

# Association Between Sunlight Exposure and Mental Health: Evidence from a Special Population Without Sunlight in Work

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**Purpose:** In recent years, mental health problems have become the most serious social problems worldwide. Past studies have proposed that some links exist between sunlight and mental health; however, relevant studies examining low-dose sunlight exposure populations are lacking. We conducted a study among a group of operating room nurses (ORNs) who work long hours in operating rooms and have limited sunlight exposure. We aim to add to and refine previous researches on the association between mental health and sunlight exposure in community population.

**Patients and Methods:** A total of 787 ORNs were interviewed and analyzed. Mental health, sunlight exposure duration, socio-demographic and work-related variables, and chronic diseases were evaluated. The Kessler 10 scale (K10) was used to assess participants' mental health status, and their sunlight exposure duration was assessed using their self-reports. Multiple linear regression analysis was adopted to examine the association between sunlight exposure and mental health.

**Results:** The average K10 score of ORNs was 25.41. ORNs exhibit poorer mental health than other populations. Poor mental health was negatively associated with greater sunlight exposure hours per day ( $\beta=-0.378$ ) and sleep regularity ( $\beta=-3.341$ ). Poor mental health was positively associated with chronic disease ( $\beta=3.514$ ).

**Conclusion:** This study indicated that the positive association between sunlight exposure and mental health existed. Appropriate enhancement of sunlight exposure will be beneficial to mental health. Hospitals, related organizations and individuals should pay greater attention to ORNs' mental health and sunlight exposure conditions. More policy recommendations as well as building structure recommendations should be proposed.

**Keywords:** sunlight exposure, mental health, operating room nurses, China

## Introduction

The World Health Organization (WHO) reinforces that there is no health without mental health.<sup>1</sup> Globally, nearly one billion people suffering from mental health problems.<sup>2</sup> Worryingly, the number of mental disorder cases increased by 48.1% from 1990 to 2019.<sup>3</sup> Depression and anxiety cases have increased by 25% from 2019 to 2022.<sup>4</sup> In addition, mental disorders was a leading cause of disability and can precipitate many negative outcomes, including distress, family breakdown, deterioration of chronic diseases and even suicide.<sup>5-10</sup>

Humans may not survive healthily without sunlight. Along with facilitating sterilization and energy supply, sunlight provided protection against a wide range of diseases—not only physical diseases but also mental disorders.<sup>11</sup> This had been supported by a number of studies conducted in people with mental disorders. A study demonstrated that long-term exposure to moderate levels of ultraviolet B can inhibit the development of depression in Taiwan, China.<sup>12</sup> Besides, light therapy is effective in treating seasonal affective disorder as well as non-seasonal depression.<sup>13,14</sup> Another study also found that mental illnesses patients living in rooms with better sunlight tend to have shorter hospital stays.<sup>15</sup> More sunlight exposure was beneficial, the lack of it was detrimental. The association between sunlight and schizophrenia was

also been proposed, it was that lack of sunlight exposure may increase the risk of hospital admission for people with schizophrenia.<sup>16</sup> In addition, some ecological studies using regional sunlight data put forward similar arguments. It was reported that people living in areas with longer and higher sunlight exposure levels exhibit fewer depressive symptoms<sup>17</sup> and were less likely to report suicidal thought<sup>18</sup> Additionally, seasonal increases in sunlight duration are associated with decreases in mental health distress.<sup>19</sup> Sunlight was also found to play a moderating role in the relationship between PM2.5 and depression.<sup>20</sup>

All these studies presented links between sunlight exposure and mental disorders. However, some inadequacies should be considered to get the conclusion about the associations between sunlight exposure and mental health.

Firstly, previous studies have focused on patients with mental disorders, such as depression,<sup>12</sup> schizophrenia<sup>16</sup> and have lacked exploration of the general community population. Secondly, many of these previous studies were ecological studies of the population and presented sunlight through objective meteorological data,<sup>12,17,21,22</sup> such as daytime sunshine hours and ultraviolet (UV) index. This neglected the characteristics of sunlight; regional sunlight data do not represent an individuals' actual receiving sunlight; rather, it is closely related to their living environment and habits. Hence, self-reported data are, indubitably, a preferable alternative. Thirdly, a study on submarine personnel<sup>23</sup> said that artificial light can also reduce depression levels. Almost all the past studies ignored the effect of artificial light, thus, eliminating the interference caused by different artificial light sources was needed in further study.

