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Cognitive Load of Registered Nurses During Medication Administration

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by

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DEDICATION

This work is dedicated to my husband, Stephen, who has been a constant source of support and encouragement during the challenges of graduate school and life. I am truly thankful for having you in my life and could not have done this without your love and continual words of encouragement. This work is also dedicated to my children, Annabelle and Levi, who have kept me grounded. This work is also dedicated to my dad, Marty, whose good example has taught me to work hard for the things that I aspire to achieve.

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ABSTRACT

Over 4 million avoidable hospital admissions result from medication errors (IMS Insitute for Healthcare Informatics, 2013). Human error accounts for 80% of all medical errors (Palmieri, DeLucia, Peterson, Ott, & Green, 2008). Medication administration is a complex process. It is important to understand the cognitive load (CL) of Registered Nurses (RNs) working in an electronic health record environment to identify the risk factors of medication errors. The purpose of this study is to investigate the factors that influence the CL of RNs during medication administration who are working in an electronic health record environment. Simulated medication administration scenarios with varying degrees of multi-tasking were completed with 30 participants. When RNs multi-task during medication administration their CL increases. Furthermore, RNs who have poor sleep quality cannot process high-level tasks as well as those RNs who report a good sleep quality. Future work can limit EEG lead placement to the frontal channels of the EEG. Furthermore, replication of this study with a larger sample and a broader range of competing tasks is indicated.

CHAPTER ONE:

INTRODUCTION

In the United States (U.S), $17 billion annually is spent on additional medical care needed due to medication errors (Shreve et al., 2010). Furthermore, preventable medical harm is tied as the fifth leading cause of death in the U.S. (Andel, Davidow, Hollander, & Moreno, 2012). At least 1.5 million people are harmed by medications annually (Dunham & Makoul, 2008). In addition, 7,000 deaths occur as a result of a patient receiving too much medication or the wrong medication (Clark, 2004). The prevention of medication errors is a $21 billion opportunity with over 4 million avoidable hospital admissions that result from medication errors (IMS Insitute for Healthcare Informatics, 2013). Registered Nurses (RNs) are the last safety check before medications are administered to patients. Errors in administration account for up to 32% of the total medication errors reported (P. Anderson & Townsend, 2010). The work environment of RNs is plagued by ineffective systems, distractions, work-arounds and workflow inefficiencies all leading to increased potential for errors and patient harm (Elganzouri, Standish, & Androwich, 2009). Ninety percent of all interruptions have a negative effect on the nurses' work (McGillis Hall, Pedersen, & Fairley, 2010).

The estimates of over 400,000 deaths annually in hospitals due to preventable medical errors necessitates a focus on identifying areas to address this patient safety epidemic (James, 2013). Medication errors occur on a daily basis in hospitals. The Institute of Medicine (IOM) estimates that hospitalized patients are subjected to at least one medication error per day (Aspden, Wolcott, Bootman, & Cronenwett, 2007).

Any nursing task, like medication administration, that takes over 30 seconds to complete has a high probability of a resulting interruption (Cornell, Riordan, Townsend-Gervis, & Mobley, 2011). In one study, an average of 3.29 (range 0-11) interruptions per medication administration were identified (Freeman, McKee, Lee-Lehner, & Pesenecker, 2013). These interruptions were from patients, other nurses and patients' families. Of all interruptions, 90% result in a negative patient care outcome (McGillis Hall, Ferguson-Pare, et al., 2010). Nurses' report that interruptions during medication administration are a serious concern (Biron, Loiselle, & Lavoie-Tremblay, 2009).

Statement of the Problem

Interruptions during medication preparation and administration can lead to preventable errors that cost $16.4 billion annually (NEHI, 2011). According to the National Quality Forum, medication errors occur in 3.8 million inpatient admissions annually (2010). Over 4 million avoidable hospital admissions result from medication errors (IMS Insitute for Healthcare Informatics, 2013). Furthermore, human error accounts for 80% of all medical errors (Palmieri, DeLucia, Peterson, Ott, & Green, 2008). Medication administration is a complex process. It is important to understand the cognitive load (CL) of RNs working in an electronic health record environment to identify the risk factors of medication errors. This quantitative study will investigate the factors that influence the CL of RNs. RN's actively practicing in an acute care setting will be enrolled in this study.

Purpose of the Study

The purpose of this study is to investigate the impact of factors that influence CL of RNs during medication administration who are working in an electronic health record environment.

Research Questions

The study will answer the following questions:

1) What is a registered nurses' cognitive load during medication administration?
2) How do individual differences impact registered nurses' cognitive load during medication administration?
3) How do competing tasks impact registered nurses' cognitive load during medication administration?

Definitions of Relevant Terms

Cognitive Load. Cognitive Load is the demand that completing a specific task imposes on a persons' cognitive system (Paas, Van Merriënboer, & Adam, 1994). Simply put, CL is the amount of information a person can retain in their working memory.

Limitations

A limitation of this study is that nurse participants will be focused on the task given to them in the lab so the distractions will have less impact than if they were at work with multiple tasks waiting to be accomplished.

Significance to Nursing

Over $16 billion annually in the U.S. is spend on preventable medical errors (NEHI, 2011). According to the National Patient Safety Foundation (2014), deduced the 2007 IOM death estimates, that there is one medication error per patient per day for every hospitalized patient in the US. According to the Food and Drug Administration (FDA), national recommendations that have been implemented to decrease medication errors to date include pharmacy intervention, computer physician order entry and the use of bar codes on medications. All of these practice changes have decreased medication errors but still have not eliminated the errors.

Results of this study may shed light on the factors that influence CL during medication administration. Medication administration is a complex human process. A more clearly cognitive understanding of the process is needed to identify future interventions that can be implemented to eliminate medication errors.

CHAPTER TWO:

REVIEW OF LITERATURE

This chapter is an empirical review of the literature. The empirical review of the literature focused on strategies used to decrease interruptions and medication errors, definitions of CL and strategies to measure CL.

Review of the Literature

Medical harm is the third leading cause of death in the United States (U.S.) behind heart disease and cancer (James, 2013) and accounts for some 400,000 deaths that occur in hospitals annually (Carayon et al., 2011). A significant proportion of these deaths can be linked to medication errors including 7,000 as a direct result of the administration of too much medication or the administration of wrong medications (Burgess, 2009). At least 1.5 million people are harmed by medications annually (Brown et al., 2010). The Institute of Medicine of the National Academies (IOM) estimates that hospitalized patients are subjected to at least one medication error per day (Carayon et al., 2007). The cost of medication errors is staggering in part because such errors result in 4 million avoidable hospital admissions each year (Bennett, Dawoud, & Maben, 2010). In the U.S., the projected annual cost of additional medical care associated with medication errors is $17 billion (Biron et al., 2009).

