

Sleep Quality and Vigilance Differ Among Inpatient Nurses Based on the Unit Setting and Shift Worked

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Objectives: Sleepiness in nurses has been shown to impact patient care and safety. The objectives of this study are to measure sleep quality, sleepiness, fatigue, and vigilance in inpatient nurses and to assess how setting (intensive care unit versus the general floor) and shift worked (day versus night) affect these measures.

Methods: Nurses from both the ICU and floor were included in the study. Participants completed questionnaires assessing self-reported sleep quality (Pittsburgh Sleep Quality Index, PSQI), sleepiness (Stanford Sleepiness Scale and Epworth Sleepiness Scale, ESS), and fatigue (Fatigue Severity Scale, FSS). Vigilance was measured by means of the psychomotor vigilance test (PVT), before and after a 12-hour duty shift.

Results: The ESS was abnormal in 22% of all nurses, the FSS was abnormal in 33%, and the global PSQI was abnormal in 63%. More ICU nurses than floor nurses reported abnormal sleep quality (component 5) on the PSQI. Sleep medication use (PSQI component 6) was higher in night shift nurses. The FSS was greater in night shift nurses. On preshift PVT testing, day-shift nurses overall provided faster mean reaction time (RT) than night-shift nurses. ICU nurses working the day shift made more than twice as many total errors and false starts than day shift floor nurses. Floor nurses demonstrated a significant decrease from preshift to postshift in the mean of the fastest 10% RT.

Conclusions: Our data indicate that a significant number of inpatient nurses have impaired sleep quality, excessive sleepiness, and abnormal fatigue, which may place them at a greater risk of making medical errors and harming patients; these problems are especially pronounced in night shift workers. PVT results were inconsistent, but floor and day shift nurses performed better on some tasks than ICU and night shift nurses.

Key Words: sleep deprivation, sleep and safety, nurses sleepiness, nurses fatigue, nurses sleep quality

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Insufficient sleep is widely prevalent in our society, as highlighted by recent nationwide surveys.¹ These trends may be both more severe and more important in the health care industry, as patient safety can be directly impacted.² Besides insufficient sleep, there is a high prevalence of shift-work among health-care workers with its attendant disruptions in circadian rhythms. Studies have demonstrated a significant prevalence of sleepiness using both subjective and objective measures in medical residents and nursing personnel.^{3–5} Current practice patterns among nurses reflect longer working hours than ever before.⁶ Measures have been taken in recent years to change the work schedule of nurses with the aim of improving patient

safety; if select at-risk groups of nurses can be identified for intensive interventions, the goal may be more reasonably achieved.

Professional vigilance, the art of “watching out,” is the essence of nursing. It is the mental process that makes the informed nursing actions of assessment, diagnosis, intervention, and evaluation possible and meaningful. Research has shown that fatigue from prolonged shift-work and sleep loss impairs vigilance performance sooner and more dramatically than most other cognitive functions.^{7–9} Studies on medical residents have shown impaired reaction times and reduced vigilance compared with controls.¹⁰ The presence of such impairment among nursing personnel has not been well established.

The goal of this study was to determine self-reported sleepiness, fatigue, and sleep quality among inpatient nurses and assess their performance on vigilance tests. We previously reported higher self-reported sleepiness in nurses working in the intensive care unit (ICU) compared with nurses working on a floor unit.⁴ We therefore aimed to study the influence of this work setting (ICU versus floor) on sleepiness, sleep quality, and vigilance. Finally, we sought to determine if the effects of shift work differed between floor and ICU nurses.

