Work Hours, Workload, and Fatigue in Nurse Anesthetists

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Boston College
William F. Connell Graduate School of Nursing

WORK HOURS, WORKLOAD, AND FATIGUE IN NURSE ANESTHETISTS

a dissertation
by
SUSAN A. EMERY

submitted in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy

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Abstract

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Fatigue is a factor in human error particularly on tasks requiring sustained attention (Dinges, 1995). Work-hour studies of staff nurses have demonstrated that the risks of making an error increased when nurses worked longer shifts (Rogers, Hwang, Scott, Aiken, & Dinges, 2004. Workload in anesthesia care can vary widely with diverse cognitive and physical demands (Gaba & Lee, 1990; Weinger, Herndon, Zornow, Paulus, Gaba, & Dallen, 1994; Weinger, Reddy, & Slagle, 2004; Weinger & Slagle 2001).

The purpose of the study was to examine the influence of work hours and workload on fatigue in certified registered nurse anesthetists (CRNAs). A predictive, correlational design was employed and utilized an electronic survey of 10,000 active certified and active recertified CRNAs. A total of 928 CRNAs completed the survey which included a self-report of work hours. Workload was measured by the NASA Task Load Index and fatigue by the Checklist Individual Strength (CIS-20).

Hierarchical multiple regression analysis was applied to the data to test the hypotheses that 1) after controlling for demographic variables, the number of work hours and workload will positively influence post-shift fatigue in nurse anesthetists and 2) after controlling for demographic variables, there will be an interaction between work hours and workload in nurse anesthetists. Work hours and workload explained 19 % of the variance in fatigue in nurse anesthetists with the greatest contribution being from the number of work hours and the workload dimension of performance satisfaction.
The study findings suggest that increasing hours of anesthesia time and increasing workload, particularly dissatisfaction with meeting the goals of the anesthetic (performance dimension) increase fatigue in nurse anesthetists. The implications for practice, policy, and research are discussed.
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Chapter 1

Statement of Problem

The United States provides healthcare on a continuous basis twenty-four hours per day, seven days per week, and 365 days per year. Accordingly, the need for surgery and anesthesia does not stop with the setting sun and patient care takes precedence over the provider’s need for rest. Provider fatigue, however, places the patient at risk, as safety is impaired when the provider struggles to remain awake (Berger & Hobbs, 2006). Recent research has examined the effect of work hours on provider fatigue and errors in practice for both nurses (Rogers, Hwang, Scott, Aiken, & Dinges, 2004; Dorrian et al., 2008) and resident physicians (Landrigan et al., 2004).

Anesthesia care is highly complex and errors in anesthesia practice can result in injury or death. Certified registered nurse anesthetists (CRNAs) are advanced care nurse providers who are often the practitioners directly caring for the patient during a surgical procedure. The CRNA is constantly monitoring physiologic changes and making adjustments in the anesthetic according to patient response. In order to prevent an adverse event, the CRNA must be alert and vigilant to subtle changes in the patient’s condition. In the course of a typical day, the CRNA provides direct patient care for the totality of her (his) shift, the only exception being a fifteen-minute coffee break and a thirty-minute lunch break. Shifts may be eight, ten, twelve or more hours in length and some CRNAs work as many as twenty-four consecutive hours. Although the effect of work hours for staff nurses has been the subject of research, there is no research examining the effect of CRNA work hours on practitioner fatigue.
Workload in anesthesia care can vary widely. Cognitive and physical demands depend on both the nature of the surgical procedure and patient acuity. The precise definition of workload in anesthesia can be difficult to articulate (Gaba & Lee, 1990; Weinger et al., 1994; Weinger, Reddy, & Slagle, 2004; Weinger & Slagle 2001). Vigilance in monitoring hemodynamic changes is a baseline requirement while the number of actual interventions needed to maintain homeostasis ranges over a broad continuum.

Although research into the effects of work hours and errors in practice has been conducted in the critical care setting (Scott, Rogers, Hwang, & Zhang, 2006; Landrigan et al., 2004), patient acuity or workload has not been a specific factor in this research. The Critical Care Safety Study estimated that 148,000 serious or life-threatening errors occur annually in teaching hospitals in the United States and one-fifth of all medication errors in a critical care setting are life-threatening (Balas, Scott, & Rogers, 2006).

**Origins in Transportation**

Fatigue related to work hours is a concern in the transportation industry where drowsy driving is considered analogous to drunken driving as sustained wakefulness for seventeen hours decreases performance by approximately as much as a blood alcohol level of 0.05 (Brookhuis, DeWaard, & Fairclough, 2003; Dement, 1997; Williamson & Feyer, 2000). The significance of operator fatigue and has led to limitation in duty hours. The National Transportation Safety Board (NTSB) considers fatigue as a possible factor whenever an accident occurs (NTSB, 1990).

There is a longstanding analogy between anesthesia and the aviation industry. The latter has examined the effect of workload on mishaps with these untoward events
resulting from either excessively high or low workload (Gaba & Lee, 1990). The proposed study will examine the influence of work hours and workload on fatigue in certified registered nurse anesthetists in an effort to advance the patient safety agenda.

**Background and Significance**

**Safety in anesthesia practice.**

The Agency for Healthcare Research and Quality (AHRQ) defines outcomes research as research that seeks to understand the end-results of particular health care practices and interventions. To facilitate such research AHRQ has identified a set of measures that screen for adverse events resulting from a patient’s exposure to the health care system. These “Patient Safety Indicators” (PSIs) are amenable to prevention by changes at the system or provider level. Included among these indicators is “Complications of Anesthesia”. This measure is used to assess the number of anesthetic overdose, reaction, or endotracheal tube misplacement per 1,000 surgery discharges with an operating room procedure (AHRQ, 2007).

Although the focus on patient safety and error management predates the Institute of Medicine report (Kohl, Corrigan, Donaldson, 2000) this publication served to raise the level of awareness in the public arena and has led to the development of other safety initiatives. One such initiative is the 2004 work of the National Quality Forum (NQF), which, with funding from AHRQ and the Centers for Medicare and Medicaid Services (CMS), identified 220 candidate Safe Practices. Following a formal consensus development process, the NQF endorsed 30 evidence-based “Safe Practices”. They recommended employing these 30 safe practices where applicable to reduce errors and patient harm. In addition, NQF endorsed 27 “Promising Practices” considered high
priority for further research. Number 8 on this list of promising practices is the “use of napping, strategic caffeine intake, and other coping strategies to mitigate the risk of harm associated with fatigue” (Kizer & Blum, 2003, p.29). Research related to the effect of CRNA work hours on fatigue and patient safety is congruent with the AHRQ agenda and NQF Promising Practices.

**Fatigue as a risk factor.**

Neurobiologically-based sleepiness/fatigue is recognized as a factor in human error as the sleepy or fatigued individual demonstrates performance problems particularly on tasks, which require sustained attention (Dinges, 1995). The complex nature of healthcare scheduling confounds the evaluation of fatigue in providers. Sleepiness may result from insufficient or poor quality sleep, excessive scheduled work hours, overtime, on-call status, and other individual provider characteristics. Neurobehavioral impairment analogous to a blood alcohol level of 0.05% occurs following work in excess of sixteen hours (Arnedt, Owens, Crouch, Stahl, & Carskadon, 2005). Maintaining a state of wakefulness beyond the normal 16-hour day requires an input of energy and a fight against accumulating sleep deficit even in the absence of a stressful work environment (Mullington, Haack, Toth, Serrador, & Meier-Ewert, 2009).

Work-hour studies of staff nurses have demonstrated that the risks of making an error increased when nurses worked longer shifts. In one study, the risk of making an error was three times higher when nurses worked 12.5 hours or more. The results further showed that errors were twice as likely when nurses worked more than 40 hours in a week (Rogers, et al., 2004). Other researchers (Dorrian, et al., 2008) found that the
primary predictor for making an error was struggling to remain awake during a shift and this was itself predicted by reports of fatigue, sleepiness, or exhaustion.

Landrigan and colleagues of the Harvard Work Hours, Health and Safety Group (2004) in a prospective, randomized study reported that interns made 36% more serious medical errors when they worked a traditional schedule of frequent 24-hour shifts than when they worked shorter shifts. In a later review of existing work hour limitations, these researchers encouraged work hour limits and scientifically designed work schedules (Landrigan et al., 2007). As evidence of the continuing problem, they note that the Institute of Medicine (2004) recommendation that all nursing shifts exceeding twelve hours be eliminated has yet to be universally adopted.

**The Libby Zion case.**

The Libby Zion case in New York City (Asch & Parker, 1988) was the impetus for a change in policy regarding resident work hours. In 1984 Libby Zion was an 18-year-old college student who died in a New York Hospital hours after being admitted through the emergency room. The grand jury investigating Ms. Zion’s death found fault with the American system of graduate medical education. Specifically, because the resident and intern, who had cared for Ms. Zion, had been working for 18 hours, the grand jury recommended that the State Department of Health should create regulations that intern and resident consecutive work hours be limited. Although this case raised awareness and changed policy within New York State, it took 19 years for the Accreditation Council for Graduate Medical Education (ACGME) to adopt such regulations. Interestingly, eighty hours per week is the limit placed on resident work hours by the ACGME. This is still double the standard workweek in the United States.
Partly in response to the changes in New York State policy regarding the 80-hour workweek, the Anesthesia Patient Safety Foundation (ASF) conducted a work-hours survey (Gravenstein, Cooper, & Orkin, 1990). The ASF mailed the questionnaire to anesthesiologists, residents, and CRNAs and seeking information concerning work hours, limits on those hours, need for rest periods, and fatigue related errors. Fatigue-related errors were reported by 50-63% of respondents. The response rate on this survey was low and, consequently, the authors caution the reliability of their results as reflective of practice. However, they urge that the issue of fatigue and sleep deprivation in anesthesia warrants additional consideration and further study. Patients deserve, and patient safety demands, that the influence of work hours and workload on fatigue in nurse anesthetists be examined.

**Purpose and Research Questions**

The overall purpose of this study is to examine the influence of work hours and workload on fatigue in nurse anesthetists. Specifically, the following research questions will be answered.

1) After controlling for the influence of the demographic variables of age, gender, level of education, and years of experience as a nurse anesthetist, to what extent do number of hours worked daily and workload explain post-shift fatigue?

2) After controlling for the influence of the demographic variables of age, gender, and years of experience as a nurse anesthetist, is there an interaction of work hours and workload on post-shift fatigue?
**Hypotheses.**

1) After controlling for the influence of demographic variables, the number of work hours and the workload will positively influence post shift fatigue in nurse anesthetists.

2) After controlling for the influence of demographic variables there will be an interaction between work hours and workload.

**Definitions of terms.**

Selected terms used in this study are defined as follows:

**Demographic variables.**

*Age* is defined as the number of years of living and is measured operationally by participant self-report in the survey.

*Gender* is defined as the sex of the participant and is measured operationally by participant self-report in the survey.

*Educational level* is defined as the highest degree held by the participant and is measured operationally by participant self-report in the survey.

*Year of experience* is defined as the number of years employed as a nurse anesthetist and is measured operationally by participant self-report.

**Certified registered nurse anesthetists.**

Certified registered nurse anesthetists (CRNAs) are advanced practice nurses who have completed an educational program accredited by the Council on Accreditation of Nurse Anesthesia Educational Programs and are certified by the National Board for Certification and Recertification of Nurse Anesthetists.
**Fatigue.**

Fatigue is a multidimensional construct defined conceptually and within the Roy Adaptation Model, specifically the cognitive processing theoretical framework (2009) as impaired arousal, attention, sensation and perception. Fatigue is operationally defined and measured by the self-administered Checklist of Individual Strength (CIS) Questionnaire (Appendix F). Measured components of fatigue include the subjective feeling of fatigue, activity, motivation, and concentration. These specific dimensions of fatigue are reported in addition to the total fatigue score.

**Work hours.**

The number of hours of work in performing anesthesia care from arrival to departure from the hospital or surgery center. Within the Roy cognitive processing theoretical framework, work hours are defined as a contextual stimulus. Operationally, actual work hours will be reported as a continuous variable by the participant.

**Workload.**

Workload is conceptually defined as a multidimensional construct affected by cognitive, psychological, and physical factors. It refers to the balance between the challenge of a task and the individual’s response to that task (Leedal & Smith, 2005; Weinger & Slagle, 2001). Within the Roy cognitive processing theoretical framework, workload is defined as a focal stimulus. Operationally workload will be measured with the NASA Task Load Index (NASA TLX). Individual components of workload within this index are mental demand, physical demand, temporal demand, performance, effort, and frustration. Participants will weight and rate each dimension of workload.
Assumptions

1. The contextual stimulus of time-on-task defined as work hours influences the input processes of arousal and attention, and sensation and perception of the cognitive processing model.

2. The focal stimulus of workload consisting of mental demand, physical demand, temporal demand, performance, effort, and frustration influences the input processes of arousal and attention, sensation and perception of the cognitive processing model.

3. Fatigue is at the opposite end of the arousal continuum from attention.

Limitations

1. Nurse anesthetist participants will accurately record time-on-task as work hours in the survey.

2. Nurse anesthetist participants will recall and accurately record workload in the survey.

3. Nurse anesthetist participants will recall and accurately record post-shift fatigue in the survey.
Summary

In this chapter, I have discussed the purpose of the proposed study, which is to examine the influence of work hours and workload on nurse anesthesia practice. Included in this discussion is a review of the background concerning work hours in healthcare (Asch & Parker, 1988) as well as the origins of similar concerns in the transportation industry. Two specific research questions are posed, together with associated hypotheses. The independent variables of work hours and workload and the dependent variable of fatigue are defined conceptually, theoretically, and operationally. Similarly, all demographic variables are defined. Finally, the assumptions and limitations of the proposed study are presented.
Chapter 2

Review of the Literature

The relationships among work hours, workload, and fatigue are both intuitive and complex. Individuals in industrialized societies are increasingly required to engage in sustained work schedules in both essential and non-essential services. This is particularly true in the health care arena but also occurs in other areas of public safety including police and fire departments as well as the transportation industry. In many of these professions, the work requirements range from sustained vigilance to active performance interfering with rest and sleep (Stampi, 1989, p. 140).

In this chapter, I will review the literature related to the theoretical framework for the proposed study. I will then summarize the research findings related to work hours, workload, and fatigue as relates to nurse anesthesia practice.

Theoretical Framework

**Roy adaptation model.**

The theoretical underpinnings for this study rest in the Roy Adaptation Model and Arousal Theory. The Roy Adaptation Model (RAM) describes the individual as an adaptive system with two broadly defined internal processes, the regulator and the cognator. Together the regulator and the cognator work to maintain integrity of the adaptive system (Roy, 2009). Catecholamine neurotransmitters maintain homeostasis through the neuroendocrine system(s) and are examples of the regulator. Cognition, perception, and emotion represent the cognator.
Assumptions of the RAM.

The assumptions of the RAM originate in systems theory. Individuals interact with the environment and environmental stimuli act as inputs to the human system and influence adaptation. Within the RAM, there are three classes of stimuli, focal stimuli, contextual stimuli, and residual stimuli. Focal stimuli are those most immediate to the individual, most present in consciousness. They may be either internal or external but in either case, focal stimuli command the attention of the individual. In the present study, workload is a focal stimulus. Included in the workload of the anesthetist are the mental demands, the physical demands, the temporal demands, performance concerns, effort required, and degree of frustration associated with accomplishing the task.

Contextual stimuli are those that contribute to the affect of the focal stimuli and, therefore, influence how the individual deals with the focal stimuli but are not the center of attention. In this study, work hours or time-on-task is the contextual stimulus. The length of the work-day contributes to fatigue but does not command the attention of the nurse anesthetist as do the multiple dimensions of workload.

Residual stimuli are factors that may have an effect on the situation at hand, but the exact effect is, now, unclear. Among possible residual stimuli in this study are the demographics of age, gender, educational level, and year of experience as a CRNA.

Adaptation level.

Roy (2009) identifies three possibilities for adaptation level, integrated, compensatory, or compromised. When the adaptation level is integrated, all processes are working together to meet the needs of the individual. If, however, there is a challenge to this integration, the cognator and the regulator are activated and the adaptation level is
compensatory. If the compensatory mechanisms are inadequate, the adaptation level becomes compromised. Both the current internal situation and the demands placed on the individual from the environment affect the ability to function adequately. Internal fatigue and the demands of patient care affect the ability of the nurse anesthetist to perform the work at hand.

*Coping.*

The coping processes of the regulator and the cognator subsystems are both innate and acquired mechanisms by which the individual adapts and responds to the changing environment. The cognator subsystem specifically reflects the cognitive and emotional responses of perception and information processing, learning, judgment, and emotion. Inputs to the cognator include internal and external stimuli. Fatigue results in changes in brain function and alteration in the biochemical processes of homeostasis and in this way the cognator subsystem affects the regulator subsystem and the neuroendocrine response. Beyond physical fatigue, the individual becomes irritable, lacks the ability to concentrate, and may become restless or disoriented. Performance declines and there is impaired problem-solving, short-term memory, and an increased risk for accidents or errors (Roy, 2009).

*Adaptive modes.*

There are four adaptive modes within the RAM: the physiologic-physical, the self-concept-group identity, the role function, and the interdependence modes. The theoretical basis for this study is found in the physiologic-physical mode. Physiologic integrity is the goal of this mode which represents the behavior associated with the functioning of the individual from the cellular level up to and including the human body.
as a system. Rest and activity are together one of the nine components of the physiologic mode. Fatigue can result in inadequate coping within the cognator subsystem. Consequently, work hours or time-on-task for the nurse anesthetist, particularly with a limited break structure, may compromise this component of the physiologic model which is essential to information processing and judgment.

**Cognition as physiologic adaptation: the Roy cognitive processing model.**

Roy defines cognition as “...a broad term for the human abilities to think, feel, and act” (2009, p.274). The individual receives information (input), the information is processed in some way (central processing), and transformed into a response (output). The Roy model of cognitive processing provides a framework for understanding this complex aspect of adaptation. The model depicts several circles with the innermost circle containing the fundamental processes of arousal and attention, sensation and perception, coding and concept formation, memory and language, and planning and motor response. The individual’s ability to function within this adaptive mode depends on intact anatomy, physiology, and integrated neurologic functioning. In nurse anesthesia practice, such integrated neurologic functioning is manifest when the CRNA differentiates specific stimuli from those present, to be processed by the central nervous system in order to generate the required response/intervention. Consequently, for the CRNA, neural integration permits the practitioner to identify and prioritize alterations in patient homeostasis. The significance of these observations is processed by the cerebral cortex, and the resultant clinical judgment prompts a course of action. These basic cognitive processes act within the field of consciousness as seen in the model. Consciousness then
requires the integration of cerebral cortex, hypothalamus, and the reticular activating system of the brain stem in a feedback mechanism.

