# A DESCRIPTIVE STUDY OF NURSES' FATIGUE AND EXECUTIVE FUNCTION

By

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# ABSTRACT

A Descriptive Study of Nurses' Fatigue and Executive Function

The work of nurses usually involves shiftwork and may include extended work hours which can disrupt the quality of sleep and circadian rhythm contributing to fatigue. Acute fatigue, a normal physical and physiological response to over exertion, may be relieved by adequate intershift recovery; however, if intershift recovery is not adequate acute fatigue can progress to chronic or prolonged fatigue. The purpose of this study was to describe nurse fatigue across multiple dimensions, explore the relationship between fatigue and executive function, and to determine the unique contribution of fatigue to executive function after controlling for demographic characteristics, sleep quality, exercise and mental health. Major findings of this study were: 1) sleep quality, the duration of fatigue and the adequacy of intershift recovery have the strongest bivariate relationship to fatigue; 2) chronic fatigue and intershift recovery were significantly related to twoof the five measures of EF, and acute fatigue was significantly related to one of the five measures of EF; 3) chronic fatigue and acute fatigue account for 5.5% of the variance in EF after controlling for selected variables and 4) approximiately 30% of the participants in this study demonstrated impaired EF as measured by the Wisconsin Card Sorting Test. This was the first study to explore EF and more studies are needed to better understand the relationship between fatigue and EF in nurses, where the EF is critical to patient safety and optimal patient outcomes.


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# CHAPTER 1

# INTRODUCTION

In 2000, the Institute of Medicine (IOM) published a sentinel report, *To Err is Human: Building a Safer Health Care System,* (Kohn, Corrigan, & Donaldson, 2000), which suggested that up to 98,000 deaths each year in the US are attributable to medical errors. These findings helped to mobilize funding for research focused on patient safety and quality of health care services. The report identified four levels for health care system intervention: the patient, nursing unit, organizational, and policy levels. In 2001 the IOM issued a second report on patient safety and quality of care that focused on the policy level: *Crossing the Quality Chasm: A New Health System for the 21st Century*. In 2004, the IOM addressed the organizational level by releasing *Keeping Patients Safe: Transforming the Work Environment of Nurses*, which contained recommendations for improving the nursing work environment as a key strategy to improve patient outcomes. This third report suggested that decreasing worker fatigue is a central strategy for the creation and sustainability of a culture of patient safety (Page, 2004). Worker fatigue is thus an important target for intervention to improve patient safety and quality of care. However, we do not fully understand worker fatigue in the nursing environment, and such knowledge is a necessary first step to intervening to decrease nurse fatigue, improve the nursing work environment, and ultimately improve patient safety and quality of care. The purpose of this study was to describe nurse fatigue and executive function in working nurses.

## Fatigue in the Health Care Professions

The concept of fatigue has received much attention. In general, definitions of fatigue acknowledge three common attributes: (a) the cause of fatigue is due to exertion or lack of resources, (b) there is a subjective assessment of the feeling of fatigue, and (C) the individual has a reduction in performance or activities. The present study draws on the work of Job and Dalziel (2001) and defines fatigue as the state in which prior physical activity and /or mental processing, in the absence of sufficient rest, results in insufficient system energy to maintain the original level of activity and/or processing using normal resources. Fatigue is thought to have six dimensions: affective (emotional), behavioral, cognitive (mental), physiological, sensory (physical), and temporal (timing, onset, and duration) (Piper, 2004). Fatigue is a common symptom or state experienced by both healthy people and people with illnesses. Work-related fatigue may be behaviorally manifested by physical fatigue, reduced level of physical activity, lack of motivation, mental fatigue, and varying combinations of all of these. In healthy individuals, fatigue is usually related to an identifiable source of exertion, has rapid onset and short duration, and is relieved by rest or an adequate night's sleep. In contrast, although people with an illness may still exhibit fatigue related to an identifiable source (chemotherapy for cancer treatment, for example), the fatigue onset is variable, the duration is often longer than short-term, and the fatigue is usually not relieved by an adequate night's sleep (Piper, 1988).

The hospital as a workplace is fast-paced, increasingly technical, and above all, dynamic; all of these factors, along with countless others—including shiftwork, lack of recovery between shifts, and obligations outside of work—can contribute to nurse fatigue. It is clear that fatigue affects safety in other industries; fatigue in aerospace may result in aircraft accidents, and fatigue in the nuclear industry is known to have contributed to the nuclear disaster at Chernobyl (Flach & Kuperman, 2001). A comprehensive treatment of the concept of fatigue and its measurement is presented in Chapter 2.

**Implications and Effects of Fatigue on Patient Safety**

Fatigue contributes to the human component of medical errors (Gaba & Howard, 2002; Leape, 1994). In 1971 the problem of interns and sleep loss was documented (Friedman, Bigger, & Kornfield, 1971), and in a recent meta-analysis, physicians were found to have greatly reduced clinical performance after being awake for 30 continuous hours (Philibert, 2005). An Australian study documented that 42% of a sample of junior physicians recalled a fatigue-related clinical error in the past six months (Gander, Purnell, Garden, & Woodward, 2007).

In 2002, the Accreditation Council for Graduate Medical Education (ACGME), issued a landmark report on medical residents' duty hours with a specific focus on fatigue and degradations in performance (ACGME), 2002). In July 2003, as concern about medical errors grew and the evidence base became overwhelming, the accrediting body for 7,800 graduate medical education programs, instituted an 80-hour-per-work-week limit on the nation's approximately 98,000 medical residents. The ACGME's approach emphasized that programs, sponsoring institutions, and the ACGME itself had the collective responsibility for safe and effective patient care and the learning environment for residents. This limitation of hours included length of time per shift, minimum recovery time between shifts, and total number of hours/shifts worked per week. The ACGME also instituted mechanisms to ensure compliance with the standards limiting work hours.

In addition to fatigued physicians being at risk of committing errors, fatigued nurses are also at risk of committing errors. Fatigue is associated with extended work hours, rotating shifts, and the demands of the work environment (Page, 2004). Gold et al. (1992) administered a questionnaire to nurses at a large academic hospital and found that nurses who worked a rotating schedule were nearly twice as likely to report committing a medication error. The risk of making an error was also significantly elevated when nurses worked longer than scheduled ($OR$ = 2.06, $p$ = .005) or longer than 12.5 hours ($OR$ 3.29, $p$ = .001; Rogers, Hwang, Scott, Aiken, & Dinges, 2004). The IOM reviewed the evidence of nurses' work hours on fatigue and medical errors, and it recommended that state regulatory bodies prohibit nursing staff from providing direct patient care in excess of 12 hours in any 24-hour period and in excess of 60 hours per 7-day period (Page, 2004). However, the IOM does not have enforcement authority governing working hours of nurses, and nursing lacks a national regulatory body with the authority to regulate working hours.

Although fatigue in physicians has been studied for more than 35 years, nurse fatigue has been a focus of studies only in the last few years. Nurses are often a final checkpoint for identification of errors before they are committed. In fact, Leape et al. (1995) found in a study of two hospitals that in a 6-month period, nurses intercepted 86% of all medication errors made by physicians, pharmacists, and others before the error reached the patient. In *Keeping Patients Safe: Transforming the Work Environment of Nurses* (2004), Page devoted a chapter to the work of nurses and the need to investigate factors such as shift work and extended work hours that are known to contribute to errors.

It is important that nurses' work be as comprehensively addressed as that of physicians to increase patient safety.

When considering the effect of fatigue on patient safety, it is important to determine whether the fatigue is acute or chronic. Piper et al. (1989) characterized acute fatigue in the following ways: protective; identifiably linked to a known cause; generally occurring in healthy individuals; perceived as normal with rapid onset and short duration; alleviated by adequate rest, diet, exercise, and stress management; and possibly having minimal effect on activities of daily living and quality of life. Acute fatigue in healthy working nurses may be alleviated by adequate intershift recovery; however, acute fatigue not alleviated by rest may result in chronic fatigue. Piper et al. (1989) stated that chronic fatigue is abnormal, persists over time, is not generally relieved by usual restorative strategies, and may have a major effect on activities of daily living and quality of life. Chronic fatigue has more detrimental effects on patient safety because chronic fatigue may require extensive rest/recovery before performance returns to normal (Winwood, Lushington, & Winefield, 2006). A chronically fatigued nurse who continues to work may have below normal performance. More comprehensive understandings of working nurse fatigue will enhance our understanding of the potentially wide-reaching implications on patient safety.

## Implications and Effects of Fatigue on the Nursing Profession

In addition to affecting patient safety, fatigue also affects the nursing profession. Fatigue among working populations has been shown to decrease productivity and increase the use of health care services, which can, in turn, increase social costs (Chen, 1986; David et al., 1990). In a large cross-sectional study of workers in multiple occupations, higher fatigue scores predicted a quicker onset of the worker's first sick leave episode and an increased likelihood of long-term sickness absence (Janssen, Kant, Swaen, Janssen, & Schroer, 2003). A random sample of 6,000 nurses from 10 states showed that as nurses self-reported an increase in physical demands in the workplace, there was an increase in the likelihood of inadequate sleep, increased use of pain medication, and absenteeism (Trinkoff, Storr, & Lipscomb, 2001). Although sick leave usage or absenteeism was not explored in this study, it is important to note that fatigued nurses may choose to work less or choose not to work at all, which may exacerbate an existing nursing shortage.

If nurses are chronically fatigued, they are more likely to leave the profession (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002). It is critical that factors contributing to chronic fatigue are mitigated in order to retain nurses who are currently practicing. This will become even more important as the nursing workforce ages and retires—an eventuality that will presumably coincide with an increased need for nurses as the general population ages (Aiken et al., 2001; Buerhaus, Donelan, Ulrich, Kirby, et al., 2005; Buerhaus, Donelan, Ulrich, Norman, et al., 2005). Nursing might be able to attract more applicants and retain current nurses if work conditions improved (Buerhaus, Staiger, & Auerbach, 2003). The nursing work environment needs modifications to retain nurses and prepare for future nursing shortages. Fatigue affects the nursing profession by decreasing the nursing workforce, and fatigue also has immediate and long-term negative effects on the individual.

## Implications and Effects of Fatigue on the Individual

There is growing evidence that sleep deprivation causes cognitive deficits (Dinges, 2006; Papp, Miller, & Stohl, 2006). Sleep deprivation may be caused by long work hours and sustained attention; and sustained attention is known to have a detrimental effect on concentration and physical performance. In a study of junior physicians in Australia, 66% had felt close to falling asleep while driving home in the prior 12 months (Gander et al. 2007). On-call medical (house) staff have increased risk for motor vehicle accidents attributable to fatigue (Marcus & Loughlin, 1996), and nurses who rotate shifts have twice the odds of falling asleep while driving home after a shift compared to nurses who do not rotate shifts (Gold et al., 1992). After 18 hours of wakefulness, performance can be impaired to a level equivalent to a blood alcohol level of .10%, a level that is considered too high to drive legally in most states (Dawson & Reid, 1997; Gold et al., 1992).

The working hours of nurses result in both acute and chronic sleep deprivation (Rogers et al., 2004), which is a factor contributing to or exacerbating fatigue as described by DeLuca (2005a). The ability to recognize impaired cognitive ability is crucial in work situations where harm or injury to the worker is possible; in the case of nurses, there is the added possibility of harm or injury to others— the patients the nurses are caring for.

The risk of injury on the job due to worker fatigue was confirmed by a large study of the general working population in the Netherlands (Swaen, van Amelsvoort, Bultmann, & Kant, 2003). Workers scoring above the cut-off point for fatigue had an increased risk of being injured in an occupational accident compared to non-fatigued workers. Sleep and recovery between shifts are restorative and protective to the individual. Workers with the least recovery between shifts had a 2.28 greater chance (Relative Risk 95% CI [1.41, 3.66]) of being injured in an occupational accident. The long working hours of nurses and the inadequate recovery time between shifts have also been shown to influence the development of sleep disorders, social disturbances, and digestive and cardiovascular symptoms (Smith et al., 1999).

Depression, or decreased emotional health, is a contributing factor to fatigue (American Psychiatric Association, 1994). The relationship between fatigue and depression may be a reciprocal causal relationship in that fatigue may cause depression and depression may cause fatigue. Nurses experiencing chronic fatigue report decreased emotional health (Winwood et al., 2006). It is important, therefore, to measure depression when evaluating fatigue.

In summary, a fatigued worker may show impaired reasoning and is at increased risk for on-the-job injury (Swaen et al., 2003). However, the most important reason for studying fatigue in nurses is the potential affect of nurse fatigue on patient safety.

## Cognitive Performance and Executive Function

Just as in the aerospace and transportation industries, the work of nurses requires constant information processing, which may contribute to mental fatigue and subsequent deficits in cognitive performance (Hockey, 1997; McEwen, 2007; Rhodes, 2004; van der Linden & Eling, 2006; van der Linden, Frese, & Meijman, 2003). The relationship between fatigue and cognitive processes is difficult to assess, yet mental fatigue and detriments to cognitive processes are critical to patient safety. The effect of fatigue on cognitive performance, particularly in apparently healthy working nurses, is not known.

Cognitive processing occurs at a routine functioning level as long as the individual is mentally processing routine information or well-learned skills. When the individual faces new, critical, or complex situations with new information, or situations requiring new skills, cognitive processing switches to executive cognitive functioning (EF). EF, or local cognitive function, is responsible for monitoring and controlling behavior, suppressing irrelevant information, contributing to reasoning or analysis, updating information in the working memory, planning, and controlling attention (Hockey, 1997; van der Linden & Eling, 2006; van der Linden et al., 2003). EF requires an increased use of resources, which is associated with decreased vigilance (Smit, Eling, & Coenen, 2004), and EF is much more vulnerable to fatigue than routine cognitive function (Hockey, 1997; van der Linden & Eling, 2006; van der Linden et al., 2003). In addition, the continued use of EF increases the fatigue level of an already fatigued individual (Hockey, 1997; McEwen, 2007). In an effort to conserve resources or energy, the fatigued individual is less likely to pay attention to details or process information that requires more mental effort. Thus, the fatigued individual relies more on routine processing with its familiar routines than on EF with its analytical capabilities (Rhodes, 2004; van der Linden & Eling, 2006; van der Linden et al., 2003). Reliance on routine processing may be appropriate for occupations with routine tasks; however, even the routine work of nurses is complex, varied, and dynamically changing. Reliance on routine processing is unacceptable when job demands are constantly changing and when workers have responsibility for other people's lives.

Studies in the aerospace and transportation industry have shown that an individual may be able to briefly access the resources necessary for critical situations; however, those resources may not be available for very long (Hockey, 1997). Cognitive processing is a hidden process, and little is known about the relationship of fatigue to mental or cognitive processing. Understanding the relationship of fatigue and EF is essential in occupations where the worker must be vigilant a good amount of the time especially to avoid potentially dangerous situations.

## Summary

Nurse fatigue has the potential to affect patient safety, the nursing profession, and the individual nurse. The work of nurses may result in acute fatigue, and nurses need adequate intershift recovery in order to return to work with optimal performance. Inadequate recovery results in acute fatigue becoming chronic fatigue. Fatigue, whether it is acute or chronic, may affect numerous dimensions of functioning: affective behavioral, cognitive, physiological, sensory, and temporal. Mental fatigue is known to have detrimental effects on EF, which is responsible for monitoring and responding appropriately to changing situations. More needs to be known about the effects of fatigue on EF in nurses.

## Purpose

This cross-sectional descriptive study used two instruments to comprehensively explore the dimensions of fatigue as well as the adequacy of intershift recovery in working nurses. This study also used a computerized program, the WCST-64:CV2™, to evaluate their executive function, the aspect of cognitive function that is most vulnerable to mental fatigue. The WCST-64:CV2™, a reliable and valid instrument for measuring EF had not been used in nurses before.  The WCST-64:CV2™ presented new tasks for the individual to solve, thereby, clearly assessing the nurses' ability to plan, solve, access working memory and inhibit impulse decisions. The two innovations in this study were the multidimensional measurement of fatigue and the premier measurement of EF.

Nurse fatigue has been described in single studies measuring either the emotional/behavioral/mental or physical dimension or the temporal dimension (duration), but the inclusion of the temporal dimension along with other dimensions has not been done. Comprehensively describing working nurse fatigue will enhance our understanding of the nurse's perception of fatigue. EF in nurses has not been described nor has the relationship between fatigue and EF been characterized. Describing working nurse EF and describing the relationship between working nurse fatigue and EF may help us to understand whether working nurses' fatigue affects EF and potentially patient safety. A more complete understanding of the relationship between fatigue and EF may also allow us to strategize interventions to minimize the effects of fatigue on the nursing profession and on patient safety.

## Specific Aims

The specific aims of this study of fatigue and executive function in nurses' were to:

1.) To describe nurses' levels of fatigue and executive function.

2.) To identify correlates of fatigue in working nurses.

3.) To test whether self-reported fatigue is significantly and independently associated with executive function in working nurses.

4.) To determine the amount of variance in EF accounted for by fatigue after controlling for age, gender, start time of shift, length of shift, sleep, mental health status and exercise.

# CHAPTER 2

## CONCEPT ANALYSIS

Previous researchers have noted the difficulty in defining fatigue (Nail & King, 1987, Piper, 2004; Potempa, Lopez, Reid, & Lawson, 1986). Thus, performing a concept analysis is an important first step in formally define fatigue. Walker and Avant (2005) suggested eight steps in the concept analysis process:

> …(1) select a concept, (2) determine the aims or purpose of the analysis, (3) identify all uses of the concept that you can discover, (4) determine defining attributes, (5) identify a model case, (6) identify borderline, related, contrary, invented, and illegitimate cases, (7) identify antecedents and consequences, and (8) define empirical referents. (p. 65)

The concept analysis presented here focuses on fatigue with the aim to determine an appropriate definition and to guide measurement of fatigue in this study. The concept analysis begins with etymology and dictionary or other reference definitions. Literature in health care and literature appropriate to fatigue in the workplace, such as in the aviation and transportation industries, is typically explored in order to indentify all applicable uses of the concept. This literature review leads to defining attributes appropriate for the study. Model cases are presented to help clarify the concept, and a discussion of antecedents and consequences of fatigue, helps to identify potential correlates of fatigue. Exploring empirical referents provides the foundation for appropriate measurement congruent with the conceptual framework.

There is less ambiguity about the concept of EF compared to the concept of fatigue; therefore, a comprehensive concept analysis with all the steps outlined in Walker and Avant (2005) is not needed. An expanded definition is given instead, to include etymological referents and physiological explanations. Defining attributes, antecedents, consequences, and empirical referents are presented. The review of literature begins with the conceptual framework and the conceptual framework provides the organization for the review of the literature.

## Concept Analysis of Fatigue

Defining the concept of fatigue has challenged science for over a century. Fatigue research has completed three phases (Cameron, 1973) and has entered a fourth phase. The first phase, with a focus on productivity in industry, occurred during the First World War. The second phase focused on the effects of fatigue on performance especially in the aviation industry. Research on fatigue in the general transportation industry took place in the third phase, and we are now in the fourth phase of study of fatigue in general industry and in medical patients.

Although fatigue has been a focus of studies for almost a century, most researchers have failed to sufficiently define the concept. Early in the first phase, Muscio (1921) suggested that the term *fatigue* be banished from scientific discussion because it was too complex to define and lacked comprehensive measurement that would adequately define the phenomenon. Cameron (1973) and Grandjean (1968), during the third phase, acknowledged the lack of a definition in most studies of fatigue; and the lack of a universal definition is still noted in current fatigue research (Bultmann et al., 2000; deVries, Michielsen, & van Heck, 2003; Nail & King, 1987; Piper, 2004).

I conducted a literature search on the concept of fatigue by searching the MEDLINE, CINAHL, and PsychInfo databases, and book and publisher websites, and by doing manual ancestry searches of reference lists of published fatigue research. Three concept analyses in the nursing literature were located (Aaronson et al., 1999; Olson 2007; Ream & Richardson, 1996) and one summary analysis (Tiesinga, Dassen, & Halfens, 1996). Aaronson et al. (1999) and Ream and Richardson (1996) did not agree on a definition, and Olson (2007) did not define fatigue but rather suggested key domains or behavioral characteristics of fatigue. Tiesinga, Dassen, and Halfens 1996) summarized definitions, dimensions, and indicators but did not provide a suggested definition. The lack of agreement among nurse scholars prompted me to conduct my own structured concept analysis to arrive at the most appropriate definition for this study. I first present etymological origins and reference definitions of fatigue followed by historical approaches in fatigue research, then approaches used in health care research, and finally a review of the literature on workplace fatigue.

## Etymological Origins and Reference Definitions

The term fatigue is derived from the Latin word *fatigare* meaning "to exhaust as with riding or working, to weary or to harass," and from the French word *fatiguer* meaning '"to tire" (Oxford English Dictionary, 1989). Fatigue is both a noun (as in a physical or mental state of exhaustion due to exertion) and a verb ("to make or become weary or exhausted"); (Collins English Dictionary, 1979). *Roget's II New Thesaurus* (2003) suggested that *fatigue*, when used as a noun, can have the synonyms of dyspnea, enervation, exhaustion, hypokinesia, hypokinesis, impuissance, languor, lassitude, lethargy, listlessness, and weariness. When used as a verb, fatigue can have the synonyms of drain, jade, tire, wear, wear down, wear out, or weary. These reference texts suggested that two initial defining attributes of fatigue may be that fatigue follows exertion and that it is associated with a change in physical state.

