Final Progress Report

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Sleep loss, sleepiness and fatigue in 12-hour nurses

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List of terms and abbreviations

TST- total sleep time, the quantity of actual sleep time per rest period (usually shorter than total time in bed).

SE- sleep efficiency- proportion of time in bed where the subject is actually sleeping.

TIB- time in bed.

PVT- Performance Vigilance Test, a test of neurobehavioral performance that is sensitive to fatigue

OFER- Occupational Fatigue Exhaustion Recovery Scale

HR-CESD- Hopkins Revised CESD (Depression scale)

Lapse- failure to respond for 500 msec or greated when a stimulus is presented

Abstract

Introduction: Sustained work days (shifts lasting 12 hours or more) have become common in nursing, especially in combination with compressed schedules (e.g. three 12-hour days in succession). This work schedule limits the opportunity for sleep, and can lead to fatigue-related accidents, injuries, and long-term adverse health effects. Because neurocognitive performance changes are an early indicator of fatigue, they are useful for exploring the impact of sustained workdays on nurses. The proposed study examined sleep, sleepiness, fatigue, and neurocognitive performance over three successive sustained workdays among critical care nurses working in hospitals. The aims of the study were to: (1) describe the number of hours of sleep that nurses actually achieve over successive sustained workdays, (2) measure sleepiness, fatigue, and changes in neurocognitive performance over these workdays, and (3) describe the relationship between achieved sleep and fatigue, sleepiness and neurocognition.

Methods: A within-subjects repeated measures design was used to compare changes from baseline in study variables over three successive days of 12-hour shifts. Female registered nurses from a large US hospital were recruited through flyers and by researcher attendance at nursing staff meetings. We screened 175 interested nurses by telephone for potential enrollment of whom 37 did not meet the inclusion criteria (i.e. nurses using sedating medications, pregnant, or with a serious emotional stressor in the past year). An additional 58 nurses were screened and eligible but did not enroll in the study because their work schedule did not conform to the study protocol near to the time of screening, resulting in the enrollment of 80 participants. When a nurse's schedule contained three consecutive 12-hour shifts preceded by two days off, she came into the research laboratory to complete baseline measures (demographic variables, OFER, HR-CESD), and to be trained on the protocol. Sleep patterns during the study period were assessed using actigraphy. Actigraphy recording began on the day off preceding the first of three 12-hour shifts, and ended after the first sleep period following the third 12-hour shift. A self-report sleep diary containing items based on the Pittsburgh Sleep Diary was kept concurrently during the entire actigraphy data collection period. Instruments measuring work demands were completed immediately after each shift. Both day and night shift nurses were included in the sample. We balanced the sample between day and night shift by increasing our face to face recruiting during the night shift hours.

Results: Between 12-hour shifts, average TST was only 5.46 hours (SD=1.07) after the first shift, and 5.62 (0.91) hours after the second shift. For the sample, TST between shifts ranged from 2.7 to 7.8 hours, with 1/3 getting less than 5.2 hours of sleep, 1/3 getting between 5.2 and 6 hours, and the final third achieving 6.1 to 7.8 hours of sleep. Sleepiness scores were generally low, with only 17% of nurses scoring high at least once during the three shifts worked during the study (high- "fighting sleep"). Intershift fatigue was high in 22% of nurses using the OFER scale. This means that at the beginning of the next shift, nurses did not feel adequately recovered from the previous shift. Neurobehavioral functioning assessed by PVT followed the expected circadian pattern. Night nurses showed slower reaction times than day shift nurses, and there was decay in performance over the 12 hours of the shift, although not statistically

significant. At the beginning of each 12-hour shift, nurses did not return to baseline on successive days, suggesting that there was not full recovery between shifts, and on average there was a significant slowing over the three study days. In this sample neurobehavioral status was not associated with prior sleep, level of sleepiness, or trait fatigue.

Discussion: With TST of less than 6 hours for several nights per week, nurses may have difficulty remaining fully effective in their role. This should concern health care employers, as well as nurses themselves since both short term and long term health consequences are possible in addition to safety concerns.

Highlights/Significant Findings

The following are the most significant findings from this study.

1. Between 12-hour shifts, average TST was only 5.46 hours (SD=1.07) after the first shift, and 5.62 (0.91) hours after the second shift. For the sample, TST between shifts ranged from 2.7 to 7.8 hours, with 1/3 getting less than 5.2 hours of sleep, 1/3 getting between 5.2 and 6 hours, and the final third achieving 6.1 to 7.8 hours of sleep. These total sleep times fall far short of the 7 to 8 hours of sleep that is necessary for adequate functioning.

2. Before the first 12-hour shift, 30% of nurses slept in excess of 9 hours, suggesting that they were still getting recovery sleep from the past work period.

3. Intershift fatigue was high in 22% of nurses using the OFER scale. This means that at the beginning of the next shift, nurses did not feel adequately recovered from the previous shift. Intershift fatigue is thought to be a precursor for chronic fatigue.

4. Sleep efficiency scores (total time asleep/time in bed trying to sleep) were below normative values for age in 43% of the sample, with night shift nurses having higher rates of poor sleep efficiency.

5. Night nurses often delayed going to bed after night shift, with half retiring between 9 and 10 AM, and 25% retiring after 10 AM. When nurses delayed retiring, they experienced more WASO for all causes, and more spontaneous awakenings. This is consistent with the circadian biology of sleep.

6. Shift overruns were common, with half of nurses remaining after 12.5. Most nurses had between 9 and 11 hours at home between shifts. No nurses with 9 hours or less time at home achieved 6 hours of sleep suggesting that a reasonable amount of time at home is necessary to achieve sufficient sleep.

7. Nurses with children showed almost no relationship of time at home between shifts to TST, whereas those without children had a large increase in TST with more time at home.

8. Sleepiness scores were generally low, with only 17% of nurses scoring high at least once during the three shifts worked during the study (high- "fighting sleep"). Caffeine use was high, with one nurse drinking as much as 160 ounces of caffeine in 24 hours to preserve alertness.

