VOLUME 10 ISSUE 1 2024

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 10, No. 1, 29-35 (2024)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Effects of Sleep-Deprived Lifestyle on Cognitive Abilities of Healthcare Professionals Working in Shifts

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Received: 1st October, 2023; **Accepted:** 22nd November, 2023; **Published online:** 6th January, 2024

https://doi.org/10.33745/ijzi.2024.v10i01.004

Abstract: The objective of this study was to assess the impacts of sleep deprivation resulting from night shift employment on the general health and quality of life of nurses. A total of 58 healthcare professionals were recruited for this investigation. The Stanford Sleepiness Scale (SSS), Epworth Sleepiness Scale (ESS), Beck Depression Inventory (BDI) and Pittsburgh Sleep Quality Index (PSQI) questionnaires were completed by them. The Montreal Cognitive Assessment (MoCA), Vigilance test, and Stroop test were utilized to evaluate the impact of sleep deprivation on the subjects' cognitive performance, the Vigilance test, and the Stroop test. The individuals were divided into three groups: Severe sleep deprivation was defined as getting less than 4 h of sleep each night (SD); person was classified as mildly to moderately sleep deprived (MD) if they slept for 4-6 h per night, and as non-sleep deprived (NonD) if they slept for more than 6 h per night. Among shift-workers in the healthcare industry, 71% claimed they had trouble sleeping. The SD group exhibited a greater ESS than the MD and NonD groups. Compared to their daytime MocA score of 27.92, 67% of nurses' nighttime MocA score was 24.62. Over the course of the evening, 33% committed more math errors. It was discovered that 72%, 84%, and 67% of nurses performed worse on the nighttime Stroop's color, alertness, and memory tests. The cognitive impairment of shift-work nurses was therefore statistically significant. These findings demonstrated that medical professionals' well-being, productivity, and ability to handle stress may all suffer from sleep deprivation, which may have an effect on the caliber of treatment given to patients.

Keywords: Sleep deprivation, Stanford Sleepiness Scale, Epworth Sleepiness Scale, Beck Depression Inventory and Pittsburgh Sleep Quality Index, Vigilance test, Stroop test, Cognitive performance,Night shift

Citation: Deshmukh S.A. and Sisodia S.S.: Effects of sleep-deprived lifestyle on cognitive abilities of healthcare professionals working in shifts. Intern. J. Zool. Invest. 10(1): 29-35, 2024.

https://doi.org/10.33745/ijzi.2024.v10i01.004

Introduction

Many individuals are impacted by sleep loss, which is most commonly caused by modern lifestyle choices and work-related issues. Sleep is essential to human health and wellness. Numerous physiological and cognitive processes occur while we sleep (Curcio *et al*., 2006). A number of studies carried out in the last few years have shown how crucial sleep is for memory consolidation after learning. Recent epidemiological data show that, on average, one in three workers currently gets less than 6 h of sleep every night (Roth , 2005). Little is now understood about how lack of sleep impacts one's ability to think clearly and feel emotionally. With more and more people experiencing inadequate sleep research must progress in knowing how sleep deprivation impacts emotional and cognitive functioning (Hossain and Shapiro, 2002). Sleep is necessary for the formation of memories, according to recent research on human memory (Yoo *et al.*, 2007). Physicians, nurses, and community health workers are among the health professionals who make up the front line of the healthcare team. They often work lengthy shifts that exceed 12 h, which significantly disrupts their sleep. It is generally acknowledged that a performance declines with extended awake due to the interaction of a sleep-wake-dependent homeostatic mechanism and an internal circadian clock. The functionality of healthcare personnel is particularly affected by sleep deprivation. Furthermore, it lessens the effectiveness of maintenance tasks, both real and virtual, by raising their complexity and error percentages (Philibert, 2005). The degree to which sleep deprivation affects staff nurses' capacity to do their tasks as well as their mental and physical health.

The objective of this study was to assess the impacts of sleep deprivation resulting from night shift employment on the general health and quality of life of nurses.