It is important to look at healthcare related references for fatigue to determine the health specific usage. *Taber's Cyclopedic Medical Dictionary* (Venes & Thomas, 2001) defined *fatigue* as an overwhelming sustained sense of exhaustion and a decreased capacity for physical and mental work at the usual level. *Taber's* further distinguished between *acute* and *chronic* fatigue: acute fatigue has a sudden onset often following excessive exertion and is relieved by rest; chronic fatigue is a "long-continued fatigue not relieved by rest, indicative of disease such as tuberculosis, diabetes, or other conditions of altered body metabolism" (p. 779). The North American Nursing Diagnosis Association (NANDA) defined *fatigue* as "the self-recognized state in which an individual experiences an overwhelming sustained sense of exhaustion and decreased capacity for physical and mental work that is not relieved by rest" (Carpenito, 1995. p. 379). NANDA diagnoses are typically used in ill populations, so the NANDA definition may not be applicable to healthy persons experiencing short-term or acute fatigue due to exertion that may be relieved by rest. The *Taber's* definition supported the non-healthcare references that two defining attributes of fatigue were: *following exertion* and *sense of exhaustion* and adds an attribute of *relieved by rest*. The NANDA definition contains one of the non-healthcare reference text attributes (*implied change in physical or mental state*), adds the attributes of *subjective awareness* and *not relieved by rest*, and omits *following exertion.* The health care references confirm the reference texts' usage of fatigue as a noun and a verb, and they add that fatigue may be a symptom, a standalone diagnosis, or a syndrome (Carpenito, 1995; Venes & Thomas, 1997).

## Historical Perspectives in Defining Fatigue

The concept of fatigue has moved from a logical-positivist paradigm of fatigue that could be concretely defined biologically as a stress response (process) and objectively measured (Grandjean, 1968; Muscio, 1921) to a critical philosophical paradigm wherein fatigue has multiple realities specific to a population or individual (Nail and King, 1987; Piper, 2004). Muscio (1921) suggested that the expression of fatigue in an intact organism be "a condition caused by activity, in which the capacity for repeating the activity that caused it is diminished" (p. 35). Fatigue was first physiologically described as the existence of electrical potentials in muscles that stemmed from the body's inability to excrete byproducts of overused muscles and as chemical changes in the central nervous system (Cameron, 1973; Muscio, 1921). Physiologists sought to address the controversy of early definitions (process vs. symptom) by describing fatigue as the poor physical performance imposed by exertion (Lewis & Haller, 1991). Physiologically, general body fatigue may be defined as functional organ failure generally attributed to excessive energy consumption and can be characterized by the depletion of hormones, neurotransmitters, or essential substrates of physiological function. Physiological fatigue has been associated with fever, infection, anemia, sleep disturbances, and pregnancy, all of which consume more resources than normal body functioning. The discussion about whether fatigue is a symptom, process, or outcome continues today (DeLuca, 2005b; Hancock and Desmond, 2001).

## The Concept of Fatigue in the Health Literature

The concept of fatigue in health-related literature offers a significant departure from dictionary definitions of the word in that exertion does not always precede fatigue.

For example, in the 19th century, physicians described upper-class women in the United Kingdom as being too weak to rise from their beds (Shorter, 1993 as cited in Torres-Harding & Jason, 2005). Scientists then and through the early 1900s could not differentiate symptoms of tiredness or weakness from biological causes such as influenza, or psychological causes such as depression. In the mid-20th century, Allen (1944) analyzed 300 cases with a chief complaint of weakness or fatigue and found that 80% of the cases could be attributed to nervous conditions and 20% could be attributed to physical disorders such as heart disease, chronic infection, nephritis, and anemia. There is a paucity of references to fatigue in health-related literature from the 1940s through the mid-1980s, when it became apparent that fatigue in itself might be a medical diagnosis in cases of persistent viral infection, such as the Epstein-Barr virus. This unrelenting fatigue became known as chronic fatigue syndrome (CFS) with specific diagnosing criteria. The diagnosing criteria seemed to be clear in the late 1970s with the inclusion of CFS in the *Diagnostic and Statistical Manual of Mental Disorders: DSM-III-R* (American Psychiatric Association, 1980); however, 14 years later CFS appeared to be accepted as having a physical cause, because it was not included the *Diagnostic and Statistical Manual of Mental Disorders DSM-IV* (American Psychiatric Association, 1994; Bailly, 2002).

Piper (1986), Nail and King, (1987), and Potempa, Lopez, Reid and Lawson (1986) were early voices about the concept of fatigue in the nursing literature. Piper (1986) defined *fatigue* as the perception of a complex interplay of both somatic and psychological factors. Potempa et al.'s (1986) definition of *fatigue* as "a state of decreased capacity for physical and mental work" (p. 165) seemed to propose a resource view of fatigue with fatigue and energy at the two ends of a continuum. This linear view is an example of the somatic factor of the amount of energy available to in individual for accomplishing tasks, a view supported in Rhodes, Watson, and Hanson (1988). At about the same time, Piper, Lindsey, and Dodd (1987) defined *fatigue* as “a subjective feeling of tiredness that is influenced by circadian rhythm; it can vary in unpleasantness, duration, and intensity. When acute, fatigue serves a protective function; when it is excessive or chronic, its function is unknown” (p. 19).

Piper et al. (1987), Nail and King, (1987), Tack (1990), and Hubsky and Sears (1992) all noted the subjective nature of fatigue in their definitions. Patients have used the words *fatigue*, *tiredness*, and *weakness* to describe their inability to care for themselves. Nail and King (1987) and Schwartz (2000) differentiated fatigue from energy or resources by stating that persons with cancer perceive fatigue and energy as distinct concepts because such persons state that they can feel fatigued and yet have energy at the same time. A later definition by Piper (1993) differentiated fatigue from tiredness by defining tiredness as “a universal sensation that is expected to occur normally at certain times of the day (circadian rhythmicity) or after certain types of activity or exertion” (p. 279), while fatigue is “unusual, abnormal or excessive whole body tiredness, disproportionate to or unrelated to activity or exertion” (p. 279). This concurrence of fatigue and energy occurring at the same time challenges the linear conceptual view that fatigue and energy exist on either end of a continuum and suggests that ill populations experience fatigue differently from fatigue in healthy populations.

Fatigue is prevalent and distressing to those with diagnoses including rheumatoid arthritis, diabetes, multiple sclerosis, AIDS, and those undergoing radiation or chemotherapy (Aaronson et al., 1999). Stuifbergen and Rogers (1997) suggested that the fatigue of multiple sclerosis is different from tiredness because it is abnormal and unrelated to exertion or activity. Still others have sought to distinguish fatigue as exertional fatigue (such as experienced with Parkinson's disease), pain-related (such as with arthritis), or caused by weakness from illness or treatment (such as terminal cancer) (Aaronson et al., 1999). Ream and Richardson (1996), who focused on illness-based definitions of fatigue, concluded that tiredness is a state in which a person feels a temporary lessening of strength and energy; fatigue is a complex concept with additional characteristics.

Fatigue is experienced as a subjective internal feeling that appears not to be the same for everyone. Although fatigue is composed of physical and psychological sensations, the experience is incomplete without individuals' evaluation of their feelings (Hart, Freel, & Milde, 1990; Kellum, 1985). Ream and Richardson (1996) proposed that fatigue be defined as "a subjective, unpleasant symptom which incorporates total body feelings ranging from tiredness to exhaustion creating an unrelenting overall condition which interferes with individuals' ability to function to their normal capacity" (p. 527). Tiesinga et al. (1996) conducted concept analysis to summarize definitions, dimensions, and indicators of fatigue. In the end, they failed to propose a definition for fatigue but suggested that a "fundamental study of fatigue is a necessary first step" in developing an instrument to consistently assess and diagnose fatigue in patients (p. 59). The subjective aspect of fatigue is also supported by Aaronson and colleagues' (1999) definition of *fatigue* as "the awareness of a decreased capacity for physical and/or mental activity due to an imbalance in the availability, utilization, and/or restoration of resources needed to perform activity” (p. 46). Ream and Richardson’s definition (1996) implies an imbalance of resources; Aaronson et al.’s definition (1999) explicitly states this imbalance. The subjectivity in both definitions is important in acknowledging that the fatigue experience is not the same for everyone.

Piper (2004) addressed the lack of clarity in the definition of fatigue by suggesting that it may be premature to adopt a universal definition or set of diagnostic criteria for fatigue. She further acknowledged that fatigue in clinical populations differs significantly from experiences in healthy populations. Piper proposed six dimensions of fatigue and suggested that fatigue be assessed on multiple dimensions to enhance differentiation among causative mechanisms and may guide strategies to manage fatigue (Table 1).

Table 1.
*Dimensions of Fatigue*

| Dimension | Description | Proposed Indicators |
|---|---|---|
| Affective, emotional, or psychological | Includes emotional manifestations/ responses to fatigue | • Degree of emotional distress or response to fatigue (increased irritability, frustration, resentment, and depression)<br>• Emotional meaning attributed to fatigue (unpleasant)<br>• Reduced motivation |
| Behavioral | Includes signs and symptoms of changes in physical performance, impact of fatigue on activities of daily living (ADL), or the amount of effort or exertion needed | • Impact of fatigue on ADL<br>• Physical performance<br>• Increased degree of effort<br>• Decreased ability to socialize or perform roles |
| Cognitive or mental | Signs and symptoms that reflect the impact of fatigue on thought or concentration | • Ability to concentrate, remember, think clearly, or direct attention<br>• Ability to perform certain tasks |
| Physiological | Mechanisms of fatigue | • Biological markers such as decreased muscle force, fluid and electrolyte shifts, melatonin, cytokines |
| Sensory or physical | Fatigue signs and symptoms and their intensities | • Generalized, somatic, physical, subjective feeling |
| Temporal | Timing, onset, pattern, duration of fatigue | • Timing/circadian pattern<br>• Onset/duration<br>• Pattern (acute or chronic)<br>• Changes in pattern over time |

Adapted from; (Piper, 2004, pp. 541-542)

Although Piper's (2004) proposed dimensions of fatigue help to comprehensively define fatigue, the dimensions do not help differentiate fatigue from tiredness or exhaustion. Olson (2007) linked adaptation and stress theory to fatigue. She described fatigue as a stress response and stated that this provides an explanation (i.e., appraisal of threat and coping ability) for the reasons that some individuals experience a stress response under certain conditions but under the same conditions others do not.

Adaptation, a key construct in stress theory (Lazarus & Folkman, 1984), provides a theoretical mechanism for movement between tiredness, fatigue, and exhaustion (Olson, 2007).

Ream and Richardson (1996) incorporated tiredness and exhaustion on a fatigue continuum. Olson (2007) differentiated tiredness, fatigue, and exhaustion as stages with distinct conceptual differences and stated that fatigue is not a point on a continuum from tiredness to exhaustion but a distinct state in adaptation (see Figure 1). According to Olson, tiredness is a state in response to challenges in homeostasis, fatigue is a nonadaptive response to tiredness, and exhaustion is an ineffective adaptation to fatigue. Although Olson argued that fatigue is not linear, nor on a continuum, the model in Figure 1 depicts lines connecting Olson’s states with arrows pointing to tiredness and to exhaustion, which does seem to imply a continuum. Olson’s explanation of adaptation as providing a theoretical mechanism for movement between tiredness, fatigue, and exhaustion also seems to imply a continuum.

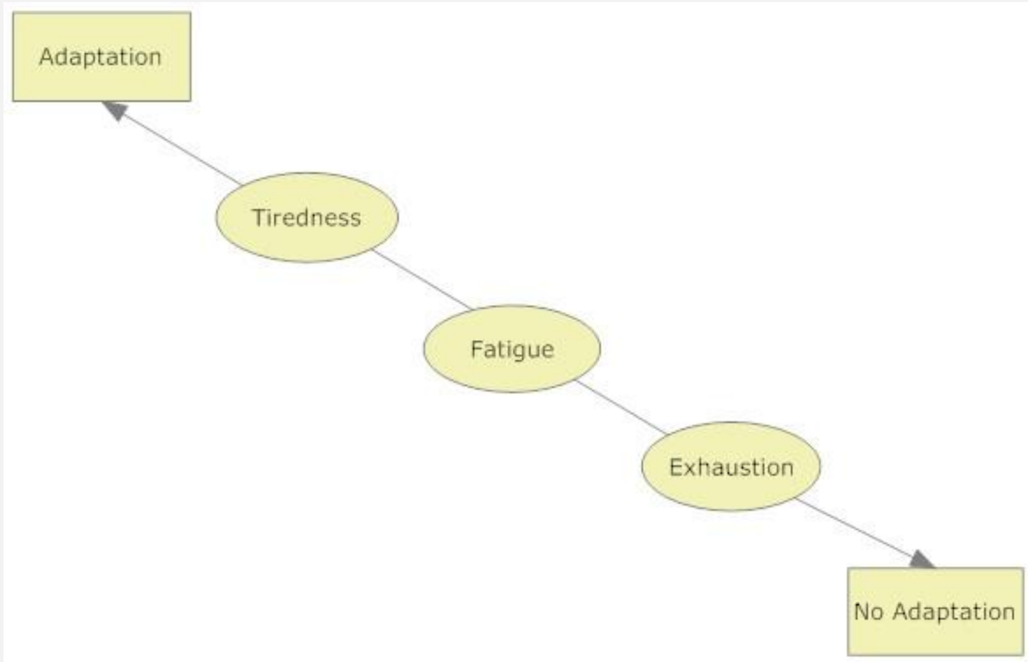


Figure 1. Olson's Fatigue Adaptation Model (2007, p. 97)

Not only did Olson (2007) propose tiredness, fatigue, and exhaustion as distinct conceptually different states but she described these differences in the key domains of sleep quality, cognition, stamina, emotional reactivity, control over body processes, and social interaction. Olson did not attempt to explicitly define fatigue but rather approached the concept of fatigue with descriptions of differences in these key domains (see Table 2).

Table 2

*Key Domains of Adaptation in Relation to Tiredness, Fatigue, and Exhaustion*

| Term | Sleep Quality | Cognition | Stamina | Emotional Reactivity | Control over Body Processes | Social Interaction |
|---|---|---|---|---|---|---|
| Tiredness | Normal sleep pattern, feel rested | Forgetful | Gradual loss of energy in proportion to energy expended | Impatient | Body and mind work together | Engages in normal social activities |
| Fatigue | Chronic disrupted sleep pattern, not feel rested | Inability to concentrate | Gradual loss of energy out of proportion to energy expended | Anxious | Mind over body | Saves energy for participation in enjoyable activities |
| Exhaustion | Erratic sleep pattern, including period of insomnia and periods of hypersomnolence | Confusion | Sudden loss of energy out of proportion to energy expended | Emotionally numb | Body over mind | Withdraws from all social activities |

Reprinted with permission from Olson, 2007, p. 96.

Olson's (2007) was the first model to suggest multiple domains of fatigue and to differentiate the domains descriptors between the similar concepts of tiredness and exhaustion. Olson's reconceptualization was developed from qualitative research involving healthy and ill populations. Lacking in Olson's domains were the temporal and physiological dimensions proposed by Piper (2004); however, Olson did differentiate fatigue from tiredness and exhaustion which Piper did not.

In healthy individuals, fatigue is generally acute; it is related to some identifiable form of exertion, is rapid in onset, short in duration, and relieved by a good night's sleep (Piper, 1988; Smets, Garssen, Bonke, & deHaes, 1995). Fatigue is commonly related to changes in affective, behavioral, and cognitive processes. These changes may include irritability, impaired thought processes, inability to make decisions, inability to concentrate on daily tasks or cope, forgetfulness, poor motivation, and family conflict (Hubsky & Sears, 1992; Nail & King, 1987).

As with *physiological* fatigue, *psychological* fatigue can be viewed as a response to demands (internal or external) that exceed available resources. The sensations associated with fatigue are the result of excessive expenditure of energy and are generally considered to be a warning sign of maladaptive stress (McEwen, 2007; Saito, 1999). Psychological fatigue has been associated with stress and other intense emotional experiences and may accompany depression and anxiety (Hardy, Shapiro, & Borrill, 1997; Stone et al., 1997).

## Definitions of Fatigue in Working Populations

The concept of fatigue in working populations followed the historical evolution of fatigue described as physical or physiologic and then moving to include the psychological component. Grandjean (1968), Saito (1999), and Gaillard (2001) provided definitions for fatigue specific to working populations. Grandjean conceptualized fatigue on a continuum, ranging from sleepy and tired to fresh and alert. Saito described fatigue as a state of being tired, which is brought on by excessive mental and physical work, resulting in a lowering or an impairment of human functioning. Gaillard described stress, workload, and fatigue as three separate biobehavioral states and described fatigue as a response of mind and body to a reduction in resources due to the execution of a mental task and as a warning for an increased risk of performance failure. These three researchers reinforced the physical or physiological viewpoint of fatigue. Saito incorporated psychological aspects by stating that in the workplace, fatigue is related to overtime work, changes in the working environment, and organizational changes. Gaillard moved to the psychological viewpoint of fatigue when he stated that fatigue is determined not only by the amount of work done but also by the work still to be done. He further posited that chronic fatigue and burnout may be symptoms of chronic stress, yet he did not define the concepts of burnout nor chronic fatigue.

Fatigue occurs when there are insufficient resources either because the demand or need is too great or because mechanisms of use and restoration have been disturbed. Van Dijk and Swaen (2003) described fatigue as the psychophysiological adaptation or a safety mechanism of an individual when confronted with the risk of overstrains or exhaustion. DeLuca (2005a), in *Fatigue as a Window to the Brain,* defined *fatigue* as “the reduction in performance with either prolonged or unusual exertion…and can be sensory, motor, cognitive, or subjective” (p. 320). Thus, resources are continually employed and replenished to support activity. Van Dijk and Swaen (2003) and DeLuca’s (2005a) definitions of fatigue both lack a differentiation of fatigue from the concepts of tiredness and exhaustion.

The most comprehensive definition was proposed by Job and Dalziel (2001), who stated that any definition of fatigue should include six essential elements: (a) identify fatigue as a hypothetical construct (not just a performance outcome), (b) not identify performance decrement as fatigue, (c) identify the cause of the fatigue state of the person, (d) reflect the meaning as ascribed by the general population, (e) describe states arising in the central nervous system or muscles, and (f) allow a distinction between fatigue and related phenomenon. They defined fatigue this way: "… 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 conceptual definition with its attention to the individual level fits well with the working population. According to Job and Dalziel (2001), *prior physical activity and/or mental processing* identifies the cause of fatigue and allows for this cause to take several different forms such as muscular exertion, prolonged attention, attention to a repetitive stimulus, prolonged performance of a complex or repetitive task, and combinations of these. *Absence of sufficient rest* encompassed the possibility of rest during ongoing performance of a task (rest or nap period), addressed the level of rest prior to the beginning of a task, and acknowledged the many factors that may lead to quicker-than-usual fatigue onset. *Insufficient system-wide energy* is the physical state of the organism at the muscular or neural cellular level. *Maintain the original level of* *activity and/or processing by using normal resources* suggestst fatigue involves a change in the organism regarding its activity or mental processing in relation to the system and allows for accommodations such as chemical stimulants to achieve near-original activity or processing. Job and Dalziel's definition identified tiredness as a drop in system energy, a typical subjective awareness prior to fatigue. In addition, this definition acknowledged the subjective nature of fatigue and the idea that a person can choose behaviors to moderate the effects of fatigue (sleep, chemicals, a decrease in activity). Job and Dalziel provided a comprehensive definition of fatigue that also supports the two initial attributes of fatigue identified in this concept analysis: fatigue follows exertion and fatigue is associated with a change in physical state.

Scientists who have studied fatigue in the workplace, particularly in the transportation industry of railroad workers, long distance truck drivers and airline pilots, have suggested categorizing fatigue according to (a) its cause (active or passive; primary or secondary), or (b) its duration . Desmond and Hancock (2001) suggested that fatigue, particularly in the transportation industry, be categorized as *active* fatigue (fatigue caused by continuous activity) or *passive* fatigue (fatigue resulting from chronic understimulation, such as long-term monitoring of systems on a computer screen). Desmond and Hancock further stated that the causal fatigue categories (active and passive) combine with subjective characteristics (not defined) to induce a transitional state in which fatigue in between alertness and somnolence. Although the active fatigue and passive fatigue categories may be applicable to transportation industry workers, it may not be useful to nursing, where work is dynamic and a single day may consist of both active and passive fatigue.