9. Neurobehavioral functioning assessed by PVT followed the expected circadian pattern. Night nurses showed slower reaction times than day shift nurses, and there was decay in performance over the 12 hours of the shift. At the beginning of each 12-hour shift, nurses did not return to baseline on successive days, suggesting that there was not full recovery between shifts, and on average there was a significant slowing over the three study days although these results did not achieve significance.

10. Neurobehavioral lapses showed a traitlike response pattern, with three latent classes: nurses who rarely lapse, occasionally lapse (the majority), and frequently lapsers (about 11%). Neurobehavioral functioning was not associated with quantity or quality of sleep achieved prior to the measurement.

11. In understanding why nurses achieve so little sleep between shifts, focus groups revealed that childcare and home responsibilities were common, however the primary reason for inadequate sleep was lack of sleep opportunity. Work stress spillover did not reduce sleep quantity or quality.

12. Sleep disorders (obstructive sleep apnea, restless leg syndrome) diagnosed by polysomnogram were more prevalent in a small sample of nurses than in the general population. Nurses were unaware of their diagnosis in nearly all cases.

13. Drowsy driving was frequently reported by night shift nurses, with many reporting more than one accident in the past year, some taking extraordinary measures to remain awake while driving home.

Translation of Findings

The results of this study were shared with the study participants, their employer, their occupational health physician and staff, a number of nursing administration leadership group (national, international), nursing specialty organizations, and a State nurses association. This PI met with a number of nurse administrators over the past three years in informal conversation and learned that there has been some movement toward partial adoption of these fatigue risk management measures. Some hospitals have gone back to offering a choice of 8 or 12 hour shifts; however the scheduling of these shifts is logistically difficult for unit managers to achieve adequate coverage (personal communications). Several hospitals have now implemented policies that allow nurses to nap during breaks on the night shift, and a few are providing "respite rooms" for nurses' use. NIOSH has developed an educational program for educating nurses about working extended hours and shiftwork that includes suggestions about

achieving adequate sleep (Dr. Claire Caruso), however this has not yet been rolled-out. We have not seen lighting changes implemented in hospitals. Shift overruns continue to be common throughout the industry despite the fact that there is now an adequate supply of nurses in many regions of the country.

These data were included in a three-part series of opinion articles in the Journal of Nursing Administration (March, April, September, 2010) that received wide press attention, and many inquiries from nurses nationally and internationally. Several of these inquiries led to formal consultations to improve the worklife of nurses. For example, the PI provided consultation to a large teaching hospital in a Midwest city and gave a Nursing Grand Rounds entitled 'Respite for Nurses' that summarized these data, taught basics of sleep, the science of napping, and summarized policy and procedure changes to improve nurses' respite. As a result of this PI consultation and presentation they will modify their policy on napping and provide education to staff. Another example is a nurse administrator from Singapore who contacted the PI wanting to know the wisdom of implementing 12-hour shifts for nurses.   She is planning the staffing schema for a new private hospital touting "lean production methods". The data were shared with her, and she is reconsidering her staffing schema. Another PI consultation was provided to a nurse administrator for a group of eldercare facilities in Illinois, assisting her to provide an evidence-based response to corporate management who had recently mandated a switch to 12-hour shifts in all of their nursing personnel. This nurse administrator saw adverse effects on workers almost immediately, but needed data to confront the business managers. Although she has not yet been successful in changing the staffing schema, she is continuing to advocate for this change. Another nurse administrator is now requiring sleep education as a part of annual training for all of her RNs. These are examples of how these data are beginning to inform decisions that are being made about nurse scheduling and support.

Outcomes/Relevance/Impact

These data suggest that nurses have enough sleep deficiency from working 12-hour shifts pose a significant risk for both acute and chronic health problems over many years of their careers. The health risks of chronic sleep deprivation are well documented, including cardiovascular (stroke, hypertension, heart disease) and metabolic (glucose intolerance, metabolic syndrome, diabetes, obesity) disease. Acute sleep deprivation is associated with increased risks for accidents and injuries.

In order to reduce workers' risk for acute and chronic health problems, there should be a re-examination of the wisdom of using the 12-hour shift organization of work in health care settings. Ideally, returning to shorter shifts could increase the quantity and quality of sleep that workers achieve. Barring this, a comprehensive system of fatigue risk management should be used in the health care industry to reduce risk for injury and chronic illness. This comprehensive system would include the following: (1) occupational screening for sleep disorder with referral and treatment by a qualified sleep specialist; (2) sleep education for nurses and other health care providers to cover basics of sleep, hazards of sleep deprivation, and practical steps to achieve

adequate sleep; (3) fatigue risk management software for management support for scheduling shifts in order to prevent acute hazards from too many successive extended shifts; (4) planned napping policies and procedures to allow for brief naps during breaks; (5) completely relieved rest breaks during the shift to allow for workers to physically and mentally rest, eat a meal, while their patients continue to receive care; (6) manipulation of ambient light to preserve alertness on the night shift- this will require an industrial engineer and circadian specialist consultation; (7) adequate staffing to allow nurses to leave on time on nearly all work shifts.

This fatigue risk management protocol could be packaged, tested for efficacy, and then disseminated as a "Toolkit" that would be used with traditional diffusion-of-innovation strategies (expert-led using consultants) or group diffusion strategies (consortium formation, train-the-trainer approaches).

Section 2

Scientific Report

Background for the project

The impetus for this study was the observation that 12-hour shifts had become ubiquitous in nursing, with hospital nurses having little choice but to work this schedule (1). The NIOSH-funded studies of Dr. Alison Trinkoff showed that the risk for musculoskeletal disorders and needlestick injuries was higher in nurses working 12-hour shifts than in 8-hour shifts (2, 3). Although Dr. Trinkoff's studies ascribed the increased injury risk to the duration of demands over the extended shift, this PI wondered whether it also had to do with how much sleep was achieved between 12-hour shifts. The work of van Dongen (4), Belenky (5)and others showed that neurobehavioral performance dropped off after successive days of reduced time in bed even though sleepiness plateaued; thus subjects were not a good judge of their actual performance. Subjects in these studies were young males without any waking responsibilities or commute time, unlike nurses who often return home to care for family members after a sometimes lengthy commute to and from work. This research was designed to describe how much sleep nurses actually achieved while working successive 12-hour shifts, how sleepy they were during their shift, how they described their fatigue level. The study also examined patterns of neurobehavioral performance over successive 12 hour shifts to determine if there was fatigue-related decay in performance on a fatigue-sensitive measure. These goals were important because nurses often consider fatigue as part of the job, and are unlikely to make attribution of later impaired health to occupational sources. Also, much of the schedule literature focused on shiftwork and shift rotation, but had not dealt with successive sustained work hours, so this study was needed since there are 2.9 million health care workers whose long term health could be affected by this scheduling schema.