METHODS

Study Design

This study was performed at Christus Spohn Hospital, a tertiary care hospital in Corpus Christi, TX, between June 2009 and January 2012. The protocol was approved by the Christus Spohn Hospital Institutional Review Board. Participants were nurses from the medical-surgical unit (floor) and ICU who volunteered for the study. Volunteers were recruited by means of flyers posted at the nursing stations and word of mouth. All participants worked a 12-hour duty shift at the time of testing. Exclusion criteria included a known self-reported sleep disorder, pregnancy, working greater than 60 hours per week, history of major cardiopulmonary or psychiatric disease, and use of any antidepressant medication. After obtaining informed consent, the participants completed a demographics and medical history questionnaire, Pittsburgh Sleep Quality Index (PSQI), Epworth sleepiness Scale (ESS), and Fatigue Severity Scale (FSS) at study entry. They also completed the Stanford Sleepiness Scale (SSS) before and after their 12-hour duty shift.

Questionnaires

The ESS is an 8-item self-rated questionnaire asking, “How likely are you to doze off or fall asleep?” in a set of 8 hypothetical situations, each scored 0 to 3, giving a total score of 0 to 24. No time frame is specified for which the questions should be applied. An ESS score of 10 is most often considered to be the upper limit of normal.¹¹ The FSS is a 9-item self-report questionnaire, initially developed to assess fatigue in medical conditions (i.e., multiple sclerosis and systemic lupus erythematosus) and subsequently validated in sleep disorders.^{12,13} Each item is scored from 1 (strongly disagree) to 7 (strongly agree) in response

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to a statement regarding the intrusion of fatigue into different aspects of living in the past week, and the average of the 9 items is calculated. A higher score indicates worsening fatigue; an FSS score of 4 is the upper limit of normal. The SSS is a single-measure 7-point scale measuring self-reported alertness (1 = feeling active, vital, alert, or wide awake; 7 = no longer fighting sleep, sleep onset soon, having dream-like thoughts) at the time of the assessment. An SSS score higher than 3 (at a time when alertness would normally be expected) is considered abnormal.¹⁴ The PSQI is 19-item self-rated questionnaires for evaluating subjective sleep quality over the previous month. Seven component scores (0–3) are derived from the 19 individual questions, which are added to obtain a global score (0–21). Increasing scores indicate worse sleep quality; global PSQI score higher than 5 is considered abnormal¹⁵; a score of 2 or higher on an individual component is also abnormal.

Vigilance Testing

Vigilance was assessed on each nurse with the Psychomotor Vigilance Test (PVT), a 10-minute computerized visual reaction-time task that evaluates sustained attention.¹⁶ Participants were instructed to respond to the appearance of a visual stimulus by pushing a response button as quickly as possible. The stimulus was a red light emitting diode displaying time in milliseconds in a window of the portable PVT-192 device (Ambulatory Monitoring, Inc., Ardsley, NY). During each 10-minute session, visual stimuli appeared at variable intervals of 2 to 10 seconds. From each PVT trial, reaction times (RT) were collected, from which the mean, median, mean of the fastest 10% of RT, and mean of the slowest 10% response speed (reciprocal RT, RRT) were calculated; the number of false starts (responding prior to a stimulus), lapses (RT >500 milliseconds, ms), and total errors (sum of the wrong key pressed, false starts, key held >3 seconds, and failure to respond within 30 seconds) were extracted using the software program. PVT has a high signal load, which allows for collecting a large data in a relatively short duration. This signal load increases the sensitivity of the test by detecting small changes in the attention function without affecting the motivation.¹⁷ Deficits in attention seem to result from “wake state instability” manifesting as increased variability in endogenous alertness and compensatory effort as a result of increases in both errors of omission (i.e., lapses) and errors of commission (i.e., incorrect responses). Testing was performed at the beginning and at the end of their 12-hour duty shift.

TABLE 1. Baseline Demographic and Clinical Characteristics of the Participants

Group	Floor Nurses†	ICU Nurses	P
N	25	42	
Female, no. (%)	25 (100%)	31 (74%)	0.005
Age, years ± SD	36.0 ± 12.4	37.1 ± 9.3	ns
Height, cm ± SD	161.4 ± 6.8	168.1 ± 9.3	0.003
Weight, kg ± SD	43.3 ± 8.2	53.5 ± 12.3	0.0007
BMI, kg/m ² ± SD	25.0 ± 4.9	28.0 ± 5.7	0.03
Night shift, no. (%)	9 (36%)	15 (36%)	ns

* ICU indicates intensive care unit; no., number; SD, standard deviation; ns, not significant.