Actually, there were also some studies did not support the positive associations between sunlight exposure and mental health. For example, in a study of 13,938 Spanish university graduates, it reported that people living in areas with longer daylight hours had higher risk of depression.<sup>24</sup> Besides, in the Cooper Center Longitudinal Study from 2013 to 2019, tanning-bed use which brought longer exposure to the sun increased unhealthy psychological symptoms.<sup>25</sup> In addition to suggesting an inverse correlation, some studies also suggested that the relationship between the sunlight exposure and mental health cannot be proven clearly. Sunlight exposure and other meteorological factors were not associated with depressive symptoms in two community populations studies.<sup>26</sup> Similarly, a study in Finnish adults found the average amount of sunshine in a year was also not related to the total number of depressive symptoms.<sup>18</sup> The different findings reminded us further research is required to explore the association between sunlight exposure and mental health and new evidence in this regard would be highly meaningful.

To enrich evidences about the associations between sunlight exposure and mental health, operating room nurses (ORNs) were interviewed in this study. There were several reasons to select ORNs to explore the association. Firstly, ORNs was a very special population without sunlight exposure in work because no windows exist in operating rooms. For most of the time, they were exposed to artificial light that met the lighting requirements of the operating room. These artificial lights had a similar intensity, therefore, the study of the ORNs facilitated the exclusion of part of artificial light's interference and focused more on the effect sunlight. Secondly, ORNs worked in operating rooms for long time per day, even longer than surgeons; thus, focusing on their mental health status is necessary. Simultaneously, their working hours are predominantly during the day, thus their sunlight exposure out of work would be also short. Fewer previous studies had been conducted on populations who are continuously exposed to low levels of sunlight. Our study would add evidence to the lack. Thirdly, compared to the submarine workers<sup>23</sup> who also worked without exposure to sunlight, ORNs had normal social interaction and work characteristics, so ORNs were more representative. These characteristics made them become suitable candidates for studying the association between sunlight exposure and mental health.

To address the gaps in previous research, we conducted this study on ORNs in Shandong Province, China. We aimed to demonstrate the association between sunlight exposure and mental health. This study can contribute evidence to deeply explore the association mechanism prevalent in the real world and provide novel ideas for treating mental disorders.

## Materials and Methods

### Participants and Data Collection

This cross-sectional study was conducted in Shandong Province, China. Shandong Province is located on the eastern coast of China, between 34°-38°north latitude and 114°-122°east longitude, and belongs to the mid-latitude region. All participants were ORNs from several general hospitals, selected between December 2021 and January 2022.

A convenience sampling method was used; we completed the following steps: Firstly, we assessed the online questionnaires carefully and delivered them to nursing supervisors. Secondly, they forwarded the questionnaires to ORNs through WeChat groups, and the nurses filled these voluntarily. Finally, 787 eligible questionnaires were collected; the average response time for each questionnaire was approximately 29 minutes.

## Measures

### Mental Health

Mental health was measured using the Chinese version of the Kessler 10 (K10) scale.<sup>27</sup> This scale has been demonstrated to exhibit great reliability and validity in the Chinese population.<sup>28,29</sup> It is a 10 items self-report scale rated on a five-point Likert scale, ranging from “barely = 1” to “all the time = 5”. The final score is the sum of all item scores, with higher scores reflecting a worse mental health status. Prior studies have used the K10 scale to estimate mental health and psychological distress,<sup>30</sup> and to screen for depression and anxiety.<sup>31–33</sup>

### Sunlight Exposure Hours/Day

Sunlight exposure hours were evaluated using the question, “In the last three months, how many hours have you been exposed to sunlight each weekday?” The number of hours was responded to by ORNs. Herein, self-reported hours were analyzed as continuous variables.

### Social-Demographic Variables

The main socio-demographic variables were gender, age, height, weight, marital status, religious beliefs, and academic degree. Gender was coded as men (1) or women (0). Height and weight were calculated as body mass index (BMI) and were analyzed as continuous variables. The response alternatives to the questions regarding marital status were single, married, divorced, widowed, and others. Considering the small proportion of the latter three answers, single was recorded as never married (1), and married, divorced, widowed, and others were combined as ever married (2). Similarly, religious beliefs were coded as yes (1) or no (0). Academic degree was asked using one question regarding the highest degree, and the responses alternatives were doctors, master, bachelor, junior college, technical secondary school, and others. As most ORNs obtained a bachelor’s degree, we recorded it as a bachelor’s degree or above (1) and lower than a bachelor’s degree (2).

