Sleep Quality, Shift Work and its Effects on Stroop Task Errors in University Student Nurses: A Feasibility Study

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Abstract

It is estimated that as many as 98,000 people die due to medical errors that occur in hospitals worldwide any given year. Studies suggest there is a deterioration in nurses’ sleep quality as a result of rotational shift work and this impairs nursing work performance. The present study determined the feasibility of using nursing students to study the impact of shift work on their sleep quality, fatigue and executive function. Results suggested a future study would be feasible after changing certain aspects of the methodology. Most importantly is a need to employ a large enough sample to include a representative array of shift types typically found in the workplace. Second, an improved test of executive function is needed. Also, a daily measure of sleep outcomes, in addition to the monthly retrospective measures used, is warranted.

Keywords

Shift work, sleep quality, errors, executive functioning, feasibility, recruitment
Lay Summary

Industries in society require around-the-clock production. Health care providers such as doctors and nurses are expected to provide medical assistance at all hours of the day. To accommodate for a 24-hour, 7-day week schedule, hospitals employ shift work schedules. Shift work schedules include day shifts and night shifts. Shift work can disrupt the body's natural sleep patterns resulting in daytime sleepiness and fatigue. This fatigue has direct influence on neurocognitive abilities that can effect a nurse's performance, putting others and them self at risk. Fatigue is a main component in the decrease of neurocognitive function, specifically executive function and decision making. This research study used a sample of university nursing students and administered sleep quality and fatigue surveys as well as executive function test to determine the extent that shift work has on sleep quality and its influence on nurse's likelihood of make a decision error.
Co-Authorship Statement

This study was designed in collaboration with Dr. Alan Salmoni. I was responsible for writing the ethics application. Dr Alan Salmoni guided me through the research process and developing methods and procedures. I was responsible for participant recruitment, data collection and data analysis. I wrote the original version of the thesis with suggestions and feedback provided from Dr. Alan Salmoni to mold and finalize this thesis submission.
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Chapter 1

1 Introduction

Due to increasing economic competition, globalization and the need for an increased work force, the necessity of a 24-hour work day has emerged and resulted in the implementation of the shift system (Gök, Peköz, & Aslan, 2017). Many industries in developed countries use shift work to accommodate a continuous work force for 24 hours a day, 7 days a week. Shift work is used in many industries including health care. Nurses are a group of individuals who are often required to participate in shift work. The continuous demand for productivity, patient safety and alertness during a shift lasting 8 hours or longer can become mentally and physically strenuous and lead to workplace errors (Clendon, & Gibbons, 2015; Wagstaff & Lie, 2011). It is evident that shifts beyond the traditional eight hours increases staff fatigue, health care errors, adverse events and outcomes, decreased alertness and productivity (Keller, Berryman, & Lukes, 2009).

A solution for an around-the-clock work schedule is the implementation of shift work. Shift work is an efficient means of maintaining continuous work; however, worker productivity may be reduced due to fatigue, weariness, lack of sleep and many other factors (Tanabe & Nishihara, 2004; Roth, 2012). Although there is no agreed upon definition for shift work, it has been characterized as work existing outside the hours of 7 a.m. to 7 p.m. Shift work can be further broken down into sub-categories of fixed and rotating shift work. Fixed schedules use crews that always work the same shift. An 8-hour shift schedule uses one crew to work a day shift, another crew works an afternoon shift, and a third crew works the night shift. A rotating schedule has multiple crews that change shifts, often on a weekly basis. A crew might work days the first week, afternoons the next week, nights the third week and return to the day shift the following week (Shift Schedule Design, 2019).

While shift work has become a norm in society, it comes with a wide range of drawbacks. There is growing evidence that links shift work to numerous adverse health outcomes including risk factors for cardiovascular disease, metabolic syndrome, diabetes, hypothyroidism, specific types of cancer, fatigue and on-duty injury (Fekedulegn et al.,
2016). Thus, shift work, particularly night shifts or rotating shift work, has long been considered a significant occupational hazard. In the case of nurses, they may be exposed to HIV or another infectious agent through a needlestick injury (AIDSinfo, 2019). First responders work has been associated with insomnia, shorter sleep duration, daytime sleepiness, and overall poor sleep quality as a result of rotating shifts (Fekedulegn et al., 2016). In addition to health hazards to the employees, shift work may compromise workplace safety through its effect on mental capabilities (e.g., human errors).

Various rotating shift schedules exist. Durations of rotating shift schedules are 8- and 12-hour shifts. Registered nurses and nursing students typically work on a 12-hour rotating shift schedule that varies between day and night shifts. Nursing students during the preceptorship of their education work various types of 12-hour shift work schedules including: Continental, a shift pattern that uses 4 teams, and three 8-hour shifts with each team rotating through a sequence of varying day shifts, swing shifts, night shifts, or days off that last 2 to 3 days (Continental Rotating Shift Schedule | 24/7 Shift Coverage, n.d.), Waterfall schedule, 4 days on (day, day, night night) and 5 days off), and the DuPont schedule (features 12-hour rotating shifts, using four teams, to ensure coverage around the clock (The Pros and Cons of 3 Common Shift Work Schedules, n.d.). It is advised to avoid shift start times between 5 a.m. and 6 a.m. because early morning shifts are associated with shorter sleeps (Canadian Centre for Occupational Health, 2019). Employees should be kept in consideration when creating shift schedules as inter-individual difference influence how a person reacts to shift work (Van Dongen & Hans, 2006; Canadian Centre for Occupational Health, 2019). To ensure nurse safety outside and inside of work, a rest period of at least 24 hours is recommended to occur after each set of night shifts. As the number of night shifts increase, the amount of rest time should increase for employees before their next rotation.

A common shift schedule has a rotation period of one week, with five to seven consecutive night shifts. However, since it generally takes at least seven days to adapt to a new sleep pattern, as nurses are beginning to adjust, they are required to begin shift work again, interrupting their bodies’ natural mental and physical recovery processes that take place during restorative sleep (Niu et al., 2015). Many human physical functions
follow a daily rhythm or a 24-hour cycle that regulates eating habits and sleep patterns. These cycles are called circadian rhythms. Circadian rhythms regulate normal body functions such as sleep/wake schedules by regulating melatonin and cortisol levels. Under normal sleeping schedules, the body uses natural cues such as clock time, social activities, the light/dark cycle, and meal times to keep the various rhythms on track. However, when working night shifts, body temperature does not have as much variation during a 24-hour period as it would normally (CCOHS, 2019). The temperature rhythm and other body rhythms desynchronize; these rhythms also get out of phase with the person’s activity pattern. This desynchronization can lead to feelings of fatigue and disorientation. Acute experience of fatigue and disorientation as a result of rhythm desynchronization is known as “jet lag”. A continuous accumulation of poor sleep quality may lead to a prolonged state of “jet lag.” The prolonged state of “jet lag” type symptoms is known as shift work sleep disorder (SWSD). Symptoms of SWSD include excessive sleepiness when you need to be awake, alert, and productive, the inability to get necessary sleep, and insomnia. SWSD can cause trouble falling asleep, waking up before one has slept sufficiently, sleep that feels unrefreshing or insufficient, difficulty concentrating, lack of energy, irritability or depression, and difficulty with personal relationships (National Sleep Foundation, 2019). SWSD is a result of chronic disruption of the circadian rhythm by not allowing the human body to adjust to nature’s light-dark cycles (Roth, 2012).

Some work schedule designers feel that a longer shift rotation should be arranged so that the worker spends from two weeks to one month on the same shift allowing circadian rhythms to adjust more effectively. Issues arise when the worker reverts to a “normal” day/night schedule on days off, thus, possibly cancelling any adaptation. Longer periods of rotational shift work may lead to longer periods of social isolation due to conflicts with family and friends’ schedules (CCOHS, 2019). A longer shift system, ranging 2 weeks or longer, may reduce disruption to body rhythms because the readjustment of circadian rhythms is minimized. In the end; however, individual differences and preferences play an important role (CCOHS, 2019).
Ergonomics examines the relationship between human beings and the system in which they interact. Ergonomics focuses on improving efficiency, productivity and job satisfaction with the goal of minimizing errors. Failing to apply ergonomic principles is a key aspect that leads to workplace errors and accidents (Health and Safety Executive, n.d.). Ergonomics draws from many established scientific disciplines such as anatomy and physiology to understand how the body performs. Two factors that impact patient safety most are stress and fatigue (Kohn, Corrigan, & Donaldson, 1999). There is strong evidence linking fatigue and performance detriments in nurses making fatigue a known risk factor for patient safety (Flin, O’Connor & Crichton, 2008).

Nurse duties include the need to be focused and perceptive of their surroundings. Reductions in hand-eye coordination as well as impaired mental performance can result in adverse medical scenarios resulting from the detrimental effects of shift work on sleep quality (Williamson & Feyer, 2000). Additional fatigue sets in as the number of hours worked exceeds 8 hours, affecting physical and mental capabilities (CCOHS, 2019).

Studies observing sleep quality resulting from shift work reported a large percentage of participants suffering from sleep disruption or fatigue. An accumulation of poor sleep quality may lead to subsequent sleep debt and ultimately lead to sleep deprivation (Ontario Association of Fire Chiefs, 2011). Sleep deprived nurses had a higher number of medical errors than normal (Ramadan & Al-Saleh, 2014). Medication errors often occur, and the most frequent type of medication error was giving the wrong dose of medication to the patient. Other types of medication errors included wrong medication, wrong patient, missed dose, intravenous pump errors, and near misses (Grayson et al., 2005).

In a study completed by Williamson and Feyer (2000), they discovered that after 19 hours without sleep, performance is equivalent to that with a 0.05% blood alcohol concentration (BAC) and after 24 hours the effect is the same as a 0.1% BAC (Williamson & Feyer, 2000; Dawson & Reid, 1997; Ontario Association of Fire Chiefs, 2011). Fatigue resulting from poor sleep quality affects the nurses and also the patient to whom care is being provided. Research in the field of sleep quality and shift work is crucial to fostering safe environments for patients and workers inside and outside of work environments. Anecdotal findings have suggested that poor sleep quality as a result of
shift work also results in errors outside of work. Nurses commuting using a motor vehicle tend to experience more motor vehicle crashes (MVC) as well as near misses (Caruso, 2014). MVC and near misses can be attributed to drowsy driving (Gold et al., 1992). It is estimated that as many as 98,000 people die due to medical errors that occur in hospitals during any given year. This total exceeds death resulting from motor vehicle accidents, breast cancer or AIDS (Kohn, Corrigan, & Donaldson, 2000). In addition to the negative impacts of errors, accidental death or injury may result in a high-profile law suit costing the health care system millions of dollars per year. The total national costs in America for lost income, lost household production, disability and health care costs are estimated to be around $37.6 billion, $50 billion for adverse events, and between $17 billion and $29 billion for preventable adverse events (Kohn, Corrigan, & Donaldson, 2000). The potential health care costs due to poor sleep quality from shift work makes a strong case to continue research on sleep quality and workplace errors.

