

Relationship between sleep quality and blood pressure level in nurses performing shift work



Original article

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Abstract: **Objective:** The aim of the study was to evaluate the quality of sleep in nurses performing shift work in therapeutic and surgical departments and to establish possible relationships between level of blood pressure (BP) and quality of sleep.

Methods: A total of 20 nurses of the therapeutic departments and 20 nurses of the surgical departments were enrolled in the study. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI). BP was measured according to the standard protocol using the Korotkoff method; a sphygmomanometer was used for this twice with an interval of 2 min between 10:00 a.m. and 10:30 a.m. The average value for the 2 indicators was calculated. The diagnosis of essential arterial hypertension (AH) was established according to the recommendations of the European Association of Cardiology and the European Association of Hypertension (2018).

Results: The overall assessment of the sleep quality of the nurses involved in shift work indicates poor sleep quality; this was true in respondents of both the surgical and therapeutic profiles. However, it was observed that the quality of sleep was significantly lower in nurses of the therapeutic departments. Moreover, poor sleep quality was associated with AH, which was diagnosed in 65% of the nurses of the therapeutic departments and 45% of the nurses of the surgical departments, that is, in almost all of the subjects. Herewith, in the nurses of the therapeutic departments, the level of systolic BP exceeded that of the nurses of the surgical departments.

Conclusions: Poor sleep quality is a significant risk factor for AH development and is relevant to nurses performing shift work. Additional clinical studies should be conducted to better understand the mechanisms underlying such adverse cardiometabolic outcomes associated with sleep disorders in the health-sector shift workers.

Keywords: blood pressure • nurses • shift work • sleep quality • Pittsburgh Sleep Quality Index

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1. Introduction

Good sleep is essential to having good health.¹ According to the definition by the World Health Organization, sleep is a general physiological function that is the periodic, reversible, and selective physical and mental withdrawal directly from the environment, accompanied by characteristic physiological changes.² From the point of view of clinical medicine, healthy sleep is a multidimensional sleep–wake pattern, adapted to individual, social,

and environmental requirements, which contributes to physical and mental well-being and is characterized by a subjective sense of satisfaction, favorable timing, adequate duration, high efficiency, and sustained vigilance under waking time.¹

Disturbance of sleep and sleeplessness are distinctive features of somatic and mental disorders. Insufficient sleep can trigger a decrease in cognitive function

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and mental performance and may lead to psychiatric morbidity, physical fatigue, decreased levels of attention and concentration, increased risk of accidents, slow complex coordination, and a weakening of the cardiovascular autonomic response system.³ The greatest comorbidity of insomnia is observed with anxiety and depressive disorders, the interrelationship of which is defined as bidirectional and which can intensify the course of each other, as well as affect the results of treatment and the occurrence of relapse in the future.⁴ It should be noted that epidemiological studies have revealed significant correlations between sleep disorders and adverse metabolic consequences in adults (impaired glucose tolerance, insulin resistance, and dyslipidemia), increased risk of cardiometabolic diseases, and mortality.⁵

Shift work is an important category leading to sleep disorders. Night shift is unlike human nature and will cause various disorders in nighttime rhythm (biological clock or circadian rhythm) and other adverse health effects, including cardiovascular disorders, digestive disorders, reproductive system disorders, depressive–anxiety disorders, and decreasing efficacy.^{6–8} Notably, sleep disorders occur more frequently in shift workers than in nonshift workers.⁹ Moreover, there are data that years of shift work negatively affect work productivity, health, and overall quality of life.⁵ In the international classification of sleep disorders (International Classification of Sleep Disorders, Third Edition—ICSD3), disorders related to shift work can include excessive sleepiness or insomnia accompanied by a reduction in total sleep time. Such disorders are a consequence of a repetitive work schedule involving unusual sleep timings for workers during the previous 3 months.¹⁰

Health-sector employees are among the most affected by such health issues, with nursing professionals being one of the most vulnerable to sleep disorders.³ Roodbandi et al.¹¹ indicate that 83.2% of nurses are not satisfied with the quality of their sleep and 30.2% complain of excessive daytime sleepiness. Fatigue and sleepiness can reduce work productivity and increase the risk of medical errors.¹²

Therefore, the aim of the study was to evaluate the quality of sleep in nurses performing shift work in therapeutic and surgical departments and to establish possible relationships between the level of blood pressure (BP) and quality of sleep.