### Work-Related Variables

The work-related variables analyzed in this study included professional title, appointed way, working years in the department and operating room, working days per week, income per month, and job familiarity. Professional titles were coded as intermediate and above (1), and junior and below (2). The appointment method was recorded as an official in preparation (1) and another way (2). Working years in department and operating room were evaluated using the following questions: “How many years have you worked in this unit?” and “How many years have you been engaged in this major in this unit?” Additionally, ORNs’ monthly income was also asked and categorized into less than 5000 (1), 5001–10,000 (2), 10,001–15,000 (3), greater than 15,000 (4). Job familiarity was coded as extremely familiar (1), familiar (2) and general, or below (3).

### Chronic Disease

Chronic disease status was collected using ORNs’ self-report, and the question used was, “Do you suffer any chronic diseases?” The answers were binary variables coded as yes (1) or no (0).

## Statistical Methods

IBM SPSS Statistics 24.0 (web version) was used to analyze the data. Continuous variables are means and standard deviations and categorical variables are numbers and percentages. *t*-tests or one-way analysis of variance (ANOVA) were used to assess the mean differences for variables across mental health. Multiple linear regression analysis was performed to examine the relationship between these variables and mental health. All significance tests were two-tailed, and a *p*-value of <0.05 was considered statistically significant.

## Results

### Sample Characteristics and Single Analysis for the Factors Associated with Mental Health Among the ORNs in Shandong, China

In this study, we interviewed 787 ORNs in Shandong Province, China. The sample characteristics and single-factor analyses are presented in Table 1. The percentage of women was higher than that of men (80.6% vs 19.4%). The sample population's mean age was 33.87 (SD=7.07) and the mean BMI was 22.86 (SD=4.22). Overall, 159 participants (20.2%) reported that they were unmarried, and 634 (79.8%) were ever married. Most participants had a bachelor's degree or

**Table 1** Sample Characteristics and Single Analysis for the Factors Associated with Mental Health Among the Operating Room Nurses

Variable	n (%) / M $\pm$ SD	K10 (M $\pm$ SD)	t/F/r	P
Observations	787 (100)	25.41 $\pm$ 8.52	–	–
Sex			1.461	0.144
Men	153 (19.4)	26.31 $\pm$ 9.11		
Women	634 (80.6)	25.19 $\pm$ 8.37		
Age	33.87 $\pm$ 7.07	–	0.005	0.885
BMI	22.86 $\pm$ 4.22	–	–0.004	0.908
Marital status			–0.264	0.792
Never married	159 (20.2)	25.23 $\pm$ 9.83		
Ever married	628 (79.8)	25.46 $\pm$ 8.17		
Academic degree			0.797	0.426
Bachelor or above	737 (93.6)	25.47 $\pm$ 8.43		
Lower than bachelor	50 (6.4)	24.48 $\pm$ 9.85		
Religious beliefs			–1.080	0.281
No	766 (97.3)	25.46 $\pm$ 8.51		
Yes	21 (2.7)	23.43 $\pm$ 8.93		
Professional title			–0.453	0.651
Intermediate and above	400 (50.8)	25.28 $\pm$ 8.40		
Junior and below	387 (49.2)	25.55 $\pm$ 8.67		
Appointment method			–0.421	0.674
Official in preparation	211 (26.8)	25.20 $\pm$ 8.64		
Another way	576 (73.2)	25.49 $\pm$ 8.50		
Working years in department	11.36 $\pm$ 7.84	–	–0.003	0.931
Working years in Operating room	10.67 $\pm$ 7.70	–	0.006	0.867
Income/month			0.618	0.603
<5000	130 (16.5)	24.97 $\pm$ 10.48		
5001–10,000	380 (48.3)	25.69 $\pm$ 7.82		
10,001–15,000	172 (21.9)	24.84 $\pm$ 8.65		
>15,000	105 (13.3)	25.89 $\pm$ 8.12		
Working days/week	5.50 $\pm$ 0.65	–	0.050	0.161
Job familiarity			2.136	0.119
Extremely familiar	380 (48.3)	24.78 $\pm$ 8.60		
Familiar	345 (43.8)	26.09 $\pm$ 8.22		
General or below	62 (7.9)	25.45 $\pm$ 9.58		
Sleep regularity			–6.189	<0.001
Regular	380 (48.3)	23.51 $\pm$ 8.11		
Irregular	407 (51.7)	27.19 $\pm$ 8.54		
Chronic disease			5.383	<0.001
Yes	177 (22.5)	28.40 $\pm$ 8.67		
No	610 (77.5)	24.54 $\pm$ 8.29		
Sunlight exposure hours/day	–	–	–0.078	0.028