Conducting research in the field of shift work and nurse safety involves many factors necessary to consider prior to finalizing methods and data collection strategies. Feasibility studies are often completed prior to a full research study to gather information about different aspects of the research process. (Thabane et al., 2010; Blatch-Jones, Pek, Kirkpatrcik & Ashton-Key, 2018). Feasibility studies often focus on methodological issues such as willingness of participants to be randomized, number of eligible participants, characteristics of outcome measures, and response rates, etc. (Arain, Campbell, Cooper, & Lancaster, 2010). The primary purpose of a feasibility study is to ensure that the implementation of a study is practical and does not impose a threat to validity of the study’s outcomes (Tickle-Degnen, 2013). That is, a feasibility study focuses on conducting research to examine whether a research study can actually be done (Osmond & Cohn, 2015). Feasibility studies are normally conducted to assess the research and intervention process.

The assessment of feasibility in the present study was done using the Osmond and Cohn (2015) model. Various surveys and questionnaires were employed to measure sleep quality, fatigue and executive function in nursing students undergoing field work. The main participants were a group of student nurses in the final preceptorship of their
nursing program. The outcome measures included the Pittsburgh Sleep Quality Index (PSQI) and the Epworth Sleepiness Scale (ESS), as well as the Stroop test (ST), a measure of executive function.
Chapter 2

2 Literature Review

The rationale for the research project evolved from the research literature on shift work and its effects on sleep and sleep outcomes. An ergonomic focus in health care was the desired field to be examined. With this focus, there was an interest on whether the measures used would effectively measure sleep outcomes resulting from shift work. For the present study executive function, specifically decision making, was measured using the Stroop test as a surrogate for workplace safety, since decisional errors by health care workers has a known effect on patient safety (Reason, 2000)

2.1 Shift Work

Existing studies do not provide consensus on a definition for shift work. A simple definition for shift work extrapolated from current studies is a shift existing outside the hours of 7 a.m. to 6 p.m. (Caruso, 2014). Shift work offers a means of employing workers to cover a 24-hour period. Automotive shift work scheduling typically uses two or three, 8-hour shifts per day with different employees working each shift. Work positions often require employees to work rotational shifts, meaning that workers cycle through the different shifts over some time period, like a week or two weeks, with rest periods interspersed. Start and end times of shifts may vary based on the industry. For example, core hours of work for automotive industry workers are Monday to Friday with a day shift starting as early as 6:15 a.m. and ending at 3:45 p.m. and an afternoon shift starting at 5:45 p.m. and ending as late as 4:15 a.m., with mandatory weekends and overtime depending on production demands. (Toyota Motor Manufacturing Canada Ltd., 2019).

Nurses are typically employed using a “rotational shift work” schedule. Rotational shift work covers a variety of schedules that rotate or change according to a set schedule. These shift schedules are continuous (e.g., hospitals), running 24 hours per day, 7 days per week, or semi-continuous, running 2 or 3 shifts per day with weekends off. Workers
normally take turns on all shifts that are part of that employers shift system. Each shift type may produce potential social, health and family issues due to the constant lifestyle disruption it produces (CCOH, 2019). Nurses may be scheduled to work day and/or night shifts. A common nurse schedule is two, day shifts followed by two, night shifts, followed by two days off. This is known as the Dupont shift schedule.

The various shift types studied vary regionally and globally. Different provinces and hospitals employ different versions of shift types. The large differences create difficulties analyzing the exact effects that shift work has. A study by Gold et al. (1992) explored five variations of shift work. Shifts examined included: day/evening (in a month more than four day or evening, no nights), night (in a month more than eight night shifts, no day evening), rotator (in a month more than four day or evening shifts and more than four nights), day/evening/occasional nights (in a month more than four day or evening and one to three nights) nights, occasional day/evening (within a month, more than eight night and one to three day or evening) and part-time rotator (in a month four to seven nights and zero to three days or evenings). The research discovered that nurses on a rotational schedule were more likely to nod off at the wheel while driving home, implicating dangers of shift work to nurse safety away from a hospital setting. The study also discovered that rotational shift workers were 2.5 times more likely to report a near-miss accident and twice as likely to report any accident or error. (Gold et el, 1992). The study demonstrates the adverse effects of rotating shifts, as opposed to standard day or night shifts.

Rotational shifts have benefits that ensure employers increase production efficiency. Rotational shifts consisting of two 12-hour shifts, one day and one night shift allow the employer to minimize personnel and scheduling requirements. From an employer’s point of view, there are eight major benefits of 12-hour shifts: a) increased productivity, reduced errors due to minimal turnover throughout the day minimizing miscommunications which can translate to lower error and accident rates; b) increased continuity and accountability minimizing social loafing and increasing motivation to pass on a well done job to the following shift; c) reduced adaptation time minimizing workers need to ramp-up and adjust to each shift, (e.g., adjusting monitors and organizing tools,
etc.); d) higher project completion rate because employees are enabled to complete longer
tasks and projects on a given shift; e) reduced absenteeism due to financial significance
of a 12-hour pay period as well as accountability to co-workers; f) lower attrition and
turnover; g) improved morale resulting from decreased disruption in social and family
lives compared to 8-hour shift schedules, improving quality of work and homelife; and h)
more dedicated employees (Circadian, n.d.). During their three to four consecutive days
on duty under a 12-hour shift system, shift-workers tend to concentrate more on their
jobs. On 12-hour workdays, employees are more likely to avoid major social events,
excessive alcohol consumption or physically taxing activities in their fewer hours of free
time (Circadian. n.d.).

An ergonomic-based view of shift work may be different from that of an employer.
Cognitive ergonomics is a division of ergonomics (human factors) whose discipline and
practices aims to ensure appropriate interaction between work, product and environment,
and human needs, capabilities and limitations (International Ergonomics Association,
2019). Relevant topics to cognitive ergonomics are work stress, training, mental work-
load, and decision-making (CCOH, 2019), all of which may ultimately be related to
workplace safety and productivity. Sleep disturbances due to shift work are a result of
disruptions to the circadian rhythm (Potter, et al., 2016). The reason for sleep
disturbances is due to the desynchronization of circadian rhythms and homeostasis
resulting from night-shift work. As a result of desynchronization, a shortening of the
sleep period occurs and a permanent increase in sleep debt and excessive sleepiness (Zee,
Attarian & Videnovic, 2013). Sleep disturbances due to shift work are mostly related to
working hours outside the day shift and can cause serious medical, social and economic

2.2 Sleep and Sleep Outcomes

Adults 18-65 years are recommended to get seven to nine hours of sleep in order to feel
alert and to maintain a healthy body (National Sleep Foundation, 2019). Good sleep
quality is defined as sleeping at least 85 percent of the time while in bed, falling asleep in
30 minutes or less, waking up no more than once per night, and being awake for 20
minutes or less after initially falling asleep (National Sleep Foundation, 2019). When adults regularly sleep less than seven hours, they accumulate sleep debt. Sleep debt is defined as the summation of the number of hours recommended of sleep, subtracted from the total hours slept (recommended hours – hours slept = sleep debt). Sleep debt symptoms are similar to those of many sleep disorders because sleep debt may progress into a larger sleep disorder, such as SWSD (Ontario Association of Fire Chiefs, 2011). Specific symptoms of fatigue resulting from SWSD are: lack of concentration, poor judgment, reduced vigilance, reduced reaction times, reduced capacity for effective interpersonal communication, reduced hand-eye coordination, difficulty concentrating, and impaired performance (Wickwire, Geirger-Brown, Scharf, & Drake, 2016; Ontario Association of Fire Chiefs, 2011).

There is a relationship between the desynchronization in circadian rhythm and night shift work. Between 40% and 80% of industrial night workers have disturbed sleep compared to 10 to 15% of day shift workers (Kuhn, 2001). Good sleep quality is characterized as constant rest for seven to nine hours. The average length of sleep for night shift workers is 4.5 hours (Kuhn, 2001). Regularly getting less than seven hours of sleep accumulates as sleep debt, increasing a person’s chances of experiencing sleep deprivation or SWSD (Rheaume & Mullen, 2018). There are widespread long-term negative effects to shift work; 32% of night shift workers and 26% of rotating-shift workers reported long-term insomnia and excessive sleepiness (Drake, Roehrs, Richardson, Walsh & Roth, 2004).

The human body’s physiological functions are regulated by the sleep-wakefulness cycle. Humans are inherently programmed to sleep through the night and wake during the day. This standard sleep pattern is governed by two basic physiological processes: a) homeostatic sleep pressure is the pressure of needing sleep after consecutive hours of wakefulness and b) the circadian body clock promotes wakefulness during the day at usual times for activities and sleepiness at usual nocturnal periods (Stanojevic, Simic & Milutinovic, 2016). The homeostatic system tends to make us sleepier as the time awake goes on, whereas, the circadian wake-promoting signal prevents us from falling asleep.
These natural patterns are accommodated for nurses working day shifts as opposed to night shifts where the natural patterns are misaligned (Kuhn, 2001; Drake et al., 2004).

Consequently, circadian rhythm misalignment in relation to a rotational schedule, particularly the night shift, requires nurses to work on the “wrong circadian phase”. Night shift workers experience higher than normal levels of melatonin during their shift (Stanojevic et al., 2016; Lin et al., 2012). Physiological processes do not work synergistically to maintain adequate sleep-wakefulness balance when a person is exposed to night shifts. Night shift nurses combat the urge to fall asleep and fight to stay awake faced with homeostatic sleep pressure and absence of wake promotion (cortisol) from the SCN (Stanojevic et al., 2016; Lin et al., 2012). An inability to adapt one’s circadian rhythm further increases levels of fatigue promoting a decline in performance and increased risk of accidents and errors (Stanojevic et al., 2016).

Sleep-wake cycles are a biological rhythm determined by the circadian timing system that is predisposed by factors such as work schedule (Menon, Karishma & Mamatha, 2015). Extensive sleep deprivation results in psychosocial stress, psychiatric disorders, decreased work effectiveness, and learning disability (Menon, Karishma & Mamatha, 2015).

A study completed by Hasson and Gustavsson (2010) monitored the development of sleep quality in nurses, starting from the last semester in higher education with subsequent follow-ups in working life. The results imply a continuous decline in sleep quality among nurses during the three years of follow-up. The most pronounced short-term decline in sleep quality seems to occur in the transition between student life and working life. Thereafter, a less sharp decline in sleep quality occurs over the subsequent follow-ups.