Specific Aims

1. To determine the number of hours of sleep nurses achieve over successive sustained-hour workdays
2. To measure sleepiness, fatigue, and changes in neurocognitive performance among nurses over successive sustained-hour workdays
3. To describe the relationship between sleep, sleepiness, fatigue, and neurocognitive performance for successive sustained-hour workdays

Procedures

The main portion of this study used a repeated measures design to examine the study variables as described below. We also conducted focus groups, and some polysomnograms to understand the meaning of the results from the main portion of the study.

Main study

Female registered nurses from fourteen nursing units of a large US hospital were recruited through flyers and by researcher attendance at nursing staff meetings. We included only female nurses because 94% of U.S. nurses are female (6) and with a small sample we would be unable to do any meaningful subgroup analysis which would be important because of gender differences in sleep neurophysiology (7). We included nurses from many nursing units to increase the diversity of types and intensity of work demands so as to have variability in these measures. We screened 175 interested nurses by telephone for potential enrollment of whom 37 did not meet the inclusion criteria (i.e. nurses using sedating medications, with a diagnosed sleep disorder, pregnant, or with a serious emotional stressor in the past year). An additional 58 nurses were screened and eligible but could not enroll because their work schedule did not conform to the study protocol near to the time of during the data collection period, resulting in the enrollment of 80 participants. When a nurse's schedule contained three consecutive 12-hour shifts preceded by two days off, she came into the research laboratory to complete baseline measures and to be trained on the protocol. Sleep patterns during the study period were assessed using actigraphy (8). Actigraphy recording began on the day off preceding the first of three 12-hour shifts, and ended after the first sleep period following the third 12-hour shift. A self-report sleep diary containing items based on the Pittsburgh Sleep Diary (9) was kept concurrently during the entire data collection period. Instruments measuring work demands were completed immediately after each shift. Both day and night shift nurses were included in the sample (N=80). We balanced the sample between day and night shift by increasing our face to face recruiting during the night shift hours.

Measures:
Sleep

Nurses wore an actiwatch beginning the 24 hours prior to the first shift, and ending after the end of the main sleep period following the third consecutive shift. Total sleep time, sleep efficiency and WASO were calculated from actigraphic recordings using one minute epochs (Philips Respironics, Actiwatch-Score). Total sleep time (minutes scored as sleep), sleep efficiency (actual sleep time/time attempting to sleep), and WASO (minutes scored as awake after sleep was achieved) were calculated by the Actiwatch scoring program, which was set at the default medium activity count threshold (< 40 activity counts per epoch scored as sleep). Rest episodes were identified using the 'autoscore' mode of the actigraph scoring program, with subsequent manual editing of rest periods using diary reported "lights out" and "out of bed" times if required, to capture all sleep episodes. Interrater reliability for total sleep time for a 10% sample was .88. When sleep was broken into several episodes, as was a common pattern for night shift nurses, the average value of the longest two sleep episodes after working a 12-hour shift was used to determine sleep efficiency and WASO.

Night shift nurses identified themselves by indicating which shift they worked during the study protocol; most night nurses worked a 7 PM to 7:30 AM schedule. Time of "lights out" was calculated for night shift nurses using diary reported time of first rest interval after return home from work. These were then categorized into three groups: lights out before 9 AM, 9 to 9:59 AM, and 10 AM or later. WASO was measured using self reported awakenings for cause (awakened by partner, children, noise, pain, go to bathroom), and those reported as spontaneous (no known cause). These were tabulated using diary entries completed at the end of each study day. Sleep opportunity was defined as all time at home between shifts, and calculated as minutes of time between the nurse's arrival at home and her departure for work the next shift. These were recategorized into hour blocks for ease of interpretation. Because we were interested in the work-relatedness of sleep opportunity, we examined the consistency of commute times across days as well as activity entries in diaries to locate non-work related activities (shopping, medical visits, child transportation, etc) and used these as an indicator variable in analyses where sleep opportunity was used as a predictor.

Sleepiness

Sleepiness was measured using the Karolinska Sleepiness Scale, a single-item scale that has been validated by comparison to electroencephalographic measurement (10, 11). It uses 9 degrees of sleepiness (1= very awake, 9= very sleepy, great effort to keep awake, fighting sleep). Nurses were cued at the beginning of their shift and then every two hours during their shift to enter their sleepiness score into a recorder built into the actiwatch. Sleepiness scores using this method are known to be an underestimate because of the temporary alerting of the stimulus cue.

Fatigue

We used the Occupational Fatigue, Exhaustion, Recovery Scale, a 15-item scale that measures trait fatigue with subscales for acute fatigue, chronic fatigue/exhaustion, and intershift fatigue. It had good test-retest reliability in a sample of registered nurses (12, 13). This was administered with the baseline measures.

Neurobehavioral status

We used the performance vigilance test (PVT) by Walter Reed Army Institute for Research (14). This is similar to the standard PVT sold by Ambulatory Monitoring but uses a Palm Pilot platform for administration. The stimulus is a bulls-eye that appears on the screen, and the respondent is to press a response button as quickly as possible after the stimulus appears, but not before it appears. The advantage of this test is that there is no learning curve, it is sensitive to fatigue, and is brief. In this study we used a 5 minute test with 2-10 msec foreperiods and 50 stimuli. We used mean response time over the 50 stimuli, standard deviation, and lapses (count of responses where response time is > 500 msec). The nurses were trained to use the device, then recorded their PVT at the beginning, middle and end of each shift.