† Demographic and clinical information is unknown for 3 floor nurses.

TABLE 2. Measures of Sleepiness, Fatigue, and Sleep Quality in Floor and Intensive Care Unit Nurses

Group	Floor	ICU	P
ESS, score ± SD	7.24 ± 4.29	7.38 ± 3.86	NS
Abnormal ESS, no. (%)	5 (20%)	10 (24%)	NS
FSS, score ± SD	3.64 ± 1.15	3.30 ± 1.29	NS
Abnormal FSS, no. (%)	11 (44%)	11 (26%)	NS
SSS Pre	1.88 ± 0.93	1.83 ± 0.79	NS
SSS Post	2.24 ± 1.39	2.17 ± 1.21	NS
Global PSQI	5.82 ± 2.63	7.40 ± 3.24	NS*

*P = 0.06.

ICU indicates intensive care unit; ESS, Epworth Sleepiness Scale; SD, standard deviation; NS, not significant; no., number; FSS, Fatigue Severity Scale; SSS, Stanford Sleepiness Scale, collected before (Pre) and after (Post) duty shift.

Statistics

The Fisher’s exact test was used to analyze binomial variables. Comparisons between 2 normally distributed groups were performed with the unpaired *t* test, between 2 non-normally distributed groups with the Mann-Whitney U test, between 2 paired non-normally distributed groups with the Wilcoxon matched pairs test, and among 3 or more non-normally distributing groups with the Kruskal-Wallis test. A 2-tailed *P* < 0.05 was considered statistically significant.

RESULTS

Seventy nurses (28 floors and 42 ICU) volunteered and met criteria for inclusion into the study. Of the 67 nurses that completed the questionnaires, 43 worked the day shift, and 24 worked during the night. Baseline demographic and clinical data are shown in Table 1. All of the floor nurses were female, whereas 74% of ICU nurses were female; the group of ICU nurses averaged greater height, weight, and body mass index than the group of floor nurses.

Results of the questionnaires (ESS, FSS, SSS, and PSQI) are shown in Table 2. The ESS was abnormal in 15 (22%) of all nurses, and the FSS was abnormal in 22 (33%), indicating excessive sleepiness and fatigue, respectively. Sleep quality, measured by the global PSQI, was abnormal in 40 (63%) of all nurses. Floor and ICU nurses did not differ significantly in ESS, FSS, SSS, or global PSQI scores, although the global PSQI scores showed a trend toward a significant difference (*P* = 0.06). The mean ESS, FSS, and SSS scores fell within normal limits, whereas the mean global PSQI scores for both groups of nurses was abnormal. There was not a significant difference between ICU and floor nurses in any of the individual domains of the ESS; more ICU nurses than floor nurses reported abnormal sleep quality (component 5) on the PSQI (*P* = 0.03). The preshift SSS did not differ significantly from postshift scores in floor or ICU nurses.

Questionnaire results from the day and night shift nurses are shown in Table 3. There was a not significant difference in the overall ESS between days shift and night shift nurses (*P* = 0.08); however, the ESS was abnormal in a higher percentage of night shift nurses (42% versus 12%, *P* = 0.01). Examination of specific domains of the ESS showed that the night shift nurses were significantly sleepier when sitting quietly (E3, *P* = 0.004) and sitting after lunch/dinner (E7, *P* = 0.046); the other domains were similar between shifts. The global PQSI

TABLE 3. Measures of Sleepiness, Fatigue, and Sleep Quality in Day and Night Shift Nurses

Group	Day	Night	P
ESS, score $\pm$ SD	6.70 $\pm$ 3.66	8.58 $\pm$ 4.33	NS*
Abnormal ESS, no. (%)	5 (12%)	10 (42%)	0.01
FSS, score $\pm$ SD	3.17 $\pm$ 1.25	3.88 $\pm$ 1.12	0.02
Abnormal FSS, no. (%)	11 (26%)	11 (46%)	NS
SSS Pre	1.84 $\pm$ 0.81	1.88 $\pm$ 0.90	NS
SSS Post	2.05 $\pm$ 1.11	2.46 $\pm$ 1.50	NS
Global PSQI	6.29 $\pm$ 2.82	7.96 $\pm$ 3.42	NS [†]

* $P = 0.08$.[†] $P = 0.06$.