Shift workers may use waking aids such as coffee and sleep aids, such as melatonin to assist in preparing the body for a daily routine or for sleep. Exposure to caffeine or sleep aids may increase the risk for developing acute and chronic illnesses (Lin et al., 2012). Nursing students with poor sleep quality have been found to be more depressed when compared to their peers (Menon et al., 2015).
Fatigue and sleepiness cause nurses to be less alert (Rheaume & Mullen, 2018). Nurses required to work night shifts are shown to perceive their sleep quality as poorer, reporting having poorer sleep quality on the PSQI than any other shift work group (Lin et al. 2012). Nurses on rotational shift schedules also report poor sleep quality compared to nurses on day shifts exclusively (Lin et al., 2012).

2.3 Measures of Sleep and Sleep Outcomes

2.3.1 Pittsburgh Sleep Quality Index (PSQI)

The PSQI has been a tool used to determine subjective sleep quality across many studies in various eastern and western countries with adaptations in multiple languages. The PSQI assesses several components (e.g., sleep quality, insomnia complaints, sleep schedules, duration, medication, or daytime dysfunction), measured through individual items (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The survey is simple, quick and a good tool to measure general sleep quality. The PSQI has been used as an insomnia diagnostic tool in many demographics including the university student population (Aloba, Adewuya, Ola, & Mapayi, 2007). As originally recommended by guidelines developed by Buysse, the PSQI is typically used in intervention studies to determine a change in sleep quality over seven days and up to a recommended 30-day test period (Buysse et al., 1989; Dietch, Taylor, Sethi, Kelly, Bramoweth. & Roane, 2016). The original test was developed by Buysse et al. (1989) using "good" sleepers (healthy subjects, n = 52) and "poor" sleepers (depressed patients, n = 54; sleep-disorder patients, n = 62). The study obtained acceptable measures of internal homogeneity, consistency (test-retest reliability), and validity. A global PSQI score greater than 5 yielded a diagnostic sensitivity of 89.6% and specificity of 86.5% (kappa = 0.75, p < 0.001) in distinguishing good and poor sleepers. The properties of the PSQI suggest its utility both in psychiatric clinical practice and research activities (Buysse et al., 1989).

Consistent with current literature, a study completed by Lin et al. (2012) using the PSQI scale determined that night shift nurses had the worst sleep quality (PSQI score: 9.04) compared to those who worked day shift (PSQI score: 7.32) or non-night shift (PSQI
score: 7.20). Other studies have shown similar findings with shift workers experiencing poorer sleep quality (Ruggiero 2005; van Mark et al. 2010; Wangsan, Chaier, Sawanyawisuth & Krisorn, 2019; McDowall, Murphy & Anderson, 2017). Ruggiero (2005) reported that nurses who worked a night shift or rotational shift had higher PSQI scores or poorer sleep quality (7.86 and 7.31 respectively) compared to those who worked a day shift (PSQI score, 6.37). A study of the general population by van Mark et al. (2010) also reported that shift workers had a significantly higher mean PSQI score compared to day workers (6.73 vs. 4.66), regardless of occupation.

2.3.2 Epworth Sleepiness Scale (ESS)

The ESS is a widely used measure, both clinically and in sleep research. The attractiveness of the ESS is its clarity of administration and the simplicity in its concept of measuring daytime sleepiness (Omachi, 2011). The ESS (Johns, 1993) is a self-report measure designed to assess recent levels of daytime sleepiness, with higher scores indicating higher sleepiness. The ESS is a simple, self-administered questionnaire that provides a measurement of a person's general level of daytime sleepiness. In an original study by Johns (1993), 180 adults completed the ESS, including 30 healthy men and women as controls and 150 patients with a range of sleep disorders. They rated the chances that they would doze off or fall asleep when in eight different situations commonly encountered in daily life. Total ESS scores significantly distinguished healthy participants from patients in various diagnostic groups, including obstructive sleep apnea syndrome, narcolepsy and idiopathic hypersomnia (Johns, 1993). ESS scores were also significantly correlated with sleep latency measured during multiple sleep latency tests and polysomnography. ESS scores of patients who simply snored did not differ from control participants (Johns, 1993).

The ESS has been shown to be useful in many sleep related studies, including nursing populations. Chaiard, Deeluea, Suksatit, Songkham, and Inta (2018) conducted a study over a 60-day period, using the Thai-ESS and a convenience sample of 233 full-time nurses with one-year of work experience. The participants were instructed to record seven consecutive days of sleep patterns in their sleep diaries and to complete a one-time,
self-administered questionnaires which included the ESS. The study determined the mean total sleep time was 6.2 hours. Of the total participants, 75.9% (n=167) experienced short sleep duration, 38.2% (n=84) experienced fatigue, and 49.5% (n=109) experienced excessive daytime sleepiness. Occupational errors were reported by 11.7% (n=25) of the nurses. Medication errors, incorrectly performed procedures and needle stick injuries were reported by 6.5% (n=13), 5.6% (n=12), and 4.7% (n=10) participants, respectively. The group that had a shorter sleep duration experienced more fatigue ($p=.044$) and excessive daytime sleepiness ($p=.001$) compared with the group that got an adequate duration of sleep. Although occupational errors were more common in the group with shorter sleep duration, the difference between the two groups did not reach statistical significance. Using a multivariate logistic regression, the study found that short sleep duration was a statistically significant predictor of excessive daytime sleepiness (OR=2.47, 95% CI=1.18-5.19). This study looked at the prevalence of daytime sleepiness in nurses and also shed light on the prevalence of errors and potential errors that can result from the effects of daytime sleepiness (Chaiard et al., 2018). In another study that used the Epworth Sleepiness Scale (ESS) in a questionnaire survey, Drake et al. (2004) reported that the prevalence of insomnia or excessive sleepiness was 32% and 26% in night and rotational shift workers, respectively, but only 18% in day workers.

The PSQI and ESS offer a valid and reliable measure of sleep outcomes. Shorter sleep durations have been linked to increased levels of fatigue in a nursing population (Chaiard et al., 2018). Increases of fatigue influence a decline in neurocognitive performance that may lead to fatigue related injury and errors (Caruso, 2014). The PSQI and ESS provide measures of sleep quality and daytime sleepiness that can influence cognitive errors and executive function.

### 2.4 Fatigue, Executive Function and Work Performance

Nurses’ productivity and work performance can suffer as a result of lack of sleep. Nurses have difficulties getting a full night of restorative sleep to replenish energy to their bodies and minds. Fatigue leads to reduced concentration and difficulty focusing; attributes
necessary for completing difficult tasks. Studies show slower reaction times and more errors occur during the night-shift (National Sleep Foundation, 2019). Poor functioning mental capacity can become a safety risk. Nursing is a shift-work industry involving the protection and care of patients while using potentially harmful tools requiring accurate and sometimes quick decision making. Shift work resulting in sleepiness may harm others because: a) sleepiness leads to slower reactions and interferes with decision making; b) working at night goes against the natural pattern of the body’s clock, even if a shift worker sleeps enough; c) a dip in alertness can come at night; d) people often misjudge their own sleepiness, believing that they are alert and capable of making good decisions, when in fact their judgment is impaired; e) on some occasions, shift workers are new to the job or have less experience than their day shift colleagues; and f) supervision is sometimes reduced on night shifts (National Sleep Foundation, 2019).

As reviewed by the National Sleep Foundation, there are many studies showing indirect safety risks for rotating nurses. A study on nurses showed that nurses who worked consistent night-shifts or rotating shifts were more likely to report poor sleep quality, nodding off at work at least once a week, drowsy driving to and from work, and reporting occasional accidents, errors, or “near misses” (Gold et al.1992). One large scale study of accidents showed a significantly higher rate occurring when workers started their jobs in the evenings, as well as higher accident rates for shifts longer than nine hours. Overall, accidents are more common at night and increase after successive night shifts (National Sleep Foundation, 2019).

Nurses who are less experienced in the field have been shown to commit more errors. There are negative correlations between the number of years in the field and the number of medical errors made by nurses (Landrigan et al., 2004). Nursing students have the least amount of practical field experience in the hospital setting. Work stress combined with academic stress may affect the student’s life and work experiences. The literature has shown a relationship between academic performance and sleep quality (Sun, Ling, Zhu, Lee & Li, 2017). Sleep difficulties and poor sleep quality have been found to be associated with poorer academic performance of nursing students. Nursing students with greater difficulties sleeping have been found to spend less time studying and earning
lower final grades than their non-nursing, student counterparts (Menon et al., 2015). A large portion of nursing students, approximately 74%, acknowledge deficits in their total sleep time and believe more sleep would result in obtaining better grades and a better academic performance (Thomas et al., 2017). These findings are not exclusive to only nursing students as students in general with better sleep habits earn higher grades (Tsai & Li, 2004). The association between academic performance and sleep quality presents a huge concern for nursing students, as this is a time when these students are expected to learn large amounts of new information and apply recently acquired knowledge practically during their time in preceptorship placements. Poor sleep quality interferes with memory formation and consolidation (Ellenbogen, Hulbert, Stickgold, Dinges & Thompson-Schill, 2006) which in turn may increase errors during a nursing practicum. It is necessary for student nurses to acquire the necessary skills early in their career as it has productivity and safety performance benefits. Relevant findings support the view that performance on simple or well-learned tasks, which can be executed in a more or less automatic way, can be upheld over long periods of time, while fatigued, after sleep deprivation, or after mentally demanding activities. On the other hand, complex tasks that require the deliberate control of behaviour are generally difficult to perform under such circumstances (Linden, Frese, & Meijman, 2003). It is reasonable to assume that nurses with less experience can be expected to make more errors while fatigued based on the findings by Linden et al. (2003). Lack of experience predisposes nursing students to creating more errors that are exacerbated by fatigue. Tasks performed by nurses involve elements of executive functioning that are affected by fatigue.

Fatigue is a usual reaction to prolonged performance and disruptions to regular circadian rhythm and sleep patterns (Stanojevic et al., 2016). Fatigue consists of different facets; however, it is not known which of these facets are most important for mechanisms of cognitive control. Pilcher, Morris, Donnelly and Feigl (2015) speculated that sleep is necessary to replenish depleted cognitive resources. Brain imaging studies of sleep-deprived participants have found that the greatest fall in cerebral metabolic rate is in the pre-frontal cortex (Harrison & Horne, 2000). Therefore, it appears that glucose levels in the pre-frontal cortex may be limited when people lack sleep. Jones and Harrison (2001) reported impaired performance on tasks of frontal lobe and executive function when
subjected to sleep reductions. Tests included measures of verbal fluency, response inhibition, creativity and planning skills (Jones & Harrison, 2001). The pre-frontal cortex plays a key role in executive functioning or conscious decision making. Lack of sleep may produce a diminished ability to make good decisions (Barnes, Schaunroeck, Huth, Ghumman, 2011; Stanojevic et al., 2016). Executive function, as defined by Nigg (2017) is the partially independent, top-down cognitive functions involved in top-down control. Top-down processing is a process by which the brain uses context and general knowledge to understand and interpret sensory perceptions Executive function controls behavior, emotion and cognition. Executive functioning is also responsible for goal-directed behavior and cognition (Nigg 2017).

