Original Paper

The Association of Sleep Deprivation on the Occurrence of Errors by Nurses Who Work the Night Shift

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ABSTRACT: *Purpose*: To determine the influence of sleep deprivation on the occurrence of errors by registered nurses working in night shift in intensive care departments. *Methods*: The study utilized a multi-part questionnaire which included items about demographic characteristics, reported medical errors, and Pittsburgh Sleep Quality Index (PSQI) 300 questionnaires were distributed to registered nurses working in intensive care departments. 138 of the 153 (51% response rate) collected questionnaires were analyzed using correlation and stepwise logistic multiple regression. *Results*: Registered nurses who were sleep deprived had worse sleep quality in terms of high PSQI than those who were not. None of the demographic variables was statistically significant, not providing evidence that these variables may explain odds for being sleep deprived in the population. *Conclusions*: Work schedule changes, offering shorter periods of time on night shift and less working hours in the week may lead to better sleep quality and less sleep deprivation.

KEYWORDS: *medical errors, sleep deprivation, sleep quality, work schedule, night shift.*

Introduction

The occurrences of errors have been examined in a number of professions [1-3]. The negative influence of sleep deprivation has been documented in truck drivers, airline pilots, and military personnel [4, 5]. In particular, the airline industry has investigated sleep deprivation to examine its effect on psychomotor performance and the number of errors [6]. Sleep deprivation impairs memory, decreases cognitive function, and results in poor decision making [7-12]. This decrease in psychomotor performance is associated with an increased occurrence of error [8, 13-16]. In medical environments, an increase in the occurrence of error reflects a decrease in safe practice which is indicated by an increase in medical errors, increased infection rates, and increased morbidity [17, 18].

Nurses need to have good concentration particularly in emergency situations. Any deterioration of awareness, memory or coordination may affect performance and lead to errors. Accordingly, research into the impact of sleep deprivation and the associated problem of sleepiness is important if medical errors linked to sleep deprivation are to be decreased or prevented effectively. Therefore, medical staffs who work the night shift should be examined [19]. While there is evidence that night-shift workers are not the only workers that are sleep deprived [20], there is also evidence that night-shift workers experience poorer quality and shorter duration of sleep than their dayshift counterparts [21].

Patient related errors are described as any accident or injury to the patient, adverse drug event, improper transfusion techniques, burns, pressure ulcers, mistaken identity, missed treatments, missed medication, omitted treatment, errors in transmission of doctors' orders, errors in documentation, or omission of an intervention that is needed. The magnitude of medical errors and its impact on health care has become a national concern [22]. The relationship between the occurrence of errors and safety in health care is discussed in reports by the Institute of Medicine (IOM) [18]. In 1997 the IOM extrapolated from two studies, one conducted in Colorado and Utah and the other in New York that approximately 44,000 Americans die every year from medical errors [18, 23]. Errors in medicine account for 2.9 to 3.9% of all adverse events resulting in death. More people die each year from medical errors than from AIDS, automobile accidents, and breast cancer combined [18]. Therefore, the purpose of this study was to examine how sleep deprivation in registered nurses who work a night shift in intensive rooms is associated with the occurrence of medical errors.

Methods

Population sample

The participants in this study were registered nurses employed at the study site. Permission to recruit participants was obtained from the participating hospitals administrative boards and

research departments prior to data collection. Registered nurses who are employed full-time and who work the night shifts in an intensive departmental setting were included to participate in this study. Participants understood the purpose of the study and gave their written consent for participation. The consent form was approved by the Institutional Review Board.

The sample consisted of nurses who worked the night shift and were free from a diagnosed sleep disease. Three territories participated in the study, with 37.7% of the sample obtained from the north territory, 49.3% obtained from the middle territory, and 13% obtained from south territory. Out of 153 collected questionnaires, a total of 138 responses were used for analysis. A coordinator recruited in each of north, middle, and south of the Kingdom of Saudi Arabia was asked to mail the collected envelopes which contained the surveys' questionnaires to the researchers. The number of returns was sufficient to enable the statistical analysis of the data necessary to complete the study.