DeLuca (2005b) suggested *primary* and *secondary* causes of fatigue. Primary fatigue is caused by primary neural mechanisms and could be exhibited by decreases in cognitive performance during sustained cognitive processing. Secondary fatigue includes factors that may precipitate or exacerbate fatigue such as decreased physical conditioning, medication, sleep habits, and current or preexisting medical conditions. Desmond and Hancock's (2001) active and passive fatigue seem to be contained in DeLuca's description of primary fatigue, yet the additional category of secondary fatigue encompasses other influences of fatigue that must be considered. For example, nurses may be at risk for primary fatigue, encompassing both active fatigue from continuous action and passive fatigue in the monitoring of technical equipment. Nurses may also experience secondary fatigue due to decreased physical conditioning, medication use, sleep habits, and current or preexisting medical conditions.

The duration of fatigue as *acute* or *chronic* has also been used to classify and define fatigue. The Maastricht Cohort Study began in 1998 to examine fatigue in the working population in the Netherlands. In this study, acute fatigue was described as a "normal phenomenon that disappears after a period of rest, when tasks are switched, or when particular compensation strategies are used" (Bultmann et al., 2000, p. 412). Prolonged fatigue was described as "not easily reversible in the short term and is not task specific" (p. 412), but the underlying concept of fatigue was not defined. Prolonged fatigue was behaviorally described as "inefficient action patterns; declining interest, involvement, and commitment; reduced concentration and motivation; and negative emotions [and]…may affect the individual's performance and functioning in the occupational setting as well as in the home setting" (p. 412). Winwood and colleagues

(Winwood & Lushington, 2006; Winwood et al., 2006, Winwood, Winefield, Dawson, & Lushington, 2005; Winwood, Winefield, & Lushington, 2006) conducted several studies in the working population in Australia and chose to describe fatigue as either acute (depletion of available energy by work activity) or chronic using the same behavioral definition of prolonged fatigue proposed by Bultmann et al. (2000).

## Dimensions of Fatigue

A dimension is a component of a complex concept (Polit & Hungler, 1995). Fatigue researchers disagree whether fatigue is unidimensional (Barton, Spelten, Totterdell, Smith & Folkard, 1995; Kunert, King, & Kolkhorst, 2007; Michielsen, deVries, & Van Heck, 2003; Ruggerio, 2003) or multidimensional (Aaronson et al., 1999; Bultmann et al., 2000; Olson, 2007, Piper, 2004; Piper et al., 1987, Pugh, 1993 Smets et al., 1995). Michielsen et al. (2003) proposed that although fatigue is multidimensional, including emotion, behavioral, cognitive, and physical components, the most salient point is an individual's total score or unidimensional assessment of fatigue. Those researchers suggested that fatigue be assessed as a unidimensional phenomenon in the working population, while other researchers have argued that a multidimensional approach to measuring fatigue is more appropriate to provide the most comprehensive picture of this ubiquitous phenomenon (Aaronson et al., 1999; Bultmann et al., 2000; Olson, 2007; Piper et al., 1987; Piper, 2004; Pugh, 1993; Smets et al., 1996; Winwood et al., 2005).

Few researchers have explicitly defined fatigue; however, a definition of fatigue is intrinsically tied to measurement of fatigue. Subscales of instruments measuring fatigue have provided clearer descriptions of the multidimensionality of fatigue. Aaronson et al.

(1999) suggested in their concept analysis that measuring dimensions of fatigue should be done using several measurement tools because no one instrument had been designed to adequately measure all salient characteristics of fatigue. Using several measurement tools addresses the multidimensionality and complexity of fatigue. According to Aaronson et al. (1996), salient dimensions of fatigue were the subjective quantification of fatigue, the subjective effects of fatigue on activities of daily living, the correlates of fatigue (sleep, depression, tension, anger, confusion), and the key biological parameters such as salivary cortisol.

It is challenging to arrive at a definition of fatigue based upon operationalizations of the concept in the published research. Researchers have stated that their study measured one (or more) dimensions of fatigue, but each dimension may in fact be a subcategory of a larger dimension. For example, Pugh (1993) concluded that fatigue had six dimensions: subjective weariness, decreased concentration, psychological, physical – lower body, physical – head and neck, and physical – generalized, but three of the six dimensions were actually sub-dimensions of physical fatigue. Operational dimensions may also have overlap (such as *physical* and *interferes with daily living*). Winwood et al. (2005) argued that it was not the emotional, behavioral, cognitive, and physical components that were crucial but rather the duration of fatigue (acute or chronic) and the intershift recovery (or lack thereof). The measured level of fatigue is expected to affect the physical, mental, and emotional well-being of the individual; measurement clarity requires that it be measured comprehensively to include subjective perceptions of fatigue but also duration of fatigue. Winwood et al. (2005) were the only researchers to identify duration and recovery as salient components of fatigue. Aligning sentinel studies or concept analysis with Piper's (2004) proposed dimensions provides clarity as to how comprehensively they define fatigue (see Table 3).

Table 3
*Sentinel Articles Aligned to Piper's Proposed Dimensions of Fatigue**

| | Piper's (2004) Dimensions of Fatigue | | | | | |
|---|---|---|---|---|---|---|
| | Affective, Emotional or Psychological | Behavioral | Cognitive or Mental | Physiological | Sensory or Physical | Temporal |
| Piper, Lindsey, & Dodd (1987) | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Pugh (1993) | | | ✓ | | ✓ | |
| Smets, Garrsen, Bonke, & De Haes (1996) | | ✓ | | | ✓ | |
| Aaronson et al. (1999) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bultmann et al. (2000) | ✓ | | | | ✓ | ✓ |
| Michielsen, deVries, & van Heck (2003)** | ✓ | | ✓ | | ✓ | |
| Winwood, Winefield, et al. (2006) | | | | | | ✓ |
| Olson (2007) | ✓ | ✓ | ✓ | | ✓ | |

*Ordered chronologically.
***(only total score used – unidimensional use)*

The approach of Aaronson et al. (1999) is aligned most closely with Piper's dimensions of fatigue (2004) and is the only published work to include the physiological dimension (e.g., biological markers of fatigue such as salivary cortisol levels). Piper et al.'s (1987) early work and Olson's (2007) conceptualization addressed four of Piper's six dimensions of fatigue, and Olson provided conceptual clarity between the concepts of fatigue, tiredness, and exhaustion. Studies in working populations (Bultmann et al., 2000; Michielsen et al., 2003; Smets et al., 1996; Winwood, Winefield, et al., 2005) addressed up to three of Piper's dimensions of fatigue. The six dimensions articulated by Piper provide clarity to the concept of fatigue and will be used to evaluate empirical referents for comprehensiveness in measuring the multidimensionality of fatigue.

## Similar Concepts

The concept of fatigue has not been extensively measured in the nursing work environment; however, nurse burnout has received much attention. Burnout has been described as a prolonged response to chronic emotional and interpersonal stressors on the job, and is characterized by exhaustion and then changes in behavior to depersonalization and inefficacy (Maslach, Jackson, & Leiter, 1996). An underlying similarity between the concepts of fatigue and burnout is the assessment of the individual that resources are not adequate to accomplish work goals and that conservation of individual resources is necessary (Desmond & Hancock, 2001; Gaillard, 2001; Maslach et al., 1996). The Maslach Burnout Inventory (MBI) is the most commonly used measure for burnout. It was designed for occupations with high emotional engagement, such as health care workers, teachers, and police officers (Maslach et al., 1996).

Emotional exhaustion is the first stage in the burnout response and is described as a feeling of being overextended and exhausted by one's work; however, the overextension or exhaustion may not be recognized by the individual. The second stage in the burnout response is depersonalization, characterized as an unfeeling or impersonal response towards the recipient of one's service and is a protective attempt by the individual to conserve individual resources. Lack of personal accomplishment is the last stage in the burnout response and describes feelings of incompetence and unsuccessful achievement of one's work with people. Lack of personal accomplishment is indicative of a chronic lack of resources needed to accomplish the service occupation (Maslach et al., 1996). The concept of burnout shares the fatigue attribute of following exertion (exhausted by one's work; attempt to conserve resources) but differs in that the burnout response does not imply a subjective awareness that the individual is burned out. Although burnout is most concerned with the emotional engagement necessary in service occupations, it is limited in its ability to capture the multidimensionality of fatigue.

Burnout has been found to be positively correlated with fatigue, stress, and negative health outcomes for nurses (Aiken et al., 2002; Firth & Britton, 1989; Lee & Ashforth, 1996; Leiter, Harvie, & Frizzell, 1998). Maslach's (1996) classic structural model of burnout described the resources available to the individual in the workplace as the individual's coping style (resource being a non-control-oriented coping); the social support of co-workers, leaders, and family; high levels of autonomy; and high levels of individual involvement in decision making within the environment. A lack of resources (diminished individual control or ineffective coping, diminished social support, and diminished autonomy or involvement in decisions) plus excessive workplace demands (work overload or interpersonal conflict in the workplace) may create an imbalance between resources and demands and may result in a burnout.

DeVries et al. (2003) reported that emotional exhaustion, a sub-concept of burnout, is often measured as an indicator of fatigue and as an assessment of an individual's response to the work environment. In a sample of working people ($N$ = 351), DeVries et al. found the MBI-Emotional Exhaustion (MBI-EE) subscale to be correlated to several other measures of fatigue ($r$ ranged from .67 – .78) suggesting that emotional exhaustion measures only a portion of the fatigue concept.

Increased levels of burnout have been linked to patient outcomes such as decreased quality of patient care and patient mortality (Aiken, Sloane, & Lake, 1997). Increased levels of burnout have also been linked to system outcomes, including greater nursing turnover, lower retention, and increased intention to leave the nursing profession (Aiken et al. 2002; Firth & Britton, 1989; Lee & Ashforth, 1996; Leiter et al., 1998).

In summary, while burnout overlaps with fatigue, it is a separate concept. A key difference is that burnout measures an individual's assessment of working in an environment where interpersonal relationships were the main component of the occupation. The emotional exhaustion subscale of the MBI was designed to measure emotional exhaustion among service workers. Although a more general form of the MBI has been designed and tested, the exhaustion subscale remains unchanged. The emotional exhaustion subscale of the MBI measures a component of fatigue but does not fully capture the concept.

## Defining Attributes of Fatigue

This analysis of fatigue reveals that fatigue is a multidimensional and complex concept with attributes specific to the population and context under study. Based on the health care and occupational literature, the three defining attributes of fatigue applicable to working populations were that it follows exertion, it is associated with a physical or mental state, and the person has a subjective awareness of the changed state.

**Definition of Fatigue**

For the purposes of this study, fatigue is defined as *the state in which prior physical activity and /or mental processing, in the absence of sufficient rest, results in insufficient energy to maintain the original level of activity and/or processing by using normal resources*. This is a modification of Job and Dalziel's (2001) definition of fatigue, which excludes the definitional components involving the cellular level.

This definition contains the first two defining attributes (follows exertion and associated with change in the physical or mental state). Job and Dalziel (2001) included in their definition the phrase "maintain the original level of activity and/or processing by using normal resources" (p. 469), implies the person is aware of the fatigue state and makes choices to address that state (e.g., work less or slower, take a break or nap, consume caffeine). This definition is applicable to an acute fatigue that might result during the workday when resting may not be possible and it is also applicable to situations where an individual may not have sufficient rest time between working shifts (chronic fatigue). By describing fatigue as a *state*, this definition can also incorporate Piper's (2004) dimensions of fatigue.

The next section discusses measures of fatigue, beginning with clarifying antecedents, consequences, and empirical referents, then turns to unidimensional and multidimensional measures of fatigue.

## Antecedents and Consequences

Antecedents are those events or incidents that must occur prior to the occurrence of the concept (Walker & Avant, 2005). In research studies with working populations, the necessary antecedent to fatigue is an excessive workload or inadequate individual resources (energy) for the expected workload, or both. In all such research studies, individuals must be conscious and cognitively able to evaluate their state in order to answer questions about fatigue.

Antecedent known to influence fatigue are depression, sleep quality, social support, work environment quality, behaviors that alleviate or aggravate stress, age, gender, and co-morbid conditions (Nail & King, 1987; Piper, 1988; Saito, 1999, Tack, 1990). Olson (2007) described tiredness as the antecedent of fatigue, and a non-adaptive response to tiredness as resulting in fatigue. Tiesinga, et al. (1999) conducted a systematic review of fatigue to determine factors that are related to it. Although they did not explicitly define fatigue, they did provide a model to explain fatigue and to develop interventions. This model divides factors related to fatigue into social-demographic factors (age, gender); cure-related factors (factors directly related to medical diagnosis and treatment such as comorbidities and depression); and care-related factors (protective factors that were not directly related to diagnosis and treatment but to keeping a person well such as exercise and sleep habits). Tiesinga et al.'s model provides a good framework for research to characterize fatigue or to test interventions designed to reduce fatigue; key independent variables from each of the four domains that impact fatigue can be included from the study design phase, and the model also explicitly depicts where interventions may be most effective.

Consequences are the outcomes of the concept (Walker & Avant, 2005). Piper (2004) suggested that consequences of fatigue could be affective, behavioral, cognitive, or sensory. Common consequences of fatigue are changes in sleep quality, cognition, stamina, emotional reactivity, control over body processes, and social interaction (Olson, 2007). These consequences have an effect upon an individual's quality of life (Ream & Richardson, 1996), and physical, mental, and emotional health (Janssen et al., 2003a, 2003b; Kant, Bultmann, Schroer, Beurskens, & van Amelsvoort, 2003; Parshuram, 2006; Scott et al., 2007; Smith et al., 1999; Swaen et al., 2003; Trinkoff et al., 2001). A consequence of fatigue to the organization may be absenteeism (Janssen et al., 2003; Saito, 1999; Trinkoff et al., 2001). In Olson's (2007) conceptualization, ineffective adaption to fatigue leads to exhaustion.

## Empirical Referents or Measurement

Empirical referents are "classes or categories of actual phenomena that by their existence or presence demonstrate the occurrence of the concept itself" (Walker & Avant, 2005, p. 73). Muscio (1921) stated that finding a fatigue test depends upon "the possibility of eliminating of or determining the precise effects of all interfering factors" (p. 40) that may affect measurement validity of fatigue. These interfering factors may be incentives, practice, illness, and diurnal rhythm. The multidimensionality and subjective nature of fatigue make the phenomenon difficult to isolate and measure. Piper's dimensions of fatigue (Table 1) provide suggestions for indicators or markers of fatigue. The dynamic nature of fatigue—levels and perceptions of fatigue may vary daily—renders measurement at any one point in time difficult. Fatigue is measured as a unidimensional or multidimensional concept depending on the researcher's theoretical foundation, conceptual framework, and research question. The empirical referents discussed below are referents that have been used in working populations and may have validity for working nurse populations.

**Unidimensional measures**

Researchers who chose a unidimensional measure of fatigue were most interested in the subjective global assessment of fatigue and argued that the person's perception is the only salient perspective (Michielsen et al., 2003). The Chronic Fatigue scale was used by Ruggerio (2003) in her work measuring fatigue in critical care nurses. Michielsen et al. (2003) developed and tested the Fatigue Assessment Scale with 10 items each on a 5-point Likert-type scale (1= *never*; 5 = *always*). A third unidimensional measurement tool used in working populations has been the Brief Fatigue Inventory, most recently used by Kunert et al. (2007).

**Multidimensional measures**

Proponents of multidimensional measures of fatigue have argued that measuring overall fatigue is not as comprehensive as describing how fatigue affects the body or affects behavior. Aligning multidimensional instruments used in working populations to Piper's dimensions of fatigue facilitates comparing and contrasting fatigue instruments (Table 4). Researchers in the Netherlands lead the field of occupational fatigue and have developed two multidimensional fatigue measures. The first is the Multidimensional Fatigue Inventory (MFI-20), which measures three dimensions of fatigue on the body (general fatigue, mental fatigue, and physical fatigue) and two dimensions of changes in behavior as a result of fatigue (reduction in activity and reduction in motivation) (Schneider, 1998; Smets et al., 1995). The second multidimensional fatigue measure developed in the Netherlands is the Checklist Individual Strength (CIS), which measures the subjective experience of fatigue (similar to a unidimensional approach) and three dimensions of change in behavior as a result of fatigue (reduction of concentration, reduction of motivation, and reduced level of physical activity) (Bultmann et al., 2000; Kant et al., 2003; Vercoulen et al., 1994).

Table 4
*Summary of Fatigue Instruments in Working Populations*

| Author | Instrument | Piper's (2004) Dimensions of Fatigue | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Affective, Emotional, Psychological | Behavioral | Cognitive, Mental | Physiological | Sensory, Physical | Temporal | Reliability Validity |
| Smets et al., 1995 | Multidimensional Fatigue Inventory (MFI-20) | ✓ | ✓✓ | ✓ | | ✓ | | α = .66 - .93 (subscales) |
| Vercoulen et al., 1994 | Checklist Individual Strength (CIS) | ✓ 4 items | ✓ 3 items | ✓ 5 items | | ✓ 8 items | | α = .96 |
| Winwood & Lushington, 2006a | Occupational Fatigue Exhaustion Recovery (OFER15) | | | | | | ✓✓✓ (15 items) | α = .83-.89 (subscales) |

*Note.* : ✓ = Each checkmark indicates a subscale on the measurement instrument

Although most researchers have explored the individual assessment of fatigue (unidimensional approaches) or described effects of fatigue on the body or impacts on behavior (multidimensional approaches), one author group has argued that it doesn't matter whether fatigue is unidimensional or multidimensional; what is most important is the longevity or intensity of fatigue (Winwood et al., 2006a). The Occupational Fatigue Exhaustion Recovery scale (OFER15) measures acute fatigue, chronic fatigue, and intershift recovery. It can be argued that acute fatigue, chronic fatigue, and adequate intershift recovery are much more important not only for the health of the individual but also for his or her productivity. The OFER15 has had limited use in research, but research samples have included ill populations, working populations, and working nurse populations. Unidimensional conceptualizations may be best for descriptive studies with a focus on subjective assessment of fatigue. Differentiation of duration, intensity, and individual behavioral components may be best for studies focusing on implications of fatigue on nurse and patient safety.

## Executive Function

Cognitive or mental fatigue is one of Piper's (2004) six dimensions of fatigue. Executive function (EF) is a subset of cognitive function, and a review of brain function and neurobiochemistry helps explain the intricate connection between fatigue and EF.

The brain processes input and controls output of motor processes. Each of these functions is primarily contained in a specific region; however, there is constant communication between regions because one function is rarely isolated. Thinking, learning, and critical decision-making primarily occur in the frontal lobe. Functional imaging (such as magnetic resonance imaging) during active thought processes has shown that all areas of the brain are involved in thinking, learning, and critical decision making. A review of brain anatomy and physiology provides the background for understanding the neurobiology of cognition. A broad conceptualization of cognitive function here will provide the foundation for clarifying the concept of EF, a specific type of cognitive functioning.

**Cognition Neurobiochemistry**

Selye (1956) was the first to describe general adaptation syndrome (GAS), or the biological stress response, which is known as the activation of the autonomic nervous system. The hypothalamo-pituitary-adrenal (HPA) axis and the “fight-or-flight”’ response are the classic descriptions of the physiological and behavioral body response to the assessment of threats or stress. Following the perception of a stressor, the hypothalamus releases corticotropin-releasing hormone, which activates the pituitary to secrete adrenocorticotropic hormone (ACTH). The levels of ACTH are detected by the adrenal glands, which then secrete stress hormones known as glucocorticoids (primarily cortisol) and catecholamines (primarily epinephrine and norepinephrine). Glucocorticoids are one of the neurobiological endogenous stress hormones that have liposoluable characteristics; i.e., they can cross the blood brain barrier and enter the brain (McEwen, 2007; Selye, 1956).

Exogenous and endogenous stress hormone levels have been explored for their effect on cognition and memory. By measuring circulating levels of stress hormones before and after a situation assumed to be stressful (e.g., parachute jumping), Mason (1968) determined that indeed parachute jumping was stressful! Mason identified three psychological determinants of a stress hormone-inducing situation: the situation is novel, the situation is unpredictable, and/or the individual has the feeling of having little control over the situation. It could be argued that an experienced parachute jumper might view the experience as less novel, perceive the situation as more predictable, and perceive more control over the situation than a novice. In fact, later studies supported the idea that the stress response is highly individualistic, which is more supportive of Lazarus and Folkman's stress appraisal theory (1984) than Selye's general adaptation syndrome (Lupien, Maheu, Tu, Fiocco & Schramek, 2007). These later studies led to the inclusion of a fourth characteristic: the presence of social evaluation of the threat or stressor. Individuals may perceive situations as potentially predictable and somewhat within their control and this may ameliorate the stress response in that individual (Lupien et al, 2007).

Eustress, or good stress, provides an adaptation to experiences that are usually of short duration with positive end results. Distress, or bad stress, is most likely to initiate a harmful fight-or-flight response, and distress over time causes negative changes within the individual commensurate with illnesses, physical symptoms, and a potentially shortened lifespan. Stress, therefore, is a change in the homeostasis of the individual with potential for positive or negative outcomes. *Allostasis* is a term in the neurobiological literature that means "the process of maintaining stability (homeostasis) by active means, namely, by putting out stress hormones and other mediators"; and *allostatic load* or *overload* means "the wear and tear of the body and brain caused by allostasis, particularly when the mediators are dysregulated, i.e., not turned off when the stress is over or not turned on adequately when they are needed" (McEwen, 2007, p. 874). As a key organ in the response to stress, the brain determines what is threatening and what is not and ultimately, through chemical processes, it processes the stressor as adaptive or damaging.