**Consciousness.**

Consciousness is a concept pivotal to the field of anesthesia, but is certainly not exclusive to it. It is defined as the awareness of the internal and external environment. In applying the concept to the clinical situation, Roy (2009) describes two components of consciousness: arousal and content. Arousal is the “awakeness” of the individual and content refers to the awareness and interpretation of the internal and external environment. Consciousness further requires reflection and the ability of the individual to adjust actions according to both input and intent. The practice of anesthesia requires that the CRNA be both awake and aware of subtle changes in the patient’s environment in order that input be received, processed, and appropriate interventions performed. The individual components of cognitive processing are information input, information processing, and output processes.

**Input processes.**

**Arousal and attention.**

Input processes consist of two distinct domains: arousal and attention, and sensation and perception. Arousal and attention consist of selective attention, speed of processing, and alertness. According to Roy (2001), the occurrence of arousal and attention is due to the orientation of sensory receptors to a stimulus. There may be three triggers for such orientation: 1) a change in stimulus level, 2) presentation of a new stimulus, or 3) presentation of a stimulus that has been learned as a signal for reward or punishment. For the nurse anesthetist, the multiple aspects of workload may signal a
change in arousal and attention. For example, the sounding of a monitor alarm or the sudden audible increase or decrease in heart rate may be such a trigger. A secondary stimulus superimposed on background vigilance is an example of presentation of a new stimulus. This may be the surgeon requesting a change in the position of the operating room table. An intraoperative stimulus that signals punishment for the anesthetist is the change in tone associated with a decline in oxygen saturation.

- Selective attention

Selective attention is one of multiple paradigms used for investigating attention and refers to the ability of the individual to respond to some stimuli while ignoring others (Matthews, Davies, Westerman, & Stammers, 2008). Posner (2004) has extensively studied the various networks contributing to attentional systems in the brain. The anterior system in the frontal lobes is associated with cognitive control and action selection. The posterior system, located in posterior structures of the brain such as the parietal and occipital lobes, is the system that controls aspects of spatial attention. This system directs attention to spatial locations where something potentially important is occurring. Finally, the arousal system modulated by the brainstem is associated with vigilance. The CRNA must be aware of potentially subtle changes in the operating room environment. For example, the surgeon and the circulating nurse may be engaged in discussion that involves a change in patient care without including the CRNA. The nurse changing the suction canister may be the only signal of increased blood loss.

The nurse anesthetist’s sensory receptors are continuously oriented towards multiple competing stimuli in the operating room. Auditory stimuli include monitor tones that vary according to tone quality such as oxygen saturation, and tone quantity, such as
heart rate. Amid this backdrop are secondary stimuli such as monitor and anesthesia
machine alarms and sporadic requests from the surgical team. In some cases, the patient
is also awake and needing reassurance, assistance, or both. Optimal patient care requires
that the CRNA be able to rapidly attend to the most important of these stimuli and still
place other demands in the proper order. In this practice setting, other stimuli are not
ignored but rather prioritized.

- Speed of processing

The speed of information processing helps to determine what stimuli will reach a
level of awareness and, consequently, the amount of information that will be missed. In
certain circumstances, the individual is required to attend to two or more tasks
simultaneously (Matthews et al., 2008). The speed with which the individual can process
incoming stimuli will determine this ability (Roy, 2001). The anterior network as
described by Posner (2004) controls detection of events, is active in discriminating visual
cues, and relates to controlled processing and working memory. As noted the nurse
anesthetist must process multiple, often unrelated stimuli, some auditory and others
visual or tactile. Anything that interferes with speed of information processing such as
fatigue or workload would translate into missed information and the potential to affect
patient care.

- Alertness

Alertness is the third type of arousal and attention and refers to that state of the
central nervous system affecting the ability to respond to stimuli, the receptivity to
external stimulation. The level of alertness may be altered by modification of the pathway
connecting sensory input to a response or by the individual’s general state of receptivity
that may be altered by such factors as fatigue, sleep, and nutrition (Davies & Parasuraman, 1981). For the nurse anesthetist in the present study, arousal and alertness is opposite to fatigue on the continuum of cognitive processing.

*Sensation and perception.*

The second aspect of the cognitive input function is sensation and perception. Following arousal and attention, the stimulus interacts with a receptor. Subsequently the neurologic signal travels by afferent pathways synapsing in the cortex and results in perception. For nurses and others, education and experience play a part in the process of perception as these are among the contextual and residual stimuli affecting the focal stimulus (Roy, 2001).

Occasionally these factors can have an effect opposite to that intended. Researchers examining the causes of error in nursing and medical practice have noted that very experienced people have made egregious errors because of what has been termed a “look but fail to see” phenomenon known as “inattentional blindness” (Green, 2004). In these cases, the efficiencies of cognitive processing should permit rapid, accurate perception by using a filter to select out irrelevant information as discussed earlier. However, experienced people become preprogrammed to see what they expect to see particularly with routine tasks. This form of adaptation creates a problem for the nurse anesthetist as she can perceive what is expected to be there rather than what is. This maladaptive behavior has been the source of medication errors. The nurse decides the patient requires a particular medication, reaches for that medication, and administers the incorrect medication without realizing it (Green, 2004; Smetzer, Baker, Byrne, & Cohen,
2010). As the domains of arousal and attention, and sensation and processing provide input to central processing and output, failure of input leads to errors of output.

**Central processes.**

The central nervous system receives the individual’s perception of the stimulus in the setting of contextual and residual stimuli. The processes of coding, concept formation, memory, and language follow to further process the information received. Coding involves the registration, consolidation, and synthesis of information; the way in which the individual understands information in the context of expectations (Roy, 2009). Nurses begin the coding process early during the education program. As experience is added to education, the nurse is able to synthesize and recognize recurring patterns that become useful in subsequent encounters.

Concept formation requires that the individual understand the complexities of the situation, discriminating similarities and differences. Memory is important in the ability to apply both education and experience to practice. The nurse needs to recall both theoretical and experiential knowledge so that each new patient encounter is viewed in the context of that knowledge. Central processing of information is predicated on understanding and articulation of appropriate linguistics including spoken and written language as well as the lingo associated with nursing, medicine, and the specialty of anesthesia. The effects of fatigue may be mediated by contextual stimulus of cognitive load such that a higher mental effort depletes mental reserve at a faster rate than tasks with a lesser mental effort (Balkin & Wesensten, 2011).
Output processes.

The output processes are the capabilities of the individual to plan and carry out the needed response to stimuli and include planning and the motor response. For the nurse anesthetist the output processes include the anesthetic plan developed from the pre-anesthesia assessment as well as the immediate response to an unanticipated change in homeostasis during the course of patient care. The nurse anesthetist must create a plan based on data obtained anticipating the anesthetic requirements determined by both the surgical procedure and the patient’s co-morbidities. The physical action of the nurse anesthetist in carrying out patient care responsibilities is the motor response. Such actions include but are not limited to intravenous cannulation, medication administration, and airway management. Under the influence of the focal stimulus of time-on-task (work hours), the contextual stimulus of workload, and the residual stimuli, the CRNA’s ability to implement an effective plan may be impaired. Similarly, she may not have the ability to react to changes in the environment in order to maintain homeostasis.

Stimuli.

As noted in the discussion of the RAM, focal stimuli are those stimuli confronting the person in consciousness and for the anesthetist the multidimensional construct of workload is an external focal stimulus. Contextual and residual stimuli are considered by Roy (2001, 2009) to represent the education and experience of the nurse. The nurse anesthetist processes contextual stimuli consisting of both educational preparation and experiential learning. However, for the nurse anesthetist, time-on-task or work hours also constitute a contextual stimulus. The dotted lines in the model demonstrate the fluidity of stimuli across the boundaries of stimulus fields.
Arousal theory.

Arousal or activation theory also serves to inform this study. According to arousal theory, there is a progressive decrease in the level of arousal or central nervous system stimulation during a vigilance task because the brain becomes less response during a monotonous vigilance situation (Davies & Parasuraman, 1982). The Yerkes-Dodson Law is also referred to as the inverted-U hypothesis (Matthews et al., 2008). It states that cortical functions are the most efficient at moderate levels of arousal. This is a time when the individual is awake and alert but not agitated or excited and is the optimal level of arousal. An explanation for the inverted-U curve was proposed by Easterbrook (1959) whose hypothesis was that arousal is related to attentional selectivity. When arousal is low, the individual attends to a broad grouping of task stimuli and other irrelevant stimuli consisting of the surrounding environment. As arousal increases, the irrelevant stimuli are dismissed and the individual focuses on task-specific stimuli.

Stress influences arousal and attention, which then influences fatigue and performance. Stress can take on a number of forms including that associated with the workplace. Matthews and colleagues (2008) reported on research conducted in the transportation industry. This demonstrated that fatigue had a negative influence on driving when the task was less demanding and that induced fatigue was associated with loss of task engagement.

Arousal theory and the inverted-U hypothesis apply to nurse anesthesia practice as the nurse operates under an elevated state of awareness that is optimal for detecting changes in homeostasis if the individual is stimulated but not bored. At a low level of stimulation, there may be little to engage the cognitive processes of the CRNA. If the
blood pressure and heart rate remain stable and there are few interventions, as in caring for a stable, healthy patient undergoing a minimally invasive procedure, workload is low and similarly the CRNA’s level of arousal may be low resulting in fatigue. Similarly, if the patient is extremely unstable, the workload is high and the CRNA’s level of arousal is high. Excessive arousal over a prolonged period of time may again result in fatigue. In both situations, a stimulus may be missed due to fatigue from extremes on the arousal continuum.
### Table 1

**Variables as defined conceptually, theoretically, and operationally**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Conceptual Definition</th>
<th>Theoretical Definition (RAM)</th>
<th>Theoretical Definition (Arousal Theory)</th>
<th>Operational Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue (DV)</td>
<td>Fatigue is a multidimensional construct defined conceptually and within the Roy cognitive processing theoretical framework as impaired arousal, attention, sensation and perception.</td>
<td>Fatigue is a multidimensional construct defined conceptually and within the Roy cognitive processing theoretical framework as impaired arousal, attention, sensation and perception.</td>
<td>Fatigue is diminished arousal, alertness at the low end of the arousal continuum.</td>
<td>Fatigue is operationally defined and measured by the self-administered Checklist of Individual Strength (CIS) Questionnaire. Measured components of fatigue include the subjective feeling of fatigue, activity, motivation, and concentration. These specific dimensions of fatigue are reported in addition to the total fatigue score.</td>
</tr>
<tr>
<td>Work Hours (IV)</td>
<td>The number of hours of work in performing anesthesia care from arrival to departure from the hospital or surgery center.</td>
<td>Within the Roy cognitive processing theoretical framework, work hours are defined as a contextual stimulus.</td>
<td>Situational stressor of time-on-task</td>
<td>Operationally actual work hours will be reported as a continuous variable by the participant.</td>
</tr>
<tr>
<td>Variable</td>
<td>Conceptual Definition</td>
<td>Theoretical Definition (RAM)</td>
<td>Theoretical Definition (Arousal Theory)</td>
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<tr>
<td>Workload (IV)</td>
<td>Workload is conceptually defined as a multidimensional construct affected by cognitive, psychological, and physical factors. It refers to the balance between the challenge of a task and the individual’s response to that task (Leedal &amp; Smith, 2005; Weinger &amp; Slagle, 2001).</td>
<td>Within the Roy cognitive processing theoretical framework, workload is defined as a focal stimulus.</td>
<td>Cognitive load</td>
<td>Operationally workload will be measured with the NASA Task Load Index. Individual components of workload within this index are mental demand, physical demand, temporal demand, performance, effort, and frustration. Participants will weight and rate each dimension of workload.</td>
</tr>
</tbody>
</table>
Literature Review

Delineation of the dependent variable.

Fatigue.

Fatigue is a subjective feeling of tiredness and discomfort associated with prolonged activity (Matthews et al., 2008). Hockey (2011) proposed that fatigue is more than energy depletion related to work and described the difficulty in identifying a theory underlying the construct. Others have noted that a major problem with fatigue research is the lack of an adequate single definition for this multidimensional construct (Job & Dalziel, 2008).

Psychological fatigue refers to a disinclination to continue a task (Brown, 1994), a lack of motivation. However, for the worker, fatigue manifests as a decrease in various aspects of performance including deficits in attention, perception, and decision-making (Cercarelli & Ryan, 1996). This definition describes an outcome that is not exclusive to fatigue as similar performance decrements may occur with illness and other antecedents. Another broader, more inclusive definition describes fatigue as “an individual’s multi-dimensional physiological-cognitive state associated with stimulus repetition which results in prolonged residence beyond a zone of performance comfort” (Hancock & Verwey, 1997, p. 497).

Job and Dalziel (2008) propose that fatigue be defined as “the state of an organism’s muscles, viscera, or central nervous system, in which prior physical activity and/or mental processing, in the absence of sufficient rest, results in insufficient cellular capacity or system-wide energy to maintain the original level of activity and/or processing by using normal resources” (p. 469). This definition identifies the cause of
fatigue as “prior physical or mental processing” which may be due to physical exertion, sustained attention or vigilance, long duration tasks, or some combination of these. It also establishes the role for rest during performance of a task as absence of “sufficient rest” places the prior physical and mental processing in context. Rest is essential for restoration and renewal and sleep is an important form of rest. Inadequate sleep, and therefore rest, compromises restoration and leads to an increased risk for accidents, inefficiency, irritability, and exacerbation of pre-existing health problems (Roy, 2009). It is possible that even brief periods of rest during performance of a task will help to counteract the effects of physical and mental processing.

Although fatigue and sleepiness are two separate constructs, the literature related to the effects of fatigue on performance overlaps substantially with that concerning the role of sleep deprivation as an antecedent of fatigue. Insufficient sleep or sleep deprivation contribute to fatigue and are associated with poor attention and performance (Mullington et al., 2009). One concept morphs into another and yet fatigue and sleepiness are not synonymous. The relationship between these two concepts is convoluted. However, the definition of fatigue implies that exertion or work is the causative factor.

The physical state of the organism associated with fatigue is insufficient energy. Job and Dalziel (2008) opine that it is important to be able to identify biologic markers of cellular processes associated with the physical aspects of fatigue in order to avoid a circular definition of cause and effect.

The final phrase of the fatigue definition refers to a performance goal namely “to maintain the original level of activity and/or processing using normal resources”. Fatigue involves a change in the physical or mental activity required for a task although this
change isn’t necessarily equated with a decline in performance. (Job & Dalziel, 2008).
The implication is that performance may be sustained by using alternative energy sources
to compensate for fatigue.

Balkin and Wesensten (2011) have conceptualized the relationships among
fatigue, sleepiness and performance according to their individual antecedents. For
fatigue, the antecedents are time on task and cognitive load. At any point in time, the
fatigued individual is at a point of balance between the forces producing fatigue and those
leading to recovery from that fatigue (Dawson & Fletcher, 2001). The conceptualization
of time on task (work hours), cognitive load (workload) and fatigue are depicted in figure
2.2 (Balkin & Wesensten, 2011, p. 50).

Figure 1. Antecedents and Consequences of Fatigue. (From Balkin, T.J. & Wesensten,
permission.
Clearly, there is overlap in the health care arena requiring consideration of all antecedent factors.

*Work-related factors influencing fatigue.*

Mental effort is required for completion of repetitive cognitive tasks such as those involved with memory, judgment, and reasoning, over a sustained period. Hockey (1997) developed a model to explain the relationship between fatigue and performance during continuous operations. The assumption is that there is a physiologic basis to our mental resources and that when these resources are depleted from continuous performance during prolonged work hours, the individual compensates by either increasing the effort expended, or by changing the performance goals in order to decrease the necessary effort. Capacity is an important consideration and an integral part of mental resources. The idea of capacity has been applied to studies of attention where there is a limit to the quantity of attention applied to a task and divided attention research addresses the ability of an individual to concentrate when task demand is high (Matthews et al., 2008).

*Task-induced fatigue.*

A task induces fatigue in more than one way. Firstly, an individual may simply be tired of performing the task and so relief may come by changing the activity. Another form of task-induced fatigue is due to the prolonged effects of work or exertion (Matthews et al., 2008). There are certain task characteristics that lead to increased mental effort, impaired learning, stress, and so to cognitive fatigue. These characteristics include cumulative intellectual demands, the resultant penalty for attentional blinks, and arousal factors. That there is a penalty for attentional blinks is considered a necessary
condition for cognitive fatigue. Typically this involves the confluence of continuous work (time-on-task) and the precise nature of the work involved (Ackerman, 2011). This certainly describes the work of a CRNA where work hours combine with the exactness of individual interventions. If there is an attentional blink, the CRNA is aware that the patient may suffer. This awareness is a significant source of fatigue.

*Cumulative intellectual demands (Time-on-task).*

The degree and extent of the intellectual demands on the individual over time relate to a number of factors including 1) time on task, 2) the need for a high degree of intellectual functioning, and 3) continuous, uninterrupted work. Time on task is the most prominent variable included in cognitive fatigue research. Studies of cognitive fatigue often involve tasks requiring a greater level of intellectual effort as “… when tasks have low levels of cognitive demands, the operative mental state is one of boredom rather than fatigue” (Ackerman, 2011, p.14). When the time-on-task is continuous, the individual does not have the opportunity to replenish cognitive resources and so continuous tasks are more likely to result in a decline in performance than those during which intermittent breaks are incorporated. One study of anesthesia residents examined the effect of a thirty-minute break on divided attention and working memory. The results of this double-blinded cross-over study were that a thirty-minute break during a 7.5 hour work day did not influence cognitive function tests (Coburn et al., 2006). The sample size for this study was small (n= 30) and the relatively short work-day are two limitations of this study. Of note, the thirty-minute break utilized in the study was double that of the usual fifteen-minute break that is routine for CRNAs.
Penalties for attentional blinks.

An attentional blink is the failure to respond to the second of two targets when presented in close succession in time (Martens & Wyble, 2010). Attention to detail, low tolerance for errors, and a significant cost for distraction are important factors in cognitive fatigue. Attention has both selective and intensive aspects. Significant resource utilization occurs when the individual selects the stimulus for which a response is necessary such that performance decrements are more likely with tasks that necessitate such attention to detail. Similarly, when there is a low tolerance for errors due to the cost to self or others, frequent checking of one’s work is essential and this checking and rechecking add to the fatigue load of the task.

Missed signals can also be costly in terms of both error causation and increasing workload as the missed signal may mean repetition of the task. Health care in general and anesthesia practice in particular has a low tolerance for errors or “blinks”. The nurse anesthetist must remain vigilant as “…the cognitive demands of intraoperative patient care requires an iteration of data collection, evaluation of its relevance to patient status, development and implementation of plans to maintain desired patient status, and monitoring the outcome of interventions” (Howard, Rosekind, Katz, & Berry, 2003, p.1282).

Arousal factors.

Arousal factors include those that are internal and external to the individual performing the task. External influences such as noise, light, temperature, and production pressure (Gaba, Howard, & Jump, 1994). Many of these stressors are not under the individual’s control and this lack of control then becomes an additional stress. Time
pressures are particularly applicable when the individual must monitor continuous
displays of information and in these circumstances, distractions or a lapse in attention can
cause performance to suffer. Examples of arousal factors for the CRNA include the
external noise of loud equipment during an orthopedic procedure, ambient light changes
during laparoscopic or ophthalmologic surgeries, or elevated room temperature during
organ transplantation procedures. In all cases, there is a background of production
pressure to optimize operating room efficiency and utilization.