Materials and Methods

The Dr. Zakir Hussain MNC Hospital staff nurses in Nashik, Maharashtra, India, who work shifts, participated in this study. Three groupings of subjects were formed: severely sleep deprived (SD) meant that they slept for less than 4 h each night; slightly to moderately deprived sleep (MD) meant that they slept for 4-6 h per night; and non-sleep deprived (NonD) meant that they slept for more than 6 h per night.

Inclusion criteria:

The inclusion criteria were as follows: staff nurses from all departments were included those who could work an 8 h shift every day without experiencing sleep issues and who had at least six months of experience working on a rotating shift schedule.

Exclusion Criteria:

Participants who satisfied any one of the subsequent requirements were excluded: having a family history of sleep issues, parasomnias, or a sleep problem such as sleep apnea.

The Stanford Sleepiness Scale (SSS) (Hoddes *et al*., 1989), the Epworth Sleepiness Scale (ESS) (Johns, 1991), the Beck Depression Inventory (BDI) (Beck *et al.*, 1961), the Pittsburgh Sleep Quality Index (PSQI) (Buysse *et al*., 1989), and the sleep questionnaire were among the tools used to assess the individuals' inadequate sleep. The study's participants' sleep patterns were assessed in connection with physical health conditions like irregular menstruation, gastrointestinal, musculoskeletal, and neurological disorders.

The amount of time spent sleeping overall, the number of sleep disruptions, the wake-up time, the bedtime, and the sleep latency are all self-reported sleep habits. Concerns over the individual's subjective assessment of the quality of their sleep and problems during the day, such as poor performance and trouble focusing.

The individuals' cognitive performance was assessed using a variety of criteria to account for alterations brought on by sleep deprivation.

Overall intelligence:

The Montreal Cognitive Assessment (MoCA) Version 7.3 (Nasreddine *et al.*, 2005) was used to evaluate a number of cognitive abilities including name, orientation, delayed recall, language, abstraction, and memory recall in relation to visuospatial competence. The typical test takes 10

Table 1: Subject characteristics both with and without sleep loss

	SD (N = 11)	MD (N = 30)	NonD (N = 17)	P-value
Age (years)	27.3 ± 2.9	27.5 ± 2.3	27.2 ± 2.2	0.809
Sex (male:female)	2:09	4:26	2:15	0.999
Body Mass Index (kg/m²)	20.6 ± 1.7	20.7 ± 2.5	21.5 ± 3.4	0.867
Job duration (h/day)	18.4 ± 0.6	14.6 ± 2.1	12.9 ± 2.1	<0.001**
Exercise (%)	9.2	10.1	11.7	0.999

S-SD, severe sleep deprived; M-SD, mild to moderate sleep deprived; Non-SD, non-sleep deprived; P < 0.05, //, P < 0.01 by Wilcoxon signed ranks test.

min to finish. We contrasted the day shift and night shift results.

Mental Skills (cognitive flexibility, reaction inhibition, and working memory):

Executive function encompasses cognitive processes such as the ability to solve problems, use working memory, plan, make decisions, resist temptation, and pay attention. This study assessed working memory for visuals and response constraint. A smartphone application called Confusion of Colors (Stroop Test) was utilized for this. Response inhibition was discovered using a program that was founded on the Stroop effect .

Attention:

Attention deficit is more commonly linked to sleep deprivation. Inattentiveness reduces a person's ability to respond quickly to inputs. Long-term focus was evaluated using the "Vigilance Test" smartphone app, which functions exactly like the Mackworth clock test. Only the quantity of targets seen and false alarms were precisely noted by the application.

Simple Reaction Duration:

The basic reaction time test involves having the participant respond to a known stimuli in order to assess their motor control and processing speed. The individual was asked to press a button when a color changed. Reaction time test, a smartphone application, was utilized for this .

Mental quickness or numerical reasoning:

A worksheet including twenty-five math problems was provided to the participants, and their mental speed was assessed. The operations of addition, subtracting, multiplying, and dividing two integers were covered in this worksheet. It was noted and compared how long it took to finish the worksheet at different shift times (Veasey *et al.*, 2002).

