exercise meter to record the quality of sleep. In addition, future studies should include participants of different ages and a larger sample size. Moreover, the number of samples with sufficient amounts of vitamin D ( $\geq 30$  ng/dl) was relatively small; hence, it was difficult to judge a significant difference in the results. In addition, further research is needed to examine the relationship between sunlight and production of vitamin D in the body, as well as explore other factors that can effectively improve the depression symptoms including eating habits and lifestyle.

## Conclusions

In this study, 95 nurses had insufficient level of vitamin D, and the incidence of depression was as high as 96.1%. In this study, we found that shift nurses had high mental disorders, however did not relate levels of vitamin D. In the future, a larger sample should be used to further objectively examine the level of depression, fatigue, and sleep disorders among shift nurses and explore their association with levels of vitamin D.

## Declarations

**Author Contributions:** The authors had full access to all the data from the study and take full responsibility for the integrity of the data and the accuracy of the data analysis.

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**Institutional Review Board Statement:** This study was approved by the Ethics in Human Research Committee (no. 10503).

**Conflicts of Interest:** We declare that we have no conflict of interest related to the publication of this manuscript.

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## Tables

Tables 1-6 are not available with this version.