Most often the chemical mediators to stress promote adaptation to stress; however, chronic elevation of these mediators (that were meant to be protective and adaptive) can cause pathological changes. For example, mediator chemicals often raise the heart rate and blood pressure; however, chronic elevations of these chemicals causes the heart rate and blood pressure to remain elevated causing negative long-term effects to the cardiovascular system.

**Definitional Analysis**

Cognition is a noun derived from Latin *co + gnoscere (to come to know)* that morphed to *cognito* and eventually to 15$^{th}$-century Middle English *cognicion* (Merriam-Webster Online Dictionary). The term *cognition* is often used in psychology and educational literature to describe knowledge and learning processes; in occupational/industrial literature, it is used to describe attention or monitoring of the environment. Cognitive, as adjective, is defined as:“of, relating to or being conscious intellectual activity (as thinking, reasoning, remembering, imagining, or learning words” (Merriam Webster Online Dictionary). *Taber’s Cyclopedic Medical Dictionary* defines *cognition* as “thinking skills that include language use, calculation, perception, memory [and] awareness” (Venes & Thomas, 2001; p.447).

**Executive Function as a Subset of Cognitive Function**

EF has been defined as “cognitive skills that enable a person to regulate behavior by modifying future behaviors based on consideration of previous actions. Deficits in EF may lead to “difficulties in impulse control, attention to tasks, adaptation, organization, prospective memory and rehabilitation” (Venes & Thomas, 2001, p. 836). EF is a very specific subset of cognitive function commonly accepted as responsible for planning, initiation, inhibition, sequencing, and monitoring of complex goal-directed behavior (Borkowski & Burke, 2005;  Denckla, 2005; Lorist, Boksem, & Ridderinkhof, 2005; Royall et al., 2002).

EF was originally termed *higher cognitive function* and was studied in people with trauma to the frontal lobes (Rabbitt, 1997). It was noted that they had deficits in programming, regulation, and verification of behavior (Elliott, 2003; Rabbitt, 1997). It is now possible to observe real-time executive functioning through modern imaging such as computerized axial tomography, positive emission tomography, and magnetic resonance imaging. Imaging has revealed that EF primarily occurs in the frontal lobes with specificity to the dorsolateral prefrontal region and a deeper region known as the anterior cingulate (Elliott, 2003; Lorist et al., 2005; Royall et al., 2002) (Figure 3). The hippocampus contributes to EF by integrating memory functions. Although discrete regions may be specific to EF, the emerging view is that executive processes are mediated by networks incorporating multiple regions with collaborative and overlapping functions (Elliott, 2003); therefore, the integration of function from different regions of the brain is critical. In fact, neural imaging demonstrates that component regions may be differentially engaged depending on the cognitive load (Elliott, 2003).

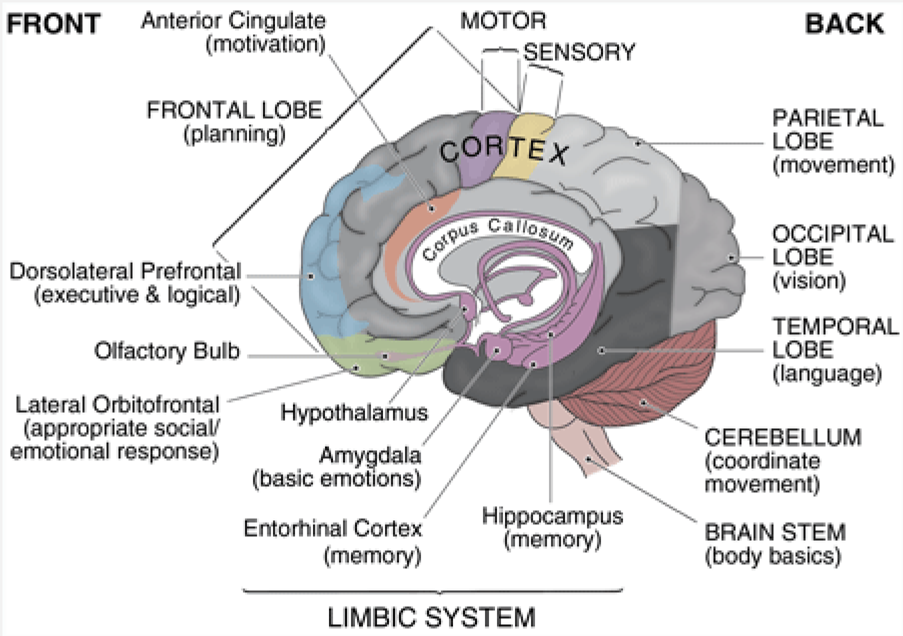


Figure 2. Diagram of Functional Brain and Limbic System
(http://www.brainwaves.com/brain_2.html)

EF is a complex phenomenon and empirical literature lacks consensus on a definition. Butterfield and Belmont (1977) defined EF as the faculty in use “[when] a subject spontaneously changes a control process…as a reasonable response to an objective change in an information processing task” (p. 284). EF involves the conscious recognition, evaluation, and choosing between different options for the best goal-directed behavior (Rabbitt, 1997). Phillips (1997) stated that executive functioning is necessary for everyday life to initiate, monitor, and terminate behavior. Funahashi (2001) described EF as “a product of the co-ordinated operation of various processes to accomplish a particular goal in a flexible manner” (p. 147). Most attempts to define EF have resorted to observable tasks such as task switching, planning, or working memory (Elliott, 2003). EFs are “those involved in complex cognitions, such as solving novel problems, modifying behaviour in the light of new information, generating strategies or sequencing complex actions" (Elliott, 2003, p. 50). Elliott (2003) suggested that EF could be summarized as three processes of co-ordination, control, and goal-orientation, which is similar to Borkowski and Burke's (2005) suggestion that EF consists of three components: task analysis, strategy selection and revision, and strategy monitoring.

Denckla (2005) described the most fundamental aspect of EF as the inhibition and delay of responding. This involves the working memory to continually assess information and determine which information should be acted upon immediately and which is held in the working memory for continual appraisal. Input of new information and assessment of that information determine a dynamic response.

Impaired EF is observed in people with dementia, Alzheimer's disease, Parkinson's disease, Huntington's disease, schizophrenia, major depression, autism, and ADD/ADHD (Buchsbaum, 1995; Elliott, 2003; Krishnan & Nestler, 2008; Royall et al., 2002). Hebert (2008) suggested that EF may be considered the new intelligence quotient (IQ), because the integrative functions of EF and the ability to tune out distractions may be a better indicator of ability and achievement than IQ.

**Defining Attributes and Definition of EF**

The following key characteristics of EF have been identified: (a) a complex process involving integrating several regions of the brain; (b) a conscious process; (c) a recognition that a novel situation has arisen or novel information is apparent; (d) processing of the information or situation, considering numerous options for intervention or behavior; (e) monitoring the situation/behavior to intervene when the situation/information changes necessitating a new and continued assessment; and (f) assessing working memory to store critical information for quick retrieval and continually prioritizing information for potential actions (Rabbitt, 1997).

Based upon my review of the literature, I define EF as: *the complex, conscious, cognitive processing of novel/ new information or novel/new situation involving flexible and continual processes of analysis, planning and implementation of the best approach to the situation for an optimal goal, and the monitoring of the situation/information to implement changes as needed.*

**Antecedents and Consequences of EF**

Antecedents of EF include a functional brain capable of correctly receiving input, appropriately processing the input, and responding appropriately to the situation. The person must be able to recognize that the information is novel and bring the information or situation to the consciousness for processing. Antecedents to impaired EF are mental fatigue (Buchsbaum, 1995; Elliott, 2003; Krishnan & Nestler, 2008; Lorist et al., 2005; Royall et al., 2002); sustained attention (Hancock & Warm, 1989); sustained operations (Lieberman et al., 2006); brain injury, disease process (e.g., Parkinson's disease); and mental illness (Buchsbaum, 1995; Elliott, 2003; Krishnan & Nestler, 2008; Royall et al., 2002).

The primary consequence of impaired EF is the inability to process new information and choose appropriate actions in response to the new information. This may be manifested by the inability to recall information from memory, inappropriate response to a situation, or slowed or delayed response (Royall et al., 2002).

Although lacking a universally accepted definition, EF has been researched in educational and psychological disciplines for 30 years (Lyon & Krasnegor, 1996). EF has been a focus of clinical research in the last 20 years, especially in patients with known deficits or injury in the frontal lobes of the brain.

**Empirical Referents of EF**

Early suggestions for measuring EF were suggested to be subsets of mental fatigue to include immediate memory, attention, apprehension, and judgment/reasoning (Muscio, 1921). Testing of cognitive performance with specificity to EF is difficult because we are unable to discern whether the individual is using automatic cognitive processing (local) or executive functioning (global). The increased understanding of EF has enabled experts to clarify EF as having five putative dimensions (concept generation, inhibition, working memory - spatial, working memory - verbal, and planning); however, not all experts or researchers agree with this list of dimensions (Funahashi, 2001).

Many measurement tools exist to test the dimensions of EF (see Table 5). Most EF tests have low test-retest reliability because EF is concerned with the performance in novel (unfamiliar) situations, processing of new information, or accomplishment of novel (unfamiliar) tasks.

Table 5.
*Selected Neuropsychological Tests of "Frontal" Executive Skills*

| Test | Dimensions Measured | | | | |
|---|---|---|---|---|---|
| | Concept Generation | Inhibition | Spatial | Verbal | Planning |
| California Card Sorting Test | √ | √ | | | √ |
| Category Test | √ | | | √ | |
| Concept Generation Test | √ | | | √ | |
| Stroop Color-Word Interference Test | | √ | | √ | |
| Tower of Hanoi | | √ | √ | | √ |
| Tower of London | | √ | √ | | √ |
| Wisconsin Card Sorting Test | √ | √ | | | √ |

Funahashi, 2001, p. 386; reprinted with permission

The Wisconsin Card Sorting Test™ (WCST-64:CV2) has been suggested as the "gold standard" for EF because of its wide use, normative data for children and adults, and use in clinical populations (Royall et al., 2002). It is generally accepted that the WCST-64:CV2 taps into functions of concept generation, response inhibition, and planning (Funahashi, 2001). However, others have stated that the WCST-64:CV2 can also quantify sustained attention and perseveration (continuing to make the same mistake) because it measures time between responses (Royall et al., 2002). The WCST-64:CV2 is reliable and valid and has proven sensitivity in healthy populations; in ill populations with psychiatric disorders (schizophrenia and Alzheimer's) and those with brain trauma, and recently in fatigued populations as well (Royall et al., 2002).

Now available on the computer, this test takes approximately 10 minutes and is automatically scored by the computer. Subjects are shown a "target" card and four additional cards. The subject sorts the target card onto the one of the four additional cards according to a “rule”: matching either the shape of the object, the color of the object, or the number of objects. The rule changes periodically throughout the test. Successful completion of the test relies upon a number of intact cognitive functions including attention, working memory, and visual processing. Persons with impaired EF have more perseveration errors, or they continue to use past sorting rules even when the rule is no longer applicable. Fatigued individuals also take longer to discover sorting rules (van der Linden et al., 2003).

# CHAPTER 3

# REVIEW OF THE LITERATURE

The dimensions of fatigue (affective, behavioral, cognitive, sensory, and temporal) were presented in the concept analysis in the preceding chapter. This chapter begins with the conceptualization of fatigue and the prevalence of fatigue in the working population. This review of the literature on fatigue and EF was guided by that conceptualization and guides the theoretical foundation. The chapter ends with a summary, the research question, and the specific aims of the study.

The Fatigue Conceptual Framework in Figure 3 was guided by Tiesinga and colleagues (1999) multidisciplinary research model, which described antecedents to fatigue as care-related factors that may decrease fatigue and cure-related factors that may exacerbate fatigue. Both care-related and cure-related factors are empirically associated with fatigue. The person-level antecedents that may affect an individual's perception of fatigue are (a) sociodemographic variables such as age and gender; (b) care-related factors such as adequate quality and quantity of sleep, intershift recovery, physical activity, and social support; and (c) cure-related factors such as mental health status (depression), lack of social support, physical illness (comorbidities), lack of quality and quantity of sleep, and inadequate intershift recovery (Tiesinga et al., 1999). The other group of antecedents are factors outside the individual's control that are known to be associated with the individual's perception of fatigue or burnout such as shift work, extended work hours, disruptions to the circadian rhythm, and workload. Person-level and organization-level factors influence the individual's perception of fatigue. Fatigue is a multidimensional state perceived by an individual where he or she may be aware of feeling emotional distress (affective), a decrease in physical performance (behavioral), a decrease in concentration (cognitive), a generalized feeling of tiredness (sensory), or an awareness of patterns of fatigue over time (temporal). As an individual consciously or unconsciously perceives fatigue, he or she may choose to consume caffeine, take a nap, or take a break to alleviate or ameliorate fatigue. Consequences of fatigue on the individual include an increased risk of illness, an increased risk of injury, decreased recall and learning, impaired decision making, and possibly decreased executive function. Consequences of fatigue on the organization include absenteeism, decreased job satisfaction, increased turnover, and decreased retention. Of utmost importance and concern is the consequence of fatigue on the patient, which is decreased patient safety.

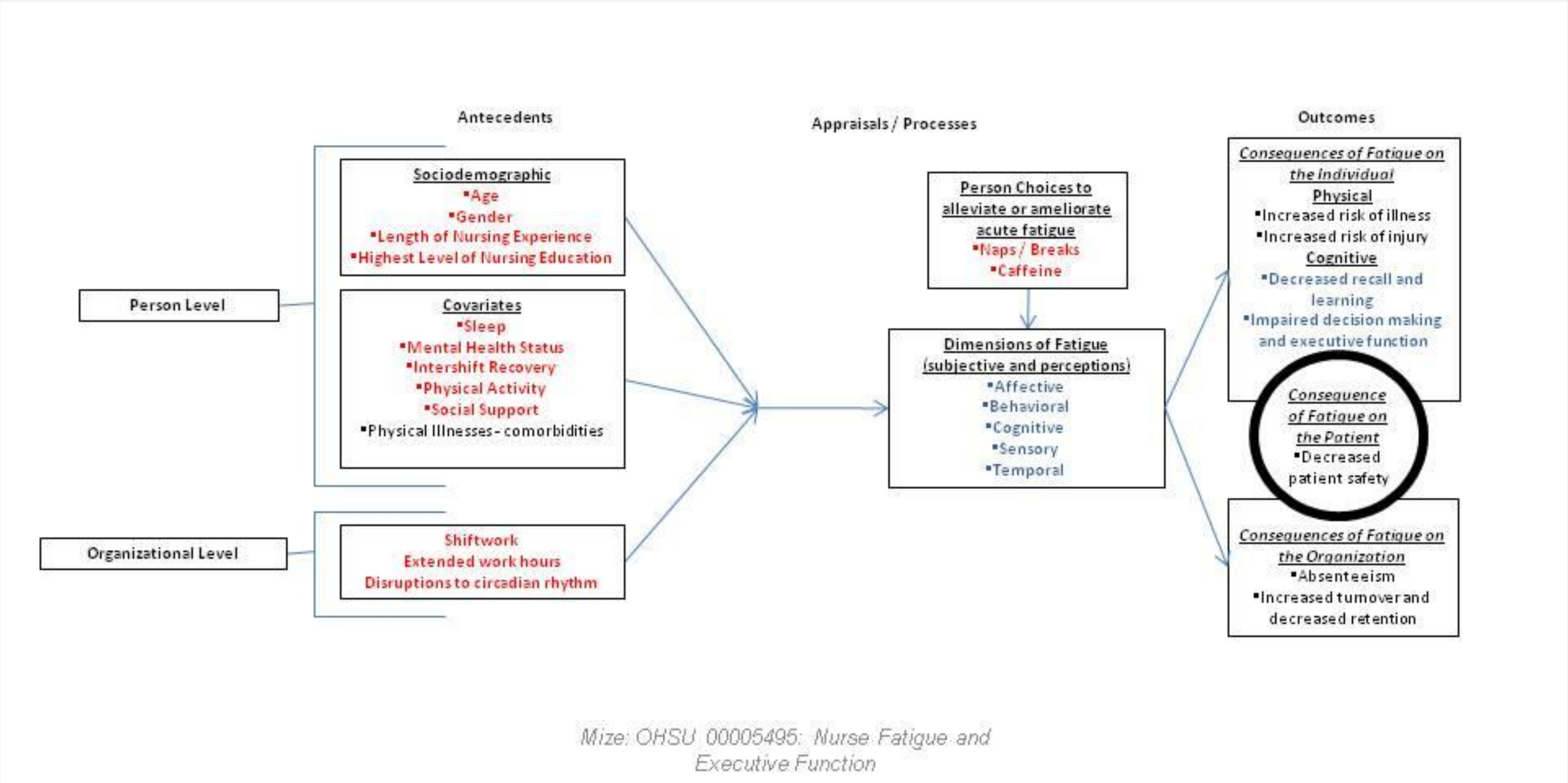

Figure 3: Fatigue Conceptual Framework

## Prevalence of Fatigue in the General and Working Population

Fatigue is common in the working population. In the United Kingdom, higher mean scores for fatigue were found in National Health Service workers ($M$ = 63.72, $SD$ = 19.93) compared to the general population ($M$ = 61.10, $SD$ = 61.10; $p < .001$; Hardy et al., 1997). A single longitudinal study ($N$ = 11,272), the Maastricht Cohort Study, begun in the Netherlands in 1998, (a) assessed the prevalence and incidence of prolonged fatigue in the working population, (b) identified risk factors involved in the onset and natural course of prolonged fatigue, and (c) began to develop preventative measures and treatments that could be used in occupational settings (Kant et al., 2003). Kant et al. (2003) estimated the prevalence of fatigue in the working population to be between 12% and 22%. Individual-level risk factors associated with fatigue in the Maastricht Cohort Study were age, gender, educational level, health and well-being (health status, lifestyle, and chronic disease), and personal characteristics (coping and negative affectivity). Several researchers have explored a few of these risk factors; however, most researchers have not comprehensively measured all known correlates or dimensions of fatigue.

In the Maastricht Cohort Study, the level of chronic fatigue was 21.9% at baseline and 12% at 1 year (Kant et al., 2003). Similar values were observed for need for recovery (25% decreasing to 16.9%), burnout (13.7% decreasing to 8.3%) and psychological distress (22.9% decreasing to 1.9%). An analysis of the non-responders ($n$ = 9625) at the one-year follow-up explained the decreases. Non-responders were more likely than responders to have more fatigue complaints at baseline ($x^2 = 10.8$, $p < .01$), meet criteria for fatigue ($x^2 = 5.7$, $p < .05$), be younger ($x^2 = 172$, $p < .0001$), have lower education levels ($x^2 = 53.5$, $p < .0001$), report more sickness absence ($x^2 = 9.7$, $p < .005$), and have more difficulties in work execution because of health complaints ($x^2 = 16.9$, $p < .0001$). In this study, positive correlations were found between fatigue and inadequate intershift recovery ($r = .63$, $p = .01$), fatigue and exhaustion ($r = .70$, $p = .01$), and fatigue and psychological distress ($r = .62$, $p = .01$).

## Person-Level Correlates of Fatigue: Sociodemographic Variables

According to the Fatigue and EF conceptual framework, sociodemographic variables are person-level characteristics that are stable attributes with little dynamic change within a short period of time. The sociodemographic variables measured in this study are: age, gender, length of nursing experience and highest level of nursing education.

### Age

The majority of working nurses are currently between 35-49 years of age, and 60% are older than 40 (Buerhaus, Needleman, Mattke, & Stewart, 2002). By 2010, 40% of the registered nurse workforce will be older than 50. As nurses age, they are less likely to work in acute care settings (Norman et al., 2005). Ruggerio (2003) found that age had a weak ($r = -.21$) yet significant ($p < .05$) relationship to chronic fatigue in 142 critical care nurses. Winwood and Lushington (2006) reported that nurses older than 55 had lower chronic fatigue scores ($p = .005$) and acute fatigue scores ($p = < .001$) than all other age categories except for the 35-44 age group. Nurses older than 55 in that study also had higher scores on adequate recovery between shifts ($p < .001$); however, the authors pointed out that this might have been because nurses older than 55 might work primarily the day shift and might have more autonomy in their position. In a study of Norwegian nurse's aides, age was not found to be a significant covariate of fatigue (Eriksen, 2006).

Age was found to be correlated with chronic fatigue but not with acute fatigue) in Australian nurses (*p* = < .001) but the relationship was small (*r* = .10; Winwood & Lushington, 2006).

**Gender**

Only a few studies have explored the relationship of gender and fatigue. In the Maastricht Cohort Study, men 46-55 reported higher levels of fatigue than men 26-35, but no significant differences were found for age categories for women (Bultmann, Kant, Kasl, Beurskens, & van den Brandt, 2002). In a sample of Australian nurses including 13% male respondents, Winwood and Lushington (2006) found gender to not be significantly associated with acute or chronic fatigue.