Sleep deprivation was determined by computing the difference between how many hours of continuous sleep a nurse rested in a 24 hour period and how many hours of continuous sleep the nurse actually obtained in a 24 hour as recorded in the sleep daily recall. If the nurse received fewer hours than he/she reported needing, then he/she was classified as sleep deprived. Otherwise, he/she was classified as not being sleep deprived when he/she received at least as many hours as he/she reported needing.

Survey content and procedures

The hospital setting was determined to be important because of the need to have a high level of psychomotor performance in order to accomplish caring duties [24, 25]. Shift lengths of 8, 10, and 12 hours were selected because there is evidence that the length of shift may influence the duration of sleep [19]. Convenience sampling was used to obtain the sample size, and potential sampling bias was identified [26]. Since there is evidence that years of experience influence the occurrence of errors and that sleep deprivation can be cumulative, male and female nurses from the ages of 21-65 years who had at least one year of experience working in the hospital were included [3, 8].

The survey instrument was adapted from four previous studies [27-31]. The survey included personal demographic information such as age, gender, marital status, other individuals to assist in the home, dependents in the home, age of dependents, highest level of staff's education, years of experience, number of hours per shift, hours worked per week, length of time on night shift, treated sleep disorders, hours slept in the last 24 hours, hours worked in the past two days, and number of patient related errors during the last year and description of the error.

Sleepiness was measured by the Pittsburgh Sleep Quality Index (PSQI) [32]. PSQI is a validated questionnaire consisting of seven components. The rating ranges of each of the seven components from zero to three. PSQI score of more than 5 indicates poor sleep quality. The entire questionnaire required 10-15 minutes to be completed. The PSQI has internal consistency and a reliability coefficient (Cronbach's alpha) of 0.83 for its components [33].

Data analysis

Correlation analysis yielded two pieces of information about the data: the nature of the linear relationship between variables and the strength of the linear relationship [26, 34, 35]. To test conformity to linear model assumptions, independence, normality, and fit were assessed. Violations of assumption were evaluated by setting a specified alpha of 0.05 and hypothesis testing about the distribution and graphical examination was remediated using modified Levene, lack of fit, and Box-Cox transformations.

Descriptive statistics were used to address the research questions. Scatter plots were used to examine the relationships between sleep deprivation and patient errors. Graphs and scatter plots were used to display the data. To test conformity to logistic regression model assumptions, the 2-log Likelihood, Pearson chi square, and Hosmer-Lemeshow test were performed.

Four hypotheses in this study were tested as follows: 1) Is there a significant decrease in the sleep quality of nurses who are sleep deprived compared to nurses who are not sleep deprived, controlling for years of experience, gender type, length of time on night shift, length of time worked on the unit?; 2) Is there a significant increase in the magnitude of the frequency of medical errors in sleep deprived nurses when compared to nurses who are not sleep deprived, controlling for years of experience, length of time on night shift and length of time worked in the unit?; 3) What is the relationship between hours of sleep and the number of medical errors, controlling for years of experiences, length of time on night shift, length of work time per

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week and length of time worked in the unit?; and 4) Is there a relationship between sleep deprivation and personal factors, including age, gender, responsibility for children, responsibility for dependent adult or aged or sick parents, marital status, and length of time on night shift?

Results

The mean number of hours for sleep deprived nurses was 4.3 (S.D. = 1.4), for non-sleep deprived nurses, 6.4 (S.D. = 2.2). The total number of nurses that were not sleep deprived was 112, approximately 81% of the sample.

Table 1 presents a summary of the night shift nurses' demographic data. Table 2 contains descriptions of hospital means for the of variables age, length of time on night shift, years of experience, years working in the same unit, and continuous hours of sleep in the last 24 hours.

Table 1 Descriptive statistics for demographic data.