Errors in medication administration account for up to 32% of the total medication errors reported in the U.S. each year (Chen & Epps, 2013). In acute care settings, registered nurses (RNs) administer a large proportion of all medication doses and frequently represent the last safeguard during the administration process. Yet RNs work environment is often plagued by ineffective systems, distractions, work-arounds and workflow inefficiencies all of which contribute to an increase in the potential for errors and patient harm (Elganzouri et al., 2009). Ninety percent of all interruptions have a negative effect on the nurses' work (McGillis Hall, Pedersen, et al., 2010).

The complex nursing environment is typified by competing tasks including telephones, questions, alarms and emergencies just to name a few. The complexity of the environment is increased given the ever-increasing integration of technology into patient care. There are limitations to how much information any person can receive, process and remember at any given point in time (G. A. Miller, 1956). The volume of information, or cognitive load, is an important factor in safe patient care.

The human and financial burdens associated with medication administration errors necessitate a focus on identifying the causes and, ultimately, strategies for reducing the incidence of these errors. Measurement of cognitive load is a necessary pre-requisite to understanding of the cognitive work of nurses thus allowing insight into those activities that cause disruptions, errors and omissions in patient care (Potter et al., 2005).

Accordingly, the foci of this discussion include (a) a review of the strategies that have been used to decrease interruptions and medication errors, (b) an examination of the concept of *cognitive load*, and (c) a review of techniques used to measure cognitive load.

Strategies Used to Decrease Interruptions and Medication Errors

In the 1990's, medication administration error studies focused on the process of medication administration (Cohen, 1999; Dean, Allan, Barber, & Barker, 1995; O'Shea, 1999; Tissot et al., 1999; D. G. Wilson et al., 1998). Researchers identified the role of multi-tasking and interruptions as contributors to errors (Biron et al., 2009; Brixey et al., 2005; Elganzouri et al., 2009; Laxmisan et al., 2007; McGillis Hall, Pedersen, et al., 2010; Palese, Sartor, Costaperaria, & Bresadola, 2009; Potter et al., 2005; Redding & Robinson, 2009). With the release of the IOM report, To Err is Human (Kohn, Corrigan, & Donaldson, 2000), the focus shifted to quantification of errors, the financial implications associated with error reduction, and the integration of technology to reduce error incidence.

Bar-coded medication administration (BCMA), physician computer order entry (CPOE), and other technologies are now widely used to reduce medication errors (Beuscart-Zéphir et al., 2005; Carayon et al., 2011; Carayon et al., 2007; DeYoung, VanderKooi, & Barletta, 2009; Harrington, Kennerly, & Johnson, 2011; Helmons, Wargel, & Daniels, 2009; Horsky, Kuperman, & Patel, 2005; Koppel, Wetterneck, Telles, & Karsh, 2008; Marini & Hasman, 2009; R. A. Miller, Waitman, Chen, & Rosenbloom, 2005; Morriss Jr et al., 2009; Ulanimo, O'Leary-Kelley, & Connolly, 2007; Zhan, Hicks, Blanchette, Keyes, & Cousins, 2006). The use of these technologies has significantly reduced, but not eliminated, medication errors (Poon et al., 2010). Overall, the integration of technology can potentially reduce medication errors by 80% (Galanter et al., 2014). Despite a large body of research in this area, little focus has been placed on what is happening cognitively with the nurse during the medication administration process when a medication error occurs.

There is a high probability of interruption associated with any nursing task that takes more than 30 seconds to complete (Cornell et al., 2011). In a study by Freeman, McKee, Lee-Lehner and Pesenecker (2013), the mean number of interruptions per medication administration episode was 3.29 (range 0-11); the primary sources include patients, other nurses and patients' families. Of all interruptions, 90% result in a negative patient care outcome (McGillis Hall, Ferguson-Pare, et al., 2010). Nurses report that interruptions during medication administration are a serious concern (Biron et al., 2009). Innovative ways to examine interruptions are needed since interruptions affect the cognitive processes of nurses (Bennett et al., 2010). One way to quantify the cognitive processes of nurses is to examine the cognitive load.

Cognitive Load Defined

Cognitive Load (CL) is the demand that completing a specific task imposes on a persons' cognitive system (Paas & Van Merriënboer, 1994; Paas et al., 1994) . Simply put, CL is the amount of information a person can retain in one's working (short-term) memory. Short-term memory has a limited capacity. According to Miller (G. A. Miller, 1956), the capacity of short-term memory is limited to approximately seven elements of stored information and two to four elements of information to process. Additionally, working memory is decreased during periods of acute stress (Gärtner, Rohde-Liebenau, Grimm, & Bajbouj, 2014).

Cognitive science and the idea that the working memory has limits was first introduced in the 1950's (G. A. Miller, 1956). In the late 1980's, Sweller developed

Cognitive Load Theory (CLT) through his examination of problem-solving (Sweller, 1988). Since that time, CLT and CL have been studied in various areas including education research, instructional design, and the multimedia-learning environment. In healthcare, CL has been examined in the context of medical decision making (Burgess, 2009). CLT and CL have been applied to the simulation training evaluation (Van Merriënboer & Sweller, 2010). Optimal patient education material design has also been evaluated using the concept of CL (E. Wilson & Wolf, 2009) as well as physician use of the electronic health record (Shachak, Hadas-Dayagi, Ziv, & Reis, 2009).

Measuring Cognitive Load

Cognitive Load has been measured using a variety of methods. There are both subjective and objective measurements to help assess CL. Each of the methods has advantages and limitations.

The National Aeronautics and Space Administration Task Load Index (NASA-TLX) is a self-report tool originally designed for aviation and has been used extensively in other disciplines (Hart & Staveland, 1988). The NASA-TLX assesses mental workload for individuals performing a specific task on six sub-scales that utilize seven-point Likert-type scales. The sub-scales evaluated include – Mental, Physical and Temporal Demands, Frustration, Effort and Performance. The NASA-TLX is available for verbal administration via pencil and paper and computer based options. Since its development in 1988, 12 culturally appropriate translations of the NASA-TLX 12 have been utilized in a variety of settings including flying, driving, data entry, visual and auditory monitoring, decision-making, teamwork and communications. Researchers and participants prefer the NASA-TLX due to the ease of administration and analysis of the tool. Limitations of the NASA-TXL include the subjective rating scale and retrospective nature of the tool. The NASA-TXL has not been tested for multiple tasks simultaneously; previous studies for validity and reliability have focused on single tasks (DiDomenico & Nussbaum, 2008).