**Length of Work Experience and Work Rewards**

Length of nursing work experience was not significantly related to chronic fatigue (*r* = -.04) but was positively related to acute fatigue (*r* = .13; *p* = < .01; Winwood et al., 2006). Rewards for work well done are a protective measure against fatigue. In a study of 4645 Norwegian nurse's aides completing a longitudinal study on persistent fatigue, the aides receiving more than a little reward for work well done had a reduced risk for persistent fatigue (OR from 0.79 to 0.50; Eriksen, 2006).

**Highest Level of Nursing Education**

In the Maastricht Cohort Study, a curvilinear association was found between fatigue and education level in women, with higher fatigue scores at the lower and higher educational levels (Bultmann et al., 2002). Highest level of nursing education had not been explored in studies on nurse fatigue.

## Person-Level Correlates of Fatigue: Care-Related Factors

According to Tiesinga et al., (1997) care-related factors were factors that are protective to health and may help to decrease levels of fatigue. Based on literature and theoretical foundations, these factors were restorative sleep, adequate intershift recovery, physical activity, and adequate and positive social support. Mental health was theorized to be protective towards fatigue if the person had positive mental health and detrimental if the person was experiencing depression or other type of negative mental health.

### Restorative Sleep

Restorative sleep encompasses both the quality of the sleep and the duration of sleep. Tiesinga et al. (1996) described restorative sleep as a care-related or protective factor that ameliorates acute fatigue allowing the individual to return to activities in a rested state. Poor sleep quality or sleep of short duration is both a contributor to and a consequence of fatigue. Sleep of adequate quality and duration should help return the person to a state of restfulness; however, multiple studies have shown that many health care workers, in fact, do not have sleep of adequate quality or duration for sleep to be restorative. For example, 30% of physicians surveyed in Australia in 2003-2004 reported they were "excessively sleepy," indicating they were at risk for being fatigued (Gander et al., 2007). Major sleep problems may also be prevalent in the working nurse population; several researchers have found that between 32% and 47% of nurses surveyed met the criteria for poor sleepers as defined by Buysse et al. (1989), which is a total sleep score greater than five on the Pittsburgh Sleep Quality Index (Ruggerio, 2003; Samaha, Lal, Samaha, & Wyndham, 2007; Winwood & Lushington, 2006). In a study of critical care nurses, 62% (324/502) reported struggling to stay awake during their shift (Scott, Rogers, Hwang, & Zhang, 2006). Barton, Spelten, Totterdell, Smith, and Folkard (1995) found that among both full- and part-time nurses permanently working night shifts, there was a negative relationship between sleep quality between shifts and sleep duration ($r = -.33$, $p < .01$), meaning that a longer period of sleep was associated with better sleep quality. They also found that the relationship between sleep quality and sleep duration between shifts was stronger for full-time nurses rotating shifts ($r = -.39$; $p < .01$) and part-time nurses rotating shifts ($r = -.46$; $p < .01$) than nurses not rotating shifts.

Sleep “debt,” defined as cumulative sleep deprivation, is known to exacerbate fatigue (Jha, Duncan, & Bates, 2001; Parshuram, 2006), and chronic fatigue is known to disrupt the quality of sleep (Kunert et al., 2007). Sleep quality was found to explain 12.6% of the variance in a sample of 111 eldercare shift-work nurses in Australia (Samaha et al., 2007). Ruggerio (2003) found sleep quality explained 22% of the variance in chronic fatigue in a sample of critical care nurses ($n$=142). In another sample of Australian nurses (n = 760), positive correlations were found between sleep and chronic fatigue ($r = .47$; $p = < .01$) and acute fatigue ($r = .43$; $p = < .01$; Winwood & Lushington, 2006).

Registered nurses, licensed practical nurses, and ancillary staff ($N = 878$) were asked about work, sleep, and accidents related to sleepiness, and the researchers did not find evidence for fatigue during the day in nurses and staff who rotated shifts ($OR = 1.40$; 95%, $CI$ - [0.90 – 2.20]; Gold et al., 1992). Nurses working night shift have been found to have shorter sleep duration, to use sleep medication more often, and to experience greater daytime dysfunction than day shift workers (Kunert et al., 2007). In addition, nurses working night shift have poorer sleep quality compared to nurses working day shifts

(Kunert et al., 2007; Ruggerio, 2003). Samaha et al. (2007) did not find any difference in sleep quality between day and night shift workers; however, they asked nurses about working night shift within the last year, which may have diluted the recall of sleep quality. In a study comparing nurses ($n$ = 1532) and industrial workers ($n$ = 370) in the United Kingdom, permanent night shift nurses who were having difficulty overcoming drowsiness ($r$ = .41; $p < .05$) and difficulty sleeping ($r$ = .31; $p < .05$) reported greater fatigue than the industrial workers (Smith et al., 1999).

In a meta-analysis of 60 studies on sleep loss (Philibert, 2005), sleep loss was found to decrease vigilance and clinical performance more than it decreased cognitive function and memory (vigilance $\delta$ = -1.33; clinical performance $\delta$ = -1.54; cognitive function $\delta$ = -.56; memory $\delta$ = -.81. Trinkoff et al. (2001), in a large study of nurses, found that as the number of physical work demands increased, so did the likelihood of inadequate sleep (*OR* = 1.72 [0.70 - 4.25] for one physical demand to 5.88 [2.30 - 15.50] for eight physical demands).

**Sleep and Cognitive Function**

Sleep deprivation is well recognized as affecting performance on even routine tasks (Parshuram, 2006). Even after one night of sleep deprivation (~4 hours a night), individuals have shown a decrease in overall cognitive performance; even if they do not recognize that their cognitive performance was impaired (Dinges, 2006). In a meta-analysis on sleep loss, Philibert (2005) found that reduced sleep was associated with reduced cognitive function. Cognitive failure is a breakdown in cognitive functioning that results in a cognitively based mistake or error in task execution that a person should normally be capable of completing (Wallace & Vodanovich, 2003).

**Adequate Intershift Recovery**

An adequate amount of sleep between shifts is necessary to restore the individual to normal activity levels, and restorative sleep is critical to recovery (Parshuram, 2006). It is estimated that between 16% and 25% of the working population has inadequate intershift recovery, which has been found to be positively correlated with fatigue ($r$ = .63, $p$ = .01; Kant et al., 2003).

Winwood and Lushington (2006), in a study of 760 Australian nurses, found that 28% of the males and 29% of the female nurses studied did not have adequate intershift recovery. In another study of 846 full-time working Australian nurses, Winwood et al. (2006) found that intershift recovery had a negative correlation with both acute fatigue ( $r$ = -.47, $p$ < .01) and chronic fatigue ($r$ = -.53, $p$ < .01). In that study, age had a positive correlation with intershift recovery ($r$ = .22, $p$ = < .01), suggesting better intershift recovery with age. Winwood et al. (2005) argued that the duration of fatigue (acute or chronic) and the intershift recovery are the most salient aspects of fatigue to measure because those who return to work fatigued may have decreased performance (increased errors, decreased attention) and may suffer from cumulative sleep deprivation.

**Physical Activity**

Tiesinga and colleagues (1996) described care-related factors, such as exercise and recreational activity, as helping to decrease the effect of fatigue on the individual. Samaha et al. (2007) found that 11% of the variance in chronic fatigue among a sample of nurses was explained by lack of exercise and lack of recreational activities. Engaging in physical leisure-time activities has been associated with decreased odds for persistent fatigue (*OR* = .62, 95% *CI* - 0.48-0.82]; Eriksen, 2006), and persons engaging in leisure physical activity had lower scores on chronic fatigue (Winwood, Bakker, & Winefield, 2007).

### Adequate and Positive Social Support

Having a partner, or not living alone, may be protective against fatigue. Winwood, Bakker, and Winefield (2007) explored the effects of non-work time behavior in buffering the effects of work strain in 314 workers in Australia. Workers with high levels of non-work time activity (social contacts, exercise, and creative or hobby activity) had less sleep difficulty and better recovery between shifts. In another study, Winwood et al. (2006) found that partnered nurses with dependents (of any age) had lower mean chronic fatigue scores; however, unpartnered nurses with dependents (of any age) had the highest fatigue scores and the lowest intershift recovery scores. When working multiple shifts (for example, day and night shifts), those with a partner and dependents reported lower chronic fatigue scores than single nurses without dependents (Winwood et al., 2006).

## Person-Level Correlates of Fatigue: Cure-Related Factors

Tiesinga (1997) further posited that a person has cure-related factors that may exacerbate fatigue. Cure-related factors, supported by the literature and having theoretical foundations in fatigue studies are: mental health status, chronic illness, and a lack of or inadequate social support.

**Mental Health Status**

Mental health status is known to be associated with fatigue and has been measured as depression (Hardy et al., 1997; Ruggiero, 2003), anxiety (Hardy et al., 1997; Ruggiero, 2003; Samaha et al., 2007), disengagement coping (Smith et al., 1999), psychological distress (Bultmann et al., 2002), and mood disturbance (Samaha et al., 2007). Ruggiero (2003) found that depression was positively related to chronic fatigue ($r = .63$; $p < .01$ with Bonferroni correction). Anxiety was positively correlated with chronic fatigue ($r = .46$; $p < .01$ with Bonferroni correction, Ruggerio, 2003; $r = .73$; $p < .01$, Samaha et al., 2007). In addition, trait anxiety and mood disturbance explained 17% of variance in chronic fatigue in a sample of 111 eldercare nurses in Australia (Samaha et al., 2007). Positive correlations ($p < .05$) were also found between disengagement coping and fatigue in nurses working permanent night shifts, nurses rotating shifts, and industrial workers ($r = .13$, .12, .16 respectively; Smith et al., 1999). In the Maastricht Cohort Study, fatigue was positively associated with psychological distress ($r = .62$); 22% of the employees met the criteria for fatigue ($n = 2573$) and 57% of these also reported psychological distress ($n = 1473$; Bultmann et al., 2002). Anxiety and depression ($r = .43$, $r = .42$, respectively, both at $p < .0001$) were found to be positively associated with fatigue in National Health Service workers in the UK (Hardy et al., 1997).

**Chronic Illness**

In the Maastricht Cohort Study, increasing numbers of co-morbid conditions were positively associated with fatigue scores (Bultmann et al., 2002). In fact, employees with a chronic disease were nearly three times more likely to have a score above the predetermined cut-off point for fatigue than employees without a chronic disease

(Franssen, Bultmann, Kant, & van Amelsvoort, 2003). These findings were supported in another study at a Dutch university with chronically ill workers perceiving more fatigue than non-chronically ill workers ($p < .001$; Donders, Roskes, & van der Gulden, 2007).

**Inadequate or Lack of Social Support**

Lack of social support and sole responsibility for the family also are associated with fatigue. Employees in the general workforce living alone had significantly higher fatigue scores than employees not living alone after controlling for age and educational status (Bultmann et al., 2002). Eriksen (2006) also found that being single was associated with increased odds for persistent fatigue in nurse's aides (*OR* = 1.35, 95% *CI* – [1.02-1.78]). In a sample of 111 eldercare nurses in Australia, Samaha et al. (2007) found that the lack of support contributed significantly to chronic fatigue ($p = .04$).

## Organization-Level Correlates of Fatigue or Burnout

Fatigue is increasingly seen as a phenomenon that is influenced not only by individual factors but also by organizational factors. Organizational characteristics known to be directly related to fatigue are shiftwork, extended work days, circadian rhythm disruption, and workload. Nursing researchers examining organizational characteristics have explored the relationship between such organizational characteristics and the level of burnout in the individual. De Vries et al. (2003) argued that burnout is conceptually distinct from fatigue because burnout primarily describes an individual's response to the job, and burnout does not adequately measure the multidimensionality of fatigue. However, the burnout literature is included here because of the research into the relationships between organizational characteristics and burnout, and because although burnout is a separate concept, burnout does share some conceptuality with fatigue.

Organizational level variables are: shiftwork and disruption to the circadian rhythm, extended work hours and workload. Recently, workload has been further explored as cognitive stacking or cognitive load (Potter, Wolf, & Boxerman, 2005) and complexity compression (Ebright, Patterson, Chalko, & Render, 2003; Krichbaum et al., 2007).

**Shiftwork and Disruption to Circadian Rhythm**

Working shifts disrupt the circadian rhythm and alters sleep-wake patterns, levels of alertness and sleepiness, and the ability to perform demanding tasks resulting in fatigue (Akerstedt, 1988; Berger & Hobbs, 2006; Spitzer, Terman, & Williams, 1999). Rotating shift workers are more susceptible to disruptions in circadian rhythm than those working a consistent time shift (Gold et al., 1992).

The major disruption to circadian rhythm disruption occurs after the first night; the circadian rhythm disruption lessens after that first night (Akerstedt, 1988; Spitzer et al., 1999. Kunert et al., 2007) examined the differences in perceptions of fatigue between night-shift and day-shift nurses as measured by the Brief Fatigue Inventory (Mendoza et al., 1999). Night-shift workers had a higher self-report BFI mean score than day-shift workers ($p$ = .0001). Winwood et al. (2006) found mean scores on the OFER15 chronic fatigue score subscale were higher for nurses working multiple shifts (rotating shifts to include night shift) compared to nurses only working day shifts.

**Extended Work Hours**

Nurses work long hours in a demanding setting (Buerhaus & Staiger, 1999; Gold et al., 1992; Rogers et al., 2004). Twelve-hour shifts are common, and attention must be paid to the duration of work. Rosa, Wheeler, Warm, and Colligan (1985), in a small sample ($n$ = 6) of clerical workers, found that extended workdays and consecutive extended workdays had a cumulative effect on worker fatigue, drowsiness, and lack of concentration. This same finding on fatigue was not supported however a few years later in a study of critical care nurses (*N* = 102); Fields and Loveridge (1988) did not find a significant difference in self-report levels of fatigue when comparing 8- and 12-hour shifts. However, the nurses in that study wanted to change to 12-hour shifts, which may have limited internal validity. In a study of critical care nurses (*N* = 502), 67% of the shifts worked exceeded 12 consecutive hours (Scott et al., 2006). In addition, 10.8% of the participants in the study worked more than 16 hours at least once during the study period, with one nurse working 16 consecutive hours on six different occasions during the 28-day study period. Of all the shifts worked, nurses left their shift on time only 13% of the time, and 87% of the time the nurses worked longer than scheduled. No nurse reported leaving the shift earlier than scheduled. All but one nurse worked some overtime during the 28-day period (Scott et al., 2006).

Extended work hours are also associated with cognitive fatigue. Length of the work day and the number of consecutive days worked showed an increase in response time on two tests of cognitive performance in nurses working 12-hour shifts compared to others working 8-hour shifts; however, the study had limitations of small sample size and strict inclusion criteria, thus limiting external validity (Rosa et al., 1985).

**Workload**

Individuals' perceptions of their work have been studied under concepts such as workload, work practices, and job stress. Ruggerio (2003) found that nurses perceived workload as a source of fatigue. In a study of acute care nurses in the Midwest, 67% (*n* = 227) said their workload was too heavy, and only 47% (*n* = 181) stated they had enough time to do their job well (Brooks & Anderson, 2004). Work demands and role conflict both positively predicted fatigue in National Health Service workers ($r^2$ change = .13, $F$ = 24.48, $p$ < .001; Hardy et al., 1997). Clerical workers stated that the most common cause of fatigue was mental and physical fatigue caused by their workload, followed by interpersonal relationships and changes in work (Saito, 1999). Workload or work demands are associated with an increased odds for persistent fatigue (*OR*s from 1.35 to 2.36, Eriksen, 2006; semipartial correlation = .30; $p$ < .001, Samaha et al., 2007). Samaha et al. (2007) found that workload explained between 4% and 9% of the variance in chronic fatigue.

Although fatigue is not often a measured variable in occupational studies, several researchers have described workload and its effect on the individual (increased use of pain medications and increased physical complaints), and its effect on the organization (increased errors and increased absenteeism). According to Trinkoff et al., 2001, nurses with increased physical work demands are up to three times more likely to use pain medication compared to nurses without physical work demands (*OR*s = 1.22 for one work demand (95% *CI* – [0.78 – 1.89]); *OR* = 3.30 for eight physical work demands (95% *CI* -[1.34 – 8.11]).

In the Maastricht Cohort Study, workers who were non-responders at the 1-year follow-up point were more likely to have had more fatigue complaints at baseline and to have had a sickness absence in the year since baseline (Kant et al., 2003). Trinkoff et al. (2001) found that when nurses had increased number of physical demands in the workplace (e.g. maintaining the head in awkward positions or moving the head in awkward motions, physical effort, rapid activity, heavy lifting), the odds for absenteeism increased (*OR* = 2.13; *CI* – [1.15-3.94]), even after adjusting for personal lifestyle factors (smoking, depression, and frequency of exercise), demographics (age, ethnicity, marital status, gender), and work schedule (overtime, shift length, shift and working weekends).

**Cognitive Stacking and Cognitive Load**

Cognitive stacking describes the tasks and priorities a nurse needs to remember or perform at any given time (Potter et al., 2005). Cognitive stacking is a dynamic process with tasks/priorities continually being added, deleted, or shifting in priority. The cognitive load is the number of tasks or priorities at any given time. In an ethnographic study, the average cognitive load for all RNs was found to be 11 activities at any given time, with a maximum average cognitive load of 16 activities (Potter et al., 2005).

Cognitive stacking and cognitive load received an individual-nurse focus when Ebright et al. (2003) found that three domains—work of nursing, systems, and personal—constituted the phenomenon of complexity compression. Ebright et al. (2003) described the complexity of nursing as patterns of work complexity (interruptions, system barriers to efficient work flow) and patterns of cognitive factors driving performance and decision making (decisions to maintain patient safety, maintaining comfortable workflow, maintaining patient and family satisfaction, and care management strategies).

> “The work of nursing factor includes the elements within the workplace that occur unexpectedly and directly interfere with nurses’ ability to carry out their work. The system factor includes unforeseen elements in the workplace that originate in the organization's structure and administration that affect the ability of the nurses to carry out their responsibilities within the time allotted. The personal factor includes the individual nurses and/or their immediate personal situations and contains unexpected occurrences that interfere with their ability to carry out work related responsibilities in the allotted time” (Minnesota Nurses Association, 2008).

Potter et al. (2005) furthered the understanding of the complexity of nurses' work by conducting a study exploring the cognitive work of nurses from a human factors engineering standpoint. They found that nurses averaged 13 physical locations an hour and completed 2 activities per location. Nurses in that study averaged between 3.4 and 5.9 interruptions per hour with 47% of the interruptions occurring during nursing interventions and almost half of those (22%) occurring during medication administration.

Krichbaum et al. (2007) defined *complexity compression* as what "nurses experience when expected to assume additional, unplanned responsibilities while simultaneously conducting their multiple responsibilities in a condensed time frame" (p. 88). The phenomenon was validated by a group of nurses who participated in focus groups that led to the identification of 129 factors influencing the experience of complexity compression. The researchers grouped the factors into six themes: personal, environmental, practice, systems and technology, administration and management, and autonomy and control (Krichbaum et al, 2007).

The complexity compression literature illustrates the high demands on cognitive function that typical nursing work requires. The relationships between cognitive stacking, complexity compression, and fatigue have not been explored.

**Burnout and Emotional Exhaustion Literature**

The underlying similarity in the concepts of fatigue and burnout is the assessment of the individual that his or her work resources are not adequate to accomplish the work goals and that conservation of his or her individual resources is necessary. Burnout has been extensively studied in many occupations and has been studied more than fatigue in relation to the nursing work environment.

In a small study of physician residents (*N* = 37), 58% had high scores on emotional exhaustion and up to 70% had high scores on depersonalization, a key element of burnout (Gelfand et al., 2004). Both fatigue and burnout are considered worker outcomes in response to the working environment. Lower levels of individual fatigue and low rates of nurse burnout may be indicators of a quality nursing work environment. Fatigue and burnout are worker outcomes that may be influenced by structural factors (e.g., shifts, adequate staffing), and they have implications for processes of care and thus on patient outcomes.

Organizational stressors in the workplace are important factors in burnout (Aiken et al., 1997; Lee & Ashforth, 1996; Maslach et al., 1996). In Lee and Ashforth's meta-analysis (1996), the job stressors with significant relationships with emotional exhaustion were decreased role clarity ( *r* = - .35, 95% *CI* – [0.51 - -0.19]); increased role conflict *(r* = .53, 95% *CI* - [0.41 - 0.65]); increased role stress ( *r* = .62, 95% *CI* – [ 0.41 - 0.72]); increase in stressful events (*r* = .52, 95% CI [0.33 - 0.71]); increased workload (*r* = 0.52, 95% *CI* – [0.55 - 0.75]); and increased work pressure (*r* = .50, 95% CI – [0.35 - 0.65]). Job dissatisfaction among hospital nurses was 4 times greater than for the average U.S. worker (Aiken et al., 2001). Job satisfaction was negatively associated with stress and non-nursing task burden, and positively associated with the number of patients assigned (Buerhaus, Donelan, Ulrich, Norman et al., 2005).