Variables	Frequency (Percent)
Territory	
A (4 participated hospitals)	52 (37.7%)
B (5 participated hospitals)	68 (49.3%)
C (7 participated hospitals)	18 (13.0%)
Gender:	
Male	60 (43.5%)
Female	78 (56.5%)
Degree:	
High school	38 (27.5%)
Diploma	98 (71.0%)
Bachelors	1 (0.75%)
Masters	1 (0.75%)
Ph.D.	0 (0%)
Shift Start:	
4 p.m.	28 (20.3%)
6 p.m.	5 (3.6%)
8 p.m.	68 (49.3%)
10 p.m.	11 (8.0%)
12 p.m.	26 (18.8%)
Marital:	
Married	99 (71.7%)
Non-married	34 (24.6%)
Caring for an aged parent:	
Yes	31 (22.5%)
No	107 (77.5%)
Caring for other sick or aged adult:	
Yes	9 (6.5%)
No	118 (85.5%)
Difficulty staying awake while at work:	
Yes	17 (12.3%)
No	119 (86.2%)
Difficulty staying awake while driving home:	
Yes	19 (13.8%)
No	105 (76.1%)
Sleep deprived	
Yes	26 (19%)
No	112 (81%)
# of participants by shift schedule	
8 hrs.	61 (44.2%)
10 hrs.	16 (11.6%)
12 hrs.	61 (44.2%)

Table 2 Descriptive statistics (mean, SD) for continuous variables by territory.

Hospital	N	Variable	Mean	S.D.
Territory A (4 participating hospitals)	52	Age	34	12.6
		Yrs. experience	10.9	7.1
		Yrs. in the unit	6.5	5.3
		Continuous sleep in hrs.	5.8	3.7
		Number of children in the home	2.2	1.3
		Hours worked per week	47.7	9.7
Territory B (5 participating hospitals)	68	Age	34.8	9.5
		Yrs. experience	11.1	6.8
		Yrs. in the unit	6.4	6.1
		Continuous sleep in hrs.	6.1	3.2
		Number of children in the home	1.8	1.1
		Hours worked per week	48.2	14.8
Territory C (7 participating hospitals)	18	Age	32.9	12.3
		Yrs. experience	11.4	7.5
		Yrs. in the unit	6.6	6.2
		Continuous sleep in hrs.	6.2	3.2
		Number of children in the home	1.5	0.9
		Hours worked per week	46.5	3.1

First hypothesis "association between sleep quality and sleep deprivation"

Log transformation procedure was applied because the distribution of sleep quality variable values was a non-normal. Non-significant covariates were removed from the model, leaving only length of time on night shift. The overall model for testing hypothesis was statistically significant. The mean sleep quality (PSQI) for sleep deprived nurses (Mean=7.85, SD=3.76) was worse than the mean sleep quality (PSQI) for non-sleep deprived nurses (Mean=4.16, SD=2.27); $p<0.0001$.

Second hypothesis "association between sleep deprivation and medical errors"

Non-significant covariates were removed from the model. The distribution of medical errors required a 2-power transform. At all levels of shift lengths, the means of medical errors in sleep deprived nurses were significantly higher than the means of medical errors of non-sleep deprived nurses, $p< 0.003$. Therefore, the hypothesis could not be rejected, and it was concluded that sleep- deprived nurses had higher number of medical errors per participant when compared to non-sleep deprived nurses at 8-, 10-, 12-shift lengths, $p<0.0001$, $p<0.014$, and $p<0.001$, respectively. The result of this analysis is presented in Table 3. In addition, there were no significant differences among territories in terms of number of errors per participant.

Table 3 Mean Number of errors per participant during last year by shift length and sleep deprivation (Standard Deviation).

Error	***Shift length***					
	8 hours		**10 hours**		**12 hours**	
	Sleep deprived		Sleep deprived		Sleep deprived	
	Yes (SD)	No (SD)	Yes (SD)	No (SD)	Yes (SD)	No (SD)
Number of errors per participant	1.14 (0.037)	0.24 (0.056)	0.8 (0.031)	0.27 (0.062)	1.06 (0.102)	0.32 (0.088)

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Third hypothesis "hours of sleep and medical errors"

Hours of sleep variable values were normally distributed. Non-significant covariates were removed from the model, leaving only length of work time per week. The overall model for hours of sleep was not statistically significant. As a result, the hypothesis that there is a relationship between hours of sleep and the number of medical errors was rejected.

An exploratory analysis, using subset logistic regression, was used to see if a best predictive model could be specified. All possible models' sizes were examined. The results showed that only length of work time per week was statistically significant with $\beta = 0.675$ with the origin; $t = 5.09$, $p<0.001$. It was concluded that the greater the number of working hours in a week, the more the number of medical errors occurred.

