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# Performance and sleepiness in nurses working 12-h day shifts or night shifts in a community hospital

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ABSTRACT

Hospitals are around-the-clock operations and nurses are required to care for patients night and day. The nursing shortage and desire for a more balanced work-to-home life has popularized 12-h shifts for nurses. The present study investigated sleep/wake cycles and fatigue levels in 22 nurses working 12-h shifts, comparing day versus night shifts. Nurses (11 day shift and 11 night shift) were recruited from a suburban acute-care medical center. Participants wore a wrist activity monitor and kept a diary to track their sleep/wake cycles for 2 weeks. They also completed a fatigue test battery, which included the Psychomotor Vigilance Test (PVT) and the Karolinska Sleepiness Scale (KSS), at the beginning, middle and end of 4 duty shifts. Daily sleep duration was 7.1 h on average. No overall difference in mean daily sleep duration was found between nurses working day shifts versus night shifts. Objective performance on the PVT remained relatively good and stable at the start, middle, and end of duty shifts in day shift workers, but gradually degraded across duty time in night shift workers. Compared to day shift workers, night shift workers also exhibited more performance variability among measurement days and between participants at each testing time point. The same pattern was observed for subjective sleepiness on the KSS. However, congruence between objective and subjective measures of fatigue was poor. Our findings suggest a need for organizations to evaluate practices and policies to mitigate the inevitable fatigue that occurs during long night shifts, in order to improve patient and healthcare worker safety. Examination of alternative shift lengths or sanctioned workplace napping may be strategies to consider.

## 1. Introduction

In order to limit the build-up of fatigue, most work settings constrain the duration of duty periods by means of industry-specific regulations or policies. It is often assumed that fatigue arises from the intensity and duration of exposure to work demands; that is, from task load and time on duty. However, the effect of task load on fatigue appears to be rather modest (Honn et al., 2016). The relationship between time on duty and fatigue depends on two factors that should be considered simultaneously: time awake and time of day. The reason is that there are two distinct neurobiological processes that both have a profound effect on fatigue (Daan et al., 1984). One is called the homeostatic process, and it involves a build-up of pressure for sleep in the brain as a function of time awake (and a dissipation of that pressure during sleep). The other is called the circadian process, and it involves a daytime waxing and nighttime waning of pressure for wakefulness, as driven by the biological clock.

These two neurobiological processes interact to produce a net level of fatigue that varies as a function of time awake and time of day (Dijk and Czeisler, 1994). Due to the interaction of the two processes, the temporal dynamics of fatigue differ between day and night shifts. Specifically, during day shift work, the build-up of pressure for sleep with time awake is counteracted by the waxing of pressure for wakefulness with time of day, producing a level of fatigue that is relatively low and stable across the duty period. In contrast, during night shift work, the build-up of pressure for sleep with time awake is amplified by the waning of pressure for wakefulness with time of night, producing a level of fatigue that steadily increases across the duty period (Van Dongen and Dinges, 2005). Shift schedules that ignore these dynamics may include duty periods – especially at night – that could be unsafe from a fatigue perspective.

For U.S. hospital settings, and for nurses in particular, there has been a trend to adopt 12-h shift schedules (Griffiths et al., 2014). These schedules are relatively easy to manage and are reportedly liked by the

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work force (Lowden et al., 1998; Stimpfel et al., 2012). However, 12-h shift durations are likely to expose discrepancies between day shifts and night shifts with regard to temporal dynamics of fatigue and the potential for medical errors, accidents and injuries. In the present field study, we investigated this by measuring objective performance and subjective sleepiness, as indices of fatigue, in a sample of nurses assigned to 12-h day or night shifts in a community hospital setting.

## 2. Materials and methods

Twenty-two full-time nurses (20 women, 2 men; ages 20–60) working in a 292 patient-bed, acute-care regional medical center located in a suburban community participated in this study. Each study participant worked a full-time schedule at the hospital; this consisted of six 12-h shifts within a two-week period. The shift hours were 07:00–19:00 for days and 19:00–07:00 for nights. During the study, 11 participants worked day shifts, and 11 worked night shifts. All participants were on their usual shift schedule; the medical center does not normally schedule shifts that rotate between day and night. The number of consecutive shifts varied among nurses. Job demands were approximately equivalent between day and night shifts, because nurse assignments and staffing ratios are generally determined by patient acuity. The study was approved by the Institutional Review Board of Washington State University, and all participants gave written, informed consent.

During the 2-week study period, participants kept a sleep/wake diary and wore a wrist activity monitor (Actiwatch-2; Philips Respironics, Bend, OR) to track their sleep/wake cycles. This is a reliable procedure for determining total sleep duration for work days and days off (Ancoli-Israel et al., 2003). Daily sleep duration was determined using Actiware software (version 6; Philips Respironics, Bend, OR).