We also administered a battery of cognitive tests developed for NASA. The WinSCAT (15) offers a variety of tests administered on a Palm Pilot, and for this study we selected five tests: code substitution, match to sample, procedural reaction time, running memory, and code substitution recall. From these tests, four parameters were calculated: cognitive throughput, accuracy, lapses and reaction time. This test took approximately 20 minutes to administer so was given only once per day at the end of each shift. There is a learning curve for this test, and nurses practiced at least two times on the test during baseline visit, and were requested to practice at least once more independently before the actual testing period.

We also measured other covariates including work demands, shift duration, commute time, and home demands (child care, elder care, student, second job) as described below.

Work demands

At the end of each shift, nurses were asked to rate their perception of work demands for that shift only, using nine items from the ICU Nurses' Workload Scale (16-18). Each item had a single word label describing the attribute to be scored, with a clarifying question to more fully explain the label. Items used a visual analog responses (0-100) anchored from low to high.

. Items included: (1) Mental Demand 'How much mental activity was required to perform your job (thinking, deciding, calculating, remembering, looking, searching);' (2) Physical Demand 'How much physical activity was required to perform your job (pushing, pulling, turning, lifting, activating)'; (3) Temporal Demand 'How much time pressure did you feel due to the rate or pace of your job'; (4) Effort 'How hard did you have to work (mentally and physically) to accomplish your level of performance'. (5) "How much effort did you have to exert in order to do your job today?" (6) 'Today, did you consider only patients' most evident problems and complaints' (anchors were not at all to extremely so); (7) 'Did you modify your standards to get the work done today' (not at all to extremely modified); (8) 'Today, could you attend to patients' minor problems' (not at all to very much so); (9) 'How insecure, discouraged, irritated, stressed, annoyed versus secure, gratified, content, relaxed and complacent did you feel during your shift today'. This was documented at the end of each shift in a paper diary that the nurses carried. Analyses of these data are in process because the factors derived from the items are not the same as the conceptualization by Dr. Gurses, so we have consulted her to assist us with interpreting the meaning of scale scores.

Shift duration

Shift duration was calculated from diary entries of actual start and end times of each work shift, and then categorized into four categories: '≤12.5 hours', '12.6-13 hours', '13.1-13.5 hours', and '≥ 13.6 hours'.

Demographic variables

Demographic variables included age, ethnicity and race, marital status (never married, married, separated or divorced, widowed). Dichotomous variables were used to measure if the nurse had children at home, was providing eldercare, or if she was a student or working second job. We also asked how many years the participant had been an RN and how many years she worked in her current job. Health risk behaviors included current smoking (yes, no), and a calculated body mass index (BMI) using self-reported height and weight values. These were classified into 'normal' (BMI < 25), 'overweight' (BMI 25-29.9), and 'obese' (BMI > 30) categories using standard definitions (19). These data were collected at baseline using paper and pencil instruments.

Methodology

The following sequence of procedures was followed during this study:

1. After completing informed consent, the nurse completed baseline measures, was instructed to use the study devices (actiwatch, Palm Pilot) and complete the diary. The nurse practiced using study devices several times during the session.
2. Data collection began on the second of two days off before the nurse worked three consecutive day or three consecutive night shifts. On the baseline day the nurse kept the diary, wore the actiwatch, and input sleepiness scores every two hours.
3. On workday 1-3 the nurse did the PVT at the beginning, middle, and end of her shift, the ARES at the end of the shift, completed the diary, and input sleepiness scores every two hours.
4. The nurse then returned all study materials to the data coordinating center.

Results

Description of the sample

Nurses ranged in age from 23 to 64 years, with a mean (SD) age of 36.9 (10.1) years. Average years working in nursing was 9.5 years (range 0.5-40). Nearly one-third were providing childcare regularly. School attendance, in addition to a full-time job, was reported by 22%, and was similar among both day and night shift nurses. Half were overweight or obese, but few (5%) currently smoked cigarettes.

Aim 1. To determine the number of hours of sleep nurses achieve over successive sustained-hour workdays

On the day prior to the first 12-hour shift, which was the second day of two days off, there was wide variation in TST, with 30% of the sample achieving 9 or more hours of sleep (Figure 1). Between 12-hour shifts, average TST was only 5.46 (1.07) after the first shift, and 5.62 (0.91) hours after the second shift. For the sample, TST between shifts ranged from 2.7 to 7.8 hours, with 1/3 getting less than 5.2 hours of sleep, 1/3 getting between 5.2 and 6 hours and the final third achieving 6.1 to 7.8 hours of sleep. TST varied widely after the third 12-hour shift, a day off for most of the sample. Sleep efficiency scores averaged 84% but ranged from 39% to 99%, with 43% of nurses falling below normative values for age (20, 21). Wake after sleep onset measured by actigraphy ranged widely, from 2 to 290 minutes, but averaged about the same on each study day (40-55 minutes).

When comparing nurses by shift, night shift nurses obtained a half hour less sleep than day shift nurses after the first 12-hour shift (5.7 vs 5.2 hours, t=-2.0 p=0.04); this pattern continued through the magnitude was somewhat diminished following the second shift (5.7 vs 5.5 hours, respectively). Thirteen percent of night nurses slept in several short rest periods rather than having one consolidated period of sleep, compared to day shift nurses who never exhibited this sleep pattern.