Cognitive fatigue then, is a consequence of time-on-task (work hours) and the
intensity of the task (workload). Mental resources have limited capacity and when that
limit is reached, the individual can either muster additional effort or redirect the goals of
the effort to conserve energy. In this way fatigue effects are a function of “task
performance” defined as a product of time-on-task and cognitive load (workload) and so
should be reversed by rest (time off task) (Balkin & Wesensten, 2011).

**Consequences of fatigue.**

The individual reports fatigue subjectively as a feeling, an inability to concentrate,
a lack of motivation, or a decrease in physical activity. Alternatively, some form of
performance decrement may measure the consequences of fatigue. Mental effects of
fatigue are due to the depletion of cognitive resources over time such that subsequent
tasks suffer.

The transportation industry considers fatigue a significant factor in accident
investigations. Fatigue is a causal factor in approximately one third of heavy truck
crashes (Arnold et al., 1997). Additionally there have been a number of high profile
accidents in which fatigue or altered work-rest patterns is including the grounding of the

Exxon Valdez, the nuclear accidents at Three Mile Island and Chernobyl, and the space shuttle Challenger accident (Howard et al., 2003).

The complex relationship between fatigue and sleepiness make it difficult to tease out the specific consequences of each separately, and in the real world environment, this may be impossible because a third factor is superimposed, that of operational work requirements. In many industries including health care, sleep deprivation occurs because the work extends beyond the normal eight-hour day or forty-hour week. In shift workers, the job mandates wakefulness at a time of day opposed to normal circadian rhythms. In addition, the task that occupies the individual producing sleep loss is the same task on which performance declines during the work period. In essence, then the consequences of sleepiness due to sleep loss or altered circadian rhythm, and those of fatigue, caused by time on task, are inseparable in the real world. For this reason and the difficulty in isolating effects, research concerning fatigue and sleepiness should at the same time acknowledge the difference and embrace the relationship.

The known performance effects of fatigue then include decreased attention and vigilance, impaired decision-making, reduced memory, and prolonged reaction times (Dinges & Kribbs, 1991; Dinges, 1992; Howard et al., 2003; Pilcher & Huffcutt, 1996). Performance variability also increases and errors are more likely. In fact fatigue causes performance impairment equivalent to that of alcohol intoxication. (Dawson & Reid, 1997).
Delineation of the independent variables.

Work hours.

The relationship between fatigue and work hours has been the subject of several studies. Longer workdays were associated with greater fatigue/sleepiness and a decline in performance in several studies of office workers (Rosa & Colligan, 1988; Rosa, Colligan, & Lewis, 1986; Rosa, Wheeler, Warm, & Colligan, 1985). The Maastricht Cohort Study on Fatigue at Work evaluated 12,095 employees from 45 different organizations by means of a self-administered questionnaire. A part of that study examined the associations between working hours and patterns and the need for recovery from work. The researchers concluded that more hours of work both per day and per week were associated with a greater need for recovery and that working overtime was particularly associated with an increased need for recovery (Jansen, Kant, van Amelsvoort, Nijuis, & van den Brandt, 2003). The variable nature of work hours in health care including hours per day, hours per week, overtime hours and the issue of call status adds a certain complexity to evaluation of studies linking work hours with fatigue in this professional arena.

Nurse work hours.

Nurses work hours were the subject of three studies (Dorrian et al., 2008; Rogers et al., 2004; Scott et al., 2006). These researchers examined the relationship among the variables of work hours, fatigue and errors in practice. They found that errors were as much as three times as likely to occur when nurses worked longer than 12.5 hours per shift (Rogers et al., 2004; Scott et al, 2006) and the primary predictor of error was fatigue or “struggling to remain awake” at work (Dorrian et al., 2008). The issue of overtime was
the subject of three additional studies (Bae, Brewer, & Kovner, 2011; Geiger-Brown, Trinkoff, & Rogers, 2011; Olds & Clarke, 2010). Bae & colleagues found that overtime regulations resulted in a decrease in mandatory overtime for nurses, however they noted that no regulations exist regarding voluntary overtime. The work of Olds and Clarke (2010) supported that of others that increased work hours including those involving voluntary overtime, as associated with an increase in adverse events and errors in practice.

The relationship of work schedule on sleep was examined by Geiger-Brown and colleagues (2011) who concluded that adverse work schedules (including mandatory overtime) may interfere with restorative sleep. The amount of sleep and therefore the fatigue level prior to work was considered in two additional studies (Dorrian et al., 2008; Seki & Yamazaki, 2006). The perceived level of fatigue was higher and the mean sleep duration was less before night shift work. Although both studies reported more errors occurring during the day shift, this is likely due to more interventions and possibility of error at that time of day. Finally, one study (Richardson, Turnock, Harris, Finley, & Carson, 2007) examined the various effects of twelve-hour shifts as indentified by focus groups. Although most respondents believed these shifts should continue, researchers concluded that fatigue was an individual and subjective experience. Individuals varied in the ability to achieve rest and sleep between shifts and experienced differences in workload.

A limitation common to these studies is the reliance on self-report. The sample sizes were also relatively small ranging from 41 (Dorrian et al., 2008) to 502 (Scott et al., 2006). Although the numbers would appear adequate in the Rogers (n = 393) and in the
Scott studies, the response rate was low at 40-43.7%. Rogers did not specify the definition of errors in their survey instrument but categories of errors were identified by Dorrian and were also cued by Seki & Yamazaki (2006). The use of an objective measure of sleep by Dorrian and colleagues would have enhanced the reliability of the sleep measurement. A final limitation of these studies is the lack of control for or measure of acuity in the work environment. The diverse nature of work environments even within critical care units makes acuity an important variable related to both fatigue and errors in practice.

In a study to evaluate the effect of a slight extension of the normal eight-hour shift to a nine-hour day on fatigue, health, and performance, Josten and colleagues (2003) studied 134 nurses from three nursing homes in the Netherlands. They concluded that the nine-hour shift combined the negative aspects of both the eight hour and the twelve hour work schedule. Nurses who worked the nine-hour shift demonstrated more fatigue and performance was slightly poorer.

**Resident work hours.**

Several studies focused on the effect of resident work hours on performance. The Accreditation Council for Graduate Medical Education (ACGME) instituted work hour limitations in 2003 in order to address the issue of fatigue in residents. Researchers who conducted a survey of resident work hours reported that nearly half of all first year residents and one third of all second year residents work more than 80 hours per week (Baldwin, Daugherty, Tsai, & Scotti, 2003).

The single qualitative study in this review (Fletcher et al., 2008) used a grounded theory analysis of focus groups involving internal medicine residents. The objective of
this study was to determine how residents perceived the impact of the ACGME rules on individual fatigue and the incidence of patient care errors. The researchers concluded that although the reduced work hours decreased fatigue and fatigue-related patient care errors, the residents were concerned about the effect of the reduced continuity of care.

Baldwin and Daugherty (2004) examined the relationship between resident work hours, sleep hours, and other variables including errors. Residents who slept five hours or less per night were 1.74 times more likely to make a significant medical error than those who slept more. The limitation of this as with other preceding studies relying on self-report is that the data lack the validity of objective measurement. The fatigued individual may not keep accurate records, may neglect or choose not to record an error. The strength of the large sample size (n=3604) is further enhanced by the 64.2% response rate.

The traditional call status of resident physicians involves a combination of long work hours and partial sleep deprivation with frequent interruptions. The Intern Sleep and Patient Safety Study was a part of the Harvard Work Hours, Health and Safety Study conducted from July 2002 to June 2003. Two studies in this review are a part of this larger project. At issue was the nature of the traditional call schedule for house staff in the medical and cardiac intensive care units. Comparison was made between the effects of the traditional call schedule with those of a reduced-hours intervention schedule. In a prospective, randomized study comparing medical errors by interns on the traditional schedule with those on the intervention schedule, interns made 35.9% more serious errors during the traditional schedule than during the intervention schedule (Landrigan et al., 2004). Similarly, Lockley and colleagues (2004) used a within subjects experimental design to evaluate the effect of work hours on attentional failure in interns. Through the
use of continuous electrooculography, attentional failures were found to be 1.5 times as likely during the day shift and twice as likely on the night shift (11 pm – 7 am) on a traditional rotation schedule.

The prospective, randomized study by Landrigan and colleagues (2004) had several strengths. The researchers collected data involving 2203 patient days and therefore had sufficient power to detect differences in error rates. They also clearly defined errors and employed physician observers rather than relying on self-report. Blinded reviewers categorized each incident and inter-rater reliability testing was conducted. The Lockley (2004) study as a within-subjects design provided a measure of control. The use of an objective measure of sleep (polysomnography) enhanced the validity of the findings, however, the small sample size (n = 20) was a limitation.

In a retrospective chart review of medication errors, resident physicians were significantly more likely to make an error during a call shift or post-call then when they were not on call (Hendey, Barth, & Soliz, 2005). A limitation of this study is that researchers did not measure sleep and that errors could have been a result of variables other than fatigue such as decreased supervision. In addition, as this was a chart review, error detection was limited to discovery by pharmacists and many errors may have gone undetected. The conclusion by Lockley and colleagues (2007) is that the hours routinely worked by health care providers in the United States pose a safety problem and work hour limits should be established and enforced.

Anesthesia providers.

Two studies focused on the relationships among fatigue, attention, and work hours in anesthesia residents. A study of New Zealand attending and resident
anesthesiologists relied on self-report of fatigued-related error. The researchers found that 86% of respondents reported having made a fatigue-related error at some point in the past with 32% having made the error in the prior six months (Gander, Millar, Webster & Merry, 2008). They further reported that 50% of residents and 27% of attending anesthesiologists considered the average workweek to exceed a safe limit.

Bartel and colleagues (2004) studied the effects of a single night shift on attention in resident anesthetists. They conducted a series of four tests of reaction time with increasing difficulty at baseline and post-call. The researchers demonstrated that important psychomotor performance deficits occurred in 52% of residents after night duty. The measured 15% deterioration in response speed is similar to that induced by a blood alcohol level of 0.05% (Bartel, Offermeier, Smith, & Becker, 2004). There were a number of limitations to this study. The small number of participants (n = 33) was insufficient to demonstrate statistical significance with some of the tests of reaction time and there was inconsistency in performance across tests.

The body of research related to work hours and fatigue is both complicated and enhanced because the focus of some of this research is sleep deprivation, shift-work, and on-call status. As sleepiness is not a variable in the proposed study, any research in which the major independent variable was sleep deprivation, on-call status, or night shift work is not included in this literature review.

Workload.

Workload is defined as the demand imposed by a task (Matthews et al., 2008) and incorporates the task, associated stress, and the effort required to complete the task. The definition of workload is subject to the expectations and biases of the individual
experiencing it. Included in the experience is the amount of “work” “loaded” onto the worker, the time constraints imposed, the amount of effort required, performance expectations, and the physical and emotional demands of the work. Because different workers view these task dimensions differently, Hart and Staveland (1988) make the assumption that the collection of attributes that together constitutes workload depend on the specific circumstances as well as the a priori bias of the worker.

For most tasks, there is an associated physical and a mental component of workload. Mental demand or workload refers to the attentional demands of a task and an individual’s capacity is the amount of attention resources available for task performance. When workload exceeds available resources, performance suffers. The measurement of workload is complex as the individual’s perception of the workload is also a factor. There is also a physiologic cost associated with performance of tasks that are cognitively demanding (Matthews et al., 2008) and so defining, measuring, and determining the consequences of workload present a challenge.

Another factor affecting task performance is workload history or the activity in which the individual was engaged immediately prior to the critical work period. Workload history is thought to have implications for performance such that when there is a shift or variation in workload, performance may suffer. This is particularly true when there is a decrease in task demand (Cox-Fuenzalida, 2007). In a study of 209 volunteers, a performance decrement was demonstrated when there was a shift in workload particularly from higher to lower workload. The researchers questioned whether this change was due to either fatigue or boredom but evaluation of this question was inconclusive. The concept of workload history as defined by these researchers has
implications for anesthesia practice as workload can shift over the course of a workday and also over the course of an individual case. As a consequence of this variability, performance decrement has significant implications for patient safety and quality care.

According to Gaba and Lee (1990) the importance of workload assessment in anesthesia is multifaceted due to the nature of the practice. For example, fatigue together with other superimposed stressors might affect the anesthetist’s ability to cope with an increase in workload even if performance is unimpaired at baseline. Complex monitoring systems have been developed to improve patient safety but these present other stimuli that may, in fact, contribute to workload making it difficult to detect and respond to emergencies. Finally, in anesthesia, either excessively high or excessively low workload may contribute to mishaps. For this reason, defining workload patterns in different types of cases will increase understanding of the role workload plays in adverse events due to human error.

In order to evaluate the effect of a superimposed secondary task on anesthesia workload, Gaba and Lee (1990) studied nine anesthesia residents during 19 cases. The secondary task was a form of mental mathematics and prior to the start of the case, the participant engaged in a 5-minute practice on the task. During the experimental period, an observer recorded the subject’s activities. Following the case, the subject rated their performance on a zero to ten scale according to six aspects of workload including attention, complexity, time pressure, mental load, busy or not, and difficulty. Response time to the secondary task was measured and converted to an “excess response time”. Cases were further classified into “simple”, “medium” or “hard” by majority opinion of anesthesiologists not associated with the study. Actual errors on the mathematical
problems were rare but response times did suffer in 40% of cases. The researchers concluded that this reflects a reduction in spare capacity to attend to a secondary task. They further conclude that this is evidence that distraction and workload can contribute to delays in response or errors in management when dealing with critical incidents.

The practice of anesthesia has the potential to be highly stressful, as critical decisions must be made that have significant consequences for the patient. The stress of the “watch” is therefore a component of the anesthetist’s workload but not the entirety. The “watch” goes back to the origins of vigilance research. Toward the end of World War II, there was interest in determining the optimum length of time that a radar operator could be on anti-submarine patrol. At that time, it was noted that the radar operator’s task was “waiting for nothing to happen” (Davies & Parasuraman, 1982).

For the CRNA, there is also the need for constant vigilance monitoring that constitutes the “watch” as all senses must be on high alert for changes in homeostasis. An integral part of vigilance is the ability to divide attention among multiple stimuli and with this vigilance as a backdrop, the anesthetist must complete many isolated tasks. Workload in anesthesia consists of individual tasks and the perception of those tasks by the CRNA.

The concept of divided attention or the “multichannel theory of attention” in particular applies, meaning that certain tasks in any profession become routine, but the individual must maintain a certain capacity to notice and respond to a non-routine stimulus or secondary task (Leedal & Smith, 2005). This complexity of anesthesia practice has led researchers to attempt to define the various cognitive, psychological, and physical factors affecting task performance and decision-making in anesthesia (Weinger et al., 1994; Weinger & Slagle, 2001). The concept of workload density proposed by
these researchers is used in successive studies to address the measurement of workload in anesthesia practice (Weinger et al., 2004).

*NASA task load index.*

Components of anesthesia workload include task demands (mental and physical), effort, performance, and the management of frustration. An additional component is attention, essential to vigilance monitoring. In the development of the Task Load Index, the Human Factors Research Division of the National Aeronautics and Space Administration (NASA) created a conceptual framework for the construct connecting the human cost associated with a particular performance level based on several assumptions. The assumptions of their framework include: 1) workload is a hypothetical construct; 2) workload is the cost to the worker for attaining a specific performance goal; 3) workload is not simply the objective task demands; 4) the relevance of the individual attributes that constitute workload for different individuals may vary; and 5) workload is a combination of factors. Consequently, this approach to workload is human-, rather than, task-oriented; the result of the interaction of the individual with the requirements of the job. In this view of workload, the subjective assessment is critical particularly when considering mental workload.

The result is that two types of information are needed concerning each of these factors. The first of these is its subjective importance as a source of workload or its weight and the second is its magnitude within a particular task or its rating (Hart & Staveland, 1988). These researchers identified three types of factors contributing to workload: task-related factors, behavior related factors, and subject-related factors and
the result of their research is the NASA Task Load Index. The NASA Task Load Index is described further in Chapter 3 of this dissertation.

There are then three broad categories of measurement of workload: performance, measures, subjective or psychological measures of fatigue and workload, and physiologic measures. Performance on a secondary task is a measurement of available capacity from which workload is extrapolated. In general, though, performance measures may be insensitive to changes in workload when the individual is able to compensate by changing the effort expended. The wide range of factors affecting outcome in anesthesia practice limits this aspect of performance as a measure of workload (Leedal & Smith, 2005).

Weinger & Slagle (2001) proposed the construct of “non-routine events” (NRE) to describe “…any event that is perceived by care providers or skilled observers to be unusual, out-of-the-ordinary or atypical” (p. 756). These researchers state that the NRE is a broader concept than the medical error or “near miss” and so does not necessarily represent an adverse event. They further postulate that analyses of NREs would lead to an understanding of the process as well as the outcome of care as a means of improving overall quality.

These researchers attempted an analysis of tasks associated with anesthesia practice while measuring the various aspects of workload in order to determine workload density. The anesthesia provider was connected to a 5-lead Holter monitor prior to the start of an actual case in order to measure the physiologic effects of workload. Workload density was calculated at 1- and 5- minute intervals throughout the case by taking the product of task duration and a previously determined workload factor for the task. Heart
rate and pulse variability were calculated each minute during the case and the progression of the case was divided into the categories of induction, maintenance, and emergence. Heart rate and workload density were analyzed with one-way ANOVA and concurrent subjective workload assessment was analyzed with Mann-Whitney U tests. There were weak correlations between psychological and physiological workload (0.52) with a significant variation in workload density across cases. The hypothesis for this pilot study was that understanding the underlying system issues related to the effect of NREs would lead to greater quality of care and patient safety.

Work hours and workload in nurse anesthesia practice.

There is arguably no area with higher acuity than the operating room and it is in that setting that nurse anesthetists provide approximately 60% of all care in the United States. Anesthesia practice is often described as ranging from boredom to terror. These descriptors although extreme represent the variability in case intensity and, therefore, workload. The CRNA’s workload includes psychomotor and affective skills and complex cognitive processes (Potter et al., 2005). The anesthetic plan for less invasive procedures may involve close monitoring but little intervention while that for complex surgeries requires constant, high level attention, critical thinking, and continuous adjustment of physiologic parameters.

Nurse anesthesia care involves continuous vigilance and attention to detail. Cognition is a complex process involving the prefrontal cortex (Miller & Cohen, 2001) and the ability to carry out the more demanding selective and executive functions of a task is contingent on being able to sustain attention to that task (Lim & Dinges, 2008). Sadly there remains controversy in the healthcare community concerning the magnitude
and significance of impaired clinical performance related to what has been considered standard work hours in that population (Weinger & Ancoli-Israel, 2002). Considered an “elusive balance” between work hours and continuity of care, some traditionalists while acknowledging excessive work hours, fear that the risk of multiple “hand-offs” presents an equivalent risk to patient safety (Okie, 2007). Important to the idea of “hand-offs” is that workload involves patient turnover and the possibility of communication gaps during such reporting (Duffield et al., 2011). In one study of the causes of near misses in the perioperative setting, researchers found that “communication between the team” was the factor ranked highest. Under the subcategory of workload, the same study found that distractions and interruptions were the highest contributors to near misses.