ESS indicates Epworth Sleepiness Scale; s.d., standard deviation; ns, not significant; no., number; FSS, Fatigue Severity Scale; SSS, Stanford Sleepiness Scale, collected before (Pre) and after (Post) duty shift.

again showed a trend toward a difference between day and night shifts (6.29 $\pm$ 2.82 versus 7.96 $\pm$ 3.42, $P = 0.06$). Sleep medication use (component 6) was higher in night shift nurses; all other components of the PSQI were similar between groups. The FSS was greater in the night shift nurses (3.88 $\pm$ 1.12 versus 3.17 $\pm$ 1.25, $P = 0.02$). SSS scores were similar between nurse's working day and night shifts; there was not a significant change from preshift to postshift in either group.

On preshift PVT testing, day-shift nurses overall provided faster mean RT than night-shift nurses; additionally, the slowest 10% of responses were faster (i.e., higher mean RRT). Interestingly, no significant differences between day- and night-shift nurses were measured on postshift testing (Table 4). No significant differences were seen between floor and ICU nurses in preshift or postshift PVT measures (data not shown); more differences were seen when taking into account the time of day the duty shift was worked. Although the mean RT was similar

for floor and ICU working both day and night shifts, the mean of the fastest 10% RT (RT-fast) scored by ICU nurses working the night shift was significantly faster than their counterparts working on the floor (Table 5). Conversely, ICU nurses working the day shift made more than twice as many total errors and false starts than day shift floor nurses and night shift ICU nurses. RT-fast in floor nurses was significantly faster after the shift than before it; no other significant changes were noted between preshift and postshift vigilance scores (data not shown). Floor nurses (mean, 204.3 ms) demonstrated a trend toward a slower RT-fast than ICU nurses (197.3 ms) preshift ($P = 0.09$); this difference was significant among night shift nurses. Although the results were non-normally distributed, no obvious outliers to account for these differences were noted on visual inspection. Vigilance improved over the duration of the shift, such that the postshift RT-fast scores were similar between the 2 groups of nurses (floor 196.7 ms; ICU 199.8 ms; $P = 0.89$). The change in PVT measures over the course of each shift is shown in Table 6. RT fast improved (faster) in ICU nurses on day shift, whereas the same measure was slower by the end of the night shift in ICU nurses ($P = 0.007$). Additionally, the floor nurses showed more improvement in RT-fast times over the course of the night shift, compared with ICU nurses ($P = 0.004$). In all groups analyzed, any difference measures in total errors, false starts, and lapses were inconsistent.

There were differences between the groups that may have influenced the measures of vigilance in unforeseen way: all male nurses included in the study worked in the ICU, and the BMI of floor nurses was significantly lower than that of ICU nurses. Therefore, analyses were repeated with data from female participants only (data not shown). Without male subjects in the ICU group, there was no significant difference in BMI (25.0 $\pm$ 4.9 versus 27.1 $\pm$ 5.8, $P = 0.18$). There was no difference between ICU and floor nurses in the mean ESS, percentage with abnormal ESS, mean FSS, percentage with abnormal FSS, mean SSS preshift, or SSS postshift. ICU nurses had a significantly higher mean Global PSQI (7.84 $\pm$ 3.05 versus 5.82 $\pm$ 2.63,