The Subjective Workload Assessment Technique (SWAT) was developed to help assess workload in the real-world environment. The SWAT subjective rating scale assumes that the participant is able to self-assess their mental effort exerted during a specific task (Paas, Tuovinen, Tabbers, & Van Gerven, 2003). Areas evaluated in the SWAT include Time Load, Mental Effort Load, and Psychological Stress Load using three levels: low, medium and high. A major limitation of the SWAT includes difficulty in analyzing the results on the first attempt of the researcher due to the complexity of the analysis (Hill et al., 1992).

Eye activity tracking is an objective measure of pupillary response as an indicator of CL (Klingner, Kumar, & Hanrahan, 2008). The use of eye movement tracking was first identified in 1901 and later improved with technology in the 1950's (Duchowski, 2007). Eye movements are continuous and therefore measurement provides a real-time measurement of mental state (Just & Carpenter, 1976). The number of eye fixations and the duration of the eye fixations are correlated with cognitive activity (Liu & Chuang, 2011). Eye tracking requires the participant to be looking at the device to measure the eye activity (Chen & Epps, 2013). Time, personnel and money are the largest constraints when using eye tracking in research (Duchowski, 2007). Furthermore, the use of eye tracking can be difficult in the clinical environment due to the needed equipment set-up and extraneous factors involved in studying the eye movements.

Functional Magnetic Resonance Imaging (fMRI) hypothesizes changes in oxygen levels in the posterior parietal cortex and Wernicke's Area is an indicator of CL (Whelan, 2007). When the brain is active, it requires more oxygen and increases blood flow to that specific area of the brain involved in the activity (Faro & Mohamed, 2006). Though non-invasive, fMRI is intrusive, expensive, provides only isolated events of changes in CL and requires a participant to lay still while scanning (Paas, Ayres, & Pachman, 2008). The stagnant nature of fMRI does not allow for a dynamic, on-going evaluation of brain activity such as during clinical practice. The delayed nature of testing (from the task itself) is a disadvantage in the fMRI use in measuring CL (Huettel, Song, & McCarthy, 2004).

Positron Emission Tomography (PET) Scan technology requires the administration of radioactive tracer elements to observe changes in the brain (Antonenko, Paas, Grabner, & van Gog, 2010). PET scan technology captures brain activity relative to glucose use. Glucose is the main fuel for the brain and the more active the area of the brain the more glucose consumption. PET Scan technology is expensive. Furthermore, PET scan technology requires the participant to lie still for an extended period of time to image the blood volume as an indicator of CL (Varvatsoulias, 2013). A PET scan also relays a delayed visualization of brain activity of a task (Bailey, Townsend, Valk, & Maisey, 2005). The PET scan, like the fMRI, does not allow dynamic on-going evaluation during clinical practice.

All of the methods listed above have advantages and limitations associated with each. Measuring CL in a real-time, objective method in the clinical environment has not been validated. There is a more efficient, non-intrusive, cost-effective way to examine CL. Electroencephalography (EEG) is a visualization of brain wave activity. This visualization is representative of the difficulty, or CL, associated with a task (E. W. Anderson et al., 2011). EEG monitoring is clinically the method of choice for monitoring brain functioning (Alan Gevins & Smith, 2003). EEG neuroimaging technique measures electrical activity produced by the brain via electrodes that are placed on the scalp. These measurements vary predictably in response to changing levels of cognitive stimuli (C. W. Anderson & Bratman, 2008). A major advantage of EEG technology is the precision in measurement down to the millisecond (Handy, 2005). Portable EEG monitoring demonstrates great promise for measuring CL in a natural environment, without cable equipment constraints and offers a way to understand the cognitive processes of complex environments (Antonenko et al., 2010). The use of EEG monitoring in a simulated driving experience has shown significant results to demonstrate the effectiveness of EEG monitoring to measure CL (Savage, Potter, & Tatler, 2013). Results of EEG interpretation are a distinguishable tool to measure intrinsic CL, and are better than self-report measures (Joseph, 2013). Concurrent tasks can be measured concomitantly using EEG monitoring (Berka et al., 2004) which makes EEG a appropriate choice for identifying the CL of RNs.

Conclusion

Research is needed to better understand the complex environment of interruptions and (medication) errors (Raban & Westbrook, 2014). Despite extensive literature related to medication error reduction and interruptions during medication administration, little is known about the cognitive process that may lead to medication errors. Future research needs to explore the CL of RN's. Once the factors that increase the CL of RN’s are explicated, the use of EEG technology can potentially be applied in complex clinical environments to reduce medication errors.

CHAPTER THREE:

APPLICATIONS

This chapter outlines the use of the EEG. The first section describes the application of the EEG followed by a discussion of the various uses of the EEG.

EEG Uses

The use of electroencephalography (EEG) in humans began in the 1920's by German Psychiatrist Hans Berger. The EEG allowed for a tool to aide in psychiatric diagnoses. The EEG was considered the gold standard in neuroscience, neurology and neurosurgery, especially for patients with seizures until the 1970's when computer tomography was discovered (Tudor, Tudor, & Tudor, 2005). The use of EEG is instrumental for the diagnosis of epilepsy in children and adults. Furthermore, EEG traditionally has been utilized to evaluate brain death.

EEG measures ongoing electrical activity of the brain recorded from electrodes placed on the scalp. It is a non-invasive medical imaging technique used clinically, in research and most recently for non-research related commercial applications.

EEG Application

To capture the EEG, electrodes are placed on the scalp. The 10-20 System is an internationally recognized system for placing the scalp electrodes to record the EEG

(Jasper, 1958). The 10-20 System allows for measurement of the EEG by electrodes placed on the scalp to reliably capture positioning of the EEG electrodes (Herwig, Satrapi, & Schönfeldt-Lecuona, 2003).

Application of the EEG electrodes is a simple procedure. The electrodes consist of a conductor attached to a wire with a plug that attaches to a recording device. The conductor, a wire disc, is attached to the scalp. The scalp is first cleaned with alcohol prep pads. The use of alcohol prep pads removes local surface oils. The scalp is then prepped with an abrasive skin prep gel (such as Nuprep®). The skin prep gel improves conductivity of the EEG. Once the skin is prepared the electrodes are then placed on the scalp. Grass EC2 electrode paste is placed into the wire electrode cup and placed on the scalp. The EC2 electrode paste dries as it is exposed to air. Once the EEG electrodes are placed on the scalp, the head is wrapped with 4-inch conforming bandage for additional securement. The electrodes wires are plugged into the EEG machine according to electrode location (i.e. P4 is plugged into the P4 location on the EEG machine). Following all of the steps maximizes EEG conductivity and minimizes EEG artifact.