A nurse’s ability to execute tasks precisely can be largely dependent on one’s ability to sleep in order to replenish glycogen stores in the prefrontal cortex. A study done by Linden et al. (2005) examined whether mental fatigue coincides with compromised executive function. They determined that executive functioning depends on one’s ability to actively hold goals and goal-related information. The overall results supported that fatigued participants showed more performance deficits than non-fatigued participants on tasks that required participants to flexibly generate and test hypotheses and to make plans (Linden et al., 2005).

A decrease in sleep quality as a result of shift work results in an inability to get consistently rested nights leading to levels of poorer sleep quality, as well as fatigue. Excessive sleepiness and abnormal fatigue in nurses, across various wards, may place nurses at greater risk of making medical errors and harming patients (Surani, Hesselbacher, Guntupallim, Surani, & Subramanian, 2015). Experience and tenure are predictors of medical errors. Student nurses who have been practicing for a fraction of time are more liable to make an error while at work, but even longstanding nurses are liable to make errors when fully rested (Kim, Kim & Kang, 2016; Ozturk et al., 2017). Student nurses are subject to medical errors like failure to comply with sterility and asepsis rules, mistaken patient identity, and administering wrong dosage of medications (Ozturk, at al., 2017)
The physical and mental state resulting from insufficient amounts of sleep can result in a reduced ability to learn, remember, consolidate memory, use sound judgement, focus and perform tasks safely (Stanojevic et al., 2016). The inability to perform tasks safely is especially true for tasks that require intensive or prolonged attention, much like tasks that are required of nursing students (Stanojevic et al., 2016). The prefrontal cortex is involved in higher-order cognitive processing. Sleep loss has altering effects on the activity of the prefrontal cortex influencing one’s decision-making. Consequently, fatigued nurses often are prone to use inadequate mental algorithms for problem solving that may lead to a misdiagnosis, risky decision making and adverse outcomes (Stanojevic et al., 2016). Along with decision making deficits resulting from a decline in prefrontal activity, nurses also experience a decrease in communicative skills as they become more sleep deprived. Communication skills are considerable since the nurse may have a difficult time finding the proper term or improperly interpret what others have said or written in a chart (Stanojevic et al., 2016). Overworked and tired nurses make mistakes in judgement causing medication errors, negligent patient care and accidents (Stanojevic et al., 2016; Kuhn 2001) Studies have shown that as work time increases above an 8-hour shift, the number of errors also increases (Stanojevic et al., 2016; Clendon, & Gibbons, 2015). Those who work a 12-hour shift versus an 8-hour shift nearly triple the chance of making an error (Stanojevic et al., 2016; Clendon & Gibbons, 2015) Elements of alertness, concentration and caution are aspects that are crucially important to a nurse’s job that suffer in quality as fatigue and shift duration increase (Stanojevic et al., 2016).

The function of sleep still remains largely unclear. Theories believe there is a restorative quality to sleep that allows our brain to restore brain function. This theory has been supported by the fact that sleep loss leads to cognitive deficits in humans (Krause et al., 2017). Cognitive deficits increase as the time spent awake increases (Koslowsky, & Babkoff, 1992). These deficits can be reversed by a night of sleep. Shift work impedes a person’s ability to acquire a restorative amount of sleep to properly alleviate cognitive dysfunction. Skills required for effective completion of nursing tasks are supported by the frontal lobe which is the center of decision making and impulse control in the brain (Bechara & Van Der Linden, 2005). Errors due to the inability to focus and consolidate
new memories or skills due to excessive fatigue are directly related to a decrease in frontal lobe function.

In summary, it is evident that shift work has a negative effect on sleep outcomes. In addition, it seems evident that poor sleep outcomes negatively affect work productivity and safety. It may also be that many of these workplace safety issues are related to (poor) executive function, and in particular decision-making speed and accuracy.

### 2.5 Measuring Executive Function: The Stroop Test (ST)

The Stroop Colour and Word Test or just Stroop Test (ST) is a neuropsychological test used extensively in experimental and clinical settings to assess executive function. The purpose of the ST test is to measure a person’s ability to inhibit cognitive interference (Macleod, 2015; Scarpina & Tagini, 2017). The ST test originally used three conditions. Two of the conditions representing “congruous conditions”, meaning participants were required to read names of colours printed in black ink and name different colour patches. Conversely, the third table, known originally as the colour-word condition and later the incongruent condition, where colour and words were printed in an inconsistent ink colour (for example, the word “red” is printed in blue ink). Thus, in the incongruent condition, participants are required to name the color of the ink instead of reading the word. The participants are required to perform a less automated task (e.g., naming ink color) while inhibiting the interference that arises from a more automated task (i.e., reading the word) resulting in what is known as the Stroop effect (Scarpina & Tagini, 2017). The Stroop effect is the difficulty experienced by participants when inhibiting the more automated process (Macleod, 2015; Scarpina & Tagini, 2017). While the ST test is widely used to measure the ability to inhibit cognitive interference, literature reports the ST’s application to measure other cognitive (executive) functions such as attention, processing speed, cognitive flexibility (Scarpina & Tagini, 2017), and working memory.

Existing literature suggests that multiple ST test scoring methods are available. Measurement of speed and accuracy of the performance are essential for proper detection
of the Stroop Effect. The reported scoring methods used in many current studies impede an exhaustive description of the performance on the ST. For instance, if only the reaction time is scored and accuracy is not computed, the consequences of possible inhibition difficulties on the processing speed cannot be assessed (Scarpina & Tagini, 2017). It must be noted that error rate and not response speed is an indication of inhibitory control (Scarpina & Tagini, 2017). However, calculating the error rate exclusively (e.g., response accuracy), without measuring reaction time, would be insufficient for an extensive evaluation of performance in the ST.

Gevers, Deliens, Hoffman, Notebaert & Peigneux (2015) disclosed that sleep deprivation selectively impairs top–down adaptation mechanisms, a mechanism involved in executive functioning. A change in attentiveness resulting from sleep deprivation is expected to impact cognitive control, as indexed by the Stroop test, by affecting top–down mechanisms. Importantly it is these top-down mechanisms that guide cognitive behaviours used in a nursing setting (Gevers et al., 2015).

### 2.6 Feasibility Studies

Conducting research involves many variables even prior to creating the methods and data collection. For this reason, feasibility studies exist and are done before a main study. The purpose of a feasibility study is to estimate parameters such as standard deviations, which may be necessary to estimate sample size (Arain et al., 2010). They may also examine willingness of participants to be randomized, number of eligible participants, characteristics of outcome measures, and response rates, etc. (Arain et al., 2010).

Feasibility studies are done to ensure that the implementation of a full study is practical and does not impose a threat to the validity of the study’s outcomes (Tickle-Degnen, 2013). According to the model proposed by Orsmond and Cohn, the objectives of a feasibility study include: (a) evaluation of recruitment capability and resulting sample characteristics; (b) evaluation and refinement of data sample collection; (c) evaluation of the acceptability and suitability of the intervention and study procedures; (d) evaluation of the resources and ability to manage and implement the study and intervention; and (e) preliminary evaluation of study outcomes (Orsmond & Cohn, 2015; National Institute for
Health Research Trials and Studies Coordinating Centre, n.d.). The present research was conducted using most of the Orsmond and Cohn evaluation criteria. It is acknowledged that the Ormsond and Cohn (2017) framework includes assessment of a research intervention and as such is not entirely applicable to the current study. Criteria (c) from the framework was omitted from the feasibility analysis of this research project.

Feasibility studies are completed prior to a major study to ensure rigor and ensure the effectiveness of proposed methods and procedures (Orsmond and Cohn, 2015; National Institute for Health Research Trials and Studies Coordinating Centre, n.d.) If the study is found to be feasible, a framework to guide future studies in the area can be developed. As such, the purpose of the present research was to determine the feasibility of using student nurses as participants. It also assessed the validity of using the chosen surveys and questionnaires as measures of sleep quality, fatigue and executive function resulting from shift work exposure.
Chapter 3

3 Methods

3.1 Institutional Approval

Ethics approval for this study (see Appendix A) was obtained from the Western University Non-Medical Research Ethics Board (NMREB protocol number 112413).

3.2 Participants

Participants in both the control and experimental group were recruited using a convenience sample. The primary investigator contacted professors in the School of Kinesiology to acquire approval to recruit participants for the control group. Multiple (5) classes with a minimum of 50 students were attended for recruitment. The recruitment process involved a 10-minute class presentation and students completing a consent form (see Appendix B) if interested in the study. Inclusion criteria for control participants included being a full-time undergraduate kinesiology student in third to fifth year in their program, able to read and write in English, and above the age of 18. The student investigator contacted the academic coordinator in the School of Nursing regarding delivering a presentation to the student nurses’ preceptor orientation meeting in order to recruit participants into the experimental group. Upon receiving permission from the academic coordinator, the student investigator attended a program wide orientation. Interested participants were advised to contact the primary investigator via e-mail to obtain more information about the study and to join the study if interested. Interested students returned a signed consent form. Inclusion criteria for the experimental group included students in the preceptor section of their program, able to read and write in English, and over the age of 18. Exclusion criteria for both groups included those who were unwilling to provide written informed consent or unable to complete questionnaires due to language or cognitive difficulties.
Ultimately 11 control participants (8 females/3 males) and seven experimental group participants (6 females/1 male) were recruited. Each participant was given a unique participant identification number after providing consent and were required to input this number as an identifier on all tests and surveys completed.

### 3.3 Measures

A demographic survey was constructed to collect general information on all participants (see Appendix C). The demographic survey was used to collect information on stimulant or depressant consumption as it related to sleep and sleep patterns. It also asked participants about current feelings of their own physical and mental well-being as these may also relate to sleep and sleep quality. Other information gathered included year in program, gender, work participation, wake/sleep aid use, and self-evaluations of mental health and stress as they relate to school and work.

For the experimental participants the nurses also answered questions regarding the shift work to which they were assigned (see Appendix C). Participants were asked to write down their assigned shift schedules to be experienced during their preceptor work. The actual shifts can be seen in Table 1.

Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI). The 9-item PSQI (see Appendix D) is an instrument used to retrospectively measure the quality and patterns of sleep in adults. The instrument distinguished from poor to good sleep over the last month by assessing 7 domains/components measured using individual questions for each: subjective sleep quality (question 9), sleep latency (question 2 and 5a), sleep duration (question 4), habitual sleep efficiency (question 1,3 and 4), sleep disturbances (question 5b to 5j), use of sleep medication (question 6), and daytime dysfunction (question 7 and 8). Each question used a Likert scale from 0 to 3, where 3 reflects the negative extreme (poor sleep) (Buysse et al., 1989; Smyth, 2003). A higher total score (maximum score of 21) indicates poorer sleep quality. In addition, a total score greater than 5 indicates poor sleep quality.
The Epworth Sleepiness Survey (ESS) was used to retrospectively assess daytime sleepiness. The ESS (see Appendix E) is an 8-item scale to retroactively determine the participants likelihood of dozing off in specific situations during the past 30 days. Each situation is rated on a Likert Scale from 0 to 3 to determine the likelihood of dozing off (Kendzerska, Smith, Brignardello-Petersen, Leung & Tomlinson, 2014; Johns, 1993). A total score (maximum of 24) indicates degrees of daytime sleepiness in participants. ESS levels of sleepiness are grouped into 5 categories. Categories range from 0 to 5 (Lower Normal Daytime Sleepiness), 6 to 10 (Higher Normal Daytime Sleepiness), 11 to 12 (Mild Excessive Daytime Sleepiness), 13 to 15 (Moderate Excessive Daytime Sleepiness), and 16 to 24 (Severe Excessive Daytime Sleepiness).

Executive functioning was measured using the Stroop test (ST). The ST test is an attentional assessment test (Dixit & Mittal, 2015) designed to measure speed and accuracy of decision making. The task (http://www.onlinestrooptest.com/; see Appendix F) consisted of colour words displayed with different ink colours. (e.g., the word RED displayed in blue ink) being displayed on a computer screen. There were two types of possible trials: congruent (word and ink colour matched) trials and incongruent (word and ink colour different). Participants were instructed to identify the ink colour of each stimulus as quickly and as accurately as possible. Stimulus words would appear on screen and participants would react by using their mouse cursor on their computer (touch-pad or conventional mouse) to click on a box with the corresponding correct colour. The ST test used five colours: black, blue, yellow, green and red displayed on the screen. The ST test consisted of 20 trials. The trials were split into 5-congruent trials and 15-incongruent trials and was administered online. Mean response times for the congruent and incongruent trials were recorded. Response inhibition is a key factor affecting response time as participants must inhibit the tendency to respond to the semantic meaning of the written word rather than the colour of the ink. Since the computer mouse was used to initiate responses (versus key presses which require relatively little movement to initiate the chosen key), the response time reported was composed of the reaction time and the movement time to execute the chosen response (Houlihan, Campbell, & Stelmac, 1994). Poor executive function as a result of fatigue may lead to increased workplace errors and therefore the ST was used as a surrogate to replace the measurement of workplace errors.
3.4 Procedures

After providing consent, participants were given the initial battery of instruments to be completed. At baseline the instruments required to be completed were a 22-item demographic survey, the PSQI, the ESS, the ST test, and for the nurses a work information form. All surveys were distributed online using Qualtrics and were done by each participant at their own personal computer and a setting and time of their choice. Participants were given separate links to access each survey. It was not mandatory but recommended that all surveys be completed at the same time.

Subsequent to the baseline data collection, participants were sent a prompt every four weeks to complete the PSQI, ESS and ST. Each monthly round of tests was expected to take no longer than 30 minutes to complete.

Participants were sent individual URL links to each individual survey/test. Upon receiving the e-mail participants were expected to open each individual URL link immediately; however, note that there was no deadline by which surveys/test needed to be completed. Completion was done consensually and when convenient. The Qualtrics website informed the researcher of who completed each survey/test. The website also indicated the time it was completed as a cross-reference to determine the time the participant completed their bout of surveys in relation to previous survey bouts.

3.5 Design

Volunteer participants were recruited into one of the two study groups: the experimental group (student nurses) and the control group (third to fifth year kinesiology students). The timeframe for the testing during the study included a baseline assessment, followed by the administration of the tests every four weeks. This meant that over the 12 weeks of the study participants were required to complete the testing a total of four times. The primary dependent variables were the total PSQI score, the total ESS score, and the mean ST test response times and accuracy for congruent and incongruent trials. A timeframe of three months was judged an effective time line based on the literature review. Studies have utilized only a one-off measurement from the previous 30 days in their assessment.
of sleep quality (e.g., Aloba et al., 2006) and daytime sleepiness (e.g., Drake et al., 2004). The 12-week longitudinal timeframe was expected to be sensitive to changes in the sleep outcomes and ST test performance.
Chapter 4

4 Results

4.1 Evaluation of Recruitment Capability and Sample Characteristics

Nursing students undergoing shift work were chosen as an experimental group due to the large group available on campus. Following REB approval, academic advisors were contacted to ensure departmental consent to participate in the study. Following departmental consent, only one orientation session, consisting of approximately 100 students, was available in order to recruit participants for the experimental group. Since only seven (experimental) participants were ultimately recruited from this meeting, experiencing a variety of shift types (see Table 1), a much larger sample of nursing students would have been advantageous. This would ensure a more representative sample of different shift types.

Control students were more widely accessible than nursing students. Following REB approval, professors lecturing upper year kinesiology courses were contacted to provide a presentation. Lecture times typically occur 2-3 times a week for a full semester allowing plenty of opportunity to gain first hand exposure to students for recruitment. However, even with more student access only 11 control participants were successfully enrolled in the study. A more effective marketing strategy to recruit control (and experimental) participants would be necessary to increase sample size. In addition, in retrospect, there was no need to recruit control participants from a single academic program such as was done here.

4.2 Evaluation and Refinement of Data Collection Procedures

The ability to complete the sleep surveys and ST test online was intended to improve feasibility by making access straightforward, particularly for out-of-town participants.
However, it came with drawbacks. Participants expressed difficulties accessing the Qualtrics surveys in the follow-up data collection. Qualtrics requires internet access on phones or a computer device. Control participants were administered surveys over the Christmas holidays where they may have been without internet service or access to a device. Nursing students in a hospital environment may not have had access to a computer or internet service, impeding completion rates.

Standardized tests (PSQI and ESS) as sleep outcome measures were chosen to increase validity and reliability. Participants were encouraged to email if they had questions about completing the PSQI and ESS surveys. Whereas the surveys themselves posed no difficulties, some e-mails were received from participants complaining of compatibility issues with their personal computers. Compatibility issues typically were the need to update Flash or closing the website because of pop-ups. Of the total data collected, only 22% of participants completed all the PSQI and ESS surveys over the 12 weeks.

To obtain an online version of the ST, the Cambridge Brain Science Institute (at Western University) which offers a catalogue of cognitive and executive functioning tests was contacted. Permission was granted to use the online 2-colour ST test on the CBSI website. However, due to software errors making the test non-functional, the student researcher was forced to find another source. One option would have been to create a tailored online ST; however, because of financial restrictions, it was not feasible to pay for the construction of a tailored ST test. This meant that other online sources of the ST test needed to be explored. For the purposes of the present research, the ST had to provide both reaction (decision) time and accuracy measurements. Many ST test websites offered one measure but not the other. Eventually, a marginally acceptable version of an ST test was found. Participants were encouraged to reply to the e-mail regarding questions or difficulties navigating the ST test provided. Four e-mails were received. The ST test was not compatible with the web browser some participants were using and they were instructed to use Google Chrome or Safari. The ST test also required participants to enable Flash which some participants were reluctant to do.
The ST test used came from a third-party website that required downloaded software. This may have been flagged as unsafe internet territory on some computers. As a result of the issues mentioned above, the ST test had the lowest rate of completion. The ST data collected was also difficult to interpret. The error response data was acceptable as the test provided a number denoting the number of correct responses to congruent (number out of five) and incongruent trials (number out of 15). Response time, however, was less clear. Contact with the website company was attempted via the e-mail address provided; however, no response was received. Since participants were required to use the touch pad on their computers to respond to the stimuli, it appeared that the scores provided included both movement time (different movements across the touch pad for different ink colors) and reaction time. It was not possible to parse out the movement times leaving reaction times (the desired metric). Thus, the data provided was the total response time for a given set of stimuli.

Of the 11 enlisted control participants and seven enlisted nurses, a total of one control and three nurses provided complete data. Complete data was defined as completion of a demographic survey, the PSQI, ESS, ST test and work information forms at baseline and every four weeks, for 12 weeks (complete data is baseline plus three rounds of the PSQI, ESS, and ST). The PSQI had the highest completion rate being completed for the full 12 weeks by 12 participants (Control n=7/12 and Nurses n=5/7). The ESS was completed by nine participants (Control n=7/11 and Nurses n=2/7) for the full 12 weeks. The ST test was completed by three controls (n=3/11) and three nurses (n=3/7).

Surveys that did not require background knowledge or practice to complete were chosen. The PSQI, ESS and work information forms were created for a general population (Reis, Pilz, Keller, Roenneberg & Paiva, 2017; Buysse et al., 2008; Johns, 1993). Each survey included a brief explanation of how to answer and complete the survey and did not include scientific jargon in their descriptions. Questions from participants involving clarification of the questions posed were requested; however, no queries were received.
4.3 Evaluation of the Resources and Ability to Implement the Study

The study was designed with the intention of being run and operated with one researcher. In retrospect, the original study design of weekly, in-person meetings may have proven to be onerous and may not have been feasible with only one researcher. Upon procedural revisions, the data collection was changed to utilize one monthly e-mail to each participant and did not require in-person meetings. The change in procedure ensured data collection was feasible with a single researcher with out-of-town participants and could have accommodated a much larger number of participants.

All assessment and survey e-mails prompts were sent by the student investigator. Expert personnel were consulted to assist with transferring the PSQI and ESS surveys to an online electronic version. Personnel needs were kept to a minimum because of the online methodology ultimately created. However, participants required highly individualized e-mail scheduling because of the different dates the first round of surveys were completed. Email prompts were sent every 30 days after the time of the completion of the baseline bout of surveys prior to shift work exposure.

Financial resources were a limiting factor to creating a tailored version of the ST. The student researcher met with faculty to discuss having a tailored ST test created. Due to a lack of financing, and backing from corporations, or research sponsors, the tailored ST test could not be created. The free online version was settled on.

4.4 Preliminary Evaluation of the Data

As demonstrated in Table 2, the overall mean PSQI for control participants and experimental participants at baseline measurement was 5.94 (sd=2.622). According to the PSQI grading system the mean values, the control and experimental groups experienced poor sleep quality at the beginning of the study. Table 3 demonstrates that the mean ESS scores were 8.3 (sd= 3.289) for control and experimental participants. These values indicate higher than normal daytime sleepiness.
Looking at the PSQI and ESS scores in Tables 2 and 3 after 4, 8 and 12-week measurements shows no signs of a trend for deteriorated sleep quality or increased sleepiness over time. Control and experimental group means for PSQI was 4 after week 12 suggesting that as a whole participants did not experience poor sleep quality as per the PSQI scoring system. Control and Experimental group means for ESS remained in the same sleepiness level as determined by the survey scoring parameters, being 7.14 and 9.5 respectively, suggesting no change in daytime sleepiness over the testing period.