Prior to the test, participants were instructed to reduce their caffeine intake and refrain from drinking alcohol for a minimum of two days.

Results

Characteristics of sleep and population:

The 58 subjects (50 women and 8 males) were studied having mean age of 27.3 ± 2.2 years. For all 58 participants, the average amount of sleep length was 5.1 ± 1.3 h, while the average labor time was 13.9 ± 2.6 h.

A description of each category's demographic features is given in Table 1. Except for job duration, there were no appreciable variations between the groups.

Using a sleep questionnaire, self-reported characteristics related to sleep:

Self-reported sleep habits were analyzed in light of survey data (Table 2). How much sleep that each participant had on both working and non-working nights varied significantly between groups, as was to be predicted ($P < 0.01$). In the SD group, every sleep metric was significantly poorer on working nights ($P < 0.05$) as compared to non-working nights. Apart from delay in sleep, the MD group likewise showed changes that are statistically significant ($P < 0.01$) between working and non-working nights in the sleep metrics, on the other

Table 2: Self-reported sleep characteristics are compared between on- and off-duty

	SD (N = 11)			MD (N = 30)			NonD (N = 17)		
	Off duty	On duty	P-value	Off duty	On duty	P-value	Off duty	On duty	P-value
Sleep latency, m	7.3 ± 4.5	4.4 ± 5.2	0.043*	15.8±16.4	12.7 ± 11.3	0.888	14.8±15.4	11.3 ±12.2	0.654
Count of arousals	0.3 ± 0.7	5.5 ± 4.7	0.018*	0.8± 1.2	4.6 ± 3.9	0.002**	0.3 ±0.5	2.2 ±3.1	0.102
Sleep, h/d	4.7 ± 0.7	1.7 ± 1.2	0.005**	5.4± 0.9	3.0 ± 1.6	<0.001**	6.6 ±0.7	6.2 ±0.5	0.065
Work, h/d	13.8 ±2.3	22.2 ± 1.5	0.003**	12.5± 2.2	18.7 ± 3.8	<0.001**	11.3 ± 3.2	14.6 ± 3.5	0.008**

m, minutes; No., number; h/d, hours per day. /, $P < 0.05$, //, $P < 0.01$ by Wilcoxon signed ranks test.

Table 3: Sleep deprivation's effects on daily activities and quality of life, as stated in a questionnaire

5-point scale on a questionnaire (from none to daily)	SD (N = 11)	MD (N = 30)	NonD (N = 17)	P Bonferroni
An unsatisfactory amount of sleep	4.3 ± 0.47	3.5 ± 0.73	3.4 ± 1.00	0.09
frequency of sleep loss	4.2 ± 0.87	3.4 ± 1.16	2.8 ± 1.20	0.054
morning awakening difficulty	4.3 ± 0.65	3.3 ± 1.23	3.2 ± 1.19	0.207
Fatigue	4.4 ± 1.03	3.9 ± 1.14	3.6 ± 1.12	1
Stress	3.5 ± 1.04	2.4 ± 0.89	2.2 ± 0.97	0.027*
Performance difficulty	4.2 ± 0.99	3.1 ± 1.16	2.2 ± 1.25	0.009**
Concentration issues	4.4 ± 1.21	3.3 ± 1.44	2.5 ± 1.38	0.045*

PBonferroni, corrected P-value by a Bonferroni correction; GI, gastrointestinal; /, $P < 0.05$, //, $P < 0.01$ by Chi-Square test with a Bonferroni correction.

hand, the NonD group's sleep patterns did not alter between working and non-working nights. When comparing the MD (11.9±3.4) and NonD (10.9±3.5) groups to the SD group (15.0±4.1), despite the fact that the mean SSS did not differ much across the groups, the mean ESS was substantially higher ($P<0.05$).