The EEG signal allows for differentiation of the various brain waves. An example of each waveform is presented in figure 1. The various waveforms are identified on the EEG: the Delta band (0.5-3 HZ); theta band (3.5 to 7.5 Hz), alpha band (8 to 11.5 Hz); beta 1 (12-16 Hz); beta 2 (16.5-20 Hz); beta 3 (20,5-25 Hz); beta 4 (25.5-32 Hz); gamma band (32.5-40 Hz).

Different band oscillations are prominent during different activities. For example, delta band oscillation is associated with non-attentive tasks (Collura, 2001). Oscillations is the theta bans are indicative of cognitive and memory performance (Klimesch, 1999). Alpha band oscillation is identified with attention and orientation

(Klimesch, 2012). Oscillations is the beta band is increased during times of drowsiness and mental activation (Tatum, 2008). Gamma band oscillation is associated with high-level processing tasks (Collura, 2001).

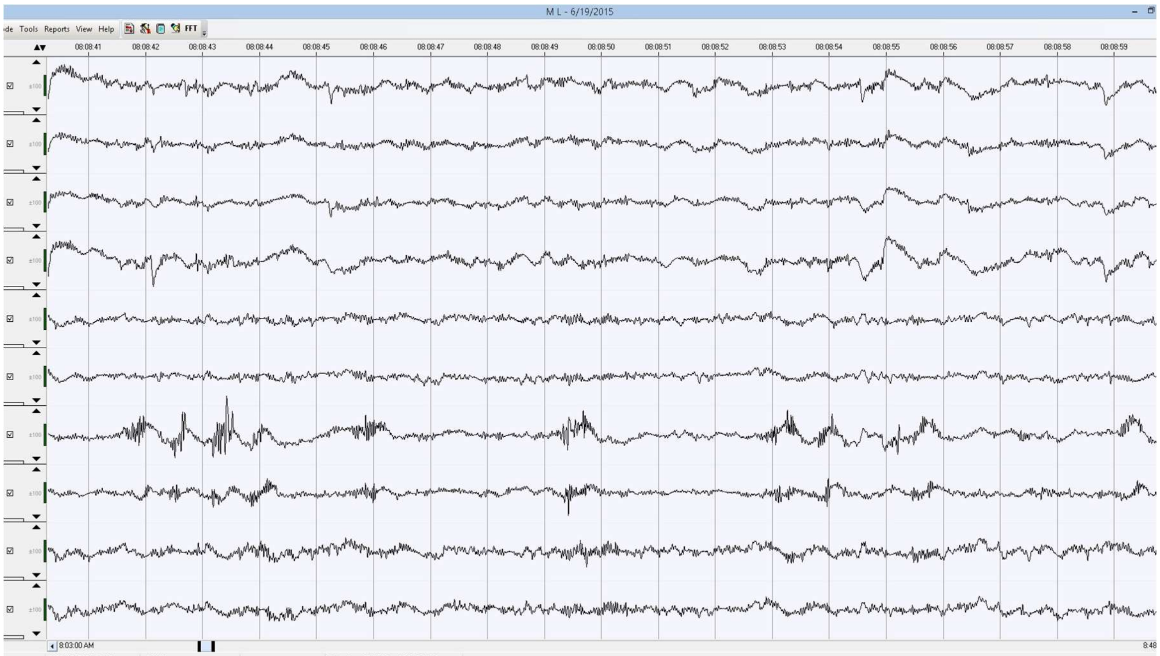

Figure 1. EEG Waveform

Uses of the EEG

The use of the EEG in the clinical setting has a specific set of uses. The EEG is extensively used in the diagnosis and medication maintenance of seizures and epilepsy (Lee, Spencer, & Spencer, 2000; Lieb et al., 1976; Marks & Ehrenberg, 1993; Martin, Gilliam, Kilgore, Faught, & Kuzniecky, 1998; Williamson et al., 1993). Also, the EEG is used in the diagnosis of brain death (Kramer, 2015). The use of EEG is used extensively in sleep analysis (Agnew, Webb, & Williams, 1966; Borbély et al., 1984; Cicchetti & Allison, 1971; Enshaeifar, Kouchaki, Cheong Took, & Sanei, 2015; Feinberg, 1974; Feinberg, Koresko, & Heller, 1967; Gillin et al., 1981; Reynolds & Kupfer, 1987; Reynolds et al., 1985; Tessier, Lambert, Scherzer, Jemel, & Godbout, 2015). EEG is also used in the diagnosis of Parkinson's disease and dementia (Bonanni et al., 2008; Soikkeli, Partanen, Soininen, Pääkkönen, & Riekkinen, 1991; Stam et al., 1995) (Neufeld, Blumen, Aitkin, Parmet, & Korczyn, 1994).

The use of EEG has more recently been used in the research setting. The EEG has been used to evaluate attention deficit hyperactivity disorder (ADHD) in the past 20 years (Clarke, Barry, McCarthy, & Selikowitz, 2001; Lubar, Swartwood, Swartwood, & O'Donnell, 1995; Snyder et al., 2008; Swartwood, Swartwood, Lubar, & Timmermann, 2003). The EEG has been used to measure focus and concentration during driving and flight simulations (Borghini et al., 2013; Lin et al., 2007; Risser, Ware, & Freeman, 2000; Sonnleitner et al., 2014). As the complexity of a task increased the EEG changes to reflect an increase in cognitive load (M. E. Smith, Gevins, & Brown, 2001). The use of EEG during flight simulation of novice learners has demonstrated a change in the frontal theta bands during the learning of the flight task (Borghini et al., 2013).

Driving distractions lead to an increase in driving errors (Young, Salmon, & Cornelissen, 2012). Prolonged braking time (reduced driver performance) has been identified during periods of increased cognitive load (Sonnleitner et al., 2014). Furthermore, EEG recordings during driving simulation demonstrated a significant increase in frontal and a significant decrease in occipital theta activity during an increase in cognitive load (Savage et al., 2013). The use of EEG is effective in providing sensitive information for driver workload detection (Lei & Roetting, 2011). During periods of driver distraction, higher levels of load were identified in the right frontal region on EEG (Almahasneh, Chooi, Kamel, & Malik, 2014). As mathematical learning occurs, significant changes are observed on the EEG (Skrandies & Klein, 2015).

The use of EEG has also been used to evaluate CL in the learning environment (E. W. Anderson et al., 2011; Antonenko & Niederhauser, 2010; Antonenko et al., 2010). EEG is a sensitive indicator of CL during online text reading (Scharinger, Kammerer, & Gerjets, 2015).

Cognitive load measurement using EEG has been minimally studied in the healthcare setting (Burgess, 2009). Medical students training in a simulation environment to identify murmurs identified that an increase in CL correlated with a decrease in correctly identifying a murmur during simulation training (Fraser et al., 2012).