Leiter and Spence-Laschinger (2006) sought to bring elements of the nursing work environment into a comprehensive model that explained relationships between the work environment and burnout. The researchers tested a model of work life among nurses in Ontario and Alberta, Canada (*N* = 8,597) using the Nursing Work Index (NWI). The

NWI contains subscale factors of staffing, physician/nurse communication, nursing leadership, policy involvement, and the nursing work-life model of care on three elements of burnout: emotional exhaustion, depersonalization, and personal accomplishment. The authors found that all 15 correlations between the work-life factors and elements of burnout were significant ($p < .01$), which is not surprising given the available power. Factors of physician/nurse communication and policy involvement were not directly associated with personal accomplishment, but channeled through a nursing model of care, which suggested that the organizational characteristics of good communication between the physician and nurse, and nurses being involved in policy development supported a nursing model of care and then to a feeling of personal accomplishment. They also found that emotional exhaustion (as an early indicator of burnout) was associated with inadequate staffing and time, but that the nurses perceived that nursing leadership was more directly associated with staffing and that nursing leadership was only indirectly associated with nurse emotional exhaustion. Leiter and Spence-Laschinger's (2006) model demonstrated the complexity of relationships between organizational factors and elements of burnout, in particular, that inadequate staffing is positively associated with emotional exhaustion. It is of importance to foster a quality work environment not only for the health of the nurse and retention of experienced nurses, but because quality work environments have demonstrated improved patient outcomes.

**Magnet Status and Quality Nursing Work Environments**

A brief review of magnet status is included here because of the relationship between quality nursing work environments and patient safety or improved patient outcomes. Nursing, patient, and organizational outcomes are affected by the environment in which care is delivered. During times of nursing shortages, nurses have perceived they have inadequate staffing and less time to detect patient complications, maintain patient safety, maintain patient quality of care, and less time to spend with patients (Buerhaus et al., 2005b). When nurses perceived an increased workload, their perceptions of fatigue are also increased (Hardy et al., 1997; Ruggerio, 2003; Saito, 1999).

The research interest in nurses and the nursing work environment began in the 1980s in response to a nursing shortage and the change in hospital reimbursement according to diagnosis-related groupings (DRG) (Aiken, 1989). The American Academy of Nursing (AAN), in 1982, identified 41 hospitals that were successful in attracting and retaining professional nurses when other hospitals in their local area had high nurse vacancy and turnover rates (Kramer & Schmalenberg, 1988a, 1988b). These hospitals were deemed to have “magnet” status, and the AAN found these hospitals to have several characteristics in common, including a flat organizational structure, decentralized decision making by bedside caregivers, inclusion of the chief nurse executive in top management decision making, flexible nurse scheduling, unit self-governance, and investment by management in the continuing education of nurses (Kramer & Schmalenberg, 1988a, 1988b). These findings supported the development of the Magnet Hospital Program, which recognizes hospitals not only for a quality work environment for nurses but also for achievements in quality indicators (Havens & Aiken, 1999). Therefore, quality work environments retain professional nurses by empowering the bedside nurse which was positively associated with several quality outcomes.

Quality nursing work environments are linked to higher quality of patient care. For example, nursing work environments that support greater autonomy and control by bedside nurses, that provide administrative support for nursing care, and that have adequate staff and facilitate good relationships between nurses and physicians are associated with lower risk-adjusted Medicare mortality rates (Vahey, Aiken, Sloane, Clarke, & Vargas, 2004). The findings on the relationship between nursing and patient outcomes in hospitals suggest that outcomes are better when nurses are able to render professional judgments about patients' needs and to act on the basis of those professional judgments.

The early 1990s saw research into the nursing work environment that explored concepts of job satisfaction, burnout, elements of nursing practice such as autonomy and empowerment, and organizational characteristics such as nursing staffing, physician and registered nurse collaboration, and nursing leadership. In the mid-1990s, hospitals began experiencing sharply escalating costs, reduced need for inpatient beds with decreased length of stay, and hospital restructuring in attempts to balance the economic picture and improve productivity. Often changes were done without including nurses in the restructuring process, which resulted in negative nursing and patient outcomes (Aiken et al., 2002; Buerhaus et al., 2002). In addition, inadequate nurse staffing and problems of uneven quality of care in hospitals were often blamed on the growth of managed care and the Balanced Budget Act of 1997, which reduced Medicare hospital payments (Buerhaus & Staiger, 1999).

Nursing shortages have been cyclical, with a major shortage in the mid-1980s (Aiken, 1989). A brief shortage in 1990 and 1991 had a national hospital RN vacancy rate of 11% (Buerhaus et al., 2005a). The most recent nursing shortage began in 1998 with a national average hospital RN vacancy rate of 13% in 2001, and the shortage continues in some parts of the country (Buerhaus et al., 2005b). Hospitals had a surge in employment of RNs between 2001 and 2003 because of an increased demand for services and because older nurses returned to the workforce (Buerhaus et al., 2003). However, RNs perceived that the nursing shortage continued and the RNs observed a decrease in hospital beds, increased patient wait time for surgery or tests, delayed discharges, and increased patient complaints about nursing (Buerhaus et al., 2005b).

## Dimensions of Fatigue

As noted in Chapter 1, Piper (2004) posited that a comprehensive description of fatigue must include six dimensions: affective, emotional or psychological; behavioral; cognitive or mental; physiological; sensory or physical; and temporal (Table 2).

Mental fatigue and EF are intricately linked. Concepts of cognitive function, vigilance, attention, and alertness were also used as search terms to obtain the most comprehensive literature review of mental fatigue and EF.

## Personal Choices to Alleviate or Ameliorate Acute Fatigue

The conceptualization of fatigue is states that fatigue does not flow from antecedent, to dimensions of fatigue, to consequences of fatigue. Personal choices or actions can alleviate or ameliorate the individual’s perception of the state of fatigue, at least for short periods of time. The resource view posits that energy is needed for task performance and these energy resources are limited (Hockey, 1997). The resource view is general and includes physical, emotional, and mental energy. Mental load or demands of the brain may refer to either the objective demands imposed by the task or to the subjective judgment of the operator regarding the task demand (Gaillard, 2001). Complex tasks may encourage the individual to use more resources to complete the task; however, cognitive performance will quickly degrade as high resource use cannot continue for long periods.

Studies in the aerospace and transportation industry have shown that an individual may be able to briefly access the resources necessary for critical mental decision-making situations; however, resources may not be available for very long, and accumulative fatigue may require extensive rest/recovery before cognitive performance returns to normal (Hockey, 1997). Smit et al. (2004) tested the resource view of task behavior on vigilance or alertness in a small sample of students (*N* = 17). They found that performance in high-demanding task conditions was affected more than performance in low-demanding tasks and that subjective alertness was decreased in all tasks.

**Caffeine**

When workers perceive they are lacking available resources, they may choose to consume caffeine, the pharmacologically active ingredient in coffee, tea, and cola beverages, to increase energy and alertness. Peak plasma levels are achieved within 30-60 minutes following consumption, and the half-life of caffeine is approximately three to five hours (Lorist & Tops, 2003). Low doses of caffeine have a positive effect on performance; however, caffeine in doses over 500 mg is associated with a decrease in performance (Patat et al., 2000). Higher doses of caffeine are also known to increase a person's tension and anxiety (Loke, 1988). Lorist and Tops (2003) concluded that caffeine may have a moderating effect on human information processing, on the individual's perception of fatigue, and on the neurochemical mechanisms regulating energy expenditure. Caffeine may improve the efficiency of information processing and attention; however, the effects vary per individual (Lorist & Tops, 2003).

**Naps and Breaks**

With the disruption of circadian rhythms and disruptions in sleep patterns, research is now looking at the benefits of brief naps and the effect of naps on levels of fatigue and subjective alertness. In one study (2002) of 16 young adults for whom sleep was restricted, Tietzel and Lack found that a 10-minute nap significantly improved subjective alertness ($F_{3,45} = 3.45$, $p < .05$), and that the individuals had reduced fatigue for 35 minutes after the nap ($F_{1,15} = 8.49$, $p < .05$). Dinges, Orne, Whitehouse, and Orne (1987) found that naps can increase alertness, performance, and communication. In a more recent study of male shift workers in an oil refinery ($N = 14$), the mean reaction time increased from the beginning of the night shift to the end of the night shift although the men taking naps had less of an increase in reaction time compared to the control group ($F_{1,12} = 33.36$, $p < .001$; Sallinen, Harma, Akerstedt, Rosa, & Lillqvist, 1998).

## Consequences of Fatigue on the Individual

Fatigue, whether acute or chronic, is known to have negative consequences to the individual. These consequences are: increased risk of illness, increased risk of injury, decreased recall and learning, impaired decision making, and executive function.

### Increased Risk of Illness

Parshuram (2006) noted that trainee physicians often experienced ketonuria, musculoskeletal symptoms, gastrointestinal symptoms, and electrocardial abnormalities suggestive of physical stress. Digestive symptoms and cardiovascular symptoms indicative of physical stress are common in night-shift workers and workers rotating shifts (Barton et al., 1995). In permanent night-shift nurses and industrial workers (Smith et al., 1999), fatigue was positively correlated ($p < .05$) with cardiovascular symptoms ($r = .27$ and .25, respectively) and digestive symptoms ($r = .22$ and .24); these relationships were stronger in nurses working rotating shifts (cardiovascular symptoms: $r = .37$, $p < .05$; digestive symptoms: $r = .35$, $p < .05$).

### Increased Risk of Injury

The Maastricht Cohort Study is the only study located that examined fatigue and occupational injury. The researchers found that fatigued workers had a relative risk of 1.75 (95% CI 1.16 – 2.64) of being injured in an occupational accident compared to non-fatigued employees (Swaen et al., 2003). In addition, those workers with the most inadequate intershift recovery had a 2.28 relative risk (95% CI: 1.41 – 3.66) of being injured in an occupational accident compared to workers with adequate intershift recovery.

**Decreased Recall and Learning**

The relationships among fatigue, decision making, and learning have not received much attention. However, several studies of sleep and decision making/learning have been conducted. Both decision making and learning require an active brain (Curcio, Ferrara, & De Gennaro, 2006). Jacques, Lynch, and Samkoff (1990) reported that family practice residents having less sleep the night before medical examinations scored lower than residents having adequate sleep; however, it was unknown how much studying was done by either group throughout the quarter or semester, which might have impacted the results. Papp et al. (2006) found that in focus groups of residents, any daytime sleepiness affected sustained reading and medical scholarship. In a meta-analysis of 60 studies on sleep loss and performance (Philibert, 2005), sleep loss reduced cognitive performance by nearly one standard deviation.

In a clinical review of sleep, learning, and academic performance, Curcio, Ferrara and De Gennaro (2006) concluded from reviewing more than 60 studies that students of all ages and in many countries are chronically sleep-deprived or suffer from poor sleep quality and daytime sleepiness; sleep quality and quantity are closely related to student learning capacity and academic performance; and students in studies in which sleep was actively restricted showed a worsening in neurocognitive and academic performance.

**Impaired Decision Making and Executive Function**

Just as recall and learning require an active brain, so does decision making. In a study of long workdays, six subjects worked both a 12-hour/4-day workweek and an 8-

hour/6-day workweek at a data entry job simulation (Rosa et al., 1985). Before and after the first shift and before and after the last shift in the series, the subjects completed a battery of tests including a test for cognition. Although the sample size was small, the 12-hour/4-day workweek was more fatiguing than the 8-hour/6-day workweek. In one of the two tests of cognition (grammatical reasoning), the performance (response time to answer the questions) either remained stable or decreased in the group who worked the 8-hour/6-day workweek, but the response time increased between the beginning and the end of the 12-hour days. This suggests an increase in fatigue across the 12-hour days (interaction of day x time of shift, ($F_{(5,20)} = 4.24$, $p < .01$). In the second test of cognition (digit addition), the number of correct additions actually increased from the beginning to the end of an 8-hour day and from the beginning to the end of the workweek; in the 12-hour/4-day workweek group, the number of correct additions decreased from the beginning to the end of the day and workweek ($F_{(1.4)} = 4.83$, $p < .01$). The external validity of this small simulation study is limited; inclusion criteria limited the sample to young, healthy men who did not suffer from baseline fatigue. However, this points to possible detrimental effects of long shifts on the speed of mental performance.

Sleep deprivation is a primary risk factor in fatigue, and sleep deprivation is known to affect performance. A study of registered nurses in five hospitals found nurses' job performance and their job-related stress were related to the shift worked (Coffey, Skipper, & Jung, 1988). In that study, job performance was highest in the day-shift nurses, followed by the night-, afternoon-, and rotating-shift nurses. Rotating nurses had the highest job stress followed by the afternoon-, day-, and night-shift nurses. Krueger (1989) found that cognitive performance may decrease 25% from baseline after one night of missed sleep and can fall to nearly 40% below baseline after the second night of missed sleep. In a later study, Krueger (1994) reported that when adults get less than 5 hours of sleep over a 24-hour period, peak mental abilities begin to decline. A meta-analysis by Pilcher and Huffcutt (1996) found that people who are sleep-deprived function at the 9$^{th}$ percentile of non-sleep-deprived people and that the sleep-deprived also had deficits in mood and motor function. Individuals with sleep deprivation are well known to be sleepy or fall asleep while driving (Gander et al., 2007; Marcus & Laughlin, 1996; Scott et al., 2007).

Poor or reduced performance may be an indicator of fatigue, and performance may be affected by length of the work day, number of shifts in a series, sleep deprivation, and the starting time of the work day. Performance, however, may be an outcome of a decision-making and learning process. The work life of nurses involves continued learning and incorporating prior experiences into current decision making (Benner, 1984), so it is imperative that nurses have adequate sleep for appropriate decision making and learning.

Mental fatigue refers to the effects that people experience during and following prolonged periods of demanding cognitive activity such as vigilance, sustained attention, or sustained operations requiring constant cognitive processing. When mental fatigue is induced in healthy individuals, these individuals demonstrated decreases in planning performance and increases in errors (perseveration) as compared to healthy non-fatigued individuals (van der Linden et al., 2003). In another study, healthy, fatigued persons shifted to energy conserving low-effort tasks after a simulated work day, and this conservation of energy resulted in  automatic information processing that was relatively unaffected by the fatigue (Schellekens, Sijtsma, Vegter, & Meijman, 2000). This may indicate that the individual has the choice to choose low-effort tasks (Gaillard, 2001), which may not be possible in all occupations, particularly where public safety is critical. A few researchers have explored a more specific relationship of mental fatigue and EF (Hockey, 1997; Rhodes, 2004; van der Linden & Eling, 2006). Although mental fatigue impairs general cognitive performance, EF is much more vulnerable to mental fatigue (Rhodes, 2004). This is extremely important, particularly in working nurses, because nurses need optimal EF to monitor and control behavior, suppresses irrelevant information, have appropriate and adequate reasoning and analysis, be able to update information in the working memory, and appropriately plan.

People show less analytic information processing under fatigue conditions (Hockey, 1997). Thus, fatigued people may more often rely on familiar thinking processes or the general picture and may be less likely to pay attention to details or information that requires more mental processing.

Van der Linden and Eling (2006) defined acute mental fatigue "as a psychophysiological state resulting from sustained or previous mental effort" (p. 395). They conducted a study of 39 undergraduate students randomly assigned to a fatigue or non-fatigue condition group, to evaluate the effects of mental fatigue specific to EF. Fatigue was induced by a 2-hour task requiring mental effort. They found the negative effect of fatigue was stronger on EF than on general cognitive function ($p < .05$). Although this study had a small sample size, it has strong implications for mental fatigue and EF in nurses.

## Consequences of Nurse Fatigue on the Organization

Clerical workers reported that fatigue was a common reason for absenteeism (Saito, 1999). Aiken et al. (1997) found that high levels of burnout were associated with diminished organizational commitment, absenteeism, and increased turnover. Increased levels of burnout have also been linked to system outcomes of lower retention rates of nurses and increased intention to leave the nursing profession (Aiken et al., 2002; Firth & Britton, 1989; Lee & Ashforth, 1996; Leiter et al., 1998).

## Consequences of Nurse Fatigue on the Patient

Up to 98,000 deaths each year are attributable to medical errors, and fatigue contributes to the human component of medical errors (Kohn et al., 2000; Leape, 1994; Gaba & Howard, 2002; Gander et al., 2007). The Institute of Medicine has focused attention on patient safety and medical errors through three reports addressing improving the quality of patient care and the safety of that care (IOM, 2001; Kohn et al., 2000; Page, 2004). In 2004, the IOM published *Keeping Patients Safe: Transforming the Work Environment of Nurses*, which contained recommendations for improving the nursing work environment as a key way to improve patient outcomes and suggested that decreasing worker fatigue is one strategy to create and sustain a culture of safety (Page, 2004).

Overwork, stress, or fatigue on the part of health professionals is associated with poor patient safety, patient outcomes, and medical errors (Blendon et al., 2002). Adequate staffing means having the right number of people to perform required tasks and much attention has been paid in the last 10 years to the consequences of inadequate nurse staffing (Aiken et al., 2001; Aiken et al., 2002; Blendon et al., 2002; Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2002).

Patients admitted to an ICU with more RN hours per patient day experienced significantly lower incidence of central line infections, ventilator-acquired pneumonia, 30-day mortality and decubiti (Stone et al., 2007) compared to patients in an ICU with fewer RN hours per patient day. In addition, in ICU units where nurses worked more overtime, patients had increased odds of acquiring urinary tract infection UTI and higher rates of decubiti (Stone, et al., 2007).

In 1971 the phenomenon of interns and sleep loss was documented (Friedman et al., 1971). As noted in Chapter 1, in recognition of the negative impact of physician fatigue on performance and patient safety, the Accreditation Council for Graduate Medical Education (ACGME) instituted a 80-hour-per-work-week limit on the nation’s approximately 98,000 residents in 2003 (ACGME, 2002). The connection between sleep loss and fatigue is intuitive; however, the relationship between the specific concept of fatigue and medical errors has been the focus of few research studies (Parshuram, 2006). In an Australian study, 42% of physicians recalled a fatigue-related clinical error in the past 6 months (Gander et al., 2007). In a meta-analysis, physicians were found to have reduced clinical performance (1.5 standard deviation units) and reduced overall performance (1 standard deviation unit) after being awake for 30 continuous hours compared to physicians who had not been awake for 30 continuous hours (Philibert, 2005).

Nurses who experience fatigue are also at risk for committing errors. Nurses who worked a rotating schedule were nearly twice as likely to report committing a medication error (Gold et al., 1992). The odds of making an error is also significantly elevated when nurses work longer than scheduled (*OR* = 2.06; *p* = .005) or longer than 12.5 hours (*OR* = 3.29; *p* = .001; Rogers et al., 2004; *OR* 1.94; *p* = .03; Scott et al., 2006). Many medical errors are intercepted before the error reaches the patient, and according to Parshuram (2006) and Reason (2000), this may be due to a robust health care system that protects patients.

When considering the effects of fatigue on patient safety, it is not only important to explore the antecedents of fatigue but also whether the fatigue is acute or chronic. Acute fatigue should be alleviated by adequate intershift recovery; however, acute fatigue not alleviated by rest can result in chronic fatigue. Because chronic fatigue may require extensive rest/recovery before performance returns to normal, chronic fatigue may have more detrimental effects on performance (Papp et al., 2006; Winwood et al., 2006). A chronically fatigued nurse who continues to work without adequate intershift recovery may be endangering patient safety.

Estabrooks, Midodzi, Cummings, & Wallin (2007) found that nurses experiencing increased emotional exhaustion are also less likely to access research studies and implement the research findings. They reported that every unit increase in emotional exhaustion was associated with a 35% decrease in research utilization ( *r* = - .35, *p* < .01; 2007). These researchers suggested that emotional exhaustion may decrease the available emotional energy to engage in reflection or inquiry into evidence-based practice and that emotional exhaustion may overlap with the concept of mental energy.

## Summary

Fatigue has serious impacts on patient care and safety as well as on retention of nurses in the profession. There is clearly cause for concern about fatigue in nurses. Projections for the nursing profession predict a substantial nursing shortage over the next 12 years (Buerhaus & Staiger, 1999). There is overwhelming evidence that changes in the circadian rhythm and changes in sleep negatively affect both the individual and his or her performance.

Work is associated with physical and mental fatigue. Inadequate restorative sleep and inadequate intershift recovery contribute to working nurse fatigue. In a study of university students, mental fatigue has been shown to be negatively associated with EF, the part of cognitive function that processes novel information and plans a response (van der Linden et al., 2003, 2007). Lowered nurse EF is therefore a threat to patient safety. The IOM has mandated transforming the work environment to improve patient safety, and quality nursing work environments (such as magnet hospitals) are known to have better patient outcomes.

Fatigue has received much research attention, but less is known about the multidimensionality of nurse fatigue and the relationship of fatigue to EF. Understanding the relationship of fatigue and EF can provide directions and strategies to improve working conditions and minimize nurse fatigue. Under conditions of minimal fatigue, EF can be maximized, with positive effects on nurse performance and ultimately patient safety.