Consequences of sleep deprivation on health, work, and society:

Based on a frequency scale of 1 to 5, where 1 means never and 5 means almost every day. Table 3 shows dysfunction during the day. Prolonged sleep deprivation have been associated with stress, difficulty focusing, and difficulties with learning. In each group, more than 70% reported experiencing a range of health concerns, including as neurological symptoms, musculoskeletal pain, and gastrointestinal disorders. The health problems raised by the different groups did not differ, though. Following a Bonferroni correction, the incidence of work missing or mistakes caused by fatigue at work was no longer markedly distinct from the NonD group, the MD group, and the SD group. SD reported missing a significant number of social and family gatherings more than the other groups did. There were no discernible differences between the groups' non-sleepiness-related mistakes and tardiness (Table 4).

Insufficient sleep's effects on cognitive functions:

In MoCA, a maximum score of 29 and 30, respectively, was reached during the day and night shifts. The lowest score, was 21, at night, and 23, during the day. While mental speed and response time show increases in mean scores, general intellect and attentiveness show decreases at night (Table 5).

An analysis of these non-parametric data was conducted using the Wilcoxon Signed-Ranks test. The findings of MoCA test revealed that the outcomes of the day shift were substantially better than those of the night shift ($Z=-5.651$, $p<0.001$). Furthermore, during the day shift, there was a substantial increase in the execution ($Z=-5.145$, $p< 0.001$) and memory ($Z=-5.132$, $p< 0.001$) test results compared to the night shift. The math task took significantly less time to complete during the day than it did at night ($Z = -5.561$,

Table 4: Effects of deprived sleep on social, professional and health outcomes

	SD (N = 11)	MD (N = 30)	NonD (N = 17)	PBonferroni
Gastrointestinal Disturbance (%) (n/N)	90.9% (10/11)	86.7% (26/30)	70.6% (12/17)	1
Musculoskeletal Signs (%) (n/N)	90.9% (10/11)	93.3% (28/30)	82.4% (14/17)	1
Neurological Signs (%) (n/N)	90.9% (10/11)	76.7% (23/30)	94.1% (16/17)	0.916
Irregular Menstruation (%) (n/N)	11.1% (1/9)	36.0% (9/25)	14.3% (2/14)	0.732
Work missed (%) (n/N)	54.5% (6/11)	53.3% (16/30)	11.8% (2/17)	0.065
Errors made at work due to sleepiness (%) (n/N)	90.9% (10/11)	60.0% (18/30)	41.2% (7/17)	0.16
Errors unrelated to sleepiness (%) (n/N)	72.7% (8/11)	66.7% (20/30)	64.7% (11/17)	1
Lateness (%) (n/N)	54.5% (6/11)	70.0% (21/30)	47.1% (8/17)	1
Missed social or familial events (%) (n/N)	81.8% (9/11)	36.7% (11/30)	29.4% (5/17)	0.027*

PBonferroni, corrected P-value by a Bonferroni correction; GI, gastrointestinal; /, P < 0.05, //, P < 0.01 by Chi-Square test with a Bonferroni correction.

Table 5: Cognitive performance

Domain		Day Shift		Night Shift		Wilcoxon Signed-Ranks Test	
		Mean	**SD**	**Mean**	**SD**	**Z***	**p**
General intelligence (MoCA)		27.92	1.257	24.62	1.48	-5.651	<0.001
Mental agility (Maths)		2.21	0.677	2.23	0.63	-5.561	<0.001
Inhibition of response		8.51	4.599	4.82	3.12	-5.145	<0.001
Simple Reaction time		0.41	0.201	0.45	0.21	-7.132	<0.001
Working Memory		12.71	4.799	8.74	4.28	-5.132	<0.001
Attention (Vigilance)	Targets detected	5.11	1.801	2.44	1.666	7.098	<0.001
	False alarms	1.41	1.201	3.12	0.901	-7.262	<0.001

*Based on positive ranks (night shift – day shift) p (2 – tail) < 0.001 is statistically significant.

p<0.001). A statistically significant variation was seen in the reaction times for the vigilance test between the day and night (Z=-7.132, p<0.001). Target detection rates were significantly greater during the day shift (Z=7.098, p<0.001), although they were significantly less during the night shift (Z=--7.262, p<0.001) (Table 5).