2. Methods

2.1. Research design

This study employed a correlational predictive design.

2.2. Setting and participants

In total, 40 nurses, undergoing ongoing training and retraining courses for junior medical and pharmaceutical specialists of the Department of Health Care of Zakarpattia Regional State Administration, took part in the study. Totally, 20 nurses of the therapeutic departments and 20 nurses of the surgical departments who do shift work were included in the study.

The characteristics of the respondents included in the study showed that the average age was 40.5 (34.5; 46.0) years, the duration of shift work was 12.0 (10.0; 15.0) years, the number of night shifts during the month was 7.0 (6.0; 7.0), which significantly did not differ between the groups of nurses of the therapeutic and surgical profiles. After analysis of the marital status, it was established that the number of married, divorced, and single women was almost the same among the nurses in the therapeutic and surgical departments.

The diagnosis of essential arterial hypertension (AH) was established according to the recommendations of the European Association of Cardiology and the European Association of Hypertension (2018 ESC/ESH Guidelines for the management of AH)¹³ and the unified clinical protocol of primary, emergency, and secondary (specialized) medical care for 'Arterial hypertension' (2012). Systolic (SBP) and diastolic blood pressures (DBP) (in mm Hg) were taken according to the standard protocol using the Korotkoff method, using a sphygmomanometer twice with an interval of 2 min between 10:00 a.m. and 10:30 a.m. The average value for the 2 indicators was calculated. The level of BP was classified according to the criteria of the European Association of Cardiology and the European Association of Hypertension: optimal—SBP <120 and DBP <80; normal—SBP: 120–129 and/or DBP: 80–84; high normal—SBP: 130–139 and/or DBP: 85–89; 1st degree hypertension—SBP: 140–159 and/or DBP: 90–99; 2nd degree hypertension—SBP: 160–179 and/or DBP: 100–109; 3rd degree hypertension—SBP ≥180 and/or DBP ≥110; isolated systolic hypertension—SBP ≥140 and DBP ≥90 mmHg.

2.3. Measurement and data collection

We used the Pittsburgh Sleep Quality Index (PSQI)¹⁴ to determine the sleep quality among nurses performing shift work in the therapeutic and surgical departments. The internal consistency of the scales of the 'Pittsburgh Sleep Quality Index (PSQI)' questionnaire was checked using the Cronbach's alpha (α) method.

If Cronbach's α coefficient values are:

- <0.5 , the questionnaire is unreliable;
- ≥ 0.5 , the quality of the questionnaire is poor;
- >0.6 , the questionnaire is average;
- >0.7 , the questionnaire is sufficiently good;
- >0.8 , the questionnaire is good; and
- >0.9 , the questionnaire is very good.

In our study, Cronbach's α coefficient for PSQI was $\alpha = 0.85$.

2.4. Data analysis

The quantitative characteristics, which were subject to the normal distribution of values (according to the obtained nomograms and Shapiro–Wilk and Lilliefors normality criteria), were presented as Mean $\pm$ standard deviation (SD). If the values did not conform to the normal distribution, the results were presented as median (*Me*) and interquartile range. The results were considered statistically significant at the probability level (P -value) < 0.05 .

The frequency characteristics of the studied indicators were described as an absolute value (*n*) and a percentage (%). To establish the influence of the factor on the investigated characteristic, frequency tables were used to determine the 2-sided Fisher's exact test. At the P -value < 0.05 , there is an influence of the factor on this feature.

2.5. Ethical consideration

Ethical principles of the 1975 (as revised in 2008) Helsinki Declaration of Human Rights were fully respected in

our study. The enrolled subjects participated in this study voluntarily; they completed and signed a written informed consent. The study protocol was approved by the Ethics Committee of the I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine.