As demonstrated in Table 4, baseline response time scores (movement and reaction time) for control and experimental groups were 13.1 s and 14.1 s respectively. Over the 12-week period, response times for both groups improved, showing a decrease in scores. Only one control participant completed the final ST test at week 12 with a response time of 8.1 s. The mean ST test response time for the three experimental participants decreased 10.8 s from baseline to week 12.

The preliminary analysis of all participants with 100% adherence rates for all data sets (n=4) revealed the following at baseline: nurses average PSQI and average ESS were 5 and 9.3 respectively. These scores qualify the nurses as having poor sleep quality and considered to have higher than normal daytime sleepiness. Mean incongruent accuracy and response times for the ST test at baseline were 13.6/15 (91%) incongruent response accuracy with mean response times of 15.24s. The individual control participant with completed data had an initial measurement of PSQI and ESS of 6 and 12. This means the participant had poor sleep quality and mild excessive daytime sleepiness.

The individual control participant with complete adherence had a ST test response time of 13.1 s. After 12 weeks of shift work, the nursing group had a mean PSQI and ESS of 4 and 9.5 demonstrating no change of sleep quality or daytime sleepiness over a 12-week shift work schedule. ST test times for the incongruent trial was 11.3 s and incongruent response times were 10.7 s. ST accuracy of incongruent trials was 100% and 98% accuracy for control and experimental groups respectively.

Grouping baseline measures for both groups showed that PSQI and ESS scores were correlated (r=0.473, p<.05). This correlation between PSQI and ESS suggests, as
expected, only a marginal overlap between the two measures of sleep outcomes. The baseline measures of PSQI and ST test produced a weak, non-significant Pearson correlation ($r=-0.279, p>0.05$). The Pearson correlation between ESS and ST test scores was also non-significant, $r=0.137, p>0.05$). It was hypothesized that there would be significant positive correlations between sleep quality, fatigue and ST test response times. The data does not support this hypothesis.
Table 1: Experiment (Nursing) Participant Shift Work Schedule.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>201</td>
<td>3 days/1 night; 5 off</td>
</tr>
<tr>
<td>202</td>
<td>4 on (day, day, night, night)</td>
</tr>
<tr>
<td>203</td>
<td>2 days on, 2 nights on, 4 days off</td>
</tr>
<tr>
<td>204</td>
<td>Monday, Tuesday, Friday, Saturday, Sunday, Wednesday, Thursday 12-hour shift alternating days and nights every 2 weeks</td>
</tr>
<tr>
<td>205</td>
<td>Wed, Thurs 4-9 p.m.; Fri, Sat 5-3 a.m.; Sun 11-4 p.m.</td>
</tr>
<tr>
<td>206</td>
<td>Day, day, night, night, 5 off</td>
</tr>
<tr>
<td>207</td>
<td>Jan. 18-20 Day, Jan. 24-25 Day, Jan. 28-29 Night</td>
</tr>
</tbody>
</table>

Note. This table shows the nurses shift work schedule data pulled from the demographic survey and work information forms
Table 1: PSQI Scores for Control and Experiment (Nursing) Participants

<table>
<thead>
<tr>
<th>Participant Number</th>
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<th>PSQI 2</th>
<th>PSQI 3</th>
<th>PSQI 4</th>
<th>Mean PSQI</th>
</tr>
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</table>

*Note.* Participant numbers in the 100s indicate control participants and in the 200s experimental participants. Scores >5 indicate poor sleep quality. Empty cells denote the participant did not complete the survey.
Table 2: ESS Scores for Control and Experiment (Nursing) Participants

<table>
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<th>ESS 3</th>
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*Note.* Participant numbers in the 100s indicate control participants and in the 200s experimental participants. Scores >5 indicate higher than normal daytime sleepiness. Empty cells denote the participant did not complete the survey.
Table 3: Control and Experiment (Nursing) Participants Accuracy and Response Times of Incongruent ST trials

<table>
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<th>Participant</th>
<th>Incongruent Accuracy 1</th>
<th>Incongruent Response Time 1</th>
<th>Incongruent Accuracy 2</th>
<th>Incongruent Response Time 2</th>
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</tbody>
</table>

Note. The table demonstrates the accuracy and response times of incongruent Stroop test trials for control (100s) and experimental participants (200s). Accuracy scores are the number of correct responses out of 15 trials. Response times are in seconds. Empty cells denote the participant did not complete trials. Scores of zero were due to not following proper Stroop test instructions and were not included in overall means.
Chapter 5

5 Discussion

The purpose of this study was to establish whether the use of online surveys and tests to track the effects that shift work has on sleep outcomes and executive functioning of nursing students is feasible. Feasibility was determined using four of the five criteria laid out by Orsmond and Cohn (2015): recruitment and sample characteristics, procedures and measures, resources and ability to manage the study, and preliminary evaluation of participant responses.

5.1 Evaluation of Recruitment Capability and Sample Characteristics

An increase in the number of participants would have been desirable. There were various preceptor sections throughout the academic year, however, only one was available at the time of testing with a longer time-frame, the researcher may have been able to increase the number of participants by attending more orientation presentations to recruit the student nurses. The recruitment of control participants was also challenging, requiring a shift from using solely fourth-year kinesiology students to kinesiology students in third, fourth and fifth years. Advertising the research around campus and opening up the study participation to all students may also have increased control group participation. It is recommended that future research should increase the incentives to increase participation rates and adherence of both experimental and control groups. For example, a study done by Fucito et al. (2017) demonstrated that offering a research project that allows a participant to curb perceived negative habits and promote positive life skills and beneficial habits increased recruitment.

Ensuring a good match between experimental and control participants is always challenging (McLeod, 1970). Expanding the demographic survey to include more extensive data on a student’s work life would be one way to check whether the two
groups ultimately matched. An additional strategy might have been to use nursing students not doing shift work as the controls.

With field studies in ergonomics it is normally a given that support for a study is obtained from both management and labour/unions (Salmoni, Cann, & Gillin, 2010; Burke, & Greenglass, 2001). A key aspect to recruitment would be getting support from union and management. Agreement from an entire medical facility ahead of time to increase participant buy-in to the research project would be essential. Support from union and management would allow the researcher to improve interest and “sell” the project. With student nurses as participants it would be necessary to get complete buy-in by the participating department, perhaps enlisting the department to help increase the motivation for students to take part in the study.

A study by Kim et al. (2016) provided evidence indicating that novice nurses made a higher number of medication errors relative to experienced nurses. The average frequency of errors committed by nurses is highest in nurses whose tenure was less than one year (Kim et al., 2016). In a future hospital-based study of the effect of shift work, using full-time nurses rather than nursing students it would be advantageous to include participants with different levels of experience, as the impact of sleep quality on decision making may interact with work experience.

The present sample consisted mainly of white females. Men are generally underrepresented in the nursing community. Males account for 9.5% (n=37,636) and females account for the other 90.5% (n=389,648) of the total nursing population in Canada (Falstaff, 2016). The sample group for this study was comprised of one male nurse (14%) and six females. The ratio of male to female student nurses in the present study is consistent with the rates of registered nurses in Canada. An additional question for future research may be whether the impact of shift work on sleep outcomes is similar to for males and females.
5.2 Evaluation and Refinement of Data Collection Procedures

The procedural change from in-person meetings to the use of online distributed surveys was a (mostly) successful data collection procedure. Assigning participants with participant numbers maintained their anonymity through the data collection process. In-person meetings may not be necessary, and a waste of human resources given the simplicity of the surveys and test used. Surveys such as the PSQI, ESS and ST test are simple and appropriate for a general population. For example, all submitted sleep-related surveys were completed in their entirety.

One nursing student participant mentioned that a daily measure of sleep quality may have been advantageous. The protocol used assessed sleep quality and daytime sleepiness retrospectively after one month. The ST test was also administered only once per month. To track the evolution of sleep and executive function outcomes over time it may be beneficial to measure these variables more frequently (e.g., daily. Whereas sleep quality may deteriorate over time there may also be acute effects of unusually demanding work periods. An individual’s previous day experiences have been shown to be predictors of morning fatigue. Sonnentag and Bayer (2005) measured fatigue using questionnaires completed in the morning before work and found significant relationships between previous day experiences and morning fatigue. This study used a similar method and measured fatigue with three items from the Profiles of Mood Scales (“tired” “exhausted”, “worn out”; McNair, Lorr, & Droppelman, 1971). Each morning, the log book used questions to assess the amount that the participant feels tired, worn-out and exhausted after a night’s sleep. As previously mentioned, increased levels of fatigue correspond to decreased levels of recovery. The question “describe how you feel today” was followed by a 5-point scale in which students could grade their level of each of the three measures of fatigue. The scale ranged from (1) “Extremely” to (5) “Not at all”, and a higher score indicated less fatigue and more recovery. Daily measures of sleep outcomes are available (Sonnentag & Bayer, 2005).
An experimental period of 12-weeks seemed to be a sufficient amount of time to collect data and expect a change in sleep quality, levels of fatigue and ST test scores (Niu at al., 2017). The literature review highlighted the effectiveness of the PSQI in diagnosing subjective sleep quality over one test session (Buysse et al., 2008; Buysse et al., 1989; Dietch et al., 2016). However, a study done by Niu at al. (2017) used a 12-week study period, measuring participants at weeks 4, 8 and 12. Niu et al. (2017) observed significant differences in various facets of sleep outcomes according to wrist actigraphy data over the 12-week period. The research design completed by Niu et al. (2017) controlled for three rotating shifts allowing a comprehensive understanding of sleep patterns and quality of nurses with different work shifts (Niu et al., 2017). The current work study did not control for shift type, presumably affecting the variation of PSQI and ESS scores observed.

Access to shift work schedules would improve timing of survey administration to ensure all participants are measured during the same period of their shift work schedule. Controlling for time of survey administration would control for circadian rhythm variances among participants. More frequent testing might also allow the researcher to determine the effectiveness of rest periods in replenishing biological resources.

Changing the ST test is imperative for a good executive functioning measure. An ST test must measure reaction time. Reaction time would be best suited if the test used response keys (e.g., keyboard letters) to respond to congruent and incongruent stimuli as opposed to moving a cursor on screen by moving across the computer’s touchpad. More ST test trials would also allow for better assessment of decision errors/accuracy to be made. The current test only used 5 congruent and 15 incongruent trials. Participant performance was very accurate which could mean that response times were slower than normal or that there was no fatiguing effect on accuracy. Participants averaged only one incorrect response per ST test session. This small number of error rates did not provide significant variation across participants or conditions. Future ST testing should use more trials to provide a more sensitive measure and to demonstrate individual differences in accuracy. More ST test trials allow for better assessment of decision errors/accuracy to be made and may make response accuracy more sensitive to changes in sleep outcomes.
5.3 Evaluation of the Resources and Ability to Implement the Study

Moving to an online version of the surveys and ST test drastically reduced the need for human resources. It may require more time to monitor survey and test completion if participant numbers were higher. Researchers often remind participants to complete online testing (Quintana et al., 2003). The online testing seemed to be a cost-effective means to accommodate a relatively large number of participants.