TABLE 4. Preshift and Postshift Vigilance Scores in Day and Night Shift Nurses

	Day Shift	Night Shift	P
Preshift			
Mean RT, ms	278.9 (264.4–293.5)	310.7 (278.2–343.3)	0.02
Median RT, ms	256.1 (243.7–268.4)	263.0 (251.9–274.1)	NS
Total errors, no.	2.65 (1.28–4.02)	1.25 (0.51–1.99)	NS
False starts, no.	2.58 (1.25–3.91)	0.83 (0.24–1.43)	NS*
Lapses (RT >500 ms), no.	2.95 (1.77–4.14)	3.96 (2.53–5.39)	NS
Mean RRT, Slowest 10%, s ⁻¹	2.41 (2.23–2.59)	2.07 (1.84–2.30)	0.02
Mean RT, Fastest 10%, ms	200.7 (192.7–208.7)	199.3 (192.7–205.9)	NS
Postshift			
Mean RT, ms	278.6 (264.1–293.0)	297.1 (270.1–324.1)	NS
Median RT, ms	255.6 (243.6–267.6)	273.6 (253.4–293.8)	NS
Total errors, no.	3.40 (1.43–5.36)	1.96 (1.00–2.92)	NS
False starts, no.	3.12 (1.29–4.94)	1.63 (0.74–2.51)	NS
Lapses (RT >500 ms), ms	2.58 (1.55–3.61)	3.71 (1.64–5.78)	NS
Mean RRT, slowest 10%, s ⁻¹	2.40 (2.21–2.58)	2.30 (1.99–2.62)	NS
Mean RT, fastest 10%, ms	197.0 (189.2–204.7)	203.8 (194.1–213.4)	NS

* $P = 0.09$.

RT indicates reaction time; ms, milliseconds; no., number; RRT, reciprocal response time; NS, not significant.

Values are reported as mean (95% confidence interval).

TABLE 5. Comparison of Floor and ICU Nurses in Preshift Testing

	ICU Nurses	Floor Nurses	P
Day shift			
Mean RT, ms	279.1 (257.1–301.1)	278.7 (262.9–294.6)	NS
Median RT, ms	253.8 (234.8–272.9)	259.8 (247.9–271.7)	NS
Total errors, no.	3.41 (1.46–5.35)	1.38 (–0.40 to 3.15)	0.02
False starts, no.	3.30 (1.42–5.17)	1.38 (–0.40 to 3.15)	0.02
Lapses (RT >500 ms), no.	3.15 (1.44–4.86)	2.63 (1.05–4.20)	NS
Mean RRT, slowest 10%, s ⁻¹	2.42 (2.16–2.67)	2.39 (2.14–2.64)	NS
Mean RT, fastest 10%, ms	198.6 (187.0–210.2)	204.3 (193.8–14.8)	NS
Night shift			
Mean RT, ms	294.1 (274.0–314.3)	338.4 (249.4–427.5)	NS
Median RT, ms	257.5 (241.0–274.0)	272.2 (259.4–285.1)	NS
Total errors, no.	0.73 (0.16–1.31)	2.11 (0.29–3.93)	NS
False starts, no.	0.53 (0.07–1.00)	1.33 (–0.20 to 2.87)	NS
Lapses (RT >500 ms), no.	3.53 (2.10–4.97)	4.67 (1.19–8.15)	NS
Mean RRT, slowest 10%, sec ⁻¹	2.15 (1.84–2.45)	1.94 (1.51–2.37)	NS
Mean RT, fastest 10%, ms	194.8 (186.0–203.7)	206.8 (197.3–216.2)	0.04

ICU indicates intensive care unit; RT, reaction time; ms, milliseconds; no., number; RRT, reciprocal response time; NS, not significant. Values are reported as mean (95% confidence interval).