3. Results

It was established that the SBP level was higher in the nurses of the therapeutic departments than it was in the nurses of the surgical departments ($P < 0.05$) (Table 1). At the same time, 65% of the nurses of the therapeutic departments and 45% of the nurses of the surgical departments were diagnosed with AH according to their BP level.

The distribution of BP levels by degrees showed that most respondents had AH of the 1st degree, which did not depend on the department profile (Figure 1).

At the same time, the grouping of BP levels as optimal + normal ($\chi^2 = 1.69$; $P = 0.430$), optimal + normal + high normal ($P = 0.341$ for Fisher's exact test [2-tailed]) and AH of various degrees did not show a potential difference within the same group and between the data of nurses from the therapeutic and surgical departments.

Indicator	Nurses of the therapeutic departments	Nurses of the surgical departments	<i>P</i> -value
SBP (mm Hg)	135.25 $\pm$ 12.08	127.75 $\pm$ 10.70	0.045*
DBP (mm Hg)	91.75 $\pm$ 9.07	86.00 $\pm$ 10.59	0.073

Note: *A statistically significant difference.

BP, blood pressure; DBP, diastolic blood pressures; SBP, Systolic blood pressures.

Table 1. BP levels in nurses performing shift work.

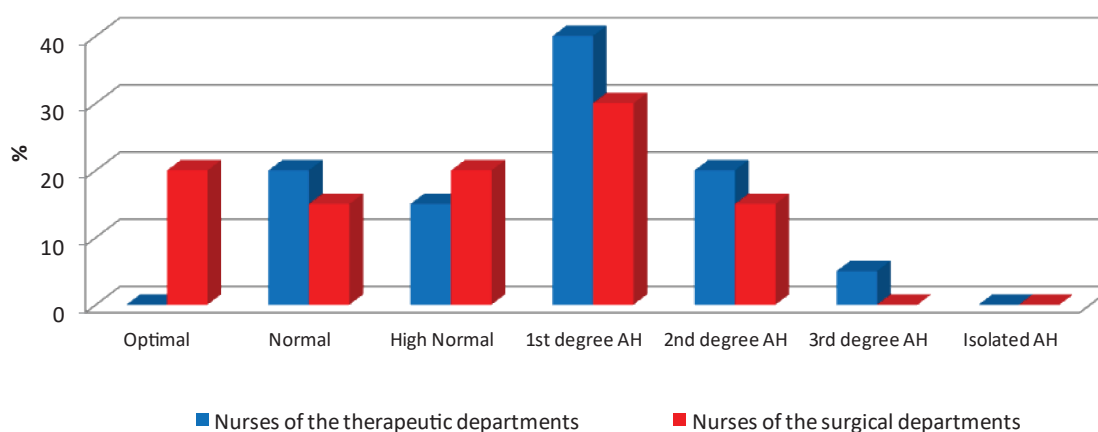


Figure 1. The BP levels of the respondents included in the study, according to the criteria of the European Association of Cardiology and the European Association of Hypertension (2018 ESC/ESH Guidelines for the management of AH), (%). Note: $\chi^2 = 5.71$; $P = 0.335$. AH, arterial hypertension; BP, blood pressure.

The overall assessment of the sleep quality among nurses who do shift work showed poor sleep quality in respondents of both the therapeutic (total score: 9 [5; 12] 9 [5; 12]) and surgical (total score: 6 [4; 7]) departments. In contrast, the sleep quality was probably lower in nurses from the therapeutic departments ($P = 0.047$). Respondents were divided into subgroups according to the PSQI Score indicator (Figure 2), and there was established the dependency of sleep quality on age. Thus, sleep quality was probably lower in older nurses from the therapeutic and surgical departments (Table 2).

During the analysis of the sleep quality among nurses, depending on the work schedule, it was found that the quality of their sleep is affected by the duration of shift work; in particular, poor sleep quality was diagnosed in nurses who worked significantly longer. At the same time, the frequency of night shifts during the month influenced the bad quality of sleep only among the nurses of the therapeutic departments (Table 3).

In general, it was established that bad sleep quality in nurses performing shift work was found in divorced respondents and those with children (Table 4).