Importantly, sufficient lead time would be necessary to procure support for the study from top management and the participants. Once this support is obtained participant recruitment may be more successful. It may also be beneficial to provide a financial or gift incentive to participants (pending ethics approval) upon completion of the study by each participant. The longer the study needs to be the more important an incentive system would become.

Obtaining an executive functioning measure with the ST test used was not successful. Adherence was poor and the data were ambiguous. Mobile phones offer a free downloadable ST. However, the free apps found did not provide measures of both accuracy and reaction time. Paid apps are the only forms of ST test apps that provide data of both measures. For future studies purchasing a tailored ST test would be essential. Union support could increase funding to provide sufficient resources, such as human resources to accommodate a larger project and lab resources to potentially incorporate objective sleep measures such as EEG (Swarnkar, Abeyratne & Hukins, 2010).

5.4 Preliminary Evaluation of the Results

Overall means for the PSQI and ESS surveys were calculated in the preliminary data analysis. Overall means for the baseline measures of PSQI and ESS were consistent with existing research (Dietch et al, 2016; Aloba et al., 2006). PSQI is a validated sleep quality measure. The PSQI instrument has been used in a wide array of studies used as an
inventory for assessing sleep quality (Shad, Thawani & Goel, 2015). The ESS has successfully been administered online to large groups to assess excessive daytime sleepiness. Past research showed it to be a valid and reliable measure of sleepiness under various daily conditions in healthy control and experimental groups (Buysse et al., 1989). Some data have suggested there may be sex differences, with women scoring lower than men on the ESS demonstrating more daytime sleepiness (Ye, Pien, Ratcliffe & Weaver, 2009). While this finding is not relevant to the present research purposes it may be important in future research where sex differences in the effect of shift work are important for health and safety.

Present findings were not consistent with existing theoretical models. It was expected that as shift work progressed, sleep outcomes would deteriorate resulting in an increase in PSQI and ESS scores over the 12-week timeframe. However, albeit small numbers, preliminary data evaluation showed no change seen in PSQI or ESS scores over the duration of the study for both the control and experimental group. Baseline measures in some cases were higher on the PSQI and ESS scales than on subsequent testing. The relation between sleep outcomes (PSQI and ESS) and executive function was also not clear with the data collected. There was no significant correlation between ST test response time and the PSQI and ESS scores at baseline. An explanation may have been the inaccurate ST test response time data. Unfortunately, with a small number of ST test trials there was insufficient data to determine a relationship between response accuracy or errors and the sleep outcomes. From a work safety perspective response errors may be more important than response time.

The significant correlation between PSQI and ESS (approximately 16% common variance) suggests the measurement of different sleep outcome factors, as intended. The two tests, PSQI and ESS, are argued to be separate measures of sleep outcomes (Buysse et al., 2008). Shift work has been shown to have dual effects on nurses, interfering with sleep quality and levels of wakeful fatigue (Axelsson, Åkerstedt, Kecklund & Lowden, 2004). It has been shown that the PSQI and ESS measure orthogonal dimensions of sleep-wake symptoms, but neither is related to objective sleep measures (Buysse et al., 2008). A dual measure protocol allows the researcher to determine which aspect of sleep
has been affected and may affect work performance (as indexed by executive functioning in the present research). It is suggested that future research in this area use at least two sleep outcome measures, and perhaps a sleep diary as mentioned above.

In the present study the baseline measures of sleep outcomes may have been misleading as testing followed a busy and potentially tiring academic semester. For example, the initial tests for control participants occurred during the mid-term semester period. Initial tests for the nurses were done following the Christmas holidays coinciding with the final exam period. Stress and sleep deprivation are thought to accumulate over time (Medic, Wille & Hemels, 2017). It is thought that a chronic inability to recover from stressful situations by way of sleep may lead to burnout as a byproduct of stress and sleep deprivation (Shad, Thawani, & Goel, 2015). Additional stresses and compounded sleep deprivation resulting from academic responsibilities may have confounded baseline data collection from both control and experimental groups. In future shift work research, the timing of baseline measures will be critical.

5.5 Future Research

Although the study as executed had significant issues, the study design and procedure seem to have scientific merit and feasibility. The PSQI and ESS tests offer valid measures of different aspects of sleep and would be useful to future research. It was suggested above that a daily measure of sleep quality (Sonnentag & Bayer, 2005) and a sleep diary may be scientifically valuable. The work information forms offer information about on-shift busyness and number of calls/tasks responded to per shift. Work information forms offer insight on the number of potential cognitively taxing episodes a nurse may face per shift, contributing to cognitive fatigue. An expanded demographic survey would also be useful, particularly to control for variables such as work and shift work experience.

Drawbacks from the study determined a viable ST test is required for future research. An accurate measure of reaction time and response accuracy are necessary. The ST test used in the present research was confounded by movement time making interpretation of
response time challenging, if not impossible. With sufficient resources, purchasing such a test should be straightforward. In addition, the ST test must be distributable online and offer measures of accuracy and reaction time. To get a more reliable index of response accuracy, an increased number of trials would be critical. To improve for low completion rates found in the present study, regular reminder e-mails should be sent to participants ensuring the completion of surveys throughout the duration of the study. An improved incentive system for participants to complete the study would also help in this regard.

The use of a control group was necessary to observe changes in sleep quality as it relates to continued shift work. When using a student population for control and experimental groups, the researcher could use a matched pair design. Gender, age, and work experience would be important factors to control for. Lastly standardizing the timing of testing for each participant would be desirable.
Chapter 6

6 Conclusion

Cognitive ergonomists, hospital administrators and occupational scientists are positioned to influence a cultural change to alter the way shift work is scheduled. This study was designed to investigate the feasibility of using online (Qualtrics) distributed sleep quality and executive functioning tests to determine the effects that shift work has on a student nursing population. Using the Osmond and Cohn (2015) model to assess feasibility, the results of the present study indicated that, with appropriate revisions, a valid study would be possible. The revised protocol may be especially valuable in studying the effect of shift work on hospital nurses.
References

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Appendices

Appendix A: Research Ethics Approval.

Date: 10 October 2018

To Dr. Alan Salzoni

Project ID: 112413

Study Title: Sleep Quality in Shift Work and its Effects on Work Place Errors in University Students.

Application Type: NMSEB Initial Application

Review Type: Delegated

Full Board Reporting Date: December 7 2018

Date Approval Issued: 30 Oct 2018

REB Approval Expiry Date: 30 Oct 2019

Dear Dr. Alan Salzoni,

The Western University Non-Medical Research Ethics Board (NMSEB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMSEB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMSEB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

<table>
<thead>
<tr>
<th>Document Name</th>
<th>Document Type</th>
<th>Document Date</th>
<th>Document Version</th>
</tr>
</thead>
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<td>Recruitment Materials</td>
<td>13 Oct 2018</td>
<td>1</td>
</tr>
<tr>
<td>Demographic survey</td>
<td>Paper Survey</td>
<td>03 Oct 2018</td>
<td>2</td>
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<tr>
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<td>13 Aug 2018</td>
<td>1</td>
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<td>03 Oct 2018</td>
<td>4</td>
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<td>14 Oct 2018</td>
<td>5</td>
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<td>Survey link image</td>
<td>Paper Survey</td>
<td>13 Sep 2018</td>
<td>1</td>
</tr>
<tr>
<td>Work Log Michael Gieser V.2</td>
<td>Paper Survey</td>
<td>11 Sep 2018</td>
<td>2</td>
</tr>
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</table>

No deviations from, or changes to the protocol should be initiated without prior written approval from the NMSEB, except when necessary to eliminate immediate hazards to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMSEB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMSEB who are named as Investigators in research studies do not participate in discussions related to, nor vote on, such studies when they are presented to the REB. The NMSEB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB-00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson, Research Ethics Officer on behalf of Dr. Barndt Graham, NMSEB Chair
Appendix B. Letter of Information and Consent Form

Letter of Information

TITLE: Sleep Quality in Shift Work and its Effects on Workplace Errors in University Students.

Principal Investigator: Dr. Alan Salmoni
Research Staff: Michael Gaspar

INTRODUCTION AND PURPOSE
You are being invited to participate in this research study about shift work, sleep quality and their effects on workplace functionality in Western University student’s. You are an involved Western University student with important information that can be gathered.

This study is being conducted because shift work schedules may interfere with sleep schedules which may lead to increased errors in the workplace and poorer functionality in the classroom. Many industries in society require employees to work around the clock. To accomplish this, employers must find associates willing to work during various hours of the day. The Western Student Emergency Response Team uses shift work as a means of providing emergency response assistance 24 hours of the day. A total of approximately 60 students will participate in the research.

Students and emergency responders hold a lot of responsibilities in their day-to-day lives that may interfere with their sleep schedules. The interruption of sleep could become a detriment to their work life, social life, and academic life. The purpose of this research is to determine the effects of shift work on sleep quality and its relation to workplace functionality. This will allow us to determine how sleep quality affects social attentiveness.

PARTICIPANT INCLUSION/EXCLUSION CRITERIA
Inclusion Criteria:
- Any 3rd, 4th, or 5th year full-time Kinesiology student at Western University
- Members of SERT Nursing students participating in shift work

Exclusion Criteria:
- Unable to provide written informed consent, or to complete questionnaires due to language or cognitive difficulties;
- Any part-time student;
- 3rd year kinesiology students that are SERT members.

Version Date: (19/11/2018)
MEASUREMENTS

The study will examine surveys which include questions on sleep quality, number of hours slept, and characteristics of sleep (snoring, dreams, and room temperature). Demographic survey will include education and diet. The Epworth Sleepiness scale entails questions of daily activities and levels of tiredness.

The study length will be 12 weeks with monthly surveys lasting 30 minutes during your participation of this study. Participation in this study will comprise of completing the Pittsburgh Sleep Quality Index, Epworth Sleepiness Scale, Stroop task and work information forms 4 times. Measurements will completed in Arts and Humanities Building, Office: 2G28

STUDY DESIGN

This project takes a short-term look at how shift work patterns relate to your overall sleep quality and potential for workplace errors and we ask that you consider participating for at least one academic term. During this time, you will be asked to participate in any one or more of several possible interventions. These interventions include one or more of the following:

1. Completing monthly online surveys
2. Completing online Stroop tasks
3. Completing work schedule forms

The questionnaires to be completed include any or all of the following:

Pittsburgh Sleep Quality Index: You will be asked to complete a 9-questions sleep quality index 4 times throughout the study period.