Sustained attention to the task of anesthesia care then requires, at a minimum, continuous vigilance during the shift. The nurse anesthetist practices with a continued heightened state of awareness that presents its own source of fatigue. Limited breaks from such vigilance translate into a prolonged and potentially stressful shift of uninterrupted cognition. As cognitive performance becomes progressively worse with extended time on task (Durmer & Dinges, 2005), research into the relationship between CRNA work hours and information processing is important to patient safety.

The effect of sleep deprivation and fatigue has been studied in health care and other industries (Arnold et al., 1997; Arnedt et al, 2005; Babkoff, Caspy, & Mikulincer, 1991; Baldwin & Daugherty, 2004; Cohen et al., 2010; Doran, Van Dongen, & Dinges, 2001; Howard, Gaba, & Smith, 2003; Petrilli, Roach, Dawson, & Lamond, 2006). Research has also been conducted related to work hours and errors in practice
The complex nature of anesthesia workload has been studied in relationship to the occurrence of non-routine events and to the role of teaching in anesthesia practice (Leedal & Smith, 2005; Weinger & Englund, 1990; Weinger et al., 1994; Weinger et al., 2004; Weinger & Slagle, 2001). Advanced practice nurses, such as nurse anesthetists, are increasingly called upon to work longer days due to regulations concerning resident work hours. All of these factors support the importance of research concerning work-hours, workload, and fatigue in nurse anesthetists.

**Summary**

In this chapter, I have described the model of cognitive processing within the Roy Adaptation Model (Roy, 2009) that together with arousal theory (Davies & Parasuraman, 1982) forms the theoretical foundation for this study. The independent variables of work hours and workload represent contextual and focal stimuli respectively. The dependent variable of fatigue represents the opposite of attention on the arousal continuum.

I have further reviewed the literature concerning work hours in nurses and other medical professionals and have referred back to the well-known hazards of prolonged work hours in the transportation industry and nursing. The literature related to workload has revealed the complex nature of this construct. Both task- and person-specific factors contribute to workload measurement. Previous attempts to define anesthesia workload as “workload density” (Weinger et al, 2004) has focused primarily on task-specific characteristics that eliminate the perception and assessment of the individual practitioner.
In the next chapter, I will describe the methodology for the present study the aim of which is to examine the influence of work hours and workload on fatigue in nurse anesthetists.
Chapter 3

Methods

Design

A predictive, correlational research design was utilized to predict fatigue in nurse anesthetists based on the values obtained for work hours and workload. The goal of this approach was to examine causal relationships among variables and to develop hypotheses for future research (Burns & Grove, 2005; Polit & Beck, 2008).

Sample

A non-probability purposive sample was drawn from the active membership in the American Association of Nurse Anesthetists (AANA). Random selection of members was accomplished based on computer generated numbers with uniform distribution such that there is an equal probability of getting any one random number. Members who have opted out of mass e-mail communications from the AANA were not included. Membership types were discriminated with the following categories included in this survey:

Certified (passed the certification exam within the past 2 years – practicing)

Recertified (passed the certification exam over 2 years ago – practicing)

Other membership types will be excluded including non-recertified, life members (not practicing), student members, graduate members (have not yet passed certification exam), and inactive members. Members from all states and practice settings will be included.
Format and Results

The AANA uses the premium services of Zoomerang survey. (www.zoomerang.com). Because the researcher could not access email addresses, the AANA programmed the survey in Zoomerang. A written and electronic pilot survey was provided to the researcher to assure the survey was programmed as desired.

Security and Privacy of Data

Personal information of members was held in secure databases protected by passwords along with database and network firewalls to prevent loss, misuse, or alteration of personal or survey information. The survey site provides SSL encryption for survey participants. Only the authorized personnel from the AANA Foundation who are in charge of the survey can access the files. The responses and surveys will be destroyed 12 months after launching the survey, as is the policy. The AANA does not keep any hard copy of the electronic survey.

The goal was to recruit a sample size of 600 based on guidelines provided by Tabachnick & Fidell (20013). This was based on the fact that there were four demographic variables: age, gender, years of experience, educational level; two independent variables: work hours and workload, the tool for which includes six subscales. Assuming a medium effect size relationship between the independent variables and the dependent variables, $\alpha = 0.05$, and $\beta = 0.20$ the $N = 116$ for multiple correlations and $N = 146$ for testing individual predictors. For statistical stepwise regression analysis, a cases-to-independent variable ratio of 40 to 1 was recommended and using this as a guideline, the required sample size was 520. Because of the anticipated 10 to 12%
response rate for the online survey, the survey was sent to the maximum of 10,000 members.

**Setting/Procedure**

Following Boston College Internal Review Board Approval (Appendix A), an email solicitation (Appendix B) was sent to potential participants, all active certified and recertified nurse anesthetist members of the AANA. Information regarding the nature of the research, the principal investigator, and Boston College Internal Review Board approval of the study was included in the solicitation. Potential participants were instructed that completion of the survey would constitute consent to participate in the study. Each participant was instructed to complete the survey by reflecting back on the last workday. As a pilot for the survey was sent electronically to 10 CRNAs, it was determined that the survey would take each participant approximately 10 minutes to complete. The survey remained open for a period of one month from April 30, 2012 through May 25, 2012. Because a few participants reported difficulty in viewing essential information required to answer the survey utilizing a smartphone, an email was sent from the researcher instructing participants to access the survey through a computer. One additional email reminder was sent to potential participants three weeks after survey launch and one week prior to the close of the survey in an attempt to maximize the response rate.
Instruments

**CRNA work and fatigue survey.**

The CRNA Work and Fatigue Survey (Appendix C) is a 47 question survey that includes demographic data, the Checklist of Individual Strength (CIS-20) fatigue measure, and the NASA Task Load Index as described below.

**Demographic data.**

The following demographic data regarding participants was collected: age, gender, work hours, years in nurse anesthesia practice, and educational level.

**Independent variables.**

**Work hours.**

Actual hours on duty were entered by each participant along with actual hours during which the participant was involved in providing anesthesia care. For the purposes of the study, the variable “work hours” used in the analysis was the actual hours of anesthesia care. This was chosen because in some cases, the CRNA may be at work and not providing anesthesia care. Such “down time” could potentially confound the results.

**Workload.**

**NASA Task Load Index.**

The NASA Task Load Index (NASA-TLX) (Appendix D) is a multidimensional workload measure. It consists of an overall workload rating score based on a weighted average on six subscales: mental demands, physical demands, temporal demands, own performance, effort and frustration. The NASA TLX is reported to have a test-retest reliability of 0.77 (Batisse & Bortolussi, 1988). In addition it correlates highly (0.97 – 0.98) with the Subjective Workload Assessment Technique (SWAT) (Rubio, Diaz,
Martin, & Puente, 2004). The specific endpoints and descriptions of individual subscales are contained in Appendix D. Permission for use of the paper and pencil version of the NASA-TLX is in Appendix E.

The rating of factors determined to be the most responsible for workload for a task are given more weight and this enhances the sensitivity of the scale. The NASA TLX has been evaluated in various tasks including simulated flight, mental arithmetic, and grammatical reasoning. The derived workload scores demonstrate less inter-rater variability than unidimensional ratings of workload and the subscales help to identify the source of the perceived workload.

The NASA-TLX involves both weights and ratings. Initially the individual was asked to evaluate each factor for its contribution to the workload of the task under study. This process of weighting allows for the potential inter-rater variability in definition of workload for a task as well as the difference in the sources of workload between tasks. Following the weighting of the six factors, the individual scored each subscale with a numerical rating that reflects the magnitude of that factor in a given task (providing anesthesia care). The Likert scale was divided into 10 equal intervals anchored by bipolar descriptors that differed according to the workload dimension rated. For the performance dimension 10 = poor performance, 5 = fair performance, and 1 = good performance. For all other performance dimensions, 10 = high, 5 = moderate, and 1 = low. Finally, the overall workload score was obtained by multiplying the rating for each factor by the weight given to that factor. The weighted combination of factors has been demonstrated in a validation study to provide a sensitive indicator of overall workload both between different tasks and among different levels of a task. The correlations
between computer and the paper/pencil version of the TLX was .94 and the correlation between test and retest rating was .83. In the TLX good performance is associated with a low number as low workload is usually associated with a better performance (Hart & Staveland, 1988).

**Dependent variable.**

**Fatigue.**

Fatigue as an experience is the symptom most commonly reported to physicians yet it remains poorly defined and measured. Researchers developed fatigue instruments to measure the construct in chronic disease such as cancer (Mendoza, et al., 1999; Yellen, Cella, Webster, Blendowski, & Caplan, 1997; Hann et al., 1998), multiple sclerosis (Krupp, LaRocca, Muir-Nash, & Steinberg, 1989), and chronic fatigue syndrome (Vercoulen, et al., 1994). Fatigue in the workplace is recognized as a safety issue and interest in this setting is directed at the threshold at which fatigue begins to degrade performance. As the purpose of the present study was to examine fatigue in a working population, specifically nurse anesthetists, I selected the Checklist of Individual Strength Questionnaire (CIS-20) as this instrument has demonstrated validity in working people (Beurkskens et al., 2000).

**Checklist of individual strength (CIS-20) questionnaire.**

The checklist of individual strength (CIS-20) (Appendix F) questionnaire is a multidimensional instrument designed to measure several aspects of fatigue. The questionnaire consists of 20 statements for which the individual must indicate on a 7-point scale to which degree the particular statement refers to aspects of fatigue experienced by the participant. The anchors for the CIS-20 are 1 = “Yes, that is true”, 5 =
Neutral, and 7 = “No, that is not true”. There are four dimensions included in the CIS-20: the subjective experience of fatigue, reduction in motivation, reduction in activity, and reduction in concentration. The CIS tool was originally developed for the measurement of fatigue in patients with chronic fatigue syndrome (CFS) and was tested in the clinical arena with patients experiencing chronic diseases utilizing healthy patients as controls (Vercoulen et al., 1996). The CIS was also utilized in research related to work schedules and fatigue (Jansen, van Amelsvoort, Kristensen, van den Brandr, & Kant, 2003) and in comparison with other measures of fatigue (DeVries, Michielsen, & Van Heck, 2003).

In order to test the validity of the CIS-20 on the working population, Beurskens and colleagues studied five sets of employees with anticipated differences in fatigue (Beurskens et al., 2000). Included in these groups were healthy white collar workers, healthy blue collar workers, workers who had recently undergone surgery, pregnant workers, and workers with a mental reason for fatigue excluding those with a psychiatric illness.

Beurskens et al. (2000) concluded that the CIS-20 was able to discriminate adequately between fatigued and non-fatigued employees in occupational groups. In addition employees with a mental reason for fatigue systematically scored higher on all dimensions of the CIS than the employees with a somatic reason for fatigue.

The CIS possesses good internal consistency with Cronbach’s alpha for the total CIS score of 0.90- 0.96 and for the subscales ranged from 0.83 to 0.92 (Beurskens et al., 2000; DeVries et al. 2003). In the present study the CIS also demonstrated good internal consistency with Cronbach’s alpha for the total CIS score of 0.95 and for the subscales 0.79 to 0.89. Permission for use of the CIS-20 is in Appendix G.
Summary

In this chapter, I have described the methodologic approach for this study. Specifically I have discussed the survey design, the selection of the study sample, maintenance of data security, and the procedure as administered by the AANA. I have also described the survey instrument including demographic data, the instrument for measuring the dependent variable, and the measurement of the independent variables. Finally, I have reported the reliability of the dependent variable instrument in the present study. In the next chapter, I will present the results of the study.
Chapter 4

Results

The results of the study are presented in three sections. Data preparation prior to hypothesis testing is presented in section one. The characteristics of the sample are described in section two. The third and final section covers the statistical testing, results, and summary.

Data Preparation Prior to Hypothesis Testing

The study sample was derived from active certified and/or recertified members of the American Association of Nurse Anesthetists. Ten thousand individuals received the electronic survey by random selection. The survey was open between April 30, 2012 and May 25, 2012. One thousand one hundred and fifty-five CRNAs responded (11.6%). Of this number, 227 responses were dropped due to fifty percent or more of missing data. The final sample size used in this study was 928.

The American Association of Nurse Anesthetists managed the electronic survey, and following completion of data collection, provided the researcher with an Excel spreadsheet of these nurse anesthetists’ survey responses. These data were then entered into SPSS, version 19.0, and saved as an SPSS datafile. Descriptive statistics were next computed on all variables and examined for systemic and random missing data, and for marked skewness due to outliers. No systematic missing data were found; random missing data were replaced with mean substitution.

Skewness was examined using the Pearson Coefficient of Skewness formula, namely: mean – median / standard deviation. According to Tabachnick and Fidell (2013), marked skewness is present if the Pearson coefficient is greater than +/- 0.20. Only two
workload subscale variables (physical demand and frustration) demonstrated a marked positive skew. Logarithmic transformations were then performed on both variables and reduced skewness in the physical demand variable. Logarithmic and square root transformations did not improve the frustration variable. The transformed physical demand variable was used in subsequent analysis. Table 2 presents the evaluation for skewness.

Table 2
*Pearson’s Coefficient of Skewness*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
<th>Pearson’s Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>48.47</td>
<td>49.00</td>
<td>10.39</td>
<td>0.05</td>
</tr>
<tr>
<td>Years of CRNA Practice</td>
<td>16.45</td>
<td>15.00</td>
<td>11.56</td>
<td>0.13</td>
</tr>
<tr>
<td>Hours of Anesthesia</td>
<td>8.40</td>
<td>8.00</td>
<td>3.14</td>
<td>0.13</td>
</tr>
<tr>
<td>Mental Demand</td>
<td>25.15</td>
<td>24.50</td>
<td>13.52</td>
<td>0.05</td>
</tr>
<tr>
<td>Physical Demand</td>
<td>10.01</td>
<td>6.00</td>
<td>11.60</td>
<td>0.35*</td>
</tr>
<tr>
<td>Temporal Demand</td>
<td>20.70</td>
<td>20.00</td>
<td>12.38</td>
<td>0.06</td>
</tr>
<tr>
<td>Performance</td>
<td>27.76</td>
<td>28.00</td>
<td>14.64</td>
<td>0.02</td>
</tr>
<tr>
<td>Effort</td>
<td>18.10</td>
<td>18.00</td>
<td>9.71</td>
<td>0.01</td>
</tr>
<tr>
<td>Frustration</td>
<td>9.46</td>
<td>2.00</td>
<td>13.47</td>
<td>0.55*</td>
</tr>
<tr>
<td>PD_LG</td>
<td>0.85</td>
<td>0.85</td>
<td>0.30</td>
<td>0</td>
</tr>
<tr>
<td>FRUS_LG</td>
<td>0.73</td>
<td>0.48</td>
<td>0.50</td>
<td>0.50*</td>
</tr>
</tbody>
</table>

*Note.* SD = standard deviation. PD_LG = logarithmic transformation physical demand. FRUS_LG = logarithmic transformation frustration. * = marked positive skew.
**Ratio of cases to independent variables.**

The cases-to-independent variable ratio must be large enough or the results of analysis will be meaningless. For the stepwise regression utilized to test study hypotheses a ratio of 40 to 1 is proposed by Tabachnick and Fidell (2013). The number of independent variables in this study was eleven, indicating that a minimum sample size of 550 cases was needed to satisfy this requirement. The sample size of 928 was more than enough to satisfy this rule.

Multicollinearity of the predictor variables was next examined. According to Tabachnick and Fidell (2013), collinearity is considered for a particular dimension if there is a condition index of greater than 30 coupled with at least two variance proportions for an individual variable of greater than 0.50. The condition indices were all less than 30; therefore, no multicollinearity was noted.

**Scoring of study variables.**

**Independent variables.**

**Work hours.**

Participants were asked to report both how many hours they were on duty during the last workday as well as actual hours of anesthesia time during that period. Only actual hours of anesthesia time were used in the analysis. This continuous variable was analyzed for measures of central tendency and variance. The mean number of anesthesia hours reported was 8.4, the median 8.0 and the mode was 8.0. The standard deviation was 3.14. Using Pearson’s Coefficient of Skewness, this variable was normally distributed in the sample.
**Workload.**

The NASA Task Load Index (NASA TLX) is a two-part evaluation that involves both weighting and rating of workload. Each participant weighted the six components of workload in a series of 15 pair-wise comparisons. The number of times that each factor was selected during the pair-wise comparisons was then tallied. The tallies could range from 0 (not relevant) to 5 (more important than any other factor). Following that, participants rated each aspect of workload on a Likert scale ranging from 1 - 10 with 1 representing low contribution to workload, 5 to 6 representing a moderate contribution to workload, and 10 representing high contribution to workload for all dimensions except performance. The performance dimension was rated similarly with the exception that 1 = good performance (satisfied with meeting goals) and 10 = poor performance (dissatisfied with meeting goals). In this case a mid-range rating of 5 or 6 meant neither satisfied nor dissatisfied with meeting the performance goals.

The adjusted rating score for each factor was the weight multiplied by the raw rating. The overall workload score for each participant was computed by taking the sum of the weighted ratings (adjusted rating) and dividing by 15 (the total number of pair-wise comparisons).

In order to analyze the TLX data it was necessary to transform the individual workload factor variables such that 0 = “not chosen” and 1 = “chosen” for each factor. In this way, it was possible to obtain the weight for each factor as reported by the participant. Consequently to measure the number of times “mental demand” was selected by a participant, variables TLX 14, 17, 18, 19, and 20 were re-coded such that 0 = not mental demand and 1 = mental demand. As above, the total number of times the
participant selected “mental demand” (mental demand total factors) was multiplied by the rating of mental demand. The result was the mental demand final score. Similar transformations were performed for the other aspects of workload (physical demand, temporal demand, performance, effort, and frustration). The total workload score was then calculated by summing mental demand final score + physical demand final score + temporal demand final score + performance final score + effort final score + frustration final score. The total workload score was divided by 15 in order to obtain the weighted rating of workload. The total workload score and the total final score of individual factors were used in the analysis. A sample “Sources of Workload Tally Sheet” can be found in Appendix H and a sample “Weighted Rating Worksheet” in Appendix I.

Dependent variable.

Fatigue.

The Checklist Individual Strength (CIS 20) Questionnaire consists of 20 questions measuring total fatigue. It contains four subscales: severity of fatigue, concentration problems, decreased motivation, and decreased physical activity. Participants were asked to relate how they felt at the end of their prior shift on a 7 point Likert scale. In order that higher scores represented increasing fatigue, 11 of the 20 questions were reverse-coded. For example question number 1 on the CIS 20 states “I feel tired”. As the tool is written, a higher rating is given if a participant strongly disagrees with that statement (i.e. “is not tired”). Consequently, this question was re-coded such that a higher score represented increased fatigue. The other questions in the original tool that were similarly re-coded were CIS 3, CIS 4, CIS 9, CIS 10, CIS 13, CIS 14, CIS 16, CIS 17, CIS 18, CIS 19.
Characteristics of Nurse Anesthetist Participants

The mean age of certified registered nurse anesthetist participants was 48.5 (SD = 10.4) years with the range being between age 26 and age 76 years. Sixty percent of respondents (n = 557) identified as female and 40% (n = 371) as male and. The majority (72.5%) reported a master’s degree as the highest level of education (n = 673). Almost 5% of the participants were doctorally prepared and the remaining participants were nearly evenly divided between those with their highest level of education being a certificate in anesthesia (11.5%) and those with a bachelor’s degree (11.1%).