## Theoretical Framework

Fatigue theory has foundations in several theoretical frameworks. Lazarus and Folkman (1984) revised Selye's (1956) general adaptation syndrome (GAS) model using a systems approach of antecedent, process, and outcome. Antecedents either related to the person (goals, beliefs, and personal resources) or to the environment (harms/losses, threats, challenges, and benefits) (Lazarus, 1991, 2000). Lazarus' Revised Model of Stress and Coping (Figure 4) included two important differences from his previous model: the antecedent of personal resources and the process of individual/personal appraisal. Lazarus argued that people suffer stress when they believe they do not have enough resources to deal with difficult events, but they may not experience as much stress if they believe that they do have enough resources. The inclusion of the process of the individual/personal appraisal to the stressor addressed the major limitation of the GAS by arguing that the individual processes or appraises the stressor, and this appraisal is critically important to explain individual differences in response to similar stressors. Lazarus and Folkman (2000) posited that stress and coping are intimately related to each other.

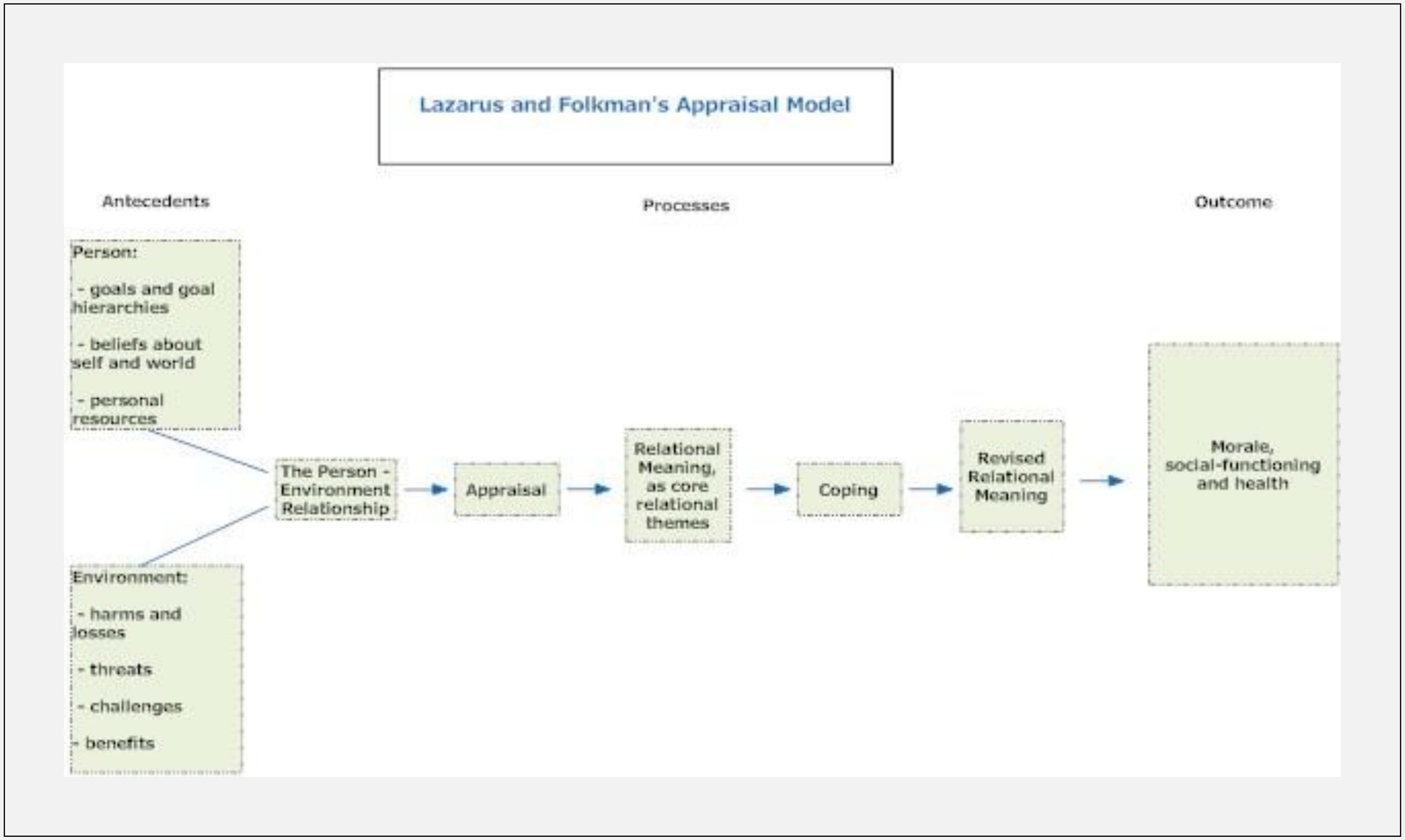


Figure 4. Lazarus and Folkman's Revised Model of Stress and Coping (Lazarus, 2000)

The adaptation process or appraisal is the process the individual goes through to make meaning of the stressor. Adaptation processes in fatigue are perceived workload, level of fatigue, and intershift recovery. Outcomes such as morale, social-functioning, and health are end results of the adaptation process.

Lazarus and Folkman's Revised Model of Stress and Coping is an appropriate model for a global perspective of fatigue, and McEwen's (2007) explanation of the neurobioiological process of stress in the individual provides the connection between fatigue and EF. McEwen enhanced the appraisal concept by explaining that the brain is the key organ in stress response because it determines what stressors are threatening. The brain determines the physiological and behavioral responses to the stressor. The brain maintains the body in a state of homeostasis or allostasis; however, when faced with an increased workload, threatening stressor, or sustained effort, the brain initiates the fight-or-flight response and the allostatic load increases. This increased allostatic load consumes more resources, and a continued allostatic load is known to have negative health outcomes such as gastrointestinal disturbances and cardiac disease (McEwen, 2007).

Stressors can be positive or negative. McEwen's neurobioiology explanation of allostasis and the inclusion of individual resources by Lazarus and Folkman are key concepts in Hockey's cognitive-energenic framework (1997, Figure 5). Hockey explained compensatory control in the regulation of human performance under stress and high workload. This model provides a theoretical framework specific to fatigue and EF. Hockey argued "that the maintenance of performance stability under demanding conditions is an active process under the control of the individual, requiring the management of cognitive resources through the mobilisation of mental effort" (1997, p. 78). Management of effort allows the individual to control behavior in an environment of competing goals and changing demands, and in consideration of available resources. There are two levels of control:  a lower-based loop using routine resources and an upper-level loop requiring effort and consuming more resources than routine. Overt performance is determined by internal appraisal of which level of control to use based on long-term/short-term goals. The lower loop represents well-learned skills with well-established goals. If either the effort monitor or the action monitor perceives that the effort or actions exceed the capabilities of the routine activity loop, they activate the upper-level effort-based control loop. Supervisory control either increases the effort of the individual or changes the task goals. The effort-based loop will be activated (and consume an increased rate of resources) until the action monitor and effort monitor perceive that effort and actions can resume effectively at the routine loop level.

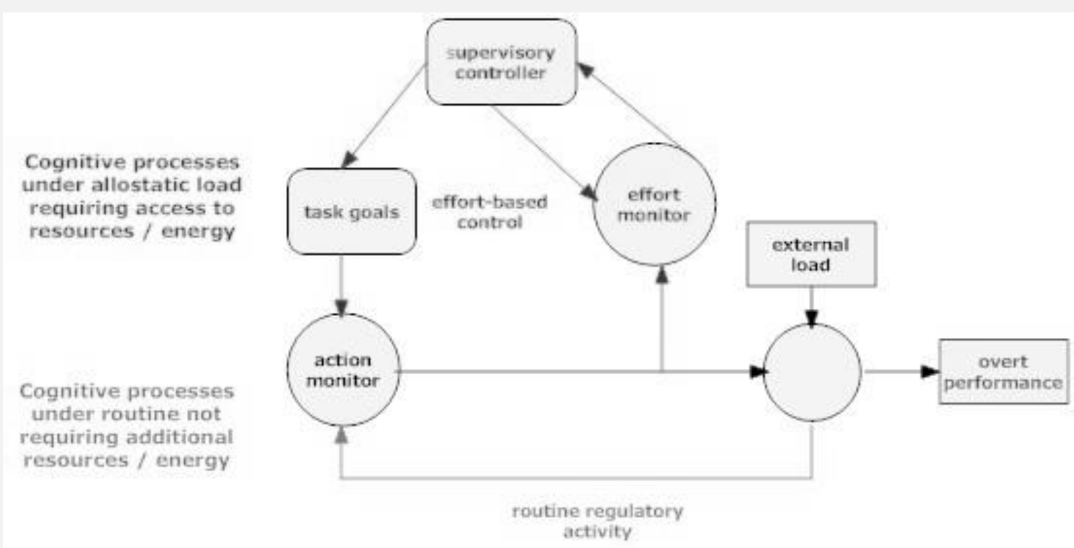


Figure 5.  Hockey's Cognitive-Energenic Framework (Hockey, 1997)

Cognitive functions reside in Hockey's cognitive-energenic framework with automatic processing of well-learned skills and routines occupying the lower control loop with routine consumption of resources. EF, the processing of new or novel information, activates the upper level control loop with modifications to effort and actions requiring an increased consumption of resources. Hockey's framework is based on stress response (Selye, 1956), includes the concept of resources and appraisal (Lazarus, 1991, 2000; Lazarus & Folkman, 1984), utilizes McEwen's (2007) explanation of brain neurophysiology in stress, and provides the connection between fatigue and EF. Figure 6 illustrates the integration of the concepts of allostasis and allostatic load, cognitive functioning and their relationship to fatigue.

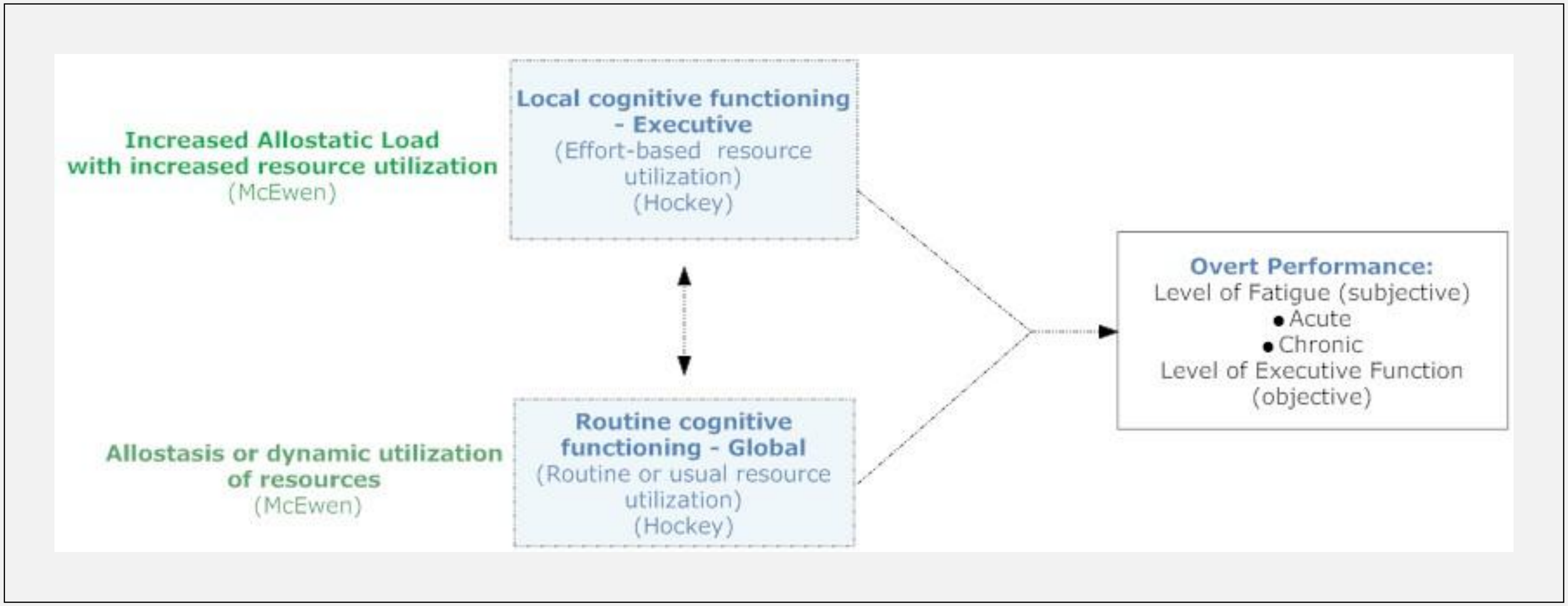


Figure 6: Fatigue and Executive Function Conceptual Model

## Research Question

What is the relationship between nurses' level of fatigue and their executive function?

# CHAPTER 4

# METHODS

The research presented here was a descriptive and correlational study of acute care nurses working in one hospital in the south Puget Sound region of Washington State, a diverse urban area. The setting for this study was all four of the medical-surgical departments in a medical center during the fall of 2010. There were approximately 470 nurses employed in the four departments. Three of the four departments had a mix of 8- and 12-hour shifts as the regularly scheduled shift, and the fourth department only had 8-hour shifts as the regularly scheduled shift. Most of the nurses (440 or 93%) worked 8-hour shifts and only 30 nurses (6%) worked 12-hour shifts. Data collection occurred during all shifts over a consecutive 7-day period. All nurses working during the time of data collection were invited to participate. Nurses completed all surveys and the computerized assessment of executive function (EF) during one of their working shifts.

The aims of this study were to describe nurses' level of fatigue and EF, to identify correlates of fatigue in working nurses, to test whether self-reported fatigue is significantly and independently associated with executive function in working nurses, and to determine the amount of variance in EF accounted for by fatigue after controlling for covariates.

Previous studies of fatigue in working populations have either used only one instrument to measure fatigue or have compared fatigue to burnout for construct validity. Aaronson et al. (1999) suggested that no one instrument can fully describe the multidimensionality of fatigue, and this study used two instruments to measure five of the six dimensions described by Piper (2004) and discussed in Chapter 2. This study also was the first study to use measurement tool specific for EF in a nursing setting. The physiological dimension of fatigue was not measured due to anticipated costs and poor feasibility associated with biometric testing in the study setting.

## Research Design

This study was a cross-sectional descriptive study of working nurses' fatigue and EF. Nurses from four medical-surgical nursing departments at one hospital were sampled. This provided a balance between internal and external validity.

## Sampling Plan

Non-random sampling enhances the feasibility of this descriptive and exploratory nature of this study. Convenience sampling may be subject to selection bias and although this cannot be completely controlled for or eliminated, attempts to mitigate this potential weakness were made by recruiting nurses from all shifts, of all ages, with a maximum range of nursing experience, with differing levels of educational preparation, and with a maximum range of experience working on all medical-surgical units of this hospital. This study was the first in a series of studies to describe fatigue, with the intent to move from quasi-experimental to experimental studies as the studies progressed.

To participate, the working nurse had to be able to read and comprehend written and spoken English because the measurement instruments were written in English. All nurses participating were registered nurses and had successfully passed the national exam to be licensed as an RN in the state of Washington, so the ability to read and comprehend English was not a limiting inclusion criteria. No assumptions are made about the level of fatigue in nurses, or the level of fatigue and hours worked, so attempts were made to recruit nurses of all ages, from minimal commitment to work to full-time working nurses, to nurses working more than one job. Nurses were recruited from all shifts, including night shifts, in an attempt to obtain maximum variability on fatigue measures. It was not known whether the measurement tool for EF had the sensitivity to capture impaired EF in working nurses, so it was hoped that the sampling plan provided a sample with maximum variability on fatigue and EF.

Effect size estimates for a power analysis were based on Ruggerio's (2003) report on the relationship between depression, sleep, and fatigue in critical care nurses and on van der Linden et al.'s (2003) report on the group difference in EF between a non-fatigued group and a fatigued group. The power analysis for a multiple regression suggested a sample size of 105 would be adequate to achieve a power of .80 to detect an R-squared of .05 on the independent variable of fatigue after adjusting for depression and sleep. Depression and sleep were estimated to account for 8% of the variance in fatigue.

## Research Protocol

Research instruments were selected based on congruence with the proposed theoretical and conceptual framework and the stated research aims. Permission was obtained from the original authors for the PSQI, CIS, and OFER15. The BDI II and WCST-64:CV2™ were obtained by purchasing the proprietary forms and handbook (BDI II) and software and professional manual (WCST-64:CV2). Approval for protection of human subjects was obtained by the appropriate process and authority at the consenting hospital, and then through the Institutional Review Board at Oregon Health & Science University.

**Recruitment**

Nurses were recruited from a hospital in the south Puget Sound area of Washington State. The researcher met with the chief nursing officer to discuss scope and significance of the research. The researcher met with the nurse administrators of the medical-surgical departments, and then presented the scope and significance to nurses from the medical-surgical departments at staff meetings to explain the research, solicit participation, and announce dates and times of data collection. The researcher was available during recruitment and the data collection phase to answer questions and facilitate recruitment.

The researcher requested quiet space for individuals to complete paper and pencil surveys and the computerized survey. The researcher provided a laptop with WCST-64:CV2™ installed. Recruitment of participants continued until the sample size was achieved.

**Preparation for Data Collection**

The researcher arranged for a data collection location that was quiet and appropriate to limit the amount of random error (e.g., misreading the question due to distractions). The researcher prepared an operations manual that contained IRB approval, institution approval, the dissertation proposal, sample instruments, instructions, and permissions to use the instruments, the timeline of data collection, and the procedure for data collection and management. The researcher assembled data collection packets (pencil and paper surveys) and ensured that survey instructions were clear and consistent on each packet, and consistent with the directions given in other research studies that had used the instruments. According to the hospital's research protocol and protection of human subjects, the questionnaire packet contained a consent form, a sociodemographic form, the PSQI, the BDI II, the CIS20R, and the OFER15.

**Data Collection**

The estimated time for completing the pencil and paper instruments was 20 minutes. Participants were given the survey packet upon recruitment into the study. The instructions on the survey instruments use time referents such as the “previous two weeks” or “over the past two months,” so timing of data collection was not critical to the study.

The consent form was the first form in the packet. It consisted of a three-page document with the signature space on the third page (required by the hospital for federal tracking purposes), so the only identifiable information visible on the front page was a survey number.  If an individual choose to participate, he or she signed the consent form and completed the surveys. All individuals completed the pencil and paper surveys during the shift when they consented to participate and returned the survey at sometime during that shift. The returned surveys were put into a zippered compartment of the researcher’s wheeled computer bag. The wheeled computer bag was never out of the researcher’s possession or sight. During the commute to and from the hospital, the wheeled computer bag was locked in the isolated trunk of the researcher’s vehicle.

Completed pencil and paper survey instruments were kept in a locked file cabinet in the researcher’s locked office, accessible only to the researcher. Completed computerized survey data were stored on the researcher’s computer, and the computer was either in the researcher’s possession, in the locked isolated truck of the car during the commute only, or in a locked cabinet in the researcher’s office. The computerized survey did contain the participants' birthdays, which were necessary for norming the results to age and education level; however, the printed individual report of the WCST-64:CV2-result only contained participant ID, age, education level, and result of the WCST-64:CV2.

Time of administration of the WCST-64:CV2 was critical to the study because the WCST-64:CV2 is sensitive to EF, which is known to be affected by fatigue. Therefore, the WCST-64:CV2 needed to be completed during the working shift of the participant. The WCST-64:CV2 was computerized and took approximately 10 minutes to complete. The computer and researcher were available during the participant's shift. The screen of the computer was not visible from the entrance to the room.

Once the data collection was complete, the participant's name and signature page was removed from the completed surveys and kept in the locked cabinet. All data entry was done with the participant ID as the key identifier only. Any data verification or returning to the survey was done by participant ID. Participant name was not stored anywhere in the computer. The date of birth was obtained because it was necessary for data analysis.

## Measurement Instruments

### Sociodemographic Characteristics

Socio-demographic variables such as age, gender, level of education, and years of nursing experience were potential confounding variables and were collected in a demographic survey developed by the researcher. These questions are presented in Appendix B.

**Mental Health Status**

Mental health status was measured by the Beck Depression Inventory II (BDI II) (Beck, Steer, & Brown, 1996). The original Beck Depression Inventory was developed to assess the severity of depression in diagnosed patients and for detecting possible depression in normal populations (Beck, Steer, & Brown, 1987). The BDI I reported reliability estimates on multiple populations from college students to psychiatric patients and demonstrated a Cronbach's alpha between .90 and .93 and test-retest reliability of $r$= .93, $p$<.01 (Beck et al., 1996). The BDI II- published in 1994, was updated in 1996. Four items were dropped (weight loss, body image change, somatic preoccupation, and work difficulty, and four new items were added (agitation, worthlessness, concentration difficulty, and loss of energy) (Beck, et al., 1996).