Forth hypothesis "sleep deprivation and personal factors"

The likelihood ratio test for the global hypothesis chi squared was 9.81 (df = 7; p = 0.2). The Hosmer and Lemeshow goodness of fit test indicated acceptable model fit ($\chi^2 = 9.16$, df = 8, p = 0.329). The overall model was non-significant; therefore, there is no relationship between odds for sleep deprivation and age, gender, responsibility for children, responsibility for dependent adult, sick parents, marital status and length of time on night shift with sleep deprivation.

An exploratory analysis, using subset logistic regression, was also utilized to see if a best predictive model could be identified. All possible models' sizes were examined, only length of time on night shift was statistically significant, $\chi^2 = 14.12$, df = 3, $p<0.007$; there is a strong association between long shift duration and sleep deprivation. In addition, none of the demographic variables was statistically significant, providing additional evidence that these variables may not explain odds for being sleep deprived in this population.

Discussion

Nineteen per cent of the sample in this study was sleep deprived. The majority (89.2%) of the sleep deprived nurses obtained 5 hours of sleep or less in a day with a total mean average of 4.3 hrs/day. However, the majority (94.6%) of non-sleep deprived nurses received 8 hours of sleep or less in a day with a total mean average of 6.4 hrs/day. There were a number of measured factors that may contribute to nurses obtaining less sleep. The importance of identifying contributing factors to sleep loss should not be underestimated.

The association between sleep deprivation and sleep quality was found to be significant. About 20% of the sample reported fairly very bad sleep quality. Monk et al. [36] found that a reduced number of sleep hours may cause poor sleep quality and circadian phase delay. This study agreed with the findings of other studies [29, 36-38]. Other factors that influence sleep quality are patient load, administrative environment, and work stress. Those factors were not evaluated in this study. However, data were collected on the number of children and responsibility of parents in the home. Those factors were not correlated with sleep quality in the study.

This study supported the theoretical framework in that when there is inadequate sleep the brain does not have an opportunity to restore to full performance potential [39]. The result of this study agreed with others in such that the direct relationship between sleep deprivation and medical errors was found to be significant [29, 40-42]. The medical errors were self-reported and documented [43]. This item may have been viewed as a threat. If the medical error item could have been viewed as a positive challenge perhaps nurses would be more willing to report medical errors.

The relationship between sleep deprivation and the demographic variables of age, gender, caring of children in the home, caring of sick adult in the home, marriage status, years of experience, and length of time on night shift was investigated. It was found that length of the shift time limits the amount of sleep time. This result agreed with the findings of some studies [3, 44, 45]. It may be important to look at length of shift in terms of individual's ability to obtain adequate sleep.

Limitations of the study were that east and west territories refused to participate in the study. In addition, all participating hospitals prohibited the investigators from interviewing their employees. It was planned to have observations and interviews with nurses to gain a better understanding of the people and work processes that the researchers were interested for studying the situations.

The high percentage of regularly scheduled shifts may reflect the predetermined scheduling pattern of the hospitals that participated in the study. Nurses who work full time in those hospitals may have limited control over their

work schedule. Extended work periods, work load, number of consecutive days of work, short time between shifts, and on-call have been known to influence sleep and circadian patterns [44-47]. These factors are suggested for more future work.

Conclusion

Examination of the relationship between sleep deprivation, performance, and the occurrence of errors specific to registered nurses will result in a better understanding of the factors related to sleep deprivation, occurrence of errors, and how to influence the development of a safe health care environment.

This study is one step in the direction of better understanding the factors that affect medical workers and occurrence of errors. Medical staff administrators may need to consider alternative scheduling methods rather than 12-hour shifts to permit adequate time for sleep between shifts. Taking a nap at work is not generally viewed as an acceptable practice in nursing and may result in punitive action. Hospitals may need to provide a nap room where medical staff could take a nap. Short naps have been shown to be recuperative [43].