Participants also completed a brief test battery three times per duty period – once immediately before their duty, once approximately halfway into the duty period while on an off-duty break, and once immediately after their duty period – for a total of four of their work shifts. To account for the possible event of illness or low census staff reductions, we asked nurses to complete data collection for four out of six scheduled shifts, giving an opportunity to “make up” a lost testing period. The test battery included a Psychomotor Vigilance Test (PVT), which is a 10-min reaction time test that measures behavioral alertness. The PVT is a validated, objective measure of performance, which is highly sensitive to fatigue (Lim and Dinges, 2008). The test battery additionally included the Karolinska Sleepiness Scale (KSS), a Likert scale that ranges from one (extremely alert) to none (very sleepy, great effort keeping awake, fighting sleep). The KSS is a validated assay of subjective sleepiness, which, like the PVT, is highly sensitive to fatigue (Åkerstedt et al., 2014). While completing the test battery, participants wore noise-cancelling headphones to help prevent environmental distractions. Furthermore, trained research staff supervised the testing to ensure a quiet, undisturbed and focused test environment within the medical center.

Sleep data (mean daily sleep durations) were analyzed with one-way analysis of variance (ANOVA) comparing the two shift types (day shift versus night shift). Data from the fatigue test battery were analyzed using mixed-effects ANOVA with fixed effects for shift type, time point (start, middle, end of shift), and their interaction, and a random effect over participants on the intercept (Van Dongen et al., 2004). The relationship between objective and subjective fatigue measures was tested with a variance ratio test. Statistical analyses were performed using SAS (version 9.4; SAS Institute Inc., Cary, NC).

## 3. Results and discussion

Fig. 1 shows the mean daily sleep durations, determined during the 2-week study period using wrist activity monitoring, for participants working day shifts and participants working night shifts. Although there appeared to be more variability in the night shift group, there was no significant difference in mean daily sleep duration between nurses working day shifts versus nurses working night shifts ($F_{1,20} < 0.01$, $P = 0.95$). This finding is consistent with other shift working populations measured across both work days and days off (Sparrow et al., 2016), and suggests that night workers compensate for lost nighttime sleep by means of daytime sleep and/or extra sleep on days off. The grand average ( ± standard deviation) of daily sleep duration in our sample was 7.1 h ( ± 1.0 h).

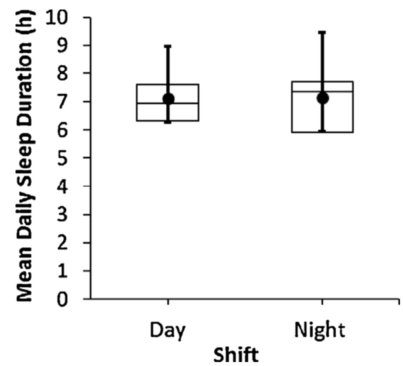


**Fig. 1.** Box plot of mean daily sleep duration, assessed using wrist activity monitoring during a 2-week study period, in nurses working 12-h day shifts versus nurses working 12-h night shifts. Circles: means; horizontal lines across: medians; boxes: range from 25th to 75th percentile; whiskers: range from minimum to maximum. (Note that the 25th percentile and the minimum are identical in the night shift group).

Fig. 2 (left) shows mean reaction times on the PVT at the start, middle, and end of the 4 duty periods with performance testing, for the day shift and night shift groups. There was a significant main effect of time point ($F_{2,236} = 10.7$, $P < 0.001$), and a significant interaction between shift type and time point ($F_{2,236} = 10.5$, $P < 0.001$). Fig. 2 (right) shows the number of lapses of attention, defined as reaction times greater than 500 ms (Lim and Dinges, 2008), on the PVT. There was again a significant main effect of time point ($F_{2,236} = 5.2$, $P = 0.006$), and a significant interaction between shift type and time point ($F_{2,236} = 7.8$, $P < 0.001$). Both outcome variables show that objective performance remained relatively good and approximately stable across the duty period in the day shift workers, but gradually degraded with time on duty in the night shift workers. There was also more variability among measurement days and participants at each time point in the night shift group. These results are congruent with data from laboratory studies involving simulated shift work (Gillberg et al., 1996; Van Dongen et al., 2011) as well as field research in other populations (e.g., Bjerner et al., 1955; Waggoner et al., 2012). The observed, greater variability among night shift workers likely reflects systematic inter-individual differences in homeostatic and circadian contributions to fatigue (Van Dongen et al., 2012).

Fig. 3 shows mean subjective sleepiness on the KSS at the start, middle, and end of the 4 duty periods with fatigue testing, comparing the day shift and night shift groups. There was a significant main effect of time point ($F_{2,236} = 24.2$, $P < 0.001$), and a significant interaction between shift type and time point ($F_{2,236} = 8.2$, $P < 0.001$). Similar to the PVT results, subjective sleepiness remained relatively low and approximately stable across the duty period in the day shift workers, but steady increases were seen for night shift workers. There was also more variability among measurement days and participants at each time point in the night shift group. These results are consistent with other studies showing that group-mean changes in subjective sleepiness over time track changes in group-mean objective performance over time within days (Van Dongen et al., 2011). Note, however, that this relationship generally does not hold across days (Van Dongen et al., 2003, 2011).