Epworth Sleepiness Scale: You will be asked to rate 8 scenarios on a 4-point scale (0-3) of your chances of dozing off or falling asleep while engaged in eight different activities. You will be asked to complete the Epworth Sleepiness Scale 4 times throughout the study period

Stroop Task: You will be asked to complete an online version of the word-colour association Stroop task once a month throughout the study period. This will be scored on time and errors of the task.

Demographic Survey: You will need to complete a general survey regarding general demographics, alcohol consumption, tobacco consumption and caffeine consumption.

Work Schedule Forms: You will complete this short questionnaire regarding work schedule, and shift activities. Forms will enable the researcher to correlate findings regarding sleep to shift work. Work schedule forms will be completed 4-times throughout the study.

STUDY BENEFITS
The expected benefits to students are two-fold: 1) improved understanding of the relationship between their choices regarding physical activity and nutrition and their overall health, particularly mental health, and 2) a direct improvement of their own health as they participate in the program.

STUDY RISKS

There are no known or anticipated risks or discomforts associated with participating in this study.

YOUR PARTICIPATION

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect on your future care, academic status, or employment. If you withdraw from the study before its completion, then you may decide whether to also withdraw your data.

All other study data (e.g., paper files, digital files) will be kept for a minimum of 7 years.

If you are participating in another study at this time, please inform the study coordinator right away to determine if it is appropriate for you to participate in this study.

Representatives of the Western University Health Sciences Research Ethics Board may contact you or require access to your study-related records to monitor the conduct of the research.

You do not waive any legal right by participating in this study.

CONFIDENTIALITY

To protect your confidentiality, your name will be replaced with a participant ID number on all documents. The master list linking your identity and participant ID number and your contact information will be stored separately in a secure and encrypted data file at Western University. Your contact information will be maintained securely at Western University to allow for setting up follow up visits. Your research records will be stored in a secure office at Western University. If the results of the study are published, your name will not be used and no information that discloses your identity will be released or published. Your data will be retained for at least 7 years. If you are a First Nations or an indigenous person who has contact with spiritual ‘Elders’, you may want to talk to them before you decide participating in this research study. Elders may have concerns about some genetic procedures.

If we find information we are required by law to disclose, we cannot guarantee confidentiality.

ALTERNATIVES TO STUDY PARTICIPATION

You may choose not to participate in this study.

REIMBURSEMENT
CONSENT FORM

TITLE: Sleep Quality in Shift Work and its Effects on Workplace Errors in University Students.

Principal Investigator: Dr. Alan Salmoni
Research Staff: Michael Gaspar

I have read the Letter of Information, have had the nature of the study explained to me and I agree to participate. All questions have been answered to my satisfaction.

Participant’s Signature

SIGNATURES

_________________________________________  Date (DD-MMM-YYYY)

Signature of Participant

_________________________________________

Print

My signature means that I have explained the study to the participant named above. I have answered all questions.

_________________________________________  Date (DD-MMM-YYYY)

Signature of Person Obtaining Informed Consent Name of Person

_________________________________________

Print

Version Date: (19/11/2018)
Appendix C: Demographic Survey

Demographic Questionnaire

Age: ______

Sex:
- Male
- Female
- "You don’t have an option that applies to me. I identify as (please specify) ____"

Which year of university are you in?
- 1
- 2
- 3
- 4
- Other (please indicate): ______

Years Working as SERT
- Just started
- 1 week to 6 months
- 6 months to 1 year
- 1 year to 2 years
- 2 years to 3 years
- Other (please indicate): ______

How many Hours on Average do you work per week?
- ______

Do you supervise others at work as a part of your job?
- Yes
- No

Which of the following best describes your usual work schedule?
- Day shift
- Afternoon shift
- Night shift
- Split shift
- Irregular shift/ou-call
- Rotating shifts
Please provide your current work schedule for the month:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

How many hours of class on average do you have per week?

____

Are you a smoker?

☐ Yes
☐ No
☐ Other (Please indicate): __________________________________________________

If answered yes to previous answer. Please indicate volume smoked.

☐ Less than a pack per week
☐ One pack per week
☐ 2 to 3 packs per week
☐ 4 to 5 packs per week
☐ 6-7 packs per week
☐ 7+ packs per week
☐ I am a social smoker
☐ I do not smoke

Alcohol Use

Please indicate on average the number of days per week you consume alcohol

☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ 6
☐ 7

Please indicate the number of standard drinks (12oz. Beer, 5oz. Wine, 1.5oz. Liquor) consumed each time you consume alcohol

☐ 0
☐ 1-2
3-4
5-6
6+

Coffee use
Please indicate the number of coffees you consume on a daily basis
0
1
2
3
4
5+

Use of Sleep Aids
Please indicate if you've used a sleep aid in the last month (over the counter or prescribed?)
Yes
No
Prefer not to answer

If answered yes to the previous question please indicate which sleep aid you used
Benadryl
Aleve PM
Nyquil
Motrin
Unisom SleepTabs
Melatonin.
Valerian.
Prefer not to answer
Other (please indicate):

Please rate the following question using a 5 point scale
In the last month, I have been stressed because of school.
1 Strongly Agree       2 Agree       3 Neutral       4 Disagree       5 Strongly Disagree
Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?
Number of days: _____

Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good.
Number of days: _____

During the past 30 days, for about how many days did your poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?
Number of days: _____

How often do you find your work stressful?
1 Often      2 Sometimes      3 Rarely      4 Never
Appendix D. Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI)

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions. During the past month,

1. When have you usually gone to bed?

2. How long (in minutes) has it taken you to fall asleep each night?

3. When have you usually gotten up in the morning?

4. How many hours of actual sleep do you get at night? (This may be different than the number of hours you spend in bed)

5. During the past month, how often have you had trouble sleeping because you...

   a. Cannot get to sleep within 30 minutes
   b. Wake up in the middle of the night or early morning
   c. Have to get up to use the bathroom
   d. Cannot breathe comfortably
   e. Cough or snore loudly
   f. Feel too cold
   g. Feel too hot
   h. Have bad dreams
   i. Have pain
   j. Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s):

   Not during the past month (0) | Less than once a week (1) | Once or twice a week (2) | Three or more times a week (3)

6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?

7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?

9. During the past month, how would you rate your sleep quality overall?

   Very good (0) | Fairly good (1) | Fairly bad (2) | Very bad (3)

Component 1

Component 2

Component 3

Component 4

Component 5

Component 6

Component 7

Add the seven component scores together for Global PSQI Score.


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Appendix E. Epworth Sleepiness Scale (ESS)

Epworth Sleepiness Scale

Name: ___________________________ Today’s date: __________________

Your age (Yrs): ___________ Your sex (Male = M, Female = F): ________

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired?

This refers to your usual way of life in recent times.

Even if you haven’t done some of these things recently try to work out how they would have affected you.

Use the following scale to choose the most appropriate number for each situation:

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>would never doze</td>
</tr>
<tr>
<td>1</td>
<td>slight chance of dozing</td>
</tr>
<tr>
<td>2</td>
<td>moderate chance of dozing</td>
</tr>
<tr>
<td>3</td>
<td>high chance of dozing</td>
</tr>
</tbody>
</table>

*It is important that you answer each question as best you can.*

<table>
<thead>
<tr>
<th>Situation</th>
<th>Chance of Dozing (0-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting and reading</td>
<td></td>
</tr>
<tr>
<td>Watching TV</td>
<td></td>
</tr>
<tr>
<td>Sitting, inactive in a public place (e.g. a theatre or a meeting)</td>
<td></td>
</tr>
<tr>
<td>As a passenger in a car for an hour without a break</td>
<td></td>
</tr>
<tr>
<td>Lying down to rest in the afternoon when circumstances permit</td>
<td></td>
</tr>
<tr>
<td>Sitting and talking to someone</td>
<td></td>
</tr>
<tr>
<td>Sitting quietly after a lunch without alcohol</td>
<td></td>
</tr>
<tr>
<td>In a car, while stopped for a few minutes in the traffic</td>
<td></td>
</tr>
</tbody>
</table>

THANK YOU FOR YOUR COOPERATION

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Appendix F. Stroop Test (ST)

The Stroop Effect Test

In this task, you will be presented with a series of color words (black, blue, yellow, green, red). These words will appear in different colors, sometimes matching the word (e.g., the word blue, written in blue), and sometimes not matching the word (e.g., the word blue, written in red).

Your job is to indicate, as quickly and accurately as possible, the color in which the word is written, whether or not that matches the word itself. Click the button that matches the color of the word. Try not to pay attention to the word, but just the color.

Start

More info about the Stroop Effect test
More info about the Emotional Stroop test

Abuse of the Stroop Test Online system can be reported to this email address.

The Stroop Effect Test

Click the button that matches the color of this word:

Green

Black  Blue  Yellow  Green  Red

More info about the Stroop Effect test
More info about the Emotional Stroop test

Abuse of the Stroop Test Online system can be reported to this email address.
The Stroop Effect Test

Click the button that matches the color of this word:

Blue

Correct response
Congruents 5 27.222 seconds
Incongruents 14 17.0578 seconds

Most people respond faster and more accurately to the congruent trials, that is, when the word matches the color. This indicates that the act of reading the word has become automatic for many of us, and we have a difficult time suppressing that response.

Abuse of the Stroop Test Online system can be reported to this email address.
Appendix G. Work Information Forms

Work Schedule Forms

Participant Study #____________________

How many **day** shifts did you work this past week? __________

How many **night** shifts did you work this past week? __________

On average, how many calls did you respond to per shift? __________

On average, how long did each call take? __________

During night shifts, do you choose to make sleeping arrangements during your shift?

YES  SOMETIMES  NO

If yes, are you able to sleep after returning from a call?

YES  SOMETIMES  NO
Appendix H: Mean, Variance, Standard Deviation and Range of PSQI and ESS

Statistical analysis was done for PSQI and ESS scores. Mean, variance, standard deviation and range

<table>
<thead>
<tr>
<th></th>
<th>Mean (Control and Experimental)</th>
<th>Variance ($s^2$)</th>
<th>Standard Deviation (s) +/-</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
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<td>5.9444</td>
<td>6.879</td>
<td>2.622</td>
<td>11</td>
</tr>
<tr>
<td>ESS</td>
<td>8.333</td>
<td>10.824</td>
<td>3.29</td>
<td>11</td>
</tr>
</tbody>
</table>

Note. Shows the mean for control and experimental data when combined for PSQI and ESS. The table lays out variance, standard deviation and range of scores for PSQI and ESS.
Curriculum Vitae

Name: Michael Gaspar

Post-secondary Education and Degrees:

- Western University, London, Ontario, Canada
  2013-2017 B.A.

- Western University, London, Ontario, Canada
  2017-2019 M.A.

Related Work Experience:

- Teaching Assistant, The University of Western Ontario
  2017-2019