Figure 1. Total sleep time by study day,
RNs working three 12-hour shifts preceded by day off (N=80)
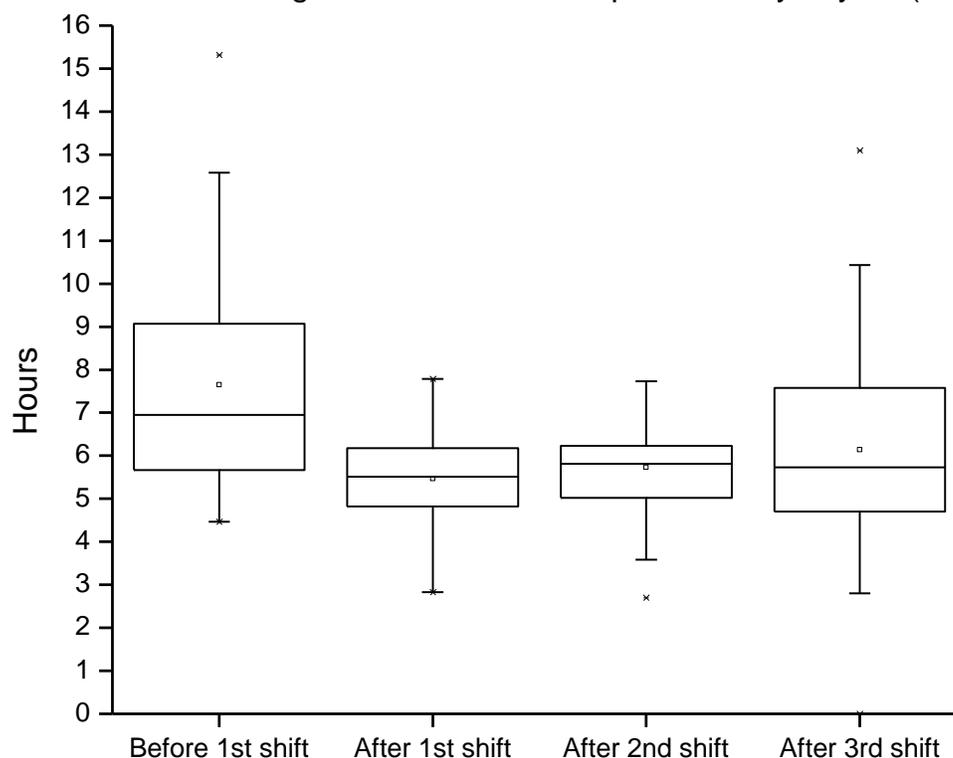
Aim 2.To measure sleepiness, fatigue, and changes in neurocognitive performance among nurses over successive sustained-hour workdays

Sleepiness

A generalized mixed linear model was used to assess the main effects of study day (1,2,3), shift (day vs night), and hour into shift (0,2,4,6,8,10,12) on Karolinska score. There was no difference between day vs night shift (3.07 vs 3.21, p= 0.14). Sleepiness increased significantly over study day (2.95, 3.09, 3.38 respectively for days 1,2, and 3, $p < 0.001$). Sleepiness also increased with hour into shift (2.72 to 3.89, $p < 0.001$). The shift by hour into shift interaction was significant ($p < 0.001$). with sleepiness increasing over the night shift (2.41 to 4.05) but remaining more stable over the day shift (2.53 to 3.87). There was no increase in sleepiness by hour into the shift over the three study days. There was a significant difference in sleepiness by study day when working day vs night shift (p=0.05). This is shown in Figure 2.

Figure 2. Sleepiness score (KSS) by study day and shift worked, nurses working three consecutive 12-hour shifts (N=80).
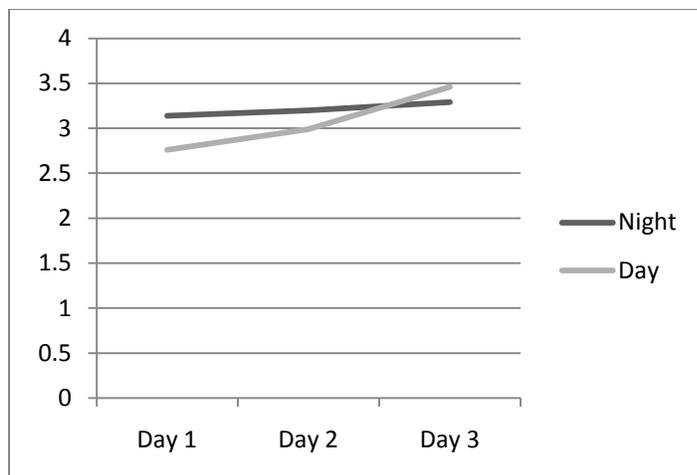
Fatigue

Fatigue scores were measured at baseline. There was surprisingly good variability in this measure of trait fatigue. Nurses had less chronic fatigue on average (mean=31, SD=20, range 0-80) than either acute fatigue (52(21), 7-80) or intershift fatigue (60(20), 10-97). When the 80th percentile was used as a cut score for "high" fatigue, 22% of nurses showed high levels of intershift fatigue.

Neurocognitive performance

These data were quite dense, with multiple parameters for each test. For the purposes of this report only the PVT data are shown, as the ARES data are still being analyzed. A generalized mixed linear model was used to assess the main effects of study day (1,2,3), shift (day vs night), and time into shift (beginning, middle, end) on mean reaction time scores. Mean reaction times were slightly different by shift (292 vs 309 msec for day versus night shift respectively, p= 0.013). There were no differences by study day, time into shift, or any two way interaction between these three factors. The difference shown for shift is a trivial difference.

Lapses were examined to assess patterns over study days, using only the final PVT of each day. There were no differences between study days. Using growth mixture modeling, a latent class analysis was performed on the lapse data, and three classes of responders were identified. A small number (25%) rarely or never lapsed during any of the study trials at the end of the shift. Most (64%) had a moderate number of lapses (3-10). There were 11% of nurses that lapsed almost continuously, suggesting a severe impairment of neurobehavioral performance. We were unable to find any pattern of variables that predicted membership in this class.

Aim 3.To describe the relationship between sleep, sleepiness, fatigue, and neurocognitive performance for successive sustained-hour workdays

Using mean reaction time as the criterion variable, we did not find any relationship between the number of hours of previous sleep, level of sleepiness, or level of trait fatigue on reaction time. These results were unexpected.

Additional Data:

Because sleep deprivation is caused by two sources (lack of time in bed and a sleep disorder) we decided to explore whether the most common screening instrument for screening adults for sleep apnea, the Berlin questionnaire, would hold up in this already sleep deprived sample. We did a telephonic screening of nurses to achieve a balanced sample of 10 positive and 10 negative screens for sleep apnea using this instrument and then sent the nurses for an overnight laboratory polysomnogram that was read by an accredited/boarded sleep physician blind to the screening result. We found that the Berlin had fair agreement (kappa=0.40) with the PSG result, but were surprised to learn that 40% of our sample had one or more sleep disorder diagnoses, including sleep apnea and restless leg syndrome. For two of the nurses, their level of sleep apnea was moderate (based on the number of respiratory disturbances per hour). None of the nurses suspected that they had a sleep disorder, and not all of them were overweight or obese.