Discussion

The goal of the study was to look into sleep deprivation patterns in healthcare professionals working night shifts. Working night shifts can cause sleep deprivation, which throws off circadian rhythms and has an impact on cognitive and general health. Seventy-six per cent of staff nurses reported sleeping fewer than 6 h a night, and 19% of participants said they slept for less than 4 h on average each day. These results were consistent with those of medical professionals on similar shift schedules (Palhares *et al.*, 2014). Human cognitive abilities, including sustained attention and working, are negatively impacted by exposure to partial or complete sleep loss (Pilcher *et al.*, 1996).

According to the research, concerns about physical health are shared by every group (monthly or more frequently), and they were primarily connected to functioning condition. Present study found a connection between sleep deprivation and difficulties with learning, concentration, and social relationships. The nurses who worked in shifts had their cognitive abilities compared between the end of the day shift and the night shift. Within the domains of cognitive abilities, working memory, mental aptitude, alertness, and simple response time, lower scores were noted. According to Thomas *et al.* (2000), sleep deprivation may have a particularly large influence on parietal function, which may in turn affect subsequent cognition. Working memory and episodic memory have been related to dorsolateral prefrontal cortex (Vandewalle *et al.*, 2009). Numerous data points (Stickgold and Walker, 2007) supported the link between sleep and memory functions. In comparison to the night shift, we saw improved visual working memory during the day shift. Sleep deprivation thus enslaves memory (Swetha and Sudhakar, 2012).

Mathematical activities during the night shift, were solved more slowly, which is consistent with the results of a study done between US medical interns (Raidy and Scharff, 2005). Furthermore, it was discovered that sleep deprivation contributed to the night shift's delayed mean simple reaction time (Gunzelmann *et al.*, 2009). A broad decline in target identification and raise in false alarms appear to be associated with sleep deprivation as well, while these outcomes could be the consequence of less focus and awareness. Sleep deprivation can modify the activity of the hypothalamic suprachiasmatic nucleus by affecting sleep states and vigilance state transition processes (Deboer *et al*., 2003). Problems with working memory, sluggish cognitive processing, and poor psychomotor vigilance test (PVT) performance have all been linked to sleep deprivation (Wei *et al*., 1999). Research has shown that sleep deprivation often slows down reaction times, increasing task completion times and leading to more execution and absentee errors. Studies on vigilance during sleep deprivation have also demonstrated susceptibility to homeostatic and circadian drivers (Lim and Dinges , 2008). Furthermore, a number of studies have demonstrated that, in comparison to working the day shift, the risk of cognitive impairment increases when working night shifts (Doran *et al*., 2001). It is important to keep in mind that those who suffer from sleep deprivation are more susceptible to its numerous detrimental effects, even when they spend the equivalent amount of time as individuals who work a day shift (Williamson and Feyer, 2000).

Comparing the subjective assessment of sleep duration provided by ESS to an actigraph or actimetry sensor for the purpose of determining sleep insufficiency has raised doubts about its validity. It is crucial to remember that, despite their application, subjective health concerns are inherently subjective. Another disadvantage is the absence of actual data on sleep disruption. No physiologic study was conducted in this instance. Furthermore, not every cognitive domain was looked at in this study. The mobile application software that measures cognition was internally validated as a result of resource constraints as well. To determine how common sleep deprivation is and what consequences it has affect on all domains of cognition will require actigraphy-based studies on a larger sample.

Conclusion

The results of present study provide some insight into the ways that sleep impacts brain and cognitive processes. Among other measures of cognitive performance, fundamental alertness, attention, and psychomotor vigilance are significantly reduced in staff nurses who are sleep deprived. It is unclear, though, how much of these decreases might be attributed to just becoming less alert and attentive. Lack of sleep can have detrimental consequences on the health, emotions, and productivity of healthcare professionals, which can affect the quality of care provided to patients.

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