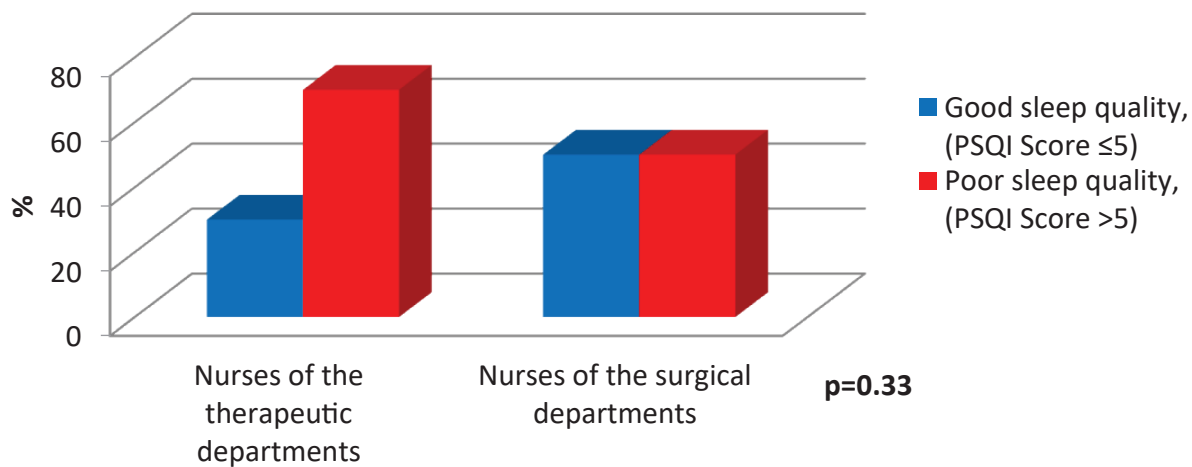


Figure 2. Percentage of nurses with good and bad sleep quality depending on the level of the PSQI Score. PSQI, Pittsburgh Sleep Quality Index.

Sleep quality	Nurses of the therapeutic departments ($n = 20$)	Nurses of the surgical departments ($n = 20$)	Total ($n = 40$)
Good	33.50 ± 3.51	33.50 ± 5.58	33.50 ± 4.77
Poor	46.14 ± 5.36	41.90 ± 4.07	44.38 ± 5.22
<i>P</i> -value	<0.001*	=0.001*	<0.001*

Note: *A statistically significant difference.

Table 2. Dependence of sleep quality on the age of nurses performing shift work.

Sleep quality	Nurses of the therapeutic departments ($n = 20$)	Nurses of the surgical departments ($n = 20$)	Total ($n = 40$)
<i>Duration of shift work</i>			
Good	10.50 ± 0.55	9.20 ± 1.69	9.69 ± 1.49
Poor	16.93 ± 3.58	14.00 ± 2.26	15.71 ± 3.38
<i>P</i> -value	<0.001*	<0.001*	<0.001*
<i>Frequency of night shifts during the month</i>			
Good	6.00 ± 0.00	6.80 ± 0.79	6.50 ± 0.73
Poor	7.14 ± 0.53	7.20 ± 0.63	7.17 ± 0.56
<i>P</i> -value	<0.001*	=0.227	=0.003*

Note: *A statistically significant difference.

Table 3. Dependence of sleep quality on the work schedule of nurses performing shift work.

The analysis showed the relationship between sleep quality and the level of BP in nurses performing shift work. Thus, almost all nurses in the therapeutic and

Characteristic	Sleep quality		χ^2 , <i>P</i> -value
	Good	Poor	
<i>Marital status</i>			$\chi^2 = 9.36$, <i>P</i> = 0.009*
Married	4 (33.33%)	8 (66.67%)	
Divorced	3 (18.75%)	13 (81.25%)	
Single	9 (75.00%)	3 (25.00%)	
<i>Number of children</i>			$\chi^2 = 15.03$, <i>P</i> < 0.001*
0	8 (100.00%)	0 (0%)	
1	4 (23.53%)	13 (76.47%)	
2	4 (26.67%)	11 (73.33%)	

Note: *Statistically significant difference.

Table 4. Dependence of sleep quality on respondents' marital status ($n = 40$).