The certified registered nurse anesthetists who responded to the survey were on duty an average of 11.9 (SD = 5.8) hours during their last shift and provided anesthesia care an average of 8.4 (SD = 3.1) hours. Fifty percent of respondents reported working in a community hospital (n = 464), 36.9% in a tertiary medical center (n = 342), and 13.1% in a free-standing surgery center (n = 122). The majority (76.3%) of respondents reported working in an anesthesia care team (n = 708) with the remainder (23.7%) in an independent practice setting (n = 220).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency (n = 928)</th>
<th>Percent (n = 928)</th>
</tr>
</thead>
<tbody>
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<td>Gender</td>
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<td></td>
</tr>
<tr>
<td>Male</td>
<td>371</td>
<td>40%</td>
</tr>
<tr>
<td>Female</td>
<td>557</td>
<td>60%</td>
</tr>
<tr>
<td>Education</td>
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<td></td>
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<tr>
<td>Certificate</td>
<td>107</td>
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<tr>
<td>Bachelor’s</td>
<td>103</td>
<td>11.1</td>
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<td>Master’s</td>
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<td>Community Hospital</td>
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<td>Free-Standing Surgery Center</td>
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<td>Practice Type</td>
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<td></td>
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<td>Anesthesia Care Team</td>
<td>708</td>
<td>76.8</td>
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<tr>
<td>Independent Practice</td>
<td>220</td>
<td>23.7</td>
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Table 4  
*Descriptive Statistics for Continuous Demographic Nurse Anesthesia & Practice Variables*

<table>
<thead>
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<th>Variable</th>
<th>Mean (n = 928)</th>
<th>SD  (n = 928)</th>
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<tr>
<td>Age</td>
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<td>Years of CRNA Experience</td>
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<td>Hours on Duty</td>
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<td>Workload Factors</td>
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<td>Performance</td>
<td>27.8</td>
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<td>Mental Demand</td>
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<td>Temporal Demand</td>
<td>20.7</td>
<td>12.4</td>
</tr>
<tr>
<td>Effort</td>
<td>18.1</td>
<td>9.7</td>
</tr>
<tr>
<td>Physical Demand</td>
<td>10</td>
<td>11.4</td>
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<tr>
<td>Frustration</td>
<td>9.5</td>
<td>13.5</td>
</tr>
<tr>
<td>Total Fatigue (CIS)</td>
<td>72.7</td>
<td>26.8</td>
</tr>
</tbody>
</table>

*Note. SD = standard deviation. Workload factor were weighted and then rated to arrive at individual factor and total workload values. All factors except performance were rated in a 1 – 10 Likert scale where 1 represented low contribution to workload and 10 represented high contribution to workload. Performance was rated such that 1 = good performance and 10 = poor performance. CIS = Checklist Individual Strength: 20 questions rated on a 7-point Likert scale such that 1 = lowest level of fatigue & 7 = highest level of fatigue.*
Characteristics of Nurse Anesthesia Workload and Resultant Fatigue

Workload factors.

The workload factors consisted of six individual demands contributing to total workload score. Among the six individual factors contributing to total workload score, performance concerns had the highest weighted rating (mean = 27.8; SD = 14.6). This dimension referred to how successful CRNA participants thought they were in accomplishing the goals of anesthesia care and how satisfied they were with their performance in accomplishing these goals.

Next in order of importance to nurse anesthetist participants was “mental demand” (mean = 25; SD = 13.5). Respondents indicate that mental and perceptual activity was significant in providing anesthesia care during the last workday. Mental demand includes the processes of thinking, calculating, deciding, remembering, and searching. This aspect of workload relates to the complexity of the task and whether it is exacting or forgiving.

Temporal demand was ranked third in the weighted rating by participants (mean = 20.7; SD = 12.4). This refers to the time pressure involved in the task, in this case anesthesia care. Participants rated effort next (mean = 18.1; SD = 9.7). Effort refers to how hard the nurse anesthetist needed to work either mentally or physically to achieve the level of performance. Physical demand (mean = 10; SD = 11.4) and frustration (mean = 9.5; SD = 13.5) were rated lowest on the weighted rating of workload dimensions. Physical demand reflects the amount of physical activity required; how physically strenuous the activity, anesthesia care was for the participant. Frustration is the degree of stress, irritation, and annoyance felt during completion of the task.
Certified registered nurse anesthetist participants reported concern with the adequacy of their performance, how successful they were in meeting the goals of anesthesia care. In addition mental demand represented an important component of workload. They reported that the mental demands of thinking, perceiving, calculating, and remembering were substantial in the exacting task of anesthesia care. They further reported that time pressure and the pace required to fulfill that exacting task was an important contributor to workload.

The lesser contributors of workload for nurse anesthetist participants were physical demand and frustration. According to respondents, nurse anesthesia care requires less physical labor than mental activity like perceiving, thinking, remembering. Nurse anesthetists also reported less frustration, irritation, and annoyance compared with satisfaction related to their performance in achieving the goals of the task.

**Fatigue factors.**

The total fatigue score combines aspects of fatigue severity, concentration problems, decreased motivation, and decreased physical activity. The mean total fatigue score reported by nurse anesthetist participants was 72.7 (SD; 26.8; range 20 – 140). Tables 3 and 4 above present the demographic, and practice characteristics of CRNA participants.
Results

Research Hypothesis 1

After controlling for the influence of demographic variables, the number of work hours and the workload will positively influence post shift fatigue in nurse anesthetists.

Hierarchical multiple regression.

Assumptions of regression model.

As noted in the data preparation section of this chapter, issues related to sample size, normal distribution of continuous variables, and multicollinearity were addressed. Additionally prior to hypothesis testing, violations to the statistical assumptions of multiple regression were examined using residual analysis.

Hierarchical regression analysis.

Hierarchical regression procedures were applied to examine how much variance in total fatigue was explained by the predictor variables of age, gender, educational level, years of experience as a CRNA, work hours, and workload including the six workload dimensions. The demographic variables of age, gender, level of education, and years of experience as a CRNA were entered into the total fatigue model in a stepwise fashion. Together these variables explained 1.7% of the variance in fatigue but only gender (p < 0.001) contributed significantly to this variance. Age, level of education and years of experience as a CRNA did not make a significant contribution. Although gender remained as a predictor in the model, the correlation coefficient, at $R = .134$ indicates a weak to nonsignificant correlation (Plitchta & Kelvin, 2013). Table 5 presents the correlation coefficients for the demographic variables.
Table 5

*Correlation Coefficients for Demographic Variables with Fatigue (CIS)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson Correlation</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.010</td>
<td>.767</td>
</tr>
<tr>
<td>Gender</td>
<td>.134</td>
<td>.000*</td>
</tr>
<tr>
<td>Education</td>
<td>.040</td>
<td>.224</td>
</tr>
<tr>
<td>Experience</td>
<td>-.027</td>
<td>.418</td>
</tr>
</tbody>
</table>

*Note.* *p* < .001. Females more likely to be fatigued.

Hours of anesthesia care (work hours) was entered into the regression model as step two and added an additional 6.1% of the variance (*p* < 0.001). This indicates that after controlling for gender, fatigued nurse anesthetists were more likely to be those who worked long hours providing anesthesia care.

Initially in the third step of the regression analysis, the total weighted rating of workload was entered. In this model, only 9% of overall variance in CRNA participant fatigue was explained. In other words, gender, hours of anesthesia care, and total workload were responsible for 9% of variance in participants. Table 6 presents the results of the initial hierarchical regression.

Table 6

*Hierarchical Multiple Regression Total Weighted Rating of Workload*

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>R² Change</th>
<th>F Change</th>
<th>df 1</th>
<th>df 2</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.134a</td>
<td>.018</td>
<td>.017</td>
<td>.018</td>
<td>16.972</td>
<td>1</td>
<td>926</td>
<td>.000*</td>
</tr>
<tr>
<td>2</td>
<td>.281b</td>
<td>.079</td>
<td>.077</td>
<td>.061</td>
<td>61.215</td>
<td>1</td>
<td>925</td>
<td>.000*</td>
</tr>
<tr>
<td>3</td>
<td>.305c</td>
<td>.093</td>
<td>.090</td>
<td>.014</td>
<td>14.525</td>
<td>1</td>
<td>924</td>
<td>.000*</td>
</tr>
</tbody>
</table>

*Note.* a Predictors: Gender; b Predictors: Gender, hours of anesthesia care; c Predictors: Gender, hours of anesthesia care, total weighted rating of workload. Dependent variable: Total CIS. *p* < .001.
The individual dimensions of workload were evaluated next. The predictors of mental demand, physical demand, temporal demand, performance, effort, and frustration were entered into the model in a stepwise fashion in place of the total workload score. Only mental demand (p < 0.001), performance (p < 0.001), effort (p = 0.002), and frustration (p < 0.001) made statistically significant contributions to explaining fatigue. The variables physical demand and temporal demand did not make a statistically significant contribution. The addition of mental demand, performance, effort, and frustration increased the proportion of fatigue variance by 11.2%. All of the variables included in this model explained 19.1% of the variance ($R^2$). When adjusted for shrinkage error (Plitchta & Kelvin, 2013), the percent of explained variance was reduced to 18.6% (adjusted $R^2$). Examination of the data reveals that the performance dimension of workload made the greatest contribution to workload as a predictor of fatigue in participants (7.1% of the variance). Tables 7 and 8 present the results of the hierarchical multiple regression of fatigue with individual workload factors.
### Table 7

**Hierarchical Stepwise Regression Analysis Summary: Individual Workload Factors**

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
<th>$R^2$ Change</th>
<th>F Change</th>
<th>df 1</th>
<th>df 2</th>
<th>Signif.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.134&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.018</td>
<td>.017</td>
<td>.018</td>
<td>16.972</td>
<td>1</td>
<td>926</td>
<td>.000&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>.281&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.079</td>
<td>.077</td>
<td>.061</td>
<td>61.215</td>
<td>1</td>
<td>925</td>
<td>.000&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>.387&lt;sup&gt;c&lt;/sup&gt;</td>
<td>.150</td>
<td>.147</td>
<td>.071</td>
<td>77.404</td>
<td>1</td>
<td>924</td>
<td>.000&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>4</td>
<td>.413&lt;sup&gt;d&lt;/sup&gt;</td>
<td>.171</td>
<td>.167</td>
<td>.021</td>
<td>22.946</td>
<td>1</td>
<td>923</td>
<td>.000&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>5</td>
<td>.427&lt;sup&gt;e&lt;/sup&gt;</td>
<td>.183</td>
<td>.178</td>
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<td>13.507</td>
<td>1</td>
<td>922</td>
<td>.000&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>6</td>
<td>.437&lt;sup&gt;f&lt;/sup&gt;</td>
<td>.191</td>
<td>.186</td>
<td>.008</td>
<td>9.298</td>
<td>1</td>
<td>921</td>
<td>.002+</td>
</tr>
</tbody>
</table>

*Note.* a Predictors: Gender; b Predictors: Gender, hours of anesthesia care; c Predictors: Gender, hours of anesthesia care, performance; d Predictors: Gender, hours of anesthesia care, performance, frustration; e Predictors: Gender, hours of anesthesia care, performance, frustration, mental demand; f Predictors: Gender, hours of anesthesia care, performance, frustration, mental demand, effort. Dependent variable: Total CIS. * = p < .001;  + = p < .005
Table 8

Significance of Coefficients in Each Model

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>Standardized B</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gender</td>
<td>.134</td>
<td>.000*</td>
</tr>
<tr>
<td>2</td>
<td>Gender</td>
<td>.127</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Anesthesia Hrs</td>
<td>.247</td>
<td>.000*</td>
</tr>
<tr>
<td>3</td>
<td>Gender</td>
<td>.110</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Anesthesia Hrs</td>
<td>.221</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
<td>-.269</td>
<td>.000*</td>
</tr>
<tr>
<td>4</td>
<td>Gender</td>
<td>.110</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Anesthesia Hrs</td>
<td>.211</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
<td>-.189</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Frustration</td>
<td>.165</td>
<td>.000*</td>
</tr>
<tr>
<td>5</td>
<td>Gender</td>
<td>.110</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Anesthesia Hrs</td>
<td>.203</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
<td>-.187</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Frustration</td>
<td>.182</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Mental Demand</td>
<td>.111</td>
<td>.000*</td>
</tr>
<tr>
<td>6</td>
<td>Gender</td>
<td>.102</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Anesthesia Hrs</td>
<td>.191</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
<td>-.167</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Frustration</td>
<td>.203</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Mental Demand</td>
<td>.109</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>Effort</td>
<td>.094</td>
<td>.000*</td>
</tr>
</tbody>
</table>

*Note. * p < .001
It is important to note that all of the standardized regression coefficients (β) are positive with the exception of the coefficient for performance. Therefore as the variables anesthesia hours and the workload dimensions of mental demand, frustration, and effort increased, fatigue increased. The opposite was true for the performance dimension. In all of the models, the performance variable had a negative standardized regression coefficient. In other words, as CRNA participants believed that they were less successful in accomplishing the goals of the anesthetic and were less satisfied with their performance, the level of fatigue increased.

In summary, hypothesis one was supported. Specifically, the results of stepwise hierarchical multiple regression as applied to this data demonstrates that female CRNAs who provided anesthesia care for more hours, and experienced greater workload in the form of mental demand, effort, and frustration, and who were less satisfied with their performance, reported a statistically significant increase in levels of fatigue than did the remainder of the sample.
Research Hypothesis 2

There will be an interaction between work hours and workload.

The interaction variable was created by multiplying the variable anesthesia hours by total workload and was entered into the regression equation as the fourth step. The interaction contributed 0.4% to the total variance (Table 9) therefore, this hypothesis was supported. Although this achieved statistical significance (p = 0.044), the practical contribution of the interaction was minor. In order to determine which of the individual workload dimensions influencing fatigue contributed to the interaction, separate interaction variables were created for the mental demand, performance, effort, and frustration variables. Only the mental demand/work hours interaction variable contributed to the total variance. Again the total contribution to overall variance was only 0.4% and therefore of no practical significance although it did achieve statistical significance (p = .024) (Table 10).
### Table 9

**Interaction Regression Analysis**

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>R² Change</th>
<th>F Change</th>
<th>df 1</th>
<th>df 2</th>
<th>Signif.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.134ᵃ</td>
<td>.018</td>
<td>.017</td>
<td>.018</td>
<td>16.972</td>
<td>1</td>
<td>926</td>
<td>.000</td>
</tr>
<tr>
<td>2</td>
<td>.281ᵇ</td>
<td>.079</td>
<td>.077</td>
<td>.061</td>
<td>61.215</td>
<td>1</td>
<td>925</td>
<td>.000</td>
</tr>
<tr>
<td>3</td>
<td>.305ᶜ</td>
<td>.093</td>
<td>.090</td>
<td>.014</td>
<td>14.525</td>
<td>1</td>
<td>924</td>
<td>.000</td>
</tr>
<tr>
<td>4</td>
<td>.312ᵈ</td>
<td>.097</td>
<td>.093</td>
<td>.004</td>
<td>4.061</td>
<td>1</td>
<td>923</td>
<td>.044</td>
</tr>
</tbody>
</table>

*Note.* a Predictors: Gender; b Predictors: Gender, hours of anesthesia care; c Predictors: Gender, hours of anesthesia care, total workload; d Predictors: Gender, hours of anesthesia care, total workload, interaction; Dependent variable: Total CIS.

### Table 10

**Interaction Regression Analysis – Individual Workload Dimensions**

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>R² Change</th>
<th>F Change</th>
<th>df 1</th>
<th>df 2</th>
<th>Signif.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.134ᵃ</td>
<td>.018</td>
<td>.017</td>
<td>.018</td>
<td>16.972</td>
<td>1</td>
<td>926</td>
<td>.000</td>
</tr>
<tr>
<td>2</td>
<td>.281ᵇ</td>
<td>.079</td>
<td>.077</td>
<td>.061</td>
<td>61.215</td>
<td>1</td>
<td>925</td>
<td>.000</td>
</tr>
<tr>
<td>3</td>
<td>.387ᶜ</td>
<td>.150</td>
<td>.147</td>
<td>.071</td>
<td>77.404</td>
<td>1</td>
<td>924</td>
<td>.000</td>
</tr>
<tr>
<td>4</td>
<td>.413ᵈ</td>
<td>.171</td>
<td>.167</td>
<td>.021</td>
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<td>1</td>
<td>923</td>
<td>.000</td>
</tr>
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<td>.012</td>
<td>13.673</td>
<td>1</td>
<td>922</td>
<td>.000</td>
</tr>
<tr>
<td>6</td>
<td>.437</td>
<td>.191</td>
<td>.186</td>
<td>.008</td>
<td>9.500</td>
<td>1</td>
<td>921</td>
<td>.002</td>
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<td>.190</td>
<td>.004</td>
<td>5.097</td>
<td>1</td>
<td>920</td>
<td>.024</td>
</tr>
</tbody>
</table>

*Note.* a Predictors: Gender; b Predictors: Gender, hours of anesthesia care; c Predictors: Gender, hours of anesthesia care, performance; d Predictors: Gender, hours of anesthesia care, performance, frustration; e Predictors: Gender, hours of anesthesia care, performance, frustration, mental demand; f Predictors: Gender, hours of anesthesia care, performance, frustration, mental demand, effort; g Predictors: Gender, hours of anesthesia care, performance, frustration, mental demand, effort, interaction_mental demand; Dependent variable: Total CIS.
Summary

In this chapter, I have reported the results of the study. In the first section, I discussed the preparation of the data prior to statistical analysis. The second section described the demographic and work-related characteristics of the study sample. The final section described the statistical analyses applied to the data.

The sample size was sufficient to satisfy the case-to-variable ratio requirements of multiple regression as recommended by Tabachnick and Fidell (2013). Specific assumptions of regression analysis were addressed including skewness and multicollinearity. Individual variables were re-coded as necessary and stepwise hierarchical regression was applied to the data utilizing SPSS version 19.0.

The average age of certified registered nurse anesthetist participants was 48.5 years. The majority were female (60%) and had a master’s degree as the highest level of education. Participants reported an average of 16.5 of years of experience, were on duty an average of 11.9 hours, during which time they provided anesthesia care for 8.4 hours. The majority (50%) worked in a community hospital as part of an anesthesia care team (76.8%).