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References

1. Helmreich R. On error management: Lessons from aviation, Brit Med J 2000; 320: 781-5.
2. Miltner M, Miller J, Lipstiz J, Walsh J, Wylie B. The sleep of long-haul trick drivers, New Engl J Med 1997; 337**:** 755-62.
3. Scott A. Shift work and health, Occup Environ Med 2000; 27: 2-6.
4. Gillis L, Li G, Baker S. General aviation crashes involving military personnel as pilots, Aviat Space Envir Med 2001; 72: 1001-5.
5. Shmuel S, Shlomo V, Natali B, Ayala L, Eliezer K. Driver drowsiness: Are physicians at a special risk? Harefuah 2003; 142: 338-41.
6. Billings C, Reynard W. Human factors in aircraft incidents: Results of a 7 year study, Aviat Space Envir Med 1984; 55: 960-5.
7. Dinges D, Pack F, Williams K, Gillen K, Powell J, Ott G. Cumulative sleepiness, mood disturbance, psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 hours per night, Sleep 1997; 20: 267-77.
8. Gold D, Rogacz S, Bock N, Tosteson T, Baum T, Speizer F. Rotating shiftwork, sleep, and accidents related to sleepiness in hospital nurses, Am J Public Health, 1992; 82: 1011-4.
9. Harrison Y, Horne J. The impact of sleep deprivation on decision making: A review. J Psychol App 2000; 6: 236-49.
10. Chee M,Tan J, Parimal S, Zagorodnov V. Sleep deprivation and its effects on object-selective attention. NeuroImage 2010; 49:1903-10.
11. Killgore W. Effects of sleep deprivation on cognition, Prog Brain Res 2010; 185: 105-129.
12. Kong D, Soon C, Chee M. Reduced visual processing capacity in sleep ;deprived persons, NeuroImage 2011; 55: 629-34.
13. Tucker A, Rakitin B, Basner R, Gazes Y, Steffener J, Yaakov S. fMRI activation during failures to respond key to understanding performance changes with sleep deprivation. Behav Brain Res 2011; 218: 73-79.
14. Anderson C, Platten C. Sleep deprivation lowers inhibition and enhances impulsivity to negative stimuli, Behav Brain Res 2011; 217: 463-466.
15. Institute of Medicine (US) Committee on Sleep Medicine and Research; Colten HR, Altevogt BM, editors. Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem. Washington (DC): National Academies Press (US); 2006. Available from: http://www.ncbi.nlm.nih.gov/books/NBK19960/
16. Williamsona A, Lombardi D, Folkard S, Stutts J, Courtney T, Connor J. The link between fatigue and safety, Accident Anal Prev 2011; 43: 498-515.
17. Goodman F. A fragmented patient safety concept: The structure and culture of safety management in health care, Nurs Econ 2004; 22: 44-6.
18. Kohn L, Corrigan J, Donaldson M. Committee on Quality of Healthcare in America, Institute of Medicine. To err is human: building a safer health system, 2000, National Academy Press, Washington (DC).
19. Rosa R.R. Examining work schedules for fatigues: it's not just hours of work. In Hancock P.A., Desmond P.A. (Ed.), Stress, Workload, and Fatigue, 2001, Lawrence Earlbaum Association, Mahwah, New Jersy, 513-28.
20. Rogers A, Caruso C, Aldrich M. Reliability of sleep diaries for assessment of sleep/wake patterns, Nurs Res 1993; 42: 368-72.
21. Hammam R, Abosrea M, Hagag S. Assessment of physicians' communication and job performance during morning and night shifts in emergency hospitals at Zagazig district, Egypt, J App Sc Res 2012; 8: 3185-92.
22. Al-Harby NA. Medical Errors is still continues. Press release, 2007, available at http://www.alriyadh.com/200702/18/article225849.html
23. Valenti W. Errors in medicine, Aids Read 2000; 10: 647-51.
24. Roseman C, Booker J. Workload and environmental factors in hospital medication errors, Nurs Res 1995; 44: 226-30.
25. Ugrovics A, Wright J. 12 hour shifts: Does fatigue undermined ICU nursing judgment, Nurs Manage 1990; 21: 64a-64g.
26. Burns N, Grove S. The Practice on Nursing Research: Conduct. Critique and Utilization (3rd Ed.), 1997, W.B. Saunders Company, Philadelphia, PA
27. Mrayyan M. Reported incidence, causes, and reporting of medication errors in teaching hospitals in Jordan: A comparative study, Contemporary Nurse 2012; 41: 216-32.