**Abbreviations:** M, mean; SD, standard deviation; K10, Kessler 10; BMI, body mass index.

**Table 2** Multiple Linear Regression Analysis for the Association Between Sunlight Exposure and Mental Health

Variables	$\beta$	95% CI	p
Men	0.838	-0.796, 2.472	0.314
Age	0.063	-0.156, 0.282	0.571
BMI	0.140	-0.010, 0.291	0.068
Ever married	-0.047	-1.858, 1.764	0.959
Academic degree (Ref.=Lower than bachelor)	-1.486	-4.009, 1.036	0.248
Religious beliefs	-2.054	-5.651, 1.543	0.263
Professional title (Ref.=Junior and below)	-0.087	-1.678, 1.505	0.915
Appointment way (Ref.=Other ways)	0.459	-0.883, 1.801	0.503
Working years in department	-0.121	-0.401, 0.159	0.395
Working years in operating room	0.082	-0.169, 0.333	0.519
Income/month (Ref.=5001–10,000)			
<5000	-0.415	-2.204, 1.374	0.649
10,001–15,000	-1.269	-2.789, 0.251	0.102
>15,000	-0.304	-2.180, 1.572	0.750
Working days/week	0.354	-0.570, 1.279	0.452
Job familiarity (Ref.=General and below)			
Familiar	0.041	-2.233, 2.314	0.972
Very familiar	-1.632	-3.958, 0.693	0.169
Sleep regularity	-3.341	-4.515, -2.168	<0.001
Chronic disease	3.514	2.087, 4.940	<0.001
Sunlight exposure hours/day	-0.378	-0.749, -0.007	0.046
Constant	21.906	12.275, 31.537	<0.001
Adjust $R^2$ =0.080			

**Abbreviations:** BMI, body mass index; CI, confidence interval; Ref., reference.

above and had no religious beliefs, with percentages of 93.6% and 97.3%, respectively. The mean K10 score of all sample ORNs populations was 25.41 (SD=8.52). The results revealed that sleep regularity ( $t=-6.189$ ,  $p<0.001$ ), chronic disease ( $t=5.383$ ,  $p<0.001$ ), and sunlight exposure hours per day ( $r=-0.078$ ,  $p=0.028$ ) were associated with mental health. Table 1 provides the detailed information.

## Multiple Linear Regression Analysis for the Association Between Sunlight Exposure Hours/Day and Mental Health

A multiple linear regression model was used to analyze the factors associated with mental health (Table 2). After controlling for work-related variables, the results revealed that poor mental health was negatively associated with more sunlight exposure hours per day ( $\beta=-0.378$ ,  $p=0.046$ ). Further, we found that poor mental health was positively associated with chronic disease ( $\beta=3.514$ ,  $p<0.001$ ) and negatively related to sleep regularity ( $\beta=-3.341$ ,  $p<0.001$ ). The multiple linear regression model that we constructed was effective (adjusted  $R^2=0.080$ ,  $p<0.001$ ).

## Discussion

We surveyed ORNs and obtained the following critical findings. First, the mean K10 score of ORNs was 25.41(>25), suggesting that they had a relatively high level of psychological distress.<sup>29</sup> Second, we found that sleep regularity, chronic diseases, and sunlight exposure time were associated with mental health. Third, sunlight exposure time still exhibited a positive correlation with mental health after adjusting for the multiple linear regression model; that is, as the sunlight exposure time increased, the mental health status improved.

Results regarding ORNs' mental health status were not optimistic. Of the 787 study subjects, 314 (39.9%) exhibited a score greater than or equal to 30 on the K10 scale—the fourth level of the scale's evaluation,<sup>29</sup> indicating a poor

psychological condition and a high risk of developing psychological disorders. The mean score was 25.41, which was significantly higher than that of the general population.<sup>34</sup>

Suffering from chronic diseases is associated with a higher risk of developing mental disorders. This finding is consistent with the results of previous studies. Patients with chronic diseases are more likely to be depressed and anxious than other people.<sup>35</sup> Physical pain increases patients' psychological stress; therefore, depressive symptoms increase with the diagnosis of chronic illness.<sup>36</sup>

High sleep regularity was associated with great mental health. This is consistent with the results of previous studies and popular perception. Sleep regularity is defined as the degree to which an individual exhibits a consistent sleep duration across days.<sup>37</sup> High sleep regularity helps keep the body and mind in great condition, and poor sleep regularity is associated with mental illness.<sup>38</sup> For example, insomnia symptoms' severity is related to the severity of symptoms of depression and anxiety.<sup>39</sup>