Commercially, the EEG has been advertised by Emotiv Insight to allow you to optimize your brain fitness and performance, and measure and monitor your cognitive health and wellbeing. The potential to increase sports performance has also been identified through the use of EEG (Park, Fairweather, & Donaldson, 2015; Thompson, Steffert, Ros, Leach, & Gruzelier, 2008a). Elite athletes demonstrate a difference on EEG than non-athletes during performance (Babiloni et al., 2009). Furthermore, elite athletes demonstrate different resting EEG compared to non-athletes (Babiloni et al., 2010). The use of portable EEG for athletes offering a promising opportunity to better understand their cortical processes (Thompson, Steffert, Ros, Leach, & Gruzelier, 2008b). The use of EEG is also a promising area of for identifying consumer preference of products. The EEG is discriminative to identify when a person will prefer one product to another (Telpaz, Webb, & Levy, 2015). The use of commercial wireless EEG headsets is also sold for computer gaming purposes as a means of hands-free gaming.

The measurement of EEG during medication administration is anticipated to see oscillations in specific bands in various locations. An increase in oscillations in the alpha and theta rhythms have been associated with increased cognitive load (Antonenko & Niederhauser, 2010). Theta and alpha and changes have been identified in (driving) distractions thought to be the distraction of a secondary task (Almahasneh et al., 2014). Theta, alpha and beta activity has been shown to be sensitive to load changes (A. Gevins et al., 1998). Scalp location of EEG lead placement can be driven from data that cognitive load is most sensitive in the frontal and temporal areas (Joseph, 2013). Occipital locations will not be as sensitive to theta oscillations, but rather alpha oscillations due to the involvement of visual factors (A. Gevins & Smith, 2000).

Summary

The use of EEG is an effective tool for a diverse number of applications. The original clinical development of the EEG has evolved to incorporate relevant applications. The EEG is an established tool to evaluate CL in various settings. The portability and ease of use make the use of EEG an optimal tool to examine CL in a variety of settings. The non-intrusive, wearable EEG allows for the ability to sue this tool in the clinical setting, not just in the research setting. Future research and clinical applications of the EEG in the healthcare setting are promising to evaluate CL in various clinical situations. EEG in the clinical setting might allow for exploration of cognitive processes related to provider distraction and patient safety.

CHAPTER FOUR:

METHODS AND RESULTS

This chapter outlines the research study. The first section presents the materials and methods. The next section discusses the measurement tools. Lastly, the data analysis procedures and results are explained in detail.

Introduction

Medical harm is the third leading cause of death in the United States (U.S.) behind heart disease and cancer (James, 2013) and accounts for some 400,000 deaths that occur in hospitals annually (Dean et al., 1995). A significant proportion of these deaths can be linked to medication errors including 7,000 as a direct result of the administration of too much medication or the administration of wrong medications (Cohen, 1999). At least 1.5 million people are harmed by medications annually (Potter et al., 2005). The Institute of Medicine of the National Academies (IOM) estimates that hospitalized patients are subjected to at least one medication error per day (O'Shea, 1999). The cost of medication errors is staggering in part because such errors result in 4 million avoidable hospital admissions each year (Biron et al., 2009). In the U.S., the projected annual cost of additional medical care associated with medication errors is $17 billion (McGillis Hall, Pedersen, et al., 2010).

Errors in medication administration account for up to 32% of the total medication errors reported in the U.S. each year (Tissot et al., 1999). In acute care settings, Registered Nurses (RNs) administer a large proportion of all medication doses and frequently represent the last safeguard during the administration process. Yet the RN work environment is often plagued by ineffective systems, distractions, work-arounds and workflow inefficiencies all of which contribute to an increase in the potential for errors and patient harm (Elganzouri et al., 2009). Ninety percent of all interruptions have a negative effect on the nurses' work (McGillis Hall, Pedersen, et al., 2010).

It is evident in the empirical research reviewed that medication errors are a significant problem in the U.S. Medication administration errors, though multiple strategies have been implemented, have not significantly decreased the financial impact associated with the errors. Cognitive Load (CL) is a way to examine the limit of information that an RN can store in short-term memory. There have been methods implemented to measure CL. However, it has been established that the current tools used to measure CL have limitations (Bailey et al., 2005; Chen & Epps, 2013; DiDomenico & Nussbaum, 2008; Duchowski, 2007; Hill et al., 1992; Huettel et al., 2004; Paas et al., 2008). The use of EEG and EOG have validated acceptability for measuring CL and offer a great option to measure CL in RNs during medication administration.

Materials and Methods

A quasi-experimental study design was used to investigate the cognitive load measured using electroencephalogram (EEG) of RN's in a setting with an electronic health record (EHR). The participants each performed three simulated medication passes in a random order. The three simulated medication administration scenarios had varying degrees of competing tasking from no competing tasking to a competing task happening every minute. The study design decision for one competing task per minute is based on the literature explaining that 74% of the nursing tasks on medical-surgical nursing units are less than one-minute in duration and therefore nurses naturally switch focus with each task (Cornell et al., 2011). Furthermore, it has been reported that on average up to 14 interruptions occur per hour (Trbovich, Prakash, Stewart, Trip, & Savage, 2010) and on average 3.29 interruptions per medication administration event (Freeman et al., 2013).

Setting

The study was conducted in the simulation skills lab of a large metropolitan hospital in the southeastern United States. During the study, the simulation skills lab was only utilized for the study. There were no other activities, classes, or simulations occurring.

Sample

Following approval of the institutional review boards, thirty nurses were recruited through a combination of word of mouth, staff meetings and emails. Potential participants were eligible for the study if they were RNs, have acute care experience and had worked in an electronic health record experience. Those excluded from participation included licensed practical nurses and non-English speaking RNs.

Measurement

Demographic Survey. A demographic survey asked each participant basic demographic information including age, gender, highest education level, highest education level in nursing, years of experience in nursing, area of nursing practice, type of facility worked.

Sleep Quality. The Pittsburgh Sleep Quality Index (PSQI) measures a persons sleep quality index (Morin, Belleville, Bélanger, & Ivers, 2011). The 19-item questionnaire evaluates sleep quality and disturbances over the past month. The first 4 items are open-ended questions, followed by items 5 to 19 that are 4-point Likert type scale items. Individual items scores yield 7 components. A total score, ranging from 0 to 21, is obtained by adding the 7 component scores. A score > 5 suggests poor sleep quality. The PSQI is a simple evaluation that can be completed within five minutes (Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002). Convergent and discriminant validity were moderately to highly correlated with single or multi-item scales of sleep quality or sleep problems (r=0.46 to 0.83) and individual question responses are stable across time (0.85, $p<0.001$). The internal consistency reliability for the PSQI is 0.80 to 0.83 (Broomfield & Espie, 2005; Buysse, Reynolds III, Monk, Berman, & Kupfer, 1989; Carpenter & Andrykowski, 1998; M. T. Smith & Wegener, 2003).