Discussion

The most important finding is that nurses are not achieving much sleep between 12-hour shifts. There are a small number of nurses that have higher levels of sleepiness, intershift fatigue, and increased lapsing, however these are not consistently the same nurses. The hypothesized relationships between the predictors (sleep, sleepiness, fatigue) and tests of neurobehavioral performance were not supported. With TSTs of less than 6 hours over several nights, nurses may have difficulty remaining fully effective in their role, despite their level of education, experience and professionalism.

We did additional analyses and focus groups to understand why nurses were not getting adequate sleep. This study found that among nurses, shift overruns, delay to bed after night shift, and short time at home between shifts all detracted from TST. With TSTs of less than 6 hours over several nights, nurses may have difficulty remaining fully effective in their role, despite their level of education, experience and professionalism. In addition, lack of quality childcare leads many night nurses to sleep "when the baby is napping" which is never long enough for the nurse to get adequate rest between shifts.

Drowsy driving is rampant, nurses are concerned about this but see no alternative but to drive while severely fatigued.

These findings also lead us to be gravely concerned about the long term effects of 12-hour shifts on nurses' health. Because this sleep deprivation occurs over several days a week for many years during a nursing career, we are concerned about the long term cardiovascular, metabolic and immune disease risks on nurses, a large group of health professionals. As the nursing workforce ages (studies show mean age has increased to about 44 years), health consequences of sleep deprivation could lead many nurses to become ill or unable to practice due to consequences of their work schedules. The nursing profession must weigh the long term health costs to nurses against their high level of satisfaction with this shift schedule.

We also question whether 12-hour shifts will ever provide enough time to get adequate sleep. Our data show that time at home between shifts is extremely short for a substantial number of nurses, thus making it logistically impossible for nurses working these hours to obtain sufficient sleep. Our findings also suggest that the problem does not appear to be associated with the work itself, but in having adequate time to sleep between extended shifts, as TST was not related to work demands. Although some nurses in our study were exposed to high levels of work demands, it may be that their sleep opportunity was already so short, that homeostatic pressure induced sleep despite any residual work demand effects. Selection may also be operating, as nurses who better tolerate work demands and have lower stress reactivity effects on sleep may be more likely to remain in these 12-hour shift jobs than are nurses who do not. In the meanwhile, we propose that there are remedies by which to improve the quantity and quality of nurses' sleep. At the bare minimum, nurses must be able to leave promptly at the end of their 12.5 hour shift as the sleep opportunity time between shifts is already woefully inadequate. In addition, interventions such as education promoting the importance of sleep and the influence of circadian rhythms on sleep, with specific strategies for improving the quantity and quality of sleep for night shift nurses, could be helpful.

There was also evidence of extended sleep (9 or more hours) occurring before the first 12-hour shift in 29% of nurses, which is further evidence of chronic partial sleep deprivation, as nurses attempted to "catch up" from a continuing failure to achieve adequate sleep after months to years of working 12-hour shifts. Dorrian's 4-week diary study of Australian nurses also found this pattern of longer sleep on a day off prior to working a block of shifts, and attributed this to chronic sleep deprivation (22). It is difficult to compare these findings, as the Australian nurse sample worked varying shift lengths, including 8, 10, or 12 hours, with only 4% of nurses reporting shift overruns, and only 9% of nurses having less than 5 hours of sleep following their shift. Whereas, our entire sample worked 12-hour shifts, with over 50% having shift overruns, and one-third slept less than 5 hours between shifts. This suggests that the longer work hours in our study were related to the higher prevalence of shortened sleep.

Night nurses who delayed the time of lights out had increased odds of waking after sleep onset, though differences were not significant. We conceptualized

spontaneous arousals as an indicator of circadian waking pressure during the sleep period. On the other hand, disturbances that might not ordinarily wake a nurse sleeping at night (partner, child, pet, outside noise, minor discomfort) may have provided enough of an alerting signal to awaken night shift nurses when daylight circadian pressure was also present. Our hypothesis that nurses who care for children, have a second job, or combine work with being a student would have shorter sleep opportunity between 12-hour shifts (and thus shorter TST) was not supported.. Nurses with second jobs are often able to hold these positions because their compressed work schedule provides them with extra days off. Thus their sleep between shifts may not differ from that of nurses holding only one job, but they would have more sleep deprived days at the end of a week.

Conclusions

 Based on these data we recommend the following:

1. Sleep education should be incorporated into nursing education programs including self-care measures that nurses should adopt to achieve adequate and high quality sleep. Lee's 2004 curricular recommendations(23) have not been adopted and the nurses professional association (American Nurses' Association) has not made a strong effort to endorse the right to sleep health for nurses. NIOSH has already begun to assist in this goal with the development of online educational materials by Dr. Caruso, and we look forward to the release of these materials
2. Sleep disorder screening should become routine at three points in the healthcare system: (1) at all occupational medicine contacts for accidents and/or injuries; (2) at hire; and (3) periodic assessment as worker age in the job. As the science arm of occupational health NIOSH could promote the setting of standards based on science, and formed with an eye to equity in the workplace.
3. Hospitals could benefit from a diffusion-of-innovation program to move the science of sleep into the workplace, including scheduling of workers, protecting their safety at work and on the drive home. There is no need to wait for additional scientific evidence to accumulate. The shape of the program would depend on how dissemination is planned, but the fatigue risk management program described above would be a good framework for developing this toolkit.
4. Because of the serious "restricted range" problem with TST in this study, it is unlikely that significant findings will be achieved when using sleep as a predictor. The holy grail for this problem of workplace sleep deprivation would be an ecologically valid test of fitness-for-duty. Clearly tests of performance vigilance will not help here, based on these data. Newer forms of neurobehavioral testing such as sway measurement have shown promise in the laboratory, and are noninvasive, and easy to implement. Additional research into this area could be helpful for health care institutions to screen workers with serious sleep deficiencies at the time they appear for work.