As the duration of sunlight exposure increased, survey respondents' mental health status improved. This discovery is enlightening for this low-dose sunlight exposure population; thus, exploring this improvement in mental health status is essential. From a physiological perspective, several explanations exist, the first of which is the role of vitamin D. Multiple cross-sectional studies,<sup>40,41</sup> longitudinal studies,<sup>42</sup> and meta-analyses<sup>43,44</sup> have demonstrated that vitamin D deficiency is associated with an increased risk of depression, and vitamin D supplementation may be beneficial in treating patients with depression.<sup>45</sup> Sunlight exposure has been—and will continue—being the primary source of vitamin D for most people.<sup>46,47</sup> Thus, sunlight may affect mental health by affecting vitamin D levels in the body. It is also worth noting that our study was conducted in December to January, three months prior to which the solar UV intensity was at a low level and the UV levels would not be sufficient to meet the body's needs.<sup>48</sup> Then the sunlight exposure duration of our study became particularly important in the production of vitamin D. Second, serum cortisol levels are significantly positively correlated with mental health scale scores,<sup>49</sup> and light is the primary medium regulating the body's circadian cortisol rhythm.<sup>50</sup> Third, decreased sunlight exposure is usually accompanied by a decrease in physical activity,<sup>51</sup> which can cause neuroplasticity, inflammation, oxidative stress, and changes in the endocrine system.<sup>52</sup> These are closely related to the occurrence of mental disorders; thus, the association between sunlight and mental health has been established. This is a complex process, and more researches are needed to further demonstrate this process using more suitable approaches, such as personal monitoring.

Our study had some limitations. First, this was a cross-sectional study and the causal association between mental health and sunlight could not be verified. Whether increased sunlight exposure leads to improved mental health, or good mental health seeks more sunlight, or a combination of the two cannot be verified and requires further research. Second, sunlight exposure was measured using self-reported daily sunlight exposure duration, which fully considered individual characteristics; however, inevitably, recall bias may affect the results' accuracy. Third, this study's participants were all ORNs from Shandong; thus, they may not be representative of other regions. Finally, we cannot rule out the presence of other contributing factors, such as diet, medication, more work-related variables, though we adjusted for some confounding factors.

Despite these limitations, this study may help explore the association between sunlight exposure and mental health. This is consistent with the view held in most previous studies that mental health status improves with increased sunlight exposure time. This is a new study of low-level sunlight exposure population of great importance. Indubitably, further studies are needed to explore the causal inference, action mechanism, and most suitable duration and intensity between sunlight exposure and mental health. Additionally, the differences in various mental disorders should be considered.

## Implications

Mental disorders are usually underdiagnosed and untreated owing to stigma, the lack of effective treatments and inadequate mental health services.<sup>53</sup> Simultaneously, in the treatment of mental disorders, more than half of people stop taking their medication within 60 days of starting treatment.<sup>54</sup> Therefore, exploring an easy, convenient, and accessible way to improve mental health and relieving symptoms of mental disorders is particularly important.

Our research supports the role of sunlight in improving mental health; therefore, indubitably, our research will help provide an available method for the prevention and treatment of mental disorders, and also provide advice on the

construction of space structures in various workplaces, such as hospitals. For example, increasing the number of windows in the ward to improve sunlight status or adopting outdoor rehabilitation measures. In the future, we need to conduct further research along this direction and collaborate with more researchers to contribute to the mental health problems that plague people worldwide.

## Conclusion

ORNs exhibit poorer mental health than other populations, and those with chronic illnesses, as well as irregular sleep, have poorer mental health. In the low-level sunlight exposure group, nurses' mental health was better with longer sunlight exposure time. Therefore, more attention should be paid to the mental health of ORNs and strategies or policies should be adopted to protect the mental health of ORNs, and nurses themselves should pay attention to regular work and rest and obtain greater sunlight exposure.

## Abbreviations

ORNs, Operating room nurses; K10, The Kessler 10 Scale; WHO, World Health Organization; UV, Ultraviolet; BMI, body mass index; SD, Standard deviation; CI, Confidence interval; Ref., Reference.

## Ethics Approval and Consent to Participate

The study was approved by the institutional review board of Shandong University School of Public Health (LL20210101). Informed consent was obtained from all participants of the study. The guidelines outlined in the Declaration of Helsinki were followed of this study.

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## Disclosure

The authors report no conflicts of interest in this work.

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