 DOI: 10.12865/CHSJ.40.02.03

28. Hogan CA. Pediatric Patient Safety: Factors pediatric nurses identify as contributing to medication administration errors, Ph.D. Thesis, 2006, Nursing School, Loyola University, Chicago: Illinois, U.S.A.
29. Johnson A., The influence of sleep deprivation on performance and the occurrence of error in staff nurses who work the night shift, Ph.D. Thesis, 2006, University of Alabama at Birmingham: Alabama, U.S.A.
30. Huang YM. Project SECURE: Safety through Empowerment- Cultivating understanding to reduce errors, Education D. Thesis, 2006, Education Dept., University of California, Los Angeles, U.S.A.
31. Hoshenhaus SM. Ethical Decision Making in Emergency Nursing Regarding Medical Error, M.Sc. Thesis, 2005, State University of New York, New York: NY, U.S.A.
32. Buysse D, Reynolds C, Monk T, Berman S, Kupfer D. The Pittsburgh Sleep Quality Index (PSQI): A new instrument for psychiatric research and practice, Psychiat Res 1989; 28: 193-213.
33. Feinstein AR. Clinimetrics, 1987, Yale University Press, New Haven, CT.
34. Kleinbaum DG, Kupper LL, Muller KE, and Nizam A. Applied Regression Analysis and Other Multivariable Methods (3rd Ed.), 1998, Duxbury Press, Pacific Grove, CA.
35. Neter J, Kutner M, Nachtsheim C, Wasserman W. Applied Linear Statistical Models (4th Ed.), 1996, McGraw-Hill, Boston.
36. Monk T, Reynolds C, Buysse D, DeGrazia J, Kupfer D. The relationship between lifestyle regularity and subjective sleep quality, Chronobiol Int 2003; 20: 97-107.
37. Graw P, Krauchi K, Knoblauch V, Wirz-Justice A, Cajochen C. Circadian and wake dependent modulation of fastest and slowest reaction times during the psychomotor vigilance task, Physiol Behav 2004; 80: 695-701.
38. Halvani G, Zare M, Mirmohammadi S. The relation between shift work, sleepiness, fatigue and accidents in Iranian industrial mining group workers, Ind Health 2009, 47: 134-8.
39. Moore-ede MM, Sulzman FM, Fuller CA. The Clocks that time us: physiology of the circadian timing system, 1982, Harvard University Press, Cambridge, MA.
40. Davidhizar R, Shearer R. Your best preparation for a good day's work: A good night's sleep, Health Care Manage 2000; 19: 38-49.
41. Taoda K, Nakamura K, Kitahara T, Nishiyama K. Sleeping and working hours of residents at a National University in Japan, Ind Health 2008; 46: 595-600.
42. Brand S, Hermann B, Muheim F, Beck J, Holsboer-Trachsler E. Sleep patterns, work, and strain among young students in hospitality and tourism, Ind Health 2008; 46:199-209.
43. Keller S. Effects of Extended Work Shifts and Shift Work on Patient Safety, Productivity, and Employee Health, Workplace Health Safety 2009; 57: 497-502.
44. Rosekind MR. Managing work schedules: Alertness and safety perspective. In M.H. Kryger, T. Roth & W.C. Dement (Eds.), Principles and Practice of sleep Medicine (4th ed.), 2005, Elsevier Saunders, Philadelphia, PA 680-90.
45. Tucker P, Barton J, Folkard S. Comparison of eight and 12 hour shifts: Impact on health, well being, and alertness during the night shift, Occup Environ Med 1996; 53: 767-72.
46. Hayashi M, Motoyoshi N, Hori T. Recuperative power of a short daytime nap with or without stage 2 sleep, J Sleep Disorder Res 2005; 28: 829-36.
47. Wagstaff A, Lie J. Shift and night work and long working hours - a systematic review of safety Implications, Scand J Work Environ Health 2011; 37: 173-185.

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