Workload factors which contributed the most to the level of fatigue were performance, mental demand, effort, and frustration. For all of these except performance, an increase in the factor resulted in an increase in the level of fatigue. Performance demonstrated a negative relationship to fatigue such that as the CRNA participant expressed less satisfaction with her performance, the level of fatigue increased.
The results of stepwise hierarchical multiple regression as applied to this data demonstrates that female CRNAs who provided anesthesia care for more hours, and experienced greater workload in the form of mental demand, effort, and frustration, and who were less satisfied with their performance, reported a statistically significant increase in levels of fatigue than did the remainder of the sample. There was no interaction between the variables of work hours and the dimensions of workload.
Chapter 5

Discussion

This chapter consists of four sections. In the first section, I present a brief overview of the study and an interpretation of the findings. In the second section I discuss the relationship of the findings to the theoretical framework and to the current body of knowledge concerning work hours, workload, and fatigue. I describe the limitations of the present study in the third section and in the fourth and final section, I identify implications for practice, policy, and future research.

Overview of the Study

Certified registered nurse anesthetists are advanced practice providers responsible for caring for patients when they are most vulnerable. The nature of anesthesia care requires sustained vigilance for often prolonged, uninterrupted periods. Anesthesia workload is multidimensional involving demands that are at the same time, mental, physical, and temporal, while also imposing factors related to performance, effort, and frustration.

Fatigue is a multidimensional construct defined conceptually and within the Roy cognitive processing theoretical framework as impaired arousal, attention, sensation and perception. Both time-on-task and cognitive load have been shown to affect fatigue. The purpose of this descriptive exploratory study was to examine fatigue in nurse anesthetists as conceptualized by Roy (2009) together with the roles of time-on-task and cognitive load as antecedents to fatigue as conceptualized by Balkin and Wesensten (2011).

The study sample consisted of 928 CRNAs who responded to the survey between April 30, 2012 and May 25, 2012. Fatigue was measured using the Checklist Individual
Strength (CIS) questionnaire. Work hours (hours of anesthesia time) was measured by self-report and workload was measured by the NASA Task Load Index (NASA TLX). Using hierarchical multiple regression analyses the direct effects of the predictors were tested. After controlling for level of education and years of experience as a CRNA, age, gender, anesthesia hours and selected dimensions of workload made statistically significant contributions to fatigue in nurse anesthetists. There was no interaction between the variables of work hours and workload.

**Findings**

*Study subjects.*

Study participants had an average age of 48.5 years. Sixty percent were female and 40% male. The majority (72.5%) reported their highest level of education to be a master’s degree, with 11.5% having a certificate of anesthesia, 11.1% having a bachelor’s degree, and 4.8% a doctorate. Participants had an average of 16.5 years of experience as a CRNA ranging from less than 1 year to 48 years, Fifty percent reported working in a community hospital, 36.9% in a tertiary medical center, and 13.1% in a free-standing surgery center. The majority (76.3%) worked in an anesthesia care team setting and the remainder in independent practice. When compared to statistics provided by the 2011 American Association of Nurse Anesthetists Membership Survey (AANA, 2011), the sample was similar with regard to age, gender, education, and years of experience and is representative of CRNAs. Table 11 presents this comparison.
Table 11

Comparison of CRNA Participants’ Selected Demographic Characteristics with AANA Membership Survey Data (2011)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Study Participants</th>
<th>AANA Membership Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 928)</td>
<td>(n = 5,067)</td>
</tr>
<tr>
<td>Age</td>
<td>48.5 years</td>
<td>49.8 years</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>40 %</td>
<td>45 %</td>
</tr>
<tr>
<td>Female</td>
<td>60 %</td>
<td>55 %</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Certificate</td>
<td>12 %</td>
<td>11 %</td>
</tr>
<tr>
<td>Bachelors</td>
<td>11 %</td>
<td>18 %</td>
</tr>
<tr>
<td>Masters</td>
<td>73 %</td>
<td>69 %</td>
</tr>
<tr>
<td>Doctorate</td>
<td>5 %</td>
<td>3 %</td>
</tr>
<tr>
<td>Experience as CRNA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 20 years</td>
<td>35 %</td>
<td>37 %</td>
</tr>
<tr>
<td>11 – 20 years</td>
<td>27 %</td>
<td>23 %</td>
</tr>
<tr>
<td>6 – 10 years</td>
<td>15 %</td>
<td>14 %</td>
</tr>
<tr>
<td>2 – 5 years</td>
<td>16 %</td>
<td>18 %</td>
</tr>
<tr>
<td>Less than 2 years</td>
<td>7 %</td>
<td>8 %</td>
</tr>
</tbody>
</table>
Fatigue in nurse anesthetists.

Nurse anesthetist participants reported more fatigue if they were female, had provided more hours of anesthesia care, and had experienced increased workload specifically the dimensions of mental demand, performance concerns, effort, and frustration. The hierarchical regression model in which all predictors were entered explained 19% of the variance in fatigue among participants. Female gender, work hours, and workload were statistically significant predictors of fatigue in participant nurse anesthetists.

Relationship of the Findings to the Theoretical Framework

The results of this study confirm a number of the tenets in the identified theoretical framework of the Roy Adaptation Model (2009). The individual interacts with the environment and environmental stimuli act as inputs influencing adaptation. The three classes of stimuli are: focal stimuli, contextual stimuli, and residual stimuli. The focal stimulus of workload including the dimensions of mental demand, performance, effort and frustration were those stimuli imost immediate to and commanding the attention of the CRNA.

Work hours were the contextual stimulus, contributing to the affect of the focal stimuli (workload factors) and influencing how the CRNA dealt with the workload. In other words, the length of the workday contributed to fatigue in the nurse anesthetist participants and influenced how they handled the workload. Therefore, in this study, the interaction of the CRNA with the environment took the form of workload, in the context of work hours, which together influenced adaption measured as the degree of fatigue. As
the CRNA becomes more fatigued due to increased work hours and workload, the input processes of arousal and attention, sensation and perception would likely be affected. The stress of the workload, particularly regarding concerns with meeting the goals of the task as reflected in the performance dimension, influence arousal and attention. Residual stimuli in the Roy Model are factors that may have an effect on the situation at hand, but the exact effect is, now, unclear. Education and experience are potential residual factors but these did not contribute to fatigue in the present study. Although Roy does not specify gender as a residual stimulus, it appeared to fulfill that role in this study.

The purpose of this study was to understand the importance of two factors, namely work hours and workload in predicting fatigue in nurse anesthetists. The findings support the hypothesis that these factors were statistically significant predictors of fatigue in participants and that gender is a statistically significant residual factor. The greatest contributor to fatigue among the six dimensions of workload was performance. In other words, the less satisfied the CRNA was with her performance, the greater the fatigue.

In considering other residual stimuli, or unexplained variance, the conceptualization by Balkin and Wesensten (2011) can be informative. In this model, as in the present study, the antecedents for fatigue are time on task and cognitive load (p. 50).
The literature related to the fatigue overlaps substantially with that concerning sleepiness, though fatigue and sleepiness are seen in the model above to be two separate constructs. Insufficient sleep or sleep deprivation has been shown to contribute to fatigue and to be associated with poor attention and performance (Mullington et al., 2009). The overlap of these concepts is depicted by Balkin and Wesensten (2011, p. 49).
Sleepiness is a residual stimulus as defined by the RAM and may be due to insufficient quantity or quality of sleep. It may also be the result of interrupted sleep for a CRNA on-call. The prevalence of sleep deprivation has been estimated as 20% in adults (Hublin, Kaprio, Patinen, & Koskenvuo, 2001) and neurobiologically-based sleepiness/fatigue has been recognized as being a factor in human error as the sleepy or fatigued individual demonstrates performance problems particularly on tasks, which require sustained attention (Dinges, 1995). Sleep deprivation due to extended work hours has been called the Achilles heel of the medical profession (Leach, 2000) and although the problem is most pronounced with residents in training, it applies to other physicians and nurses as well (Gaba & Howard, 2002). Again, sleepiness and fatigue are treated as similar, if not identical, concepts particularly in many work applications.
In many industries including health care, sleep deprivation occurs because the work extends beyond the normal eight-hour day or forty-hour week. Residual stimuli that may explain a significant proportion of the variance in fatigue in nurse anesthetists include sleepiness and altered circadian rhythms. Because of the length of the instrument and the exploratory nature of this study, sleepiness and altered circadian rhythms were not measured. Other potential residual stimuli are variations in workload during nonworking hours. Family responsibilities, academic pursuits, and other life stressors may also be significant for the individual nurse anesthetist. Additional factors that may influence alertness are the underlying state of health and wellness including nutrition, exercise, and consumption of substances such as caffeine or alcohol as well as the use of sleeping aids and/or other psychotropic medications.

**Relationship of the Findings to Current Knowledge**

**Work hours as a predictor of fatigue.**

This study supports the work of other researchers concerning the relationship of work hours and fatigue, specifically that longer workdays were associated with greater fatigue (Dorrian et al., 2008; Jansen et al., 2003; Josten et al., 2003; Rosa & Colligan, 1988; Rosa et al., 1986; Rosa et al., 1985). An important consideration is that nurse anesthetists frequently arrive well in advance of a scheduled shift in order to adequately prepare for the day. Appropriate set-up for a complex case could take up to an hour or more and the availability of support personnel is quite variable. Likewise, the end of a case does not equate to the end of the work as completion of hand-offs, paperwork, pre-anesthesia and post-anesthesia visits may further lengthen the day. This study captured “anesthesia hours” but did not include information concerning these tasks.
The purpose of this study was to evaluate the influence of the length of a single workday on post-shift fatigue. Participants were not asked to report the number and length of consecutive workdays or the total number of hours worked in a week, nor were they asked to report overtime either voluntary or mandatory. Olds and Clarke (2010) evaluated the effect of work hours on adverse events and errors in registered nurses. They found that for each additional hour of voluntary paid overtime work each week, there was a 2% increase in the likelihood of a nurse making a medication error. These researchers assumed that overtime was a proxy measure for fatigue but acknowledged that fatigue was not directly measured. As policy-makers attempt to legislate work hours and mandatory overtime, it is important to note the importance of the total number of work hours per day and per week in all settings. Limitation on mandatory overtime is an important first step however; these regulations do not prohibit the nurse from voluntarily working beyond reasonable limits.

**Workload as a predictor of fatigue**

Workload specifically the dimensions of mental demand, performance, effort, and frustration made statistically significant contributions to fatigue in nurse anesthetists. Physical demand and temporal demand were not significant contributors. As others have reported (Ricci, Chee, Lorandeau, & Berger, 2007), workers whose job required a high degree of control and decision-making, were more likely to experience fatigue than those in low control positions. Increased stress in the workplace translated to increased fatigue in the worker.

The role of the nurse anesthetist involves a high degree of control and decision-making. It necessitates continuous mental demand in the form of assessment and
planning often requiring her to react quickly and competently to changes in homeostasis. The cognitive load is high and the environment complex as he or she must closely monitor the patient’s condition and share vital information with other members of the surgical team. The nurse anesthetist must focus his/her effort at meeting the goals of the anesthetic and frustration may result from a lack of resources and competing agendas among members of the perioperative team. In contrast, physical demand is not great for the nurse anesthetist. Often the CRNA sits next to the patient while monitoring and charting and physical activity is minimal.

The greatest contributor to workload-related fatigue for the nurse anesthetist is concerns with performance or the success in meeting the goals of the anesthetic. King (1999) describes goal attainment as relating outcomes to quality. This involves an understanding of the role of the nurse (in this case the nurse anesthetist) as well as many other interactions with individuals and the environment. Activities are behaviors both overt and covert and may be either verbal or nonverbal. Nurse anesthetists, like other nurses, are susceptible to feelings of inadequacy, decreased self-confidence, and increased stress in patient care situations. Although this has been described particularly in new graduates (Boswell, Lowry, & Wilhoit, 2004), the results of this study demonstrate that concerns with goal attainment persist. Goals for the nurse anesthetist are complex. Outcomes desired by the patient for a routine general anesthetic include amnesia, loss of consciousness, adequate analgesia, and lack of postoperative complications such as pain and nausea and vomiting. The surgeon would add immobility, rapid induction and rapid emergence to that list. Finally, the nurse anesthetist desires all of the preceding plus hemodynamic stability and homeostasis. Clearly, the individual members of the
perioperative team have both shared and individual goals and, consequently, views of workload.

Performance shaping factors are characteristics of individual cases that influence workload and these may be intrinsic to the specific team member, the operating room environment, or to the underlying conditions of the workplace. Others have demonstrated that determination of workload characteristics and case difficulty is in the eye of the beholder (Minnick, Donaghey, Slagle, & Weinger, 2011). In other words, performance-shaping factors vary across the continuum of team members such that workload cannot be defined for a single group by any other and certainly the CRNA has broad responsibility for the whole patient during the course of the anesthetic.

**Demographic variables as predictors of fatigue.**

The results of this study indicate that female CRNAs are more likely to experience post-shift fatigue than their male counterparts. This is likely less due to biologic differences than to the traditional social roles in society. Women are more often the caretakers of the home, the spouse, children, and, frequently, aging parents. Although in some cases, there is likely a more equitable division of labor, gender-related role differences remain. In previous research concerning fatigue in the United States workforce, researchers found that compared with workers without fatigue, 65.2% of fatigued workers were female as compared with 34.8% who were male (Ricci et al., 2007). Similarly, the prevalence of fatigue in a 2-week period was significantly greater in women than in men after adjusting for other demographic, health, and employment differences. Oginska and colleagues (1993) evaluated gender and shift-work intolerance in matched-for-age-and occupation groups of men and women steel workers. They
concluded that women were more likely to be drowsy during work and that the reason for gender differences in shift-work tolerance may be the double burden for female workers. They emphasized the fact that it is difficult to separate the worker from his/her social and family context. There was also a difference in the way that males and females spent passing “leisure time”. Whereas the male worker returns home to watch television (36%), go out (33%), or read (25%), the female worker begins a second job doing housework 48% of the time (Oginska, Polorski, & Oginski, 1993). These results contrast with the findings of Beerman and Nachreiner, however, who did not find more severe psychosocial or health problems in females as opposed to males (1995).

**Limitations**

**Limitations related to the survey design.**

This study had several limitations. Although the sample size was more than adequate to achieve desired power, the survey response rate was low (11.6%). There may be several explanations for the low response rate including an unanticipated technical problem, survey length, and self-selection bias. There was a technical problem discovered in the first day or two following launch of the survey. Some participants contacted the researcher by email reporting that the anchors to the Likert scales were not visible if they attempted to access the survey on a “smart phone”. This likely resulted in either a decrease in the response rate or, possibly, incorrect results if the participant guessed at the high/low discrimination. The subsequent email asking participants to complete the survey on a computer may have also decreased the response rate because of a perceived inconvenience.
The length of the survey was a limitation. Due to the weighting and rating of workload dimensions of NASA Task Load Index and the 20 - question CIS measure of fatigue, the survey contained a total of 47 questions. Some participants emailed the researcher that they were fatigued by the survey and, consequently, declined to complete it. The length of the survey also caused the researcher to forgo both an instrument for measuring sleep and qualitative questions to further inform the study. Finally, some participants may have chosen not to complete the survey due to concerns related to the results. Specifically, the results possibly could indicate that longer work days (over 8 hours) may contribute to fatigue and possible errors. For example, given the current strong safety record in anesthesia, the results, if published, might jeopardize a desirable work schedule for many CRNAs. Many individuals prefer to work longer days either to take advantage of long stretches of time off or to pursue employment at multiple sites. There was very likely concern that this study could persuade administrators to curtail such activity and negatively influence both income and lifestyle.

Although survey research assumes participants will answer honestly, participant self-report is another limitation. Results were dependent on CRNAs accurately recalling and reporting levels of fatigue and workload. Certainly, a fatigued individual may not be the best judge of his/her current status although fatigue is a common human condition and most people have experienced it and are aware of the symptoms. Another design limitation was that participants completed the survey at varying intervals following the completion of the shift. It would be preferable for participants to respond to questions concerning workload and fatigue immediately following the workday but the time of response could not be controlled.
Limitations related to the measured constructs.

The concept of workload and workload density in anesthesia has been difficult to define. Most attempts at doing so have focused on specific tasks associated with anesthesia care (Weinger et al., 1994; Weinger & Slagle, 2001; Weinger et al., 2004). The intent of this study was to consider the subjective nature of workload as interpreted by the individual CRNA and not to catalog the type and number of individual tasks. Given the specific aim of the study, the researcher selected the NASA TLX. The NASA TLX is a subjective measure based on the respondent’s perception of workload and personal cost. The instrument design may lead to individual interpretations of workload by CRNA participants.

Most research on fatigue has investigated the associations between fatigue and chronic illness. Although work-related fatigue has been the subject of research utilizing the CIS, the construct has been confounded by factors such as sleepiness and sleep deprivation. The findings in this study would have been strengthened if a measure of sleep and sleepiness had been included together with information concerning family responsibilities and role issues.

The final predictor in this study was work hours defined as hours of anesthesia care. The consecutive anesthesia hours and the number and types of breaks during that time was not measured. As with other constructs, this was open to interpretation by the participant and internal consistency could not be assured.
**Recommendations**

**Practice.**

There was a statistically significant influence of both work hours and workload on post-shift fatigue in nurse anesthetist participants. These factors combined with gender explained 19% of the variance in participant fatigue. Study results then have important implications for patient safety and provider wellness. Nurse anesthetists should be aware of the risks associated with prolonged time-on-task and excessive workload. Although the most obvious risk is that to patient safety, the health of the provider cannot be ignored. Nurse anesthetists who attend to their own homeostasis are best prepared to monitor that of others. Certainly, the fatigued nurse has little reserve and may not tolerate an unanticipated, sudden increase in demand. In a national study by Biddle and Aker (2011) concerning sleep-related behaviors in nurse anesthetists, 15.7% of respondents reported falling asleep while providing anesthesia care and 48.8% of respondents said they observed a colleague engaged in sleep-related behavior while delivering anesthesia care. Geiger-Brown and Trinkoff (2010) reported on the accumulated evidence that shift durations of 12 hours or more contributed to fatigue in nurses, which consequently had a negative influence on performance due to fatigue-related changes in vigilance.

Work-hours is a modifiable risk factor for fatigue and one that should be monitored and modified by both the individual and the employer. Anesthesia departments, staffing agencies, and hospital administrators must work together to insure safe patient care and individual wellness. Similarly, consciousness must be raised related to the influence of workload on fatigue. Although this aspect of practice may be less
easily modified in the moment, awareness of the significance of the factors involved may lead to strategies for management of those factors.

A question that remains unanswered is the influence of work hours, workload, and post-shift fatigue on performance in nurse anesthetists. The work of Rogers and colleagues (2004) and that of the Harvard Work Hours Health and Safety Group (Landrigan et al., 2004) have demonstrated an increase in errors with increasing work hours. Nurse anesthesia care requires the completion of specific tasks but beyond that sustained attention and vigilance. Until the influence of work hours, workload, and fatigue on vigilance tasks in nurse anesthetists is understood, it would be wise to be attentive to and limit work hours and workload for their own health as well as that of the patients in their care. Further research in this area may also benefit other professions including first responders such as police, fire, and emergency personnel.