Subjective sleepiness on the KSS explained 4.9% of variance in the

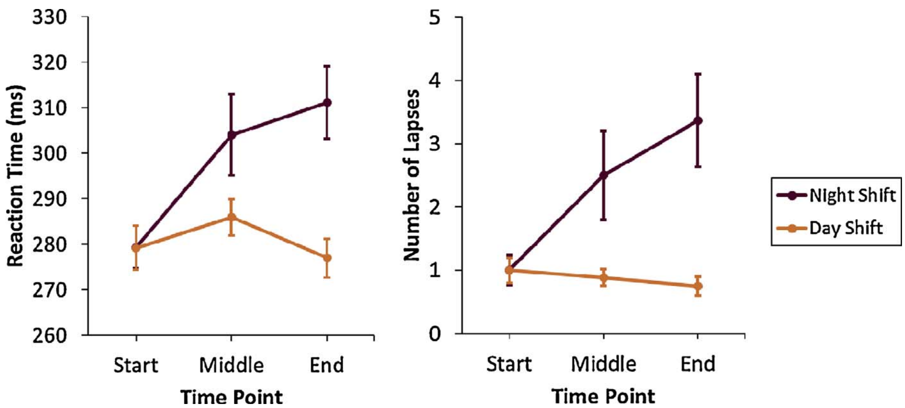


**Fig. 2.** Mean reaction times (left) and lapses of attention (right) on the Psychomotor Vigilance Test (PVT) at the start, middle, and end of the duty period, in nurses working 12-h day shifts versus nurses working 12-h night shifts. Error bars indicate ± 1 standard error of the mean.

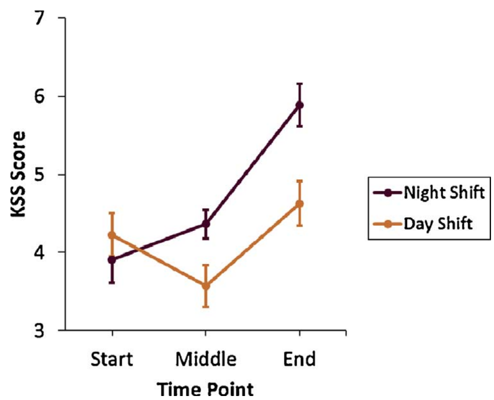


**Fig. 3.** Subjective sleepiness on the Karolinska Sleepiness Scale (KSS) at the start, middle, and end of the duty period, in nurses working 12-h day shifts versus nurses working 12-h night shifts. Error bars indicate ± 1 standard error of the mean.

objective performance (lapses of attention) on the PVT ($F_{236} = 13.16$, $P < 0.001$). This means that the correlation between these subjective and objective measures was only $r = 0.22$. This finding is consistent with poor correspondence between subjective and objective indices of fatigue among individuals in other shift work studies in the laboratory and in the field (Van Dongen et al., 2011; Zhang et al., 2014; Honn et al., 2016; Sparrow et al., 2016). It reinforces a point made previously (Satterfield and Van Dongen, 2013): self-monitoring of sleepiness is not a reliable approach to managing fatigue in the workplace.

## 4. Conclusions

Our findings are consistent with expectations, based on the neurobiology of fatigue, that night shift nurses experience greater difficulties with performance and their sleepiness is accentuated by the end of a 12-h shift. This occurred despite no significant difference in mean daily sleep duration and is attributable at least in part to the different temporal dynamics of fatigue at night due to the influence of the circadian process (biological clock). That is, the interaction of the effects of time awake and time of day on fatigue results in relatively good and stable performance across the hours of the day shift, but causes a steady increase of impairment across the hours of the night shift. Our study findings align with others who have studied fatigue in nurses (Eldevik et al., 2013; Wolf et al., 2017) and adds to mounting evidence of increased risks to patients and nurses associated with long hours and shift work (Caruso, 2014).

Because 12-h shifts are becoming the popular norm for nurses, it is critical that organizations consider the potential risks to patients, particularly with regard to night shift employees. Practices and policies are needed that mitigate the inevitable fatigue that occurs during long night shifts. Patient safety as well as worker safety must be considered, including the critical hours after work when employees drive home at their sleepiest (Rogers, 2008; Lee et al., 2016). Because 12-h night shifts are not equivalent to 12-h day shifts in terms of fatigue, it is possible that differential shift lengths should be examined within healthcare. A return to traditional 8-h shifts in nursing, at least during nighttime hours, might be one way of reducing risks.

Sanctioned workplace napping may be another strategy to consider – it has been successfully trialed (McDonald et al., 2013; Geiger-Brown et al., 2016) but not yet widely accepted in healthcare settings. While the battle against biology will not likely be won completely, finding approaches to mitigate the consequences of night shift fatigue may afford some protection to patients and workers.

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