BP level	Sleep quality		<i>P</i> -value
	Good	Poor	
<i>Total (n = 40)</i>			<0.001*
Optimal + normal + high normal	15 (83.33%)	3 (16.67%)	
AH	1 (4.55%)	21 (95.45%)	
<i>Nurses of the therapeutic departments (n = 20)</i>			=0.005*
Optimal + normal + high normal	6 (85.71%)	1 (14.29%)	
AH	0 (0%)	13 (100.00%)	
<i>Nurses of the surgical departments (n = 20)</i>			=0.006*
Optimal + normal + high normal	9 (81.82%)	2 (18.18%)	
AH	1 (11.11%)	8 (88.89%)	

Note: *Statistically significant difference.

AH, arterial hypertension; BP, blood pressure.

Table 5. Relationships between sleep quality and BP levels in nurses performing shift work.

Sleep quality	Nurses of the therapeutic departments ($n = 20$)	Nurses of the surgical departments ($n = 20$)	Total ($n = 40$)
<i>SBP</i>			
Good	121.67 $\pm$ 2.58	122.00 $\pm$ 1.11	121.88 $\pm$ 8.73
Poor	141.07 $\pm$ 9.44 [#]	133.50 $\pm$ 6.69	137.92 $\pm$ 6.08
<i>P</i> -value	<0.001*	<0.001*	=0.012*
<i>DBP</i>			
Good	81.67 $\pm$ 7.53	81.00 $\pm$ 1.08	81.25 $\pm$ 6.40
Poor	96.07 $\pm$ 5.61	91.00 $\pm$ 8.10	93.96 $\pm$ 7.07
<i>P</i> -value	<0.001*	<0.001*	=0.031*

Note: *A statistically significant difference.

[#]a statistically significant difference between nurses of therapeutic and surgical departments.

BP, blood pressure; DBP, diastolic blood pressures; SBP, systolic blood pressures.

Table 6. Dependence of BP level on sleep quality in nurses performing shift work.

surgical departments performing shiftwork and with diagnosed AH had poor sleep quality (Table 5).

At the same time, SBP and DBP were probably higher in nurses from both the departments and having poor sleep quality than in nurses having good sleep quality. It is important to note that the SBP level was higher in the nurses who performed shift work in the therapeutic departments and have poor sleep quality compared to the nurses from the surgical departments (Table 6).

4. Discussion

Good sleep is an essential component of a person's mental health, necessary for proper memory and attention, maintaining activity during the day, and even ensuring the functioning of the immune system. In an adult, the duration of one cycle of night sleep is about 1.5 h, during which a person goes through 4 successive stages of slow sleep, which are replaced by a phase of rapid sleep. A physiological 6–9-h sleep includes

4–6 cycles of night sleep. At the same time, with each 90-min cycle, the ratio of sleep phases shifts in favor of the rapid eye movement (REM) sleep phase.² Under the conditions of nurses' shift work, normal sleep is problematic to achieve: night shifts are accompanied by a forced transfer of sleep to daytime hours, a reduction in duration, and a decrease in quality.¹²

We utilized the PSQI, which showed a high level of internal consistency and high test–retest reliability, to determine the sleep quality among nurses who performed shift work in therapeutic and surgical departments.¹⁴ The PSQI total score of nurses' sleep quality indicates poor sleep in nurses from both departments; however, sleep quality was likely to be lower comparatively in nurses from the therapeutic departments. Age, marital status (divorced), and the presence of children were factors that had a negative impact on the quality of sleep of nurses from both the departments. A greater number of night shifts was an additional negative impact on nurses in the therapeutic departments. In total, 65% of the nurses in therapeutic departments and 45% of the nurses in surgical departments were diagnosed with AH, which correlated with poor sleep quality in almost all the respondents. In contrast, the nurses from therapeutic departments had higher levels of SBP vs. nurses from surgical departments.