Publications

Trinkoff, A., Geiger-Brown, J., Caruso, C.C., Lipscomb, J., Johantgen, M., Nelson, A., Sattler, B. Personal Safety for Nurses. (Invited and peer-reviewed). Chapter 26 in: R. Hughes, R., (Ed.) <u>Advances in Patient Safety & Quality – an Evidence-based Handbook for Nurses.</u> Published by Agency for Healthcare Research and Quality (AHRQ), 2008.

Geiger-Brown, J., Rogers, V., Trinkoff, A., Selby, V. Work schedules and stress among health professionals. Chapter 10 in: Halbesleben, J., (Ed.) Handbook of Stress and Burnout in Health Care. Nova Science Publishers, 2008.

Geiger-Brown, J. & McPhaul, K. (2011- In press). Sleep and occupational health. In Redeker, N., & Phillips-McEnany, G. <u>Sleep promotion in nursing practice: a guide to the evidence.</u> Springer.

Geiger-Brown, J., Trinkoff, A. (2010). Is it time to pull the plug on 12-hour shifts? Part I. The Evidence. Journal of Nursing Administration, 40(3), 100-102.

Montgomery, KL, Geiger-Brown, J. (2010). Is it time to pull the plug on 12-hour shifts? Part II. Obstacles and leadership strategiew. Journal of Nursing Administration, 40(4), 147-149.

Geiger-Brown, J., Trinkoff, A. (2010). Is it time to pull the plug on 12-hour shifts? Part III. Harm reduction strategies if keeping 12-hour shifts. Journal of Nursing Administration, 40(9), In Press.

Geiger-Brown, J., Rogers, V.E., Trinkoff, A.M., Bausell, R.B., Scharf, S.M. (2010). The relationship of work demands, circadian alerting and sleep opportunity to sleep deprivation in nurses working 12-hour shifts. (reviewed, under revision).

Geiger-Brown, J., Trinkoff, A.M., Rogers, V.E. (2010). Work schedules and self-reported sleep in registered nurses (reviewed, under revision).

Geiger-Brown, J., Rogers, V.E., Bausell, R.B., Kane, R., Scharf, S.M. (2010). Lapses of attention and reaction time in sleep-deprived nurses working successive 12-hour shifts. (accepted for publication).

Geiger-Brown, J. & Trinkoff, A. (2011). Work schedules and self-reported sleep in registered nurses. Journal of Environmental and Occupational Medicine. (accepted for publication)

Geiger-Brown, J. & Lipscomb, J. (2011). The health care work environment and adverse health and safety consequences for nurses. Annual Review of Nursing Research. (In Press).

Presentations (selected)

Geiger-Brown, J. (2010). Respite for Nurses. Rush University Medical Center, Chicago, Il. October 25, 26, 2010.

Geiger-Brown, J. & Trinkoff, A. (2010). Rethinking the 12-hour shift, sleep research and consequences. Maryland Nurses' Association, October 8, 2010, Annapolis Maryland.

Geiger-Brown, J. (2010). Keynote. 12-hour shifts for nurses, is it time to change the paradigm. Pennsylvania Organization of Nurse Leaders. September 16, 2010. Harrisburg, PA.

Geiger-Brown, J. (2010). Keynote. 12-hour shifts for nurses, is it time to change the paradigm. Illinois Organization of Nurse Leaders. March 26, 2010. Bloomington, Il.

Geiger-Brown, J. & Trinkoff, A. (2010). Is it time to 'pull the plug' on 12-hour shifts? Chesapeake Chapter, Maryland Critical Care Nurses. March 17, 2010. Towson, MD.

Geiger-Brown, J. & Trinkoff, A. (2009). Is it time to 'pull the plug' on 12-hour shifts? International Nursing Administration Research Conference. October 15, 2009. Baltimore, MD.

Geiger-Brown, J. Rogers, V., Kane, R., Trinkoff, A., Scharf, S. (2009). Short total sleep time in 12-hour shift nurses: slow unwinding, circadian disruption or time allocated to sleep. Associated Professional Sleep Societies. June 5, 2009. Seattle, WA.

Geiger-Brown, J. & Trinkoff, A. (2009). Is it time to 'pull the plug' on 12-hour shifts? International Nursing Administration Research Conference. October 15, 2009. Baltimore, MD.

Geiger-Brown, J. (2008).   Sleep, sleepiness and neurocognition in 12-hour nurses, preliminary results. Developing tomorrow's leaders in clinical and translational research, 2008 National Annual Meeting for CTSA, KL@, K12 and K30 Clinical

Research Scholars, NIH National Center for Research Resources and Association for Clinical Research Training, March 25, 2008.

Geiger-Brown, J. (2009).   Short total sleep time in 12-hour shift nurses: slow unwinding, circadian disruption, or time allocated to sleep? Empowering individual and team success, 2009 National Clinical & Translational Research Education Annual Meeting, April 14-15, 2009.

Geiger-Brown, J. (2009).   Short total sleep time in 12-hour shift nurses: slow unwinding, circadian disruption, or time allocated to sleep? Sleep 2009. American Academy of Sleep Medicine and Sleep Research Society joint meeting. June 5, 2009.

Geiger-Brown, J. Research Brown-Bag, University of Maryland School of Nursing, "Nurses' sleep and work schedules- how many shifts are too many?", 2007.

Trinkoff, A., Geiger-Brown, J. Schedules, sleep and injury, highlighting research in nurses. WorkLife 2007, Protecting and Promoting Worker Health, A National Symposium. National Institute for Occupational Safety and Health, CDC. Washington, DC.

Geiger-Brown, J. (2008). Work Hours. Our Patients, Ourselves: How to Advocate for a Safe and Secure Environment for Nurses and Patients. 2008 Nurse Alliance of PA Nurse Week CE Day May 6, 2008 in Allentown, Pennsylvania.