$P = 0.02$), which is a new finding in this female-only group. The night shift had a significantly higher percentage of nurses with abnormal ESS (43% versus 15%, $P = 0.03$) and higher mean FSS (3.91 ± 1.13 versus 3.21 ± 1.34 , $P = 0.02$). There remains a trend toward higher mean ESS for night shift nurses compared with day shift ($P = 0.07$). No significant difference exists between shifts in the proportion of abnormal mean FSS, mean SSS preshift, mean SSS postshift, or mean Global PSQI. In preshift PVT testing, the day shift nurses had more false starts than night shift nurses (2.76 ± 4.54 versus 0.83 ± 1.44 ,

$P = 0.04$). Otherwise, there were no significant differences preshift or postshift between ICU and floor nurses or between day and night shift nurses, in mean RT, median RT, total errors, false starts, lapses, mean RRT of the slowest 10%, or the mean RT of the fastest 10%.

DISCUSSION

Sleepiness among nurses is widely prevalent and has implications for the safety of patients as well as for themselves. Several studies have indicated the adverse effects of sleep

TABLE 6. Change in Vigilance Testing Preshift to Postshift

ICU Nurses	Day Shift	Night Shift
Mean RT, ms	–2.73 (–15.79 to 10.32)	4.59 (–26.41 to 35.59)
Median RT, ms	–1.13 (–11.34 to 9.08)	17.73 (–9.88 to 45.34)
Total Errors, no.	1.41 (–0.34 to 3.15)	0.53 (–0.33 to 1.39)
False Starts, no.	1.11 (–0.47 to 2.70)	0.33 (–0.25 to 0.91)
Lapses (RT >500 ms), no.	–0.52 (–1.88 to 0.84)	0.33 (–2.01 to 2.68)
Mean RT, slowest 10%, sec ⁻¹	–0.003 (–0.19 to 0.19)	0.18 (–0.14 to 0.50)
Mean RT, fastest 10%*, ms	–3.73 (–8.24 to 0.78)	13.89 (2.48–25.29)
Floor nurses		
Mean RT, ms	3.55 (–18.58 to 25.69)	–44.02 (–142.6 to 54.52)
Median RT, ms	0.63 (–14.28 to 15.53)	–1.33 (–28.09 to 25.42)
Total errors, no.	–0.38 (–1.99 to 1.24)	1.00 (–0.72 to 2.72)
False starts, no.	–0.44 (–2.03 to 1.16)	1.56 (–0.45 to 3.56)
Lapses (RT >500 ms), no.	–0.13 (–2.08 to 1.83)	–1.22 (–5.34 to 2.90)
Mean RT, slowest 10%, sec ⁻¹	–0.02 (–0.32 to 0.29)	0.32 (–0.37 to 1.02)
Mean RT, fastest 10%, ms	–3.77 (–10.76 to 3.23)	–11.23 (–23.17 to 0.72)

*ICU nurses demonstrated significant differences in Mean RT, Fastest 10% between day and night shifts ($P = 0.007$); the difference between ICU and floor night shift nurses was significant for Mean RT, Fastest 10% ($P = 0.004$).

† $P = 0.08$.

RT indicates reaction time; ms, milliseconds; no., number; RRT, reciprocal response time; NS, not significant.

Values are reported as mean (95% confidence interval).

deprivation on the physical and psychological performance of an individual and particularly so in the health-care setting.^{18,19} Our data showed that many nurses have impaired sleep quality, perhaps more impaired in ICU nurses. Nearly two thirds of nurses had an abnormal PSQI, and more than 1 in 5 reported excessive sleepiness. Night shift nurses were more likely to doze off when sitting quietly or sitting after a meal, more likely to use sleep medications, and reported higher fatigue scores than day shift nurses.

These data are in line with previous studies that have shown that the sleep quality of nurses working night shift was worse than those working day shift.^{20,21} Disturbance in sleep quality associated with shift work has been shown to negatively impact job satisfaction, and day shift nurses' job satisfaction has been shown to be higher than night shift and rotating day-night shift nurses previously.²² The use of sleep aids is a common treatment for shift work sleep disorder, which is more likely to afflict nurses working nights; thus, the higher use of sleep medications in this population may be expected. Although nurses are unlikely to spend much time "sitting quietly" while on a duty shift, the higher abnormal response rate on these components of the ESS by night shift nurses may indicate a subtle difference in sleepiness, requiring greater effort (and/or pharmacological treatments) to maintain vigilance.