Authentic Diagnostic Assessment of Medication Dosage Calculation (MDC) and Technical Competence. The safeMedicate Authentic Diagnostic Assessment, developed by Authentic World Ltd, is a screen-based simulation that was used to assess baseline medication dosage calculation (MDC) and technical competence (TC) prior to the simulated medication administration scenarios (Sabin et al., 2013; Weeks, Clochesy, Hutton, & Moseley, 2013; Weeks, Hutton, et al., 2013; Weeks, Meriel Hutton, Coben, Clochesy, & Pontin, 2013; Weeks, Sabin, Pontin, & Woolley, 2013). The instrument contains 30 multiple choice and fill in the blank questions. Concurrent, convergent, divergent and construct validity has been demonstrated using this authentic environment and traditional pedagogical practice (Weeks, Hutton, et al., 2013; Weeks, Meriel Hutton, et al., 2013). The internal consistency reliability for the safeMedicate Authentic Assessment is 0.94 (Coben et al., 2010; Sabin et al., 2013).

Electroencephalography (EEG) CL was measured using analysis of EEG indices that were acquired using the SOMNOtouch system (SOMNOmedics GmbH, Randersacker, Germany) wearable EEG device. The EEG electrodes were placed on both hemispheres at the frontal, temporal, parietal and occipital sites. According to the international 10-20 system of EEG electrode placement (Jasper, 1958), the sites corresponded to the locations F3 and F4 (left and right frontal, respectively), F7 and F8 (left and right frontal, respectively), T3 and T4 (left and right temporal, respectively), and P3 and P4 (left and right parietal, respectively). The choice of electrode placement was based on results reported in the literature which suggests that CL was associated with an increase in the theta rhythm (4-8 Hz) and reduction in the alpha wave (8-12 Hz) powers at the frontal, temporal, and parietal sites (Antonenko et al., 2010).

Randomization of Scenarios

Each of the 30 participants received all three-medication simulations scenarios. The order in which the participants received the simulations was randomized. A random number generator was used to identify which scenario each participant would receive first. Then, a coin was flipped to identify what scenario would follow. For example, if scenario number one was identified on the random number generator a coin was then flipped; if the coin flip resulted in heads then scenario number two would follow. However if the coin toss resulted in tails scenario number three would follow scenario number one. The heads denoted the lower number of the remaining options. Medication simulation scenario one included a medication pass without any competing tasks. Medication simulation scenario two consisted of a medication pass with one competing task every five minutes. Medication simulation scenario three consisted of a medication pass with a competing task every minute. The competing tasks included the telephone ringing, background talking, co-workers asking for assistance, family members asking questions, talking at the medication-dispensing device, IV pump beeping, and questions about other patients.

Statistical Analysis

Data were managed using SPSS (Statistical Package for Social Sciences, IBM SPSS, Inc, Chicago, IL) version 22.0. Descriptive statistics and T-tests was used for between group comparisons.

Results

Thirty participants consented to participate in this study. Characteristics of participants demonstrated a variety of nursing experience (Table 1). The nursing education of the participants varied including one diploma nurse, associate degree nurses (n=9), bachelors degree nurses (n=15) and masters prepared nurses (n=5). The specialties of nurses varied. Of the 30 participants, critical care, medical-surgical and pediatrics each had five participants. The other half of the participants came from emergency services (n=6), women's health (n=2), medical-surgical nurse managers (n=2), emergency services managers (n=2), and one nurse each from NICU, critical care, medical-surgical float team and emergency, medical-surgical float team.

Table 1. Participant Characteristics.

	Range	Mean (SD)	Median (1QR)
Age	26-65	41.1 ± 11.1	42.5 (18.0)
Years of Nursing Experience	1-44	11.7 ± 10.5	7.0 (13.0)

T-tests comparing Simulation 1 to Simulation 3 demonstrate differences in the CL when a RN does not have any competing tasks versus when they have a competing task every one minute (Tables 2 and 3). There are numerous sites (F3, F4, F7 and F8) in which there were statistically significant results when comparing Simulation 1 to Simulation 3 ($p \leq .05$).

Sixty percent (*n=18*) of the nurses reported poor quality on the PSQI (Table 4). The t-test comparison with statistically significant results was the T4 site in the beta 3 ($p \leq .05$) and beta 4 bands ($p \leq .05$). The overall sample that had multiple statistically significant results in many of the bands in F3, F4, F7 and F8. The participants who reported poor sleep quality on the PSQI did not have as many statistically significant results in the bands on the F3, F4, F7 and F8 sites.

When examining the results of the Authentic Diagnostic Assessment of Medication Calculation and Technical Competence it was noted three participants had scores below 10 (out of 30) on the conceptual portion of the exam (Table 5). The T-tests removing the three participants noted above was re-analyzed and no significant changes were noted.

Table 2. Cognitive load mean p-values of simulation 1, 2 and 3.