Geiger-Brown, J., Rogers, V., Trinkoff, A., Kane, R., Scharf, S. (2008) Sleep, sleepiness, and neurocognition in 12-hour nurses, Preliminary results. American Academy of Sleep Medicine, Sleep 2008, Baltimore, MD

Geiger-Brown, J., Trinkoff, A., Rogers, V., Brubaker, A. (2008). Impaired sleep, work schedule and home demands in nurses. American Academy of Sleep Medicine, Sleep 2008, Baltimore, MD

Geiger-Brown, J. Work hours in nurses: a case for more healthful schedules. Keynote: 100th anniversary of Good Shepherd Hospital, Allentown, PA, May, 2008

Geiger-Brown, J. Work schedules of nurses. What do we know? How should that inform practice? Research Brown Bag. University of Maryland School of Nursing, Baltimore, MD, June 2008

Geiger-Brown, J., Trinkoff, A. (2008) Inadequate and restless sleep in nurses related to adverse work schedules. 2008 National State of the Science Congress in Nursing Research, Washington, DC

Inclusion of Gender and Minority Subjects

The final sample size for this study was 80; all were female as was planned and justified in the project application.

	N (%)
Ethnicity (% Hispanic)	2 (2.5%)
Race	
White	47 (58.8%)
Black	12 (15.0%)
Asian	20 (25.0%)
AIAN	1 (1.2%)

<u>Inclusion of Children</u>

Not applicable.

<u>Materials Available for Other Investigators</u>

Data analysis and manuscript preparation continues. Other investigators interested in using these data may contact the PI in writing stating the data set they would like to access and for what research purpose. If the request is legitimate and does not involve data analysis underway by the research team, the PI will provide access to de-identified data via CD.

References

References

1. Trinkoff A, Geiger-Brown J, Brady B, Lipscomb J, Muntaner C. How long and how much are nurses now working? Am J Nurs. 2006 Apr;106(4):60,71, quiz 72.

2. Trinkoff AM, Le R, Geiger-Brown J, Lipscomb J, Lang G. Longitudinal relationship of work hours, mandatory overtime, and on-call to musculoskeletal problems in nurses. Am J Ind Med. 2006 Nov;49(11):964-71.

3. Trinkoff AM, Le R, Geiger-Brown J, Lipscomb J. Work schedule, needle use, and needlestick injuries among registered nurses. Infection Control & Hospital Epidemiology. 2007 Feb;28(2):156-64.

4. Van Dongen HP, Maislin G, Mullington JM, Dinges DF. The cumulative cost of additional wakefulness: Dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. Sleep. 2003 Mar 15;26(2):117-26.

5. Belenky G, Wesensten NJ, Thorne DR, Thomas ML, Sing HC, Redmond DP, et al. Patterns of performance degradation and restoration during sleep restriction and subsequent recovery: A sleep dose-response study. J Sleep Res. 2003 Mar;12(1):1-12.

6. Health Resources and Services Administration. National sample survey of registered nurses. 2004.

7. Lee KA, Kryger MH. Women and sleep. Journal of Women's Health. 2008 Sep;17(7):1189-90.

8. Ancoli-Israel S, Cole R, Alessi C, Chambers M, Moorcroft W, Pollack C. The role of actigraphy in the study of sleep and circadian rhythms. Sleep. 2003;26(3):342-92.

9. Buysse DJ, Reynolds CF,3rd, Monk TH, Berman SR, Kupfer DJ. The pittsburgh sleep quality index: A new instrument for psychiatric practice and research. Psychiatry Res. 1989 May;28(2):193-213.

10. Akerstedt T, Gillberg M. Subjective and objective sleepiness in the active individual. Int J Neuroscience. 1990;52:29-37.

11. Torsvall L, Akerstedt T, Gillander K, Knutsson A. Sleep on the night shift: 24-hour EEG monitoring of spontaneous sleep/wake behavior. Psychophysiology. 1989;26:352-8.

12. Winwood PC, Winefield AH, Dawson D, Lushington K. Development and validation of a scale to measure work-related fatigue and recovery: The occupational fatigue Exhaustion/Recovery scale (OFER). J Occup Environ Med. 2005 Jun;47(6):594-606.

13. Winwood PC, Lushington K, Winefield AH. Further development and validation of the occupational fatigue exhaustion recovery (OFER) scale. J Occup Environ Med. 2006 Apr;48(4):381-9.

14. Thorne DR, Johnson DE, Redmond D, Sing HC, Belenky G, Shapiro JM. The walter reed palm-held psychomotor vigilance test. Behavior Research Methods. 2005 2005 Feb;37(1):111-8.

15. Kane RL, Roebuck-Spencer T, Short P, Kabat M, Wilken J. Identifying and monitoring cognitive deficits in clinical populations using automated neuropsychological assessment metrics (ANAM) tests. Arch Clin Neuropsychol. 2007 Feb;22(Suppl 1):S115-26.

16. Gurses AP, Carayon P. Performance obstacles of intensive care nurses. Nurs Res. 2007 May-Jun;56(3):185-94.

17. Carayon P, Gurses AP. A human factors engineering conceptual framework of nursing workload and patient safety in intensive care units. Intensive Crit Care Nurs. 2005 Oct;21(5):284-301.

18. Gurses AP, Carayon P, Wall M. Impact of performance obstacles on intensive care nurses' workload, perceived quality and safety of care, and quality of working life. Health Serv Res. 2008 Dec 16.

19. Defining overweight and obesity [homepage on the Internet].

20. Budhiraja R. Objective sleep quality in midlife in the general population. Sleep. 2005;28:A112.

21. Ohayon MM, Carskadon MA, Guilleminault C, Vitiello MV. Met-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: Developing normative sleep values across the human lifespan. Sleep. 2004;27(7):1255.

22. Dorrian J, Tolley C, Lamond N, van den Heuvel C, Pincombe J, Rogers AE, et al. Sleep and errors in a group of australian hospital nurses at work and during the commute. Applied Ergonomics. 2008 9;39(5):605-13.

23. Lee KA, Landis C, Chasens ER, Dowling G, Merritt S, Parker KP, et al. Sleep and chronobiology: Recommendations for nursing education. Nursing Outlook. 2004 May-Jun;52(3):126-33.