**Policy.**

Results of this study support that of others (Dorrian et al., 2008; Rogers et al., 2004; Scott et al., 2006) in suggesting that excessive work hours may have negative consequences for patient care. Individual practitioners, anesthesia department administrators, and hospital administrators should consider this research in monitoring work hours and workload of nurse anesthetists. This includes scheduling paradigms as well as the managing of unplanned overtime. A significant barrier to implementing limitations on work hours is the desire on the part of the practitioner to work longer hours as a lifestyle choice. Many CRNAs choose to compress and compartmentalize their work schedule in order to have longer stretches of days off without taking vacation time or to work another job during days off in order to supplement their income. There are certainly
economic factors at work and the latter further complicates the situation. Work hour restrictions are present in a number of industries but there are no federal regulations or guidelines for nurses or physicians. The Accreditation Council for Graduate Medical Education limits on resident duty hours are still excessive and so should not be used as a template. These limit residents to an 80-hour workweek that may be averaged over a four-week period. In addition, residents must obtain ten hours of rest between duty periods. Although there is a 24 hour limit on continuous duty, that can be extended to 30 hours for continuity of care or educational purposes. Although the American Nurses Association has supported the limitation of mandatory overtime, these issues remain (Olds & Clarke, 2010).

The Institute of Medicine reports that there are lessons to be learned from other industries. In the transportation industry, airline pilots cannot work more than 8 hours in a 24-hour period with the exception that if there are two or more pilots, then they may work for 10 hours in a 24-hour period. They also cannot be assigned to fly more than 30 hours in 7 days. In addition to these restriction, pilots are mandated a 9 hour rest period for flights of 8 hours or less and 10 hours of rest is required for flights of 8 to 9 hours in duration. Longer rest periods are also required if a pilot exceeds daily flight time from unavoidable circumstances. In the trucking industry, individuals may drive 10 hours out of every 18-hour period with a weekly limit of 60 hours in 7 consecutive days. They must have 8 consecutive hours between trips and 48 hours off after reaching the maximum. Drivers must also maintain records of hours driven each day (2004).

Recent legislation in Massachusetts has passed Senate Bill 02400 that prohibits hospitals from requiring nurses to work in excess of 12 hours in any 24-hour period.
and/or to work mandatory overtime except in an emergency. It remains to be seen how
this will affect CRNAs particularly as the burden in on the hospital to report violations
and many CRNAs are not employed by the hospital. The challenges to tracking work
hours are substantial and personal accountability needs to be emphasized. Perhaps
ongoing licensure and/or certification should require the CRNA to attest to the fact that
she has not worked more than a predetermined number of hours per week or per month in
much the same way that other aspects of professionalism are acknowledged.

Efforts to determine workforce projections for nurse anesthetists have focused on
the current supply and the aging workforce (Merwin & Jordan, 2006). It is important that
in planning for future needs, that any model for nurse anesthesia supply include provision
for work hour limits particularly as patient acuity and surgical complexity increase.
Lothschuetz Montgomery & Geiger-Brown (2010) caution that a culture change is
needed to move away from the 12-hour shift and that the prior emphasis on simple
recruitment and retention is no longer enough. Rather administrators need to develop
staffing models based on the research evidence and suggest that “dashboard” measures
for which administrators are held accountable be expanded beyond financial targets and
patient outcomes to include “fatigue risk”.

The need to provide continuous patient care and the unpredictable nature of both
the operating room schedule and individual surgical procedures all contribute to
unanticipated long work hours. The effect of resident physician work hour limits, as
mandated by the ACGME, on nurse anesthesia hours must be monitored. The hazards of
excessive time-on-task must not be shifted from one group to another. Although the shift-
work typical of staff nursing is rarely the routine in nurse anesthesia practice, in some
situations, the CRNA may have no choice but to continue working beyond normal hours. Monitoring and planning for sufficient break time is an avenue for future work.

Directors of nurse anesthesia educational programs should also monitor clinical hours and workload of nurse anesthesia students. Arguably, the workload for a nurse anesthesia student is substantially higher at baseline than that for an experienced nurse anesthetist. Although this work did not include nurse anesthesia students as participants and consequently, cannot be generalized to that population, caution is none-the-less advised.

Research.

The results of this study add to the body of knowledge concerning the influence of work hours and workload on fatigue in nurse anesthetists. Findings have implications for the health and wellness of individual nurse anesthetists and are congruent with the wellness initiative of the AANA. There is a need for additional research directed at other antecedents of post-shift fatigue including sleep deprivation. There is also a need to examine the consequences of work hours, workload, and post-shift fatigue relating to vigilance and performance. If CRNAs take this issue on themselves, there is less risk of others passing policy legislation that might not be acceptable to the profession.

In order to eliminate some of the confounding variables of this study such as workload variability, continuous anesthesia time vs. breaks, a smaller pilot study in a simulated environment may inform future research directions. In a controlled environment with a smaller number of participants, measurement strategies could include both sleep and vigilance task measures. If each participant were utilized as his/her own control, additional variability would be minimized. An objective measure of vigilance
would also eliminate the limitations of self-report. Similarly, a pre- and post-test design would narrow the measured variance to that influenced by work hours, workload, and sleep characteristics. Finally, the construct of performance and goal attainment in nurse anesthesia practice is worthy of exploration.

**Summary**

In this chapter, I have discussed the findings of the current study. I have also described the relationship of the findings to the underlying theoretical framework, the Roy Model of Cognitive Processing (2009). My model and analyses were able to explain nearly 20% of the variance in fatigue in nurse anesthetists. In that context, I have identified possible residual stimuli which may explain additional variance in the dependent variable of fatigue but which were not measured in the current study. I have identified several limitations of the current study and made recommendations for nurse anesthesia practice, policy, and future research.
References


Appendix A

Boston College Internal Review Board Approval
BOSTON COLLEGE
Institutional Review Board
Office for Research Protections
Waul House, 3rd Floor
Phone: (617) 552-4778, fax: (617) 552-0498

IRB Protocol Number: 12.214.01

DATE: February 10, 2012
TO: Susan Emery
CC: Patricia Tabloski
FROM: Institutional Review Board – Office for Research Protections
RE: Work Hours, Workload, and Fatigue in Nurse Anesthetists

Notice of IRB Review and Approval

Expedited Review as per Title 45 CFR Part 46.110, FR 60366, FR, # 7
Waiver of Documentation of Informed Consent [Title 45 CFR 46.117 (c)]

The project identified above has been reviewed by the Boston College Institutional Review Board (IRB) for the Protection of Human Subjects in Research using an expedited review procedure. This is a minimal risk study. This approval is based on the assumption that the materials, including changes/clarifications that you submitted to the IRB contain a complete and accurate description of all the ways in which human subjects are involved in your research.

This approval is given with the following standard conditions:

1. You are approved to conduct this research only during the period of approval cited below;
2. You will conduct the research according to the plans and protocol submitted (approved copy enclosed);
3. You will immediately inform the Office for Research Protections (ORP) of any injuries or adverse research events involving subjects;
4. You will immediately request approval from the IRB of any proposed changes in your research, and you will not initiate any changes until they have been reviewed and approved by the IRB;
5. The IRB has waived the requirement for the documentation of informed consent as allowed under 45CFR 46.117 (c) (2). The research presents no more than minimal
risk of harm to subjects, and involves no procedures for which written consent is normally required outside of the research context.

6. You will only use the informed consent documents that have the IRB approval dates stamped on them (approved copies enclosed).

7. You will give each research subject a copy of the informed consent document;

8. You may enroll up to 600 participants.

9. If your research is anticipated to continue beyond the IRB approval dates, you must submit a Continuing Review Request to the IRB approximately 60 days prior to the IRB approval expiration date. Without continuing approval the Protocol will automatically expire on February 9, 2013.

Additional Conditions: Any research personnel that have not completed an acceptable education/training program should be removed from the project until they have completed the training. When they have completed the training, you must submit a Protocol Revision and Amendment Form to add their names to the protocol, along with a copy of their education/training certificate.


If you are conducting research using an online survey (e.g. Survey Monkey, Qualtrics), the IRB requires that the approval dates appear on the online consent page of your survey. Please copy and paste the statement below onto your survey:

The Boston College IRB has approved this protocol from February 10, 2012-February 9, 2013.

Boston College and the Office for Research Protections appreciate your efforts to conduct research in compliance with Boston College Policy and the federal regulations that have been established to ensure the protection of human subjects in research. Thank you for your cooperation and patience with the IRB process.

Sincerely,

[Signature]

Stephen Erickson
Director
Office for Research Protections

It's
Appendix B

E-Mail Solicitation
You are being asked to participate in a research study titled “Work hours, Workload, and Fatigue in Nurse Anesthetists”. You were selected to participate in this project because you are 1) an active nurse anesthetist, certified or recertified by the National Board of Certification and Recertification for Nurse Anesthetists; 2) currently employed to provide anesthesia care in a healthcare institution; and 3) have an email address on file with the American Association of Nurse Anesthetists.

The purpose of this study is to investigate the influence of work hours and workload on fatigue in nurse anesthetists.

The study will be conducted through this online survey. It is anonymous and there is no way that you can be identified and linked to your responses. The survey should take you approximately 20 minutes to complete. There are minimal risks or discomforts anticipated from participation in this survey.

There are no direct benefits to you, but knowledge gained from this study may increase awareness of the influence of shift length and workload factors in post-shift fatigue in nurse anesthetists and possibly discover information that may ultimately improve patient safety. You will not be compensated for the time you take to complete this survey. There are no costs to you associated with your participation.

Your participation is voluntary. If you choose not to participate it will not affect your relations with Boston College. You are free to withdraw or skip questions for any reason. There are no penalties for withdrawing or skipping questions.

If you have any questions or concerns concerning this research you may contact the Principal Investigator Susan Emery, PhD (c), CRNA at 617 552-6844 or emerysu@bc.edu. If you have questions about your rights as a research participant, you may contact the Office for Research Protections, Boston College, at 617 552-4778 or irb@bc.edu.

This study was reviewed by the Boston College Institutional Review Board and its approval was granted on __________.

If you agree to the statements above and agree to participate in this study, please press the “Consent Given” button below.
Appendix C

CRNA Work and Fatigue Survey
The following survey asks about your work hours and workload for the last shift worked. Please complete the survey as soon as possible following the completion of your shift.

1. Age _____ Years
2. Gender ___ M/F
3. What is your highest educational level?
   ___Certificate in anesthesia
   ___Bachelors degree
   ___Masters degree
   ___Doctoral degree
4. For how many years have you practiced as a CRNA? ______
5. During your last workday, how many hours were you on duty? ______
6. How many of the above hours were “on-call” time? ______
   *On-call time refers to hours during which you did not provide anesthesia care but were available by either phone or pager.*
7. If you were on-call were you required to be physically present in the facility?
   Y ___ N ___
8. During your last workday, for how many hours did you provide anesthesia care? ______
   *Anesthesia care refers to time spent in preparation of patient and equipment, actual anesthesia administration, and report and clean-up following the anesthetic.*
9. In which of the following types of facilities did you work?
   ___Tertiary medical center
   ___Community hospital
   ___Free-standing surgery center
10. During your last workday in which of the following practice settings did you work?
    ___Anesthesia care team
    ___Independent practice
11. How many hours following completion of your shift did you complete this survey? ______
12. In what state do you work? ______
The following questions from the Checklist Individual Strength (CIS-20) Questionnaire ask how you felt at the end of your shift. On the following scale, please answer each question according to how you felt at the end of your workday. If you feel that the statement is entirely true, check the left box. If you feel the statement is not true at all, check the right box. If you feel the statement is somewhere in between, check one of the boxes that is most in accordance with how you felt.

13. I felt tired

Yes that is true

No that is not true

14. I felt very active

Yes that is true

No that is not true

15. Thinking required effort

Yes that is true

No that is not true

16. Physically, I felt exhausted

Yes that is true

No that is not true

17. I felt like doing all kinds of nice things

Yes that is true

No that is not true

18. I felt fit

Yes that is true

No that is not true

19. I was physically very active

Yes that is true

No that is not true

20. When I was doing something, I could concentrate quite well

Yes that is true

No that is not true
21. I felt weak, powerless

Yes that is true

Yes that is true

No that is not true

22. I wasn’t physically very active

Yes that is true

Yes that is true

No that is not true

23. I could concentrate well

Yes that is true

Yes that is true

No that is not true

24. I felt rested

Yes that is true

Yes that is true

No that is not true

25. I had trouble concentrating

Yes that is true

Yes that is true

No that is not true

26. I did not feel well physically

Yes that is true

Yes that is true

No that is not true

27. I was full of plans

Yes that is true

Yes that is true

No that is not true

28. I got tired very quickly

Yes that is true

Yes that is true

No that is not true

29. I had a low level of physical activity

Yes that is true

Yes that is true

No that is not true
30. I didn’t feel like doing anything
   Yes that is true   No that is not true

31. My thoughts easily wandered
   Yes that is true   No that is not true

32. Physically I felt in a good shape
   Yes that is true   No that is not true

The following questions asking about your workload are from the NASA Task Load Index.
For the following questions, please consider these aspects of workload during your last workday.

<table>
<thead>
<tr>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental demand</td>
<td>How much mental and perceptual activity was required (i.e. thinking, deciding, calculating, remembering, looking, searching, etc.?</td>
</tr>
<tr>
<td>Physical demand</td>
<td>How much physical activity was required?</td>
</tr>
<tr>
<td>Temporal demand</td>
<td>How much time pressure did you feel due to the rate or pace at which the task or task elements occurred?</td>
</tr>
<tr>
<td>Performance</td>
<td>How successful do you think you were in accomplishing the goals of the task? How satisfied were you with your performance?</td>
</tr>
<tr>
<td>Effort</td>
<td>How hard did you have to work mentally and physically to accomplish your level of performance?</td>
</tr>
<tr>
<td>Frustration level</td>
<td>How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed, and complacent did you feel during your shift?</td>
</tr>
</tbody>
</table>
33. Please rate the following aspects of your workload during your shift from high to low, good to poor.

### Mental demand

How much mental and perceptual activity was required (i.e. thinking, deciding, calculating, remembering, looking, searching, etc.?)

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
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49. Physical demand

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<th>High</th>
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50. Temporal demand

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<th>High</th>
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51. Performance

<table>
<thead>
<tr>
<th>Good</th>
<th>Poor</th>
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<tbody>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

52. Effort

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

53. Frustration

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please rate the sources of workload during your last workday according to which of the following factors in the following pairs contributed most to that workload. For example when considering the pair “effort” and “performance”, if effort contributed more to your perception of workload you should check the box following “effort”. If, on the other hand, your concern with performance contributed more to your workload, the box after “performance” should be checked. Do not assign numbers or percentages.

33. Effort _____ or performance _____
34. Temporal demand _____ or effort _____
35. Performance _____ or frustration _____
36. Physical demand _____ or performance _____
37. Temporal demand _____ or frustration _____
38. Physical demand _____ or frustration _____
39. Physical demand _____ or temporal demand _____
40. Temporal demand _____ or mental demand _____
41. Frustration ____ or effort 
42. Performance _____ or temporal demand ______
43. Mental demand _____ or physical demand ______
44. Frustration ____ or mental demand ______
45. Performance _____ or mental demand ______
46. Mental demand _____ or effort ______
47. Effort _____ or physical demand ______
Appendix D

NASA Task Load Index
TASK LOAD INDEX

(NASA-TLX)

V 1.0

NASA

Ames Research Center
Appendix D.

<table>
<thead>
<tr>
<th>Scale Title</th>
<th>Tally</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>MENTAL DEMAND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHYSICAL DEMAND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEMPORAL DEMAND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PERFORMANCE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EFFORT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FRUSTRATION</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total count = ________

(Note: The total count is included as a check. If the total count is not equal to 15, then something has been miscounted. Also, no weight can have a value greater than 5.)
NASA Task Load Index (NASA-TLX)  
Version 1.0  
Paper and Pencil Package

This booklet contains the materials necessary to collect subjective workload assessments with the NASA Task Load Index. This procedure for collecting workload ratings was developed by the Human Performance Group at NASA Ames Research Center during a three year research effort that involved more than 40 laboratory, simulation, and inflight experiments. Although the technique is still undergoing evaluation, this booklet is being distributed to allow other researchers to use it in their own experiments. Comments or suggestions about the procedure would be greatly appreciated. This package is intended to fill a “nuts and bolts” function of describing the procedure. A bibliography provides background information about previous empirical findings and the logic that supports the procedure.

1. BACKGROUND

The NASA Task Load Index is a multi-dimensional rating procedure that provides an overall workload score based on a weighted average of ratings on six subscales: Mental Demands, Physical Demands, Temporal Demands, Own Performance, Effort, and Frustration. A definition of each subscale is provided in Appendix A.

An earlier version of the scale had nine subscales. It was designed to reduce between-rater variability by using the a priori workload definitions of subjects to weight and average subscale ratings. This technique (referred to as the “NASA Bipolar Rating Scale”) was quite successful in reducing between-rater variability, and it provided diagnostic information about the magnitudes of different sources of load from subscale ratings (Hart, Buxton, & Lester, 1984; Vidulich & Tsang, 1985a & b). However, its sensitivity to experimental manipulations, while better than found for other popular techniques and for a global unidimensional workload rating, was still not considered sufficient. In addition, it was felt that nine subscales are too many, making the scale impractical to use in a simulation or operational environment. Finally, several of the subscales were found to be irrelevant to workload (e.g.: Fatigue) or redundant (e.g.: Stress and Frustration). For these reasons, the NASA Task Load Index was developed. Some of the subscales from the original scale were revised or combined, others deleted.
Appendix B

Sources of Workload Comparison Cards

The Task Load Index has been tested in a variety of experimental tasks that range from simulated flight to supervisory control simulations and laboratory tasks (e.g., the Sternberg memory task, choice reaction time, critical instability tracking, compensatory tracking, mental arithmetic, mental rotation, target acquisition, grammatical reasoning, etc.). The results of the first validation study are summarized in Hart & Staveland (in press). The derived workload scores have been found to have substantially less between-rater variability than unidimensional workload ratings, and the sub-scales provide diagnostic information about the sources of load.

2.2. Sources of Load (Weights)

The NASA Task Load Index is a two-part evaluation procedure consisting of both weights and ratings. The first requirement is for each rater to evaluate the contribution of each factor (its weight) to the workload of a specific task. These weights account for two potential sources of between-rater variability: differences in workload definition between raters within a task, and differences in the sources of workload between tasks. In addition, the weights themselves provide diagnostic information about the nature of the workload imposed by the task.

There are 15 possible pair-wise comparisons of the six scales (Appendix B). Each pair is presented on a card. Subjects circle the member of each pair that contributed more to the workload of that task. The number of times that each factor is selected is tallied. The tallies can range from 0 (not relevant) to 5 (more important than any other factor).