The established relationship between AH and poor sleep quality in our study is consistent with the results of other researchers. Stadnik¹⁵ indicates that poor sleep quality is associated with a higher risk of hypertension development and an increase in SBP and DBP. In the study by Puttonen et al.¹⁶ it has been shown that the risk of AH development increases with a reduction in sleep time in middle-aged people. Robillard et al.¹⁷ observed that sleep disturbances led to increased SBP and DBP in normotensive patients. To conclude, lack of sleep alters the mechanisms of BP regulation and increases the risk of hypertension development in healthy individuals with normal BP. Lanfranchi et al.¹⁸ argued that patients with chronic insomnia had a higher SBP level during sleep. At the same time, they had a lower difference between SBP during wakefulness and sleep compared to healthy individuals without chronic insomnia by gender and age.

Regarding the mechanisms underlying cardiometabolic disorders, in particular AH, associated with sleep disorders, BP decreases by 10%–20% during sleep (dipper type of daily BP profile) and rises quickly enough upon awakening in a healthy person. Absence of night BP reduction is associated with an increased risk of coronary and cerebrovascular complications in hypertensive and normotensive patients.^{19–22} Many of the circadian genes are responsible for the circadian

rhythms of BP, which regulate BP throughout the day, partly through the connections of the suprachiasmatic nucleus of the hypothalamus with the sympathetic nervous system and the hypothalamic–pituitary–adrenal system. Since sleep is an important homeostatic function of the body, including an inhibitory effect on the stress and proinflammatory systems, insomnia and sleep deprivation are associated with the activation of the sympathetic nervous system and inflammatory processes.²³ Experimental sleep deprivation led to the appearance of a non-dipper type of BP diurnal profile and an increase in BP during the day.²⁴ On the other hand, the free radical flux theory of sleep states that free radicals accumulate during wakefulness and are removed during sleep. Thus, sleep essentially has an antioxidative role.²⁵ Excess free radicals and oxidants give rise to a phenomenon known as oxidative stress, which leads to structural damage due to oxidative modification of nucleic acids, protein, and lipids.^{26,27} Researchers showed that excessive production of reactive oxygen species (ROS) contributes to AH and that scavenging of ROS decreases BP.²⁸

As researchers continue to uncover the sleep-related determinants of cardiometabolic health, the essential role of working in shifts should not be overlooked. To date, no nationwide survey has been published in Ukraine on the overall assessment of the sleep quality among nurses performing shift work. Our results support considering inconsistent sleep patterns as a novel cardiovascular diseases (CVD) risk factor in health-sector shift workers and suggest the need to better understand the mechanisms underlying such cardiometabolic violations. Moreover, our results indicate the need to develop and implement a number of preventive measures to improve sleep quality in health-sector shift workers as a strategy for cardiovascular risk reduction.

5. Conclusions

The overall assessment of the sleep quality among nurses performing shift work indicates poor sleep quality in respondents of both surgical and therapeutic profiles. At the same time, the quality of sleep was significantly lower in nurses of the therapeutic departments. Moreover, poor sleep quality was associated with AH, which was diagnosed in 65% of the nurses of the therapeutic departments and 45% of the nurses of the surgical departments, and thus, in almost all the subjects. Herewith, in the nurses of the therapeutic departments, the levels of SBP exceeded the values in the nurses of the surgical departments. Therefore, poor sleep quality is a significant risk factor for AH

development in nurses performing shift work. Additional clinical studies should be conducted to better understand the mechanisms underlying such cardio-metabolic violations associated with sleep disorders in health-sector shift workers.

Implication and limitation

The current study has certain limitations. First, the research object only consisted of 40 nurses, and the results can only have a certain reference value. Second, because it is only a cross-sectional survey, the causal relationship between various influencing factors and shift work is difficult to explain.

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Authors contribution

Marushchak provided the conception and design of the study, revised the manuscript critically for important intellectual content and provided the final approval of the version to be submitted; K Kozak provided the statistical analysis of variables; A. Tsipkalo supplied the acquisition of data, drafted the manuscript; and supplied the design of the study and analysis and interpretation of the obtained results.

Ethical approval

The study protocol was approved by the Ethics Committee of the I. Horbachevsky Ternopil National Medical University, Ternopil, Ukraine.

Conflicts of interest

All contributing authors declare no conflicts of interest.

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