	F3	F4	F7	F8	T3	T4	P3	P4	O1	O2
Theta	p=0.83 η^2= .004 CI=95%	p=0.94 η^2=.001 CI=95%	p=0.92 η^2=.002 CI=95%	p=0.98 η^2=.000 CI=95%	p=0.80 η^2=.005 CI=95%	p=0.97 η^2=.001 CI=95%	p=0.52 η^2=.015 CI=95%	p=0.34 η^2=.025 CI=95%	p=0.83 η^2=.004 CI=95%	p=0.71 η^2=.008 CI=95%
Alpha	p=0.63 η^2=.010 CI=95%	p=0.75 η^2=.007 CI=95%	p=0.79 η^2=.006 CI=95%	p=0.92 η^2=.002 CI=95%	p=0.74 η^2=.007 CI=95%	p=0.97 η^2=.001 CI=95%	p=0.53 η^2=.015 CI=95%	p=0.32 η^2=.026 CI=95%	p=0.84 η^2=.004 CI=95%	p=0.83 η^2=.004 CI=95%
Delta	p=0.59 η^2=.012 CI=95%	p=0.96 η^2=.000 CI=95%	p=0.77 η^2=.006 CI=95%	p=0.98 η^2=.000 CI=95%	p=0.76 η^2=.006 CI=95%	p=0.83 η^2=.004 CI=95%	p=0.45 η^2=.018 CI=95%	p=0.34 η^2=.024 CI=95%	p=0.74 η^2=.007 CI=95%	p=0.70 η^2=.008 CI=95%
Beta 1	p=0.59 η^2= .012 CI=95%	p=0.63 η^2=.011 CI=95%	p=0.75 η^2=.006 CI=95%	p=0.70 η^2=.008 CI=95%	p=0.77 η^2=.006 CI=95%	p=0.88 η^2=.003 CI=95%	p=0.55 η^2=.014 CI=95%	p=0.27 η^2=.030 CI=95%	p=0.95 η^2=.001 CI=95%	p=0.90 η^2=.002 CI=95%
Beta 2	p=0.51 η^2= .015 CI=95%	p=0.62 η^2=.011 CI=95%	p=0.66 η^2=.010 CI=95%	p=0.67 η^2=.009 CI=95%	p=0.74 η^2=.007 CI=95%	p=0.77 η^2=.006 CI=95%	p=0.50 η^2=.016 CI=95%	p=0.27 η^2=.294 CI=95%	p=0.92 η^2=.002 CI=95%	p=0.92 η^2=.002 CI=95%
Beta 3	p=0.53 η^2=.014 CI=95%	p=0.72 η^2=.008 CI=95%	p=0.78 η^2=.006 CI=95%	p=0.70 η^2=.008 CI=95%	p=0.68 η^2=.009 CI=95%	p=0.64 η^2=.010 CI=95%	p=0.51 η^2=.015 CI=95%	p=0.25 η^2=.031 CI=95%	p=0.95 η^2=.001 CI=95%	p=0.87 η^2=.003 CI=95%
Beta 4	p=0.54 η^2=.014 CI=95%	p=0.71 η^2=.008 CI=95%	p=0.73 η^2=.007 CI=95%	p=0.66 η^2=.009 CI=95%	p=0.71 η^2=.008 CI=95%	p=0.64 η^2=.010 CI=95%	p=0.63 η^2=.011 CI=95%	p=0.18 η^2=.039 CI=95%	p=1.00 η^2=.000 CI=95%	p=0.85 η^2=.004 CI=95%
Gamma	p=0.61 η^2=.000 CI=95%	p=0.67 η^2=.009 CI=95%	p=0.57 η^2=.013 CI=95%	p=0.68 η^2=.011 CI=95%	p=0.66 η^2=.010 CI=95%	p=0.60 η^2=.012 CI=95%	p=0.57 η^2=.013 CI=95%	p=0.19 η^2=.038 CI=95%	p=0.98 η^2=.000 CI=95%	p=0.75 η^2=.007 CI=95%

**Simulation 1 – no competing tasks; Simulation 2 – One competing task every five minutes; Simulation 3 – One competing task every one minute.*

Table 3. Cognitive load mean p-values of simulation 1 and 3.

	F3	F4	F7	F8	T3	T4	P3	P4	O1	O2
Theta	p=0.22	p=0.51	p=0.56	p=0.81	p=0.32	p=0.89	p=0.29	p=0.16	p=0.57	p=0.35
Alpha	p=0.18	p=0.02	p=0.05	p=0.24	p=0.32	p=0.48	p=0.27	p=0.16	p=0.50	p=0.40
Delta	p=0.12	p=0.61	p=0.39	p=0.78	p=0.32	p=0.45	p=0.27	p=0.19	p=0.45	p=0.34
Beta 1	p=0.15	p=0.00	p=0.02	p=0.00	p=0.32	p=0.38	p=0.29	p=0.14	p=0.78	p=0.53
Beta 2	p=0.09	p=0.01	p=0.00	p=0.00	p=0.31	p=0.40	p=0.27	p=0.15	p=0.77	p=0.58
Beta 3	p=0.06	p=0.05	p=0.05	p=0.02	p=0.30	p=0.29	p=0.28	p=0.14	p=0.75	p=0.49
Beta 4	p=0.03	p=0.05	p=0.01	p=0.05	p=0.29	p=0.28	p=0.26	p=0.13	p=0.96	p=0.46
Gamma	p=0.01	p=0.04	p=0.00	p=0.04	p=0.29	p=0.30	p=0.24	p=0.10	p=0.95	p=0.38

Table 4. Frequency Distribution of Pittsburgh Sleep Quality Index.

PSQI Score	Frequency
0	1
2	2
3	2
4	7
6	4
7	2
8	3
9	3
10	2
11	2
13	1
14	1

Table 5. Descriptive statistics of Authentic Diagnostic Assessment.

	Minimum Score	Maximum Score (out of 30)	Mean
Conceptual	0	30	24.9
Calculation	20	30	25.5
Technical Measurement	9	30	27.5

CHAPTER FIVE:

DISCUSSION

This chapter discusses the results of the study. Furthermore, this chapter discusses future research needed.

Discussion

It is not surprising the statistical significance was not achieved in the delta band. The delta band oscillation is associated with non-attentive tasks (Collura, 2001). Alpha band oscillation is identified with attention and orientation (Klimesch, 2012). Differences in F4, frontal right, achieved statistical significance ($p \leq .05$). Oscillations is the beta band is increased during times of drowsiness and mental activation (Tatum, 2008). The process of medication administration requires critical thinking. Therefore, it is not surprising to see statistically significant differences in the beta band in all frontal locations (F3, F4, F7 and F8). It is also assumed that critical thinking is needed to process medication calculations. It is not a surprise that all frontal locations (F3, F4, F7 and F8) also achieved statistically significant differences in the gamma band. Gamma band oscillation is associated with high-level processing tasks (Collura, 2001).

When accounting for those nurses who report a poor sleep quality, it is interesting to note the decrease of statistical significance in the beta and gamma bands as previously shown when comparing all participants. As oscillations in the gamma bands are associated with high-level processing tasks, nurses who have poor sleep quality cannot process high-level tasks as well as those nurses who report a good sleep quality.

Though there were not any changes when removing the three participants that scored much lower than the others on the conceptual portion of the Authentic Assessment, the sample size was limited. A larger sample size would be needed to identify any correlation in participants who score low on the Authentic Assessment and differences on the EEG. Literature suggests that nurses may experience more than one competing task per minute (McGillis Hall, Ferguson-Pare, et al., 2010; McGillis Hall, Pedersen, et al., 2010; Palese et al., 2009).

Implications for Research and Practice

Statistically significant changes in the frontal channels of the EEG (F3, F4, F7 and F8) indicate that future research in CL can limit electrode placement to F3, F4, F7 and F8. This localized electrode lead placement can allow for design of smaller portable monitoring devices that can be used in clinical areas. Future research could focus on two main areas. First, replication of this study with a larger sample size will allow for a more dynamic statistical analysis. It is believed statistical significance was not reached due to the small sample size. Second, would examining a wider range of competing tasks produce different results?

Conclusions

Due to the pilot nature of this study, sample size was limited. Though the use of the simulation lab was beneficial to identify baseline information, the simulation lab did not expose each participant to the ordinary, busy complex nursing environment. The use of portable EEG is an inexpensive way to examine CL. The identification of CL as an indicator to potentially decrease medication errors is a dynamic way to examine the nursing environment.