A different set of weights is obtained for each distinctly different task or task element upon its completion. The same set of weights can be used for many different versions of the same task if the contributions of the six factors to their workload is fairly similar. For example, the same set of weights was used for many different versions of a target acquisition task in which time pressure, target acquisition difficulty, and decision making load were varied. Obtaining separate weights for different experimental manipulations increased the sensitivity of the derived workload score only slightly, and did not warrant the additional time required to gather them. On the other hand, the weights obtained from the same subjects for a compensatory tracking task or a memory search task would not have been appropriate for the target acquisition task.
7. **SUBJECT INSTRUCTIONS: SOURCES-OF-WORKLOAD EVALUATION**

Throughout this experiment the rating scales are used to assess your experiences in the different task conditions. Scales of this sort are extremely useful, but their utility suffers from the tendency people have to interpret them in individual ways. For example, some people feel that mental or temporal demands are the essential aspects of workload regardless of the effort they expended on a given task or the level of performance they achieved. Others feel that if they performed well the workload must have been low and if they performed badly it must have been high. Yet others feel that effort or feelings of frustration are the most important factors in workload; and so on. The results of previous studies have already found every conceivable pattern of values. In addition, the factors that create levels of workload differ depending on the task. For example, some tasks might be difficult because they must be completed very quickly. Others may seem easy or hard because of the intensity of mental or physical effort required. Yet others feel difficult because they cannot be performed well, no matter how much effort is expended.

The evaluation you are about to perform is a technique that has been developed by NASA to assess the relative importance of six factors in determining how much workload you experienced. The procedure is simple: You will be presented with a series of pairs of rating scale titles (for example, Effort vs. Mental Demands) and asked to choose which of the items was more important to your experience of workload in the task(s) that you just performed. Each pair of scale titles will appear on a separate card.

Circle the Scale Title that represents the more important contributor to workload for the specific task(s) you performed in this experiment.

After you have finished the entire series we will be able to use the pattern of your choices to create a weighted combination of the ratings from each task into a summary workload score. Please consider your choices carefully and make them consistent with how you used the rating scales during the particular task you were asked to evaluate. Don't think that there is any correct pattern; we are only interested in your opinions.

If you have any questions, please ask them now. Otherwise, start whenever you are ready. Thank you for your participation.

3.4. **Weights**

Subjects complete the "Sources-of-Workload Evaluation" once for each task or group of tasks included in the experiment that share a common structure (although difficulty levels may vary). For example, in an experiment with several memory tasks and several tracking tasks, two Sources-of-Workload Evaluations would be performed: one for the memory tasks and one for the tracking tasks. One set of cards should be made in advance of the experiment for each subject X evaluation condition combination. The pairs of factors should be cut apart and presented individually in a different, randomly selected order to each subject. Subjects instructions for doing the Sources of Workload Evaluation are in Section 7. (Note that the exact time when the weights are obtained is not critical. However, in order for them to provide useful information, they must be obtained after at least some exposure to the relevant task conditions.)

3.5. **Summary**

Following this procedure, you should end up with: (1) a set of workload weights from each subject for each group of similar tasks, and (2) at least one rating sheet for each subject for each experimental task. Typically, we have run within-subject experiments and therefore ended up with a larger number of rating sheets for each subject.

To conserve paper and speed up the subsequent analysis, we often enclose the Rating Sheet and the Sources-Of-Workload comparison cards in clear plastic. Subjects mark the scales with an erasable felt tip marker. Immediately after they are marked, the experimenter transfers the responses onto the appropriate form or worksheet. Then the plastic sheets are cleaned and reused. If this procedure is followed, DOUBLE CHECK YOURSELF BEFORE ERASING THE SUBJECT'S RESPONSES!

4. **DATA ANALYSIS PROCEDURE**

The procedure for computing a weighted workload score follows.


Figure 1: Graphic example of the composition of a weighted workload score

written to gather ratings and weights and compute the weighted workload scores. These are available upon request from NASA Ames Research Center. However, if this is not a viable option, all the necessary materials are included in this booklet. If you have any questions, comments, or suggestions please do not hesitate to contact us. This procedure is still under evaluation and we are always looking for new ideas.
5. BIBLIOGRAPHY


1.1. Tally Sheet

For each subject, the "Sources-of-Workload Tally Sheet" (Appendix D) is used to compute the weight for each factor. The scorer simply leafs through the evaluation cards and puts a mark on the appropriate row of the tally column for each response of the subject (e.g., each time the subject circled "Mental Demand" on a comparison card, the experimenter would put a mark in the "Mental Demand" row of the tally column). After going through the Sources-of-Workload evaluation, the experimenter adds the tallies for each scale and writes the totals in the "Weight" column.

1.2. Worksheet

The Weight column from the tally sheet is then transferred to the "Weighted Rating Worksheet" (Appendix E). Each subject would have his or her individual workload parameters counted on a separate worksheet for the appropriate task or set of similar tasks. If subjects rated more than one task, the appropriate number of copies of the worksheet should be made.

Ratings are placed in the 'Raw Rating' column of the worksheet. The 'Adjusted Rating' is formed by multiplying the Raw Rating by the Sources-of-Workload Weight. The adjusted ratings are summed across the different scales. The sum is divided by 15 to obtain the overall weighted workload score for the subject in that one task condition.

The weighted ratings are then used as a dependent measure in whatever type of analyses the experimenter chooses.

Figure 1 depicts the composition of a weighted workload score graphically. The bar graph on the left represents six subscale ratings. The width of the subscale bars reflects the importance of each factor (its weight) and the height represents the magnitude of each factor (its rating) in a particular task. The weighted workload score (the bar on the right) represents the average area of the subscale bars.

1.3. Summary

The above procedure, although simple, can be laborious for a large experiment. Thus it is highly advantageous to computerize the procedure. A set of programs that run on IBM-PC compatible machines has been

6. SUBJECT INSTRUCTIONS: RATING SCALES

We are not only interested in assessing your performance but also the experiences you had during the different task conditions. Right now we are going to describe the technique that will be used to examine your experiences. In the most general sense we are examining the 'workload' you experienced. Workload is a difficult concept to define precisely, but a simple one to understand generally. The factors that influence your experience of workload may come from the task itself, your feelings about your own performance, how much effort you put in, or the stress and frustration you felt.

The workload contributed by different task elements may change as you get more familiar with a task. Perform easier or harder versions of it, or move from one task to another. Physical components of workload are relatively easy to conceptualize and evaluate. However, the mental components of workload may be more difficult to measure.

Since workload is something that is experienced individually by each person, there are no effective 'rules' that can be used to estimate the workload of different activities. One way to find out about workload is to ask people to describe the feelings they experienced. Because workload may be caused by many different factors, we would like you to evaluate several of them individually rather than lumping them into a single value of overall workload. This list of six rating scales was developed for you to use in evaluating your experiences during different tasks. Please read the descriptions of the scales carefully. If you have any question about any of the scales in the table, please ask me about it. It is extremely important that they be clear to you. You may keep the descriptions with you for reference during the experiment.

After performing each of the tasks, you will be given a sheet of rating scales. You will evaluate the task by putting an 'X' on each of the six scales at the point which matches your experience. Each line has two endpoint descriptors that describe the scale. Note that 'bad' performance goes from 'good' on the left to 'bad' on the right. This order has been confusing for some people. Please consider your responses carefully in distinguishing among the different task conditions. Consider each scale individually. Your ratings will play an important role in the evaluation being conducted. Thus your active participation is essential to the success of this experiment and is greatly appreciated by all of us.
2.3. Magnitude of Load (Ratings)

The second requirement is to obtain numerical ratings for each scale that reflect the magnitude of that factor in a given task. The scales are presented on a rating sheet (Appendix C). Subjects respond by marking each scale at the desired location. In operational situations, rating sheets or verbal responses are more practical, while a computerized version (available from NASA Ames Research Center) is more efficient for most simulation and laboratory settings. Ratings may be obtained either during a task, after task segments, or following an entire task. Each scale is presented as a 12-cm line divided into 20 equal intervals anchored by bipolar descriptors (e.g., High/Low). The 21 vertical tick marks on each scale divide the scale from 0 to 100 in increments of 5. If a subject marks between two ticks, the value of the right tick is used (i.e., round up).

2.4. Weighting and Averaging Procedure

The overall workload score for each subject is computed by multiplying each rating by the weight given to that factor by that subject. The sum of the weighted ratings for each task is divided by 15 (the sum of the weights). (See Appendix D and E for a sample Tally Sheet and Worksheet.)

3. EXPERIMENTAL PROCEDURE

The usual sequence of events for collecting data with the NASA Task Load Index is as follows:

3.1. Instructions

Subjects read the scale definitions and instructions. A set of generic instructions is included in Section 6. Some modifications may be necessary depending on your situation.

3.2. Familiarization

Subjects practice using the rating scales after performing a few tasks to insure that they have developed a standard technique for dealing with the scales.

3.3. Ratings

Subjects perform the experimental tasks, providing ratings on the six subscales following all task conditions of interest. The number of rating sheets needed equals the number of subjects X

<table>
<thead>
<tr>
<th>RATING SCALE DEFINITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title</strong></td>
</tr>
<tr>
<td>MENTAL DEMAND</td>
</tr>
<tr>
<td>PHYSICAL DEMAND</td>
</tr>
<tr>
<td>TEMPORAL DEMAND</td>
</tr>
<tr>
<td>PERFORMANCE</td>
</tr>
<tr>
<td>EFFORT</td>
</tr>
<tr>
<td>FRUSTRATION LEVEL</td>
</tr>
</tbody>
</table>
and two added. Three dimensions relate to the demands imposed on the subject (Mental, Physical, and Temporal Demands) and three to the interaction of a subject with the task (Effort, Performance, and Frustration).

Although it is clear that definitions of workload do indeed vary among experimenters and among subjects (contributing to confusion in the workload literature and between-rater variability), it was found that the specific sources of loading imposed by different tasks are an even more important determinant of workload experiences. Thus, the current version of the scale (the Task Load Index) combines subscale ratings that are weighted according to their subjective importance to raters in a specific task, rather than their a priori relevance to raters' definitions of workload in general.

2. DESCRIPTION

2.1. General Information

The degree to which each of the six factors contribute to the workload of the specific task to be evaluated, from the raters' perspectives, is determined by their responses to pair-wise comparisons among the six factors. Magnitude ratings on each subscale are obtained after each performance of a task or task segment. Ratings of factors deemed most important in creating the workload of a task are given more weight in computing the overall workload score, thereby enhancing the sensitivity of the scale.

The weights and ratings may or may not covary. For example, it is possible for mental demands to be the primary source of loading for a task, even though the magnitude of the mental demands might be low. Conversely, the time pressure under which a task is performed might be the primary source of its workload, and the time demands might be rated as being high for some versions of the task and low for others.

Since subjects can give ratings quickly, it may be possible to obtain them in operational settings. However, a videotaped replay or computer regeneration of the operator's activities may be presented as a mnemonic aid that can be stopped after each segment to obtain ratings retrospectively. It was shown in a helicopter simulation and in a supervisory control simulation (Harlow, Shaw, and Shively, 1986; Haworth, Bivens, and Shively, 1986) that little information was lost when ratings were given retrospectively, a high correlation was found between ratings that were obtained 'online' and those that were obtained retrospectively with a visual re-creation of the task.

<table>
<thead>
<tr>
<th>Effort</th>
<th>Temporal Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>or</td>
</tr>
<tr>
<td>Frustration</td>
<td></td>
</tr>
</tbody>
</table>

| Temporal Demand  | or  |
| Physical Demand  | or  |
| Frustration       |     |

| Performance  | Physical Demand  |
| Frustration | or  |

| Temporal Demand  | or  |
| Physical Demand  | or  |
| Mental Demand  | 15  |
Appendix C

Subject ID: ____________ Task ID: ____________

RATING SHEET

MENTAL DEMAND

Low | High

PHYSICAL DEMAND

Low | High

TEMPORAL DEMAND

Low | High

PERFORMANCE

Good | Poor

EFFORT

Low | High

FRUSTRATION

Low | High
Appendix E.

Subject ID: ________  Task ID: ________

WEIGHTED RATING WORKSHEET

<table>
<thead>
<tr>
<th>Scale Title</th>
<th>Weight</th>
<th>Raw Rating</th>
<th>Adjusted Rating (Weight X Raw)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MENTAL DEMAND</td>
<td></td>
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<tr>
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<tr>
<td>FRUSTRATION</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sum of "Adjusted Rating" Column = ________

WEIGHTED RATING = 

[i.e. (Sum of Adjusted Ratings)/15]
Appendix E

NASA Task Load Index Permission
Hi Susan-

The paper and pencil version is available by simply downloading the tool here- http://humansystems.arc.nasa.gov/groups/TLX/paperpencil.html

If you want to download the computer version, you will need to complete/submit a "software usage agreement" to the NASA Software Release Authority- http://humansystems.arc.nasa.gov/groups/TLX/computer.php

You will also need to register your user info. on that same page before you can access the tool.

Regards, Phil

On 12/20/11 5:39 AM, Susan Emery wrote:
Hello
I am a doctoral student interested in using the task load index as part of my dissertation. Could you please advise me on the procedure for obtaining and using this tool.
Thank you.

Susan Emery, PhD (c), CRNA
Clinical Associate Professor
Program Director
Nurse Anesthesia Program
Boston College, William F. Connell School of Nursing
140 Commonwealth Avenue
Chestnut Hill, MA 02467-3812
P: 617 552-6844
F: 617 552-0913

-- Phil So
Multimedia Specialist
Dell/perotsystems®
NASA AMES Research Center, MS 262-6
Moffett Field, CA 94035
760-814-8317 - Office
Phil.W.So@nasa.gov
Appendix F

Checklist Individual Strength – 20
Instruction:
On the next page you find 20 statements. With these statements we wish to get an impression of how you have felt during the last two weeks. For example:

I feel relaxed

If you feel that this statement is entirely true, tick the left box; as follows:

<table>
<thead>
<tr>
<th>I feel relaxed</th>
<th>yes, that is true</th>
<th>X</th>
<th>no, that is not true</th>
</tr>
</thead>
</table>

If you feel that this statement is not true at all, tick the right box; as follows:

<table>
<thead>
<tr>
<th>I feel relaxed</th>
<th>yes, that is true</th>
<th>no, that is not true</th>
</tr>
</thead>
</table>

If you feel that this statement is neither "yes, that is true", nor "no, that is not true", tick the box that is most in accordance with how you have felt.
For example, if you feel relaxed, but not very relaxed, tick one of the boxes close to "yes, that is true": as follows:

<table>
<thead>
<tr>
<th>I feel relaxed</th>
<th>yes, that is true</th>
<th>X</th>
<th>no, that is not true</th>
</tr>
</thead>
</table>

Do not skip any statement and tick each statement only once.
1. I feel tired. | yes, that is true | no, that is not true
2. I feel very active. | yes, that is true | no, that is not true
3. Thinking requires effort. | yes, that is true | no, that is not true
4. Physically I feel exhausted. | yes, that is true | no, that is not true
5. I feel like doing lots of nice things. | yes, that is true | no, that is not true
6. I feel fit. | yes, that is true | no, that is not true
7. I am physically very active. | yes, that is true | no, that is not true
8. When I am doing something, I can keep my thoughts on it. | yes, that is true | no, that is not true
9. I feel powerless. | yes, that is true | no, that is not true
10. I am physically not very active. | yes, that is true | no, that is not true
11. I find it easy to focus my mind. | yes, that is true | no, that is not true
12. I am rested. | yes, that is true | no, that is not true
13. It takes a lot of effort to concentrate on things. | yes, that is true | no, that is not true
14. Physically I feel I am in bad form. | yes, that is true | no, that is not true
15. I have a lot of plans. | yes, that is true | no, that is not true
16. I tire easily. | yes, that is true | no, that is not true
17. My level of physical activity is low. | yes, that is true | no, that is not true
18. I don't feel like doing anything. | yes, that is true | no, that is not true
19. My thoughts easily wander. | yes, that is true | no, that is not true
20. Physically I feel I am in an excellent condition. | yes, that is true | no, that is not true
SCORING  CISoR_08

For the items: 2, 5, 6, 7, 8, 11, 12, 15, 20 is the scoring as follows:

| yes, that is true | 1 2 3 4 5 6 7 | no, that is not true |

For the items: 1, 3, 4, 9, 10, 13, 14, 16, 17, 18, 19 is the scoring as follows:

| yes, that is true | 7 6 5 4 3 2 1 | no, that is not true |

Subsequently the four subscales are calculated by summing the respective items. A higher the score means more problems.

subscale 1: Severity of fatigue  
items 1, 4, 6, 9, 12, 14, 16, 20

subscale 2: Concentration problems  
items 3, 8, 11, 15, 19

subscale 3: Decreased Motivation  
items 2, 5, 15, 18

subscale 4: Decreased Physical Activity  
items 7, 10, 17
Appendix G

Checklist Individual Strength Permission Email
Dear Ms Emery,

Thank you for your enquiry. I herewith send you the CIS.

Kind regards,

Ellis Gielink
Secretary

Radboud University Nijmegen Medical Centre
Expert Centre Chronic Fatigue
Internal code 4628
PO Box 9101 6500 HB Nijmegen
The Netherlands
tel: 0031-(0)24-3610042
fax: 0031-(0)24-3610041
e-mail: nkcv@umcn.nl
www.umcn.nl/chronicfatigue

Van: Susan Emery <susan.emery@bc.edu>
Datum: 27 februari 2012 21:36:22 GMT+01:00
Aan: "G.Bleijenberg@nkcv.umcn.nl" <G.Bleijenberg@nkcv.umcn.nl>
Onderwerp: Checklist Individual Strength

Dr. Bleijenberg
I am a doctoral student interested in using the Checklist Individual Strength questionnaire as part of my dissertation. I am trying to determine if permission is needed to use this instrument and if so, from whom that permission should be requested. I would be grateful for any assistance in this matter.

Regards,

Susan Emery, PhD (c), CRNA
Clinical Associate Professor
Program Director
Nurse Anesthesia Program
Boston College, William F. Connell School of Nursing
140 Commonwealth Avenue
Chestnut Hill, MA 02467-3812
P: 617 552-6844
F: 617 552-0913
Het UMC St Radboud staat geregistreerd bij de Kamer van Koophandel in het handelsregister onder nummer 41055629.
The Radboud University Nijmegen Medical Centre is listed in the Commercial Register of the Chamber of Commerce under file number 41055629.
Appendix H

NASA TLX Sources of Workload Tally Sheet
### SOURCES OF WORKLOAD TALLY SHEET

<table>
<thead>
<tr>
<th>Scale Title</th>
<th>Tally</th>
<th>Weight</th>
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<tbody>
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<td></td>
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<tr>
<td>TEMPORAL DEMAND</td>
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<tr>
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<tr>
<td>EFFORT</td>
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<tr>
<td>FRUSTRATION</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Count = ____________________

(Note: The total count is included as a check. If the total count is not equal to 15, then something has been miscounted. Also, no weight can have a value greater than 5.)
Appendix I

Weighted Rating Worksheet
## WEIGHTED RATING WORKSHEET

<table>
<thead>
<tr>
<th>Scale Title</th>
<th>Weight</th>
<th>Raw Rating</th>
<th>Adjusted Rating (Weight X Raw)</th>
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<td></td>
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</tr>
</tbody>
</table>

Sum of “Adjusted Rating” Column _____________

\[
WEIGHTED RATING = \frac{\text{Sum of Adjusted Ratings}}{15}
\]

[i.e., (Sum of Adjusted Ratings)/15]