The prevalence of abnormal daytime sleepiness amongst nurses in our study was 22%. Geiger-Brown et al. recently reported that 45% of hospital nurses had a high level of sleepiness on at least one of three consecutive 12-hour duty shifts.²³ Scott et al., in national surveys of 895 full-time hospital staff nurses,²⁴ found that 67% reported at least one episode of drowsy driving over a 4-week period; additionally, of 502 critical care nurses,²⁵ almost two-thirds struggled to stay awake at least once during the study period, and 22% fell asleep at least once during their work shift. The percentage of nurses reporting a moderate or high likelihood of falling asleep while driving in our study was 7.4%. Our data also demonstrate that working night shifts, or working in the ICU, do not seem to significantly influence the prevalence and degree of self-reported sleepiness. Interestingly, fatigue levels do seem to be influenced by working night shifts. Factors that may be responsible for this include chronic disruptions to the circadian clock, neuroendocrine alterations—particularly perturbations in the hypothalamo-pituitary axis—that may be associated with chronic nocturnal awakening and concomitant depression.

Professional nursing vigilance has been defined as "a state of attention to and identification of clinically significant observations/signals/cues; calculation of risk inherent in nursing practice situations; and readiness to act appropriately and efficiently to minimize risk and to respond to threats."²⁶ Vigilance is negatively correlated with sleepiness, and errors are directly related to the state of vigilance. Nurses who work night and rotating shifts have been shown to more often have difficulty remaining awake on duty and make twice as many errors as nurses who worked day and evening shifts.²⁷ Longer work duration increased the likelihood for errors and near errors among nurses.²⁸ Interventions aimed at reducing the duty hours of house staff have been shown to reduce medical errors.²⁹ In our study, PVT measures did not change from the beginning to the end of an ICU duty shift. This finding suggests that the sleep deficit acquired over the course of an ICU does not significantly impair vigilance or PVT may not be a sensitive measure of such impairment in this setting.

Any impairment in nursing performance has potential implications for patient's safety, especially in the critical care environment. Each year, approximately 1.3 million patients are

injured because of error during their hospitalization, and more than 100,000 deaths due to preventable adverse events occur.³⁰ The risk of making an error is related to shift-length (longer than 12 hours), working overtime, and work-week greater than forty hours.^{31,32} Although our present study was not designed to specifically address the influences of working in an ICU environment or during the night shift on patient safety outcomes, the associated poor sleep quality and abnormal sleepiness may confer an additional patient risk; therefore, additional studies are needed. Further data may lead to changes in allotment of duty hours, shift length, and work load.

This current study does have some limitations. It was performed at a single institution, which allows for improved control of external confounder but makes application of the findings to a broader population difficult. Sleepiness was not correlated with clinical performance, which would be an important area of focus for future studies. The number of participants is small, limiting the statistical power of the findings. Some external factors, such as light exposure, caffeine/stimulant intake, physical activity levels, and workload, were not controlled. All male nurses included in the study worked in the ICU; although differences were noted in sleep quality, daytime sleepiness, and fatigue in the group of female nurses, these differences were not reflected in the PVT results. Thus, most of the differences in PVT testing could potentially be attributed to male sex or higher BMI.

CONCLUSIONS

The role of nurses in hospitals and the increasing scope of health care have led to increased staffing needs and stressful work hours for nurses with resultant sleep loss and circadian rhythm disruptions. Our data show that sleep quality in nurses is significantly impaired, and the problem is especially pronounced in night shift worker; there may also be impairment related to the ICU setting, where higher patient acuity requires even more vigilance. Changes have been made to the schedules of hospital-based nurses in recent years with the goal of improving patient safety; our data suggest that there is still work to do, especially with regard to ICU and night shift nurses. Further research may help define strategies to optimize duty hours, shift length, and frequency so as to minimize this sleep impairment.

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