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APPENDICES

Appendix A: IRB Approval Letter

UNIVERSITY OF SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

3/4/2015

Sarah Perron
College of Nursing
12901 Bruce B Downs Boulevard
MDC22
Tampa, FL 33612

RE: **Expedited Approval for Initial Review**
IRB#: Pro00021192
Title: Cognitive Load of Registered Nurses during Medication Administration

Study Approval Period: 3/3/2015 to 3/3/2016

Dear Ms. Perron:

On 3/3/2015, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents outlined below.

Approved Item(s):
Protocol Document(s):
Perron - V2 Clean

Consent/Assent Document(s)*:
Perron - Consent March 1.pdf

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s).

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR

56.110. The research proposed in this study is categorized under the following expedited review category:

(4) Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing.

(6) Collection of data from voice, video, digital, or image recordings made for research purposes.

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval by an amendment.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

VJorgensen MD

E. Verena Jorgensen, M.D., Chairperson
USF Institutional Review Board

Appendix B: Recruitment Flyer

Are you a Registered Nurse (RN) who administers medications using an Electronic Medical Record?

Researchers at the University of South Florida would like to observe you administering medication.

Would the study be a good fit for me?

This study might be a good fit for you if have:

- **RN license**
- **Worked in an Electronic Health Record Environment**
- **Acute care experience**

If you are an RN that would like to participate in this research study, please contact Sarah Perron at sperron1@health.usf.edu for more information

You will be compensated for your time

Appendix C: Pittsburgh Sleep Quality Index

Request for Use Please

Gasiorowski, Mary <GasiorowskiMJ@upmc.edu>

Fri 11/21/2014 8:35 AM

To:Perron, Sarah <sperron1@health.usf.edu>;

1 attachment (54 KB)

showFile.asp-2.pdf;

Sent on behalf of Dr. Buysse

Dear Sarah,

You have my permission to use the PSQI for your research study. You can find the instrument, scoring instructions, the original article, links to available translations, and other useful information at www.sleep.pitt.edu under the Instruments tab. Please ensure that the PSQI is accurately reproduced in any on-line version (including copyright information). We request that you to cite the 1989 paper in any publications that result.

Note that Question 10 is not used in scoring the PSQI. This question is for informational purposes only, and may be omitted during data collection per requirements of the particular study.

This copyright in this form is owned by the University of Pittsburgh and may be reprinted without charge only for non-commercial research and educational purposes. You may not make changes or modifications of this form without prior written permission from the University of Pittsburgh. If you would like to use this instrument for commercial purposes or for commercially sponsored research, please contact the Office of Technology Management at the University of Pittsburgh at 412-648-2206 for licensing information.

Good luck with your research.

Sincerely,

Daniel J. Buysse, M.D.
Professor of Psychiatry and Clinical and Translational Science
University of Pittsburgh School of Medicine
E-1123 WPIC
3811 O'Hara St.

Pittsburgh, PA 15213
T: (412) 246-6413
F: (412) 246-5300
buyssedj@upmc.edu

From: Buysse, Daniel
Sent: Wednesday, November 19, 2014 9:44 PM
To: Gasiorowski, Mary
Subject: FW: Request for Use Please

From: Perron, Sarah [sperron1@health.usf.edu]
Sent: Wednesday, November 19, 2014 7:31 PM
To: Buysse, Daniel
Subject: Request for Use Please

Good Evening,
Attached please find permission request for PSQI.
Thank you for the consideration.
Regards,
Sarah

AM
Subject's Initials________________ID#__________________Date_______________Time_____PM

PITTSBURGH SLEEP QUALITY INDEX

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.

1. During the past month, what time have you usually gone to bed at night?

   BED TIME ___________

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

   NUMBER OF MINUTES ___________

3. During the past month, what time have you usually gotten up in the morning?

   GETTING UP TIME ___________

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

   HOURS OF SLEEP PER NIGHT ___________

For each of the remaining questions, check the one best response. Please answer all questions.

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

a) Cannot get to sleep within 30 minutes

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Wake up in the middle of the night or early morning

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Have to get up to use the bathroom

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Cannot breathe comfortably

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Cough or snore loudly

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

f) Feel too cold

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

g) Feel too hot

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

h) Had bad dreams

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

i) Have pain

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

j) Other reason(s), please describe____

____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

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

Very good ____________

Fairly good ____________

Fairly bad ____________

Very bad ____________

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

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

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

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

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

No problem at all ___________

Only a very slight problem ___________

Somewhat of a problem ___________

A very big problem ___________

10. Do you have a bed partner or room mate?

No bed partner or room mate ___________

Partner/room mate in other room ___________

Partner in same room, but not same bed ___________

Partner in same bed ___________

If you have a room mate or bed partner, ask him/her how often in the past month you have had . . .

a) Loud snoring

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Long pauses between breaths while asleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Legs twitching or jerking while you sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Episodes of disorientation or confusion during sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Other restlessness while you sleep; please describe________________________________

____

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

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Appendix D: safeMedicate Authentic Diagnostic Assessment Template

<table>
<tr><th></th><th>Tablet & Capsule</th><th>Liquid Meds</th><th>Injections</th><th>IV Volume & Rate</th></tr>
<tr><td>Conversion</td><td>2</td><td>2</td><td>2</td><td rowspan="2">mL per Hour</td></tr>
<tr><td>Complex Math</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td>Sub/ Multiple Unit Dose</td><td>3</td><td>3</td><td>3</td><td rowspan="2">Drops per Minute</td></tr>
<tr><td>Unit Dose</td><td>3</td><td>3</td><td>3</td></tr>
</table>

Appendix E: Demographic Survey

Demographic Survey

Age: ______

Sex:
- ☐ Male
- ☐ Female

Years of Nursing Experience: _____

Highest Education Level in Nursing:
- ☐ ADN
- ☐ BSN
- ☐ MSN
- ☐ Doctorate

Highest Education Level:
- ☐ Associates
- ☐ Bachelors
- ☐ Masters
- ☐ Doctoral

In your current employment, what type of nursing specialty do you work?
- ☐ Critical Care
- ☐ Medical/Surgical/Telemetry
- ☐ Emergency Services
- ☐ NICU
- ☐ Women's Health
- ☐ Management/Leadership/Education
- ☐ Pediatrics
- ☐ N/A – I am currently not employed

In your current employment, what is the type of facility?
- ☐ Acute Care
- ☐ Long-term Care
- ☐ Doctoral
- ☐ N/A – I am currently not employed

ABOUT THE AUTHOR

Sarah Perron graduated from Bellevue Community College with an Associate's Degree in Nursing in 1998. She then earned her Bachelor's (2000) and Master's Degree in Nursing Education (2005) from The University of South Florida.