The BDI II has 21 items measuring cognitive, affective, somatic, and performance-related symptoms over the previous two weeks and takes between 5 and 10 minutes to complete. A cumulative score is calculated with possible scores ranging from 0 to 63 and higher scores indicating a higher degree of depressive symptomology. A cumulative score between 0-13 is categorized as minimally depressed; 14-19 is categorized as mildly depressed, 20-29 is moderately depressed and 30 or higher is categorized as severely depressed. The purpose of the BDI II in this study was not to diagnose depression; and therefore, the cut score guidelines in the BDI II manual were used for descriptive purposes only (Beck et al. 1987). Beck et al., (1996) suggested that anyone using the BDI II pay attention to items #2 and #9 as possible indicators of suicidal risk and during data collection of this study referral processes were in place at the time of administration of the BDI II for anyone scoring high on these two items. No participant scored high on either item.

**Reliability of the BDI II**. The BDI II coefficient alpha in outpatients with known psychological disorders was .92, and for 120 college students with no known psychological disorder, the coefficient alpha was .93 (Beck et al., 1996). When used with critical care nurses, the BDI II demonstrated a Cronbach's alpha of .90 (Ruggerio, 2003). The Cronbach's alpha for the BDI-II for this study was .90.

**Validity of the BDI II.** Convergent validity of the BDI II was supported by the strong correlation between the original BDI and the BDI II (r =.93, *p* <.001; Beck et al., 1996). Content validity was supported because both instruments were developed using the *DSM-III* and *DSM-IV* symptom assessment criteria. More evidence for convergent validity of the BDI II was that the BDI-II was positively related to the *Beck Hopelessness Scale* (*r* =.68, *p*<.001), and the *Scale for Suicide Ideation* (*r* =.37, *p*<.001), given that both hopelessness and suicide were known to be positively related to depression (Beck et al., 1996). Discriminant validity was supported with the correlation between the BDI II and the Beck Anxiety Inventory (*r* =.60, *p* <.001: Beck et al., 1996) and with the Hamilton Anxiety Rating Scale (*r* =.47, *p* <.001; Beck et al, 1996).

**Sleep**

Sleep was measured with the Pittsburg Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989); see Appendix B. The PSQI is a 19-item measurement tool assessing subjective sleep quality and sleep disturbances over the previous month. Possible total scores range from 0 to 21, with a score >10 indicating sleep problems. The seven subscales were subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of medication, and daytime dysfunction. The PSQI was developed and tested on four groups: a control group without sleep complaints, a group diagnosed with major depression (depressives), a group diagnosed with disorder in initiating and maintaining sleep (DIMS), and a group diagnosed with disorders of excessive somnolence (DOES; Buysse et al., 1989).

**Reliability of the PSQI.** Buysse (1989) developed the PSQI in 1989 with initial Cronbach's alpha of .83. Test-retest reliability ranged from $r$ =.65 to .84 for subscales in healthy normal subjects, individuals with depression, and patients with sleep disorders. Ruggerio (2003) in the study with critical care nurses estimated the Cronbach's alpha to be .70; however, the author stated that portions of the PSQI were reworded to be more appropriate for shift workers and that this type of revision may have affected the alpha. The PSQI was not reworded for this study. The Cronbach's alpha for the PSQI scale in this study was .73.

**Validity of the PSQI.** Buysse et al. (1989) reported that depressed patients and patients with DIMS had significantly different component scores than did the control group (ANCOVA, F range 7.9 – 45.1; $p$ <.001). The control group and the group diagnosed with DOES differed from the depressive and DIMS group on subjective sleep quality ($F$=35.9, $p$ <.001), on sleep latency ($F$=15.3, $p$ <.001), on sleep duration $F$=20.4, $p$ <.001), on habitual sleep efficiency ($F$=25.2, $p$ <.001), on use of sleeping medication ($F$=7.9, $p$ <.001), and on the PSQI global score ($F$=45.1, $p$ <.001). Group differences in the PSQI global scores were also substantiated by polysomnographic results with significant group differences for sleep latency ($F$=4.53, $p$ <.001), sleep efficiency ($F$=5.578, $p$ <.001), and sleep duration ($F$=4.82, $p$ <.003), although specific group differences were not identified. Buysse et al. (1989) did report that the group differences were in the expected direction, and supported by clinical group differences.

**Fatigue**

Fatigue was measured using two measurement tools to more comprehensively describe the multidimensionality of fatigue (Table 4). Five of the six dimensions described by Piper (2004) were measured.

The Checklist Individual Strength (CIS; Vercoulen, Swanink, Galama, Fennis, & van der Meer, 1994) contained 20 items that measured four of the six dimensions described by Piper (affective, behavioral, cognitive, sensory; 2004); see Appendix C. These four dimensions (accounting for 67% of the variance in the items) include subjective experience of fatigue (eight items, Piper's affective dimension), concentration (five items, Piper's cognitive dimension), motivation (four items, Piper's behavioral dimension), and physical activity level (three items, Piper's sensory dimension). The items are rated on a 7-point scale Likert-type from "no, that is not true" = 1 to "yes, that is true" = 7.

The subjective fatigue subscore was summed from eight of the 20 questions. Scores on subjective fatigue can range from 8 to 56 with higher scores indicating high levels of fatigue. According to Vercoulen et al. (1994), subjective fatigue scores ranging from 0 through 27 indicated a self-perceived state of no fatigue to mild fatigue; scores ranging from 28 through 35 indicated a self-perceived elevated state of fatigue; and scores ranging from 36 through 56 indicated a self-perceived severe state of fatigue. The motivation subscale was summed from four items and can range from 4 to 28 with higher scores indicating more motivation needed to plan and accomplish those plans. The concentration subscale was calculated from summing five items with a possible range between 5 and 35 with higher scores indicating more difficulty concentrating. The activity subscale was summed from three items and had a possible score ranging from 3 to 21 with lower scores indicating higher activity levels.

**Reliability of the CIS20R**. Vercoulen and colleagues (1994) reported the Cronbach's alpha coefficient for the entire CIS to be .90; and Cronbach's alphas for the subscales to be .88 (subjective experience), .92 (concentration), .83 (motivation), and .87 (physical activity level). The Cronbach's alpha for subscales in this study were .89 (subjective subscale), .80 (concentration subscale), .62 (motivation subscale), and .77 (activity subscale). The Cronbach's alpha for the entire CIS20R scale for this study was .91.

**Validity of the CIS20R.** In a study of five groups (two groups of apparently healthy workers and three groups with known reasons to be fatigued), the CIS demonstrated discriminant validity when the group with mental reason for fatigue or the two groups with physical reasons for fatigue had systematically higher scores on all dimensions of the CIS. Three groups hypothesized to have higher total scores on the CIS (patients after surgery, pregnant women, and employees with a mental reason for fatigue) did score higher than the two groups of healthy employees with scores of 67.7, 70.7, 89.7,47.3, and 47.3, respectively ($p$ <.01; Beurskens et al. 2000). Convergent validity was supported by comparing group scores on the CIS to the exhaustion subscale of the Maslach Burnout Inventory-General Survey. The employees with a mental reason for fatigue had significantly different mean scores ($M$ = 3.6 ) on the CIS than the other four groups ($M$ = 1.7, 1.7, 1.8, 2.0, respectively; $p$ < .001; Beurskens et al, 2000). Beurskens et al. also stated that divergent validity data were available; however, they did not provide a citation or other psychometric evidence for this claim.

Vercoulen et al. (1994) used the CIS20R in the Netherlands in a convenience sample of patients experiencing debilitating fatigue lasting for more than one year. However, patients with medical conditions known to produce chronic fatigue (such as taking certain heart medications) and patients with certain psychiatric disorders, substance use disorder, eating disorder, or proven organic brain disease were excluded ($n = 298$). Criterion-related validity showed that patients with known reasons for fatigue (chronic fatigue syndrome and functional bowel disorder) had higher mean scores on all four subscales than the group of healthy patients ($p < .001$). A limitation of this instrument is the lack of further evidence for validity and a lack of evidence of its use in the U.S. or with working nurses.

The Occupational Fatigue Exhaustion Recovery (OFER15) was used to capture the fifth dimension (temporal) of fatigue as described by Piper (2004; Winwood, 2006) see Appendix D. The OFER15 was a revision of the OFER that was designed specifically to measure occupational fatigue. Winwood et al., (2005) developed the original OFER, which contained 22 items, had subscale face validity based on the literature, and had acceptable reliability and validity. A few of the items loaded onto more than one factor, so the researchers revised the OFER with the result that the OFER15 had better goodness of fit model fit statistics (GFI = .95; Winwood et al., 2006) with confirmatory factory analysis than the OFER (GFI = .87; Winwood et al., 2005).

The OFER15 contains three subscales (chronic fatigue, acute fatigue, and lack of intershift recovery), each with five questions. The total possible calculated score for each subscale is 100. Chronic fatigue measures fatigue of greater than two weeks or an enduring trait of maladaptive fatigue or exhaustion compromising physical, cognitive, and emotional elements. The acute fatigue subscale measures the energy left after a worker completes a given shift and energy available during non-work time. Higher scores on these subscales indicate higher levels of fatigue. The intershift recovery subscale measures the extent that a nurse recovers the energy expended during a working shift. Higher scores indicate greater recovery.

**Reliability of the OFER15**. The OFER15 had reliability estimates of the subscales ranging from .84 to .89 in a population of Australian nurses (Winwood et al., 2006). Test-retest correlations range from .61 to .62. It is important to note that the test-retest estimates were based on a convenience sample of subjects in the initial sample who were willing to be retested, and thus there may have been some sampling bias. The Cronbach's alpha for the subscales in this study was .89 (chronic fatigue subscale), .89 (acute fatigue), and .87 (intershift recovery). The Cronbach's alpha for the total OFER15 in this study was .78.

**Validity of the OFER15**. The OFER15 also demonstrated appropriately directional correlations with the Nottingham Health Profile (NHP) containing subscales of emotional health, sleep health, and energy health (Winwood et al., 2006a, Winwood et al., 2006b). Convergent validity is supported by the relatively moderate relationships between the OFER15 chronic fatigue subscale and the NHP emotional health scale ($r = -.58$ $p < .01$); and the NHP sleep health ($r = -.31$ $p < .01$). Convergent validity is supported by the NHP energy health subscale being moderately associated to all three subscales of the OFER15 (acute fatigue: $r$ = -.57; chronic fatigue: $r$ = -.52; and lack of intershift recovery: $r$ = .50: all at $p$ < .01; Winwood et al., 2006).

**Executive Function**

EF was measured by the Wisconsin Card Sorting Test-64™ (WCST-64:CV2; Kongs, Thompson, Iverson, & Heaton, 2000). The WCST-64:CV2 is an abbreviated and computerized version of the original Wisconsin Card Sorting Test, which was developed in 1948 as a measure of abstract reasoning ability and the ability to shift cognitive sets. The WCST-64:CV2 can be considered a test of EF because it requires problem-solving strategy across changing information conditions to achieve a goal (Luria, 1973 and Shallice, 1982, as cited in Kongs et al., 2000). Similar to other tests of EF, the WCST-64:CV2 requires concentration, planning, organization, cognitive flexibility in shifting set, working memory, and inhibition of impulse responding (Lyon & Krasnegor, 2005).

The WCST-64:CV2 consists of four stimulus cards and 64 response cards. The four stimulus cards are placed before the subject and display one red triangle, two green stars, three yellow crosses, and four blue circles, respectively. The stimulus cards reflect three, and only three, stimulus parameters: color, form, and number. The subject is given the 64 response cards and instructed to match each consecutive card from the deck with whichever one of the four stimulus cards he or she thinks it matches. The subject is only told whether each response is right or wrong and is never told the correct sorting category. Once the subject has made a specified number of correct sorting responses to the first sorting rule (color), the sorting rule changes to a second sorting rule (form) without warning, and the subject uses only the computer feedback to develop a new sorting strategy.

After the administration of the test, five subscale scores (raw and normalized) are calculated by the computer.  The WCST-64:CV2 has normative data for ages 6½ to 89 years and is normed to education level; thus, it has applicability to the wide range of ages expected in working nurses. The five subscales are total number of errors, perseverative responses, nonperseverative errors, categories completed, and number of trials to complete the first sorting category (Kongs et al., 2000). Perseverative errors are those in which the subject persists in responding to an incorrect dimension or principle of the key or stimulus card. In other words, when the subject had discovered the current sorting rule and correctly sorted ten cards, the computer changes the sorting rule without any indication to the subject. If the subject persists in attempting to sort according to the last sorting rule, this counts as a perseverative error. According to van der Linden et al. (2003), perseverative errors are the most vulnerable to fatigue, and thus this subscale was initially explored as the primary measure of EF. However, because the WCST-64:CV2 had not been used in a population of nurses before, more variables or subscale scores were selected for inclusion and analysis for this current study. Total errors included perseverative error and nonperseverative error (any other type of sorting error). The number of trials to complete the first category and failure to maintain a category could be an indication of lack of motivation or a lack of concentration.

The WCST provides raw scores and normalized scores (t-scores) for total errors, perseverative errors, and non-perseverative errors. The raw scores are interpreted such that a high score denotes worse executive functioning (more errors), whereas the normalized scores are interpreted such that a high score means *better* executive functioning (less errors). Raw scores were used in correlations so interpretation to other variables is more interpretable (i.e. high EF total score denotes worse EF or more errors). Normalized (t-scores) were used in the multiple regressions because they were adjusted for age and educational level, and by using t-scores I avoided having to add another covariate in the regression. Using normalized scores for EF total errors, perseverative errors and nonperseverative errors makes interpretation of the direction of the regression coefficients less intuitive because as noted above, higher t-scores denotes *better* executive function. Normalized scores are not provided for the number of categories completed and number of trials to complete are non normalized. Thus, raw scores from those two subscales are interpreted as follows: a high number of categories completed denotes better executive functioning, and a high number of trials to complete the first category denotes lower executive functioning.

**Reliability of the WCST-64:CV2™.** In an early study of administration accuracy using cards, over 70% of the studies contained at least one examiner error; however, a videotape and handbook have become available and a computerized version is also available that will do all of the recording and scoring (Kongs et al., 2000). A limitation of the WCST-64:CV2 Professional Manual is that it does not provide information how reliability changed after the videotape and handbook became available. The computerized version eliminated inter-rater reliability error and errors in scoring because the computer administers the test, presents the cards to the subject, and computes the scores at the conclusion of the test. The generalizability coefficient for the perseverative error subscale was .76 in a group of adults at the University of Colorado Health Sciences Center (*N* = 33) with a mean test-retest interval of 6.7 weeks (*SD* = 1.1 weeks). Phillips (1997) pointed out that the concept of test-retest reliability for tests of EF was problematic because any test of EF must be novel in content and format or the subject may have learned the test, and the test, therefore, cannot be novel a second time.

**Validity of the WCST.** Convergent validity was supported by administering the WCST-64:CV2-64 and a battery of other cognitive tests to undergraduate students and having the students obtain similar scores on several different tests of EF (Kongs et al., 2000). Rabbitt (1997) suggested in *Methodology of Frontal and EF* that because measurement of EF was determined by behavioral output, numerous cognitive processes could have interfered with true measurement of EF. For example, short- or long-term memory impairment, special processing, and/or motor/verbal responses may have had a deleterious effect on the EF performance. Phillips (1997) pointed out that most EF tests are validated by a criterion or their sensitivity to frontal lobe lesions. It is a strength, however, that the WCST-64:CV2 has been widely used in the normal, healthy adult population and is considered by some to be the “gold standard” for measurement of EF (Kongs et al., 2000; Rabbitt, 1997).

## Data Entry and Verification

The data packet was assigned a participant ID so the data packet and WCST-64:CV2 scores could be matched per participant for entry into Microsoft Excel. As noted above, the WCST-64:CV2 survey asked the participant's date of birth so the result could be normed to age and education level; however, only age was entered into the Excel spreadsheet. Data from the surveys and the WCST-64:CV2 scores were entered into one data file in Excel. The researcher achieved data verification by stopping every ten surveys and comparing the previous ten surveys to data in the spreadsheet cells. Any discrepancies were corrected before data entry was continued. The data file was copied and one of the data files was imported into IBM SPSS 19 as a working file for data analysis. The original data file was not used for analysis and was kept for archival purposes. A data management protocol was developed according to OHSU School of Nursing guidelines (personal communication, Michael Leo, October 19, 2010). Any changes to the working file were noted in a data management log that contained date, data set used, comments, and computer hard drive location of subsequent data files, SPSS syntax files, and SPSS output files.

## Data Cleaning

The researcher ran frequencies and histograms on all variables to identify out-of-range values that may have indicated data entry error and missing values that may not have been coded as missing. Crosstabs were used to investigate any illogical patterns of data (e.g., nurse age 32 with 20 years of experience).

## Analysis Plan

**Aim 1: To describe nurses' levels of fatigue and executive function.**

Descriptive statistics were used to summarize and describe work fatigue and EF. Results contained measures of central tendency (mean, median, and mode), variability (standard deviation, range), and distribution (skewness and kurtosis) for the variables of fatigue (CIS, OFER15), and EF (WCST-64:CV2). A histogram of each of these variables was used to visualize the frequency distribution of scores and to identigy potential outliers.

**Aims 2 and 3: To identify correlates of fatigue in working nurse; to test whether self-reported fatigue is significantly and independently associated with EF in working nurses.**

The Pearson product moment correlation coefficient describes the direction and magnitude of a relation between two interval- or ratio-level variables and has a possible range from -1.00 (perfect negative correlation) to . +1.00 (perfect positive correlation). Each of the variables was checked for assumptions of correlation: normal distribution, linear relationship, and homoscedasticity. The direction and magnitude of the relation between fatigue and EF were described and the level of significance for the relationship.

**Aim 4: To determine the amount of variance in EF accounted for by fatigue after controlling for covariates.**

According to the literature, fatigue, mental health status, and quality of sleep could be expected to be strongly correlated with one another, and it was anticipated that all three would share variance with EF. Therefore, hierarchical multiple regressions were used to determine the amount of variation in EF accounted for by fatigue after controlling for age, gender, living situation,  mental health status, sleep quality, and exercise. Age was controlled in the first three EF variables, and so was not entered into the first three multiple regressions. Age was controlled for in EF variables ‘categories completed’ and ‘trials to complete the first category’. Age (if appropriate for that multiple regression), gender, living situation, start time of shift, and length of shift were entered into block one. Mental health status, sleep and exercise were entered into block two.

EF total error, perseverative error and nonperseverative error scores used the WCST-64CV2 generated t-score because this was corrected for age and educational level. EF categories completed used the WCST-64CV2 generated raw score, and age was entered into block one. EF trials to complete the first category score was skewed which violated an assumption of multiple regression so scores were transformed by natural log which eliminated the skewness. The amount of unique variance was assessed by the statistical test of change in $R^{2.}$

# CHAPTER 5
# RESULTS

The setting for this study was all four of the medical-surgical departments in a medical center in the Pacific Northwest during the fall of 2010. Data collection occurred during selected shifts over a seven-day period including weekdays and weekend. Three of the four departments had a mix of 8- and 12-hour shifts as the regularly scheduled shift and the fourth department had only 8-hour shifts as the regularly scheduled shift. A few participants were regularly scheduled to work 10-hour shifts to provide efficient overlap between the shifts, and these were resource or float nurses able to assist where needed. Twenty percent of the nurses assigned to work 8-hour shifts participated in the study; and 100% of the nurses assigned to work longer than 8-hour shifts participated.

Approximately 470 nurses were employed in the four departments at the time of data collection. The nature of data collection necessitated the researcher be present to administer the computerized WCST-64:CV2™, so a balanced variety of shifts were selected for data collection. Approximately 170 nurses were working the selected shifts during the time of data collection and all were invited to participate; 120 agreed to participate (70%); 105 completed all of the data surveys; and 3 completed just the EF computerized survey. Of the original 120 nurses who agreed to participate, 12 nurses were not able to complete the surveys during or immediately after their shift. Of nurses who worked during the time of data collection, 62% (105 out of 170) completed all surveys. The majority of the nurses who participated in the study (78% or 82 out of 105) worked 8-hour shifts and 22% (23 out of 105) worked longer than 8-hour shifts.

Data were collected on the sociodemographic variables of age, gender, length of nursing experience, and highest degree of nursing education. The sociodemographic characteristics for the sample are presented in Table 6. One hundred eight nurses participated in this study and ranged in age from 20 years to 64 years of age with a mean of 33 years (*SD* = 9.43). Both males (20.4%) and females (79.6%) participated.

The participants in the study had a wide range of nursing experience (0-29 years) with a mean of 6.05 years (*SD* = 6.61 years). They reported a range of 0-29 years at their current job with a mean of 4.28 years (*SD* = 5.21 years). Of the participants, 40% had an associate's degree in Nursing as the highest degree achieved in nursing, 56% had a BSN, and 4% had an MN/MSN degree. Of the participants, 89% were not certified in any nursing specialty; 9% were certified in medical-surgical nursing; and 2% were nurse practitioners. The two nurse practitioners were not employed or practicing as nurse practitioners at this medical center at the time of the study; instead, they were employed as bedside nurses on the medical-surgical departments.

Table 6.
*Sociodemographic Characteristics of the Study Sample*

| Characteristic | *n* | *M (SD)* | Range |
|---|---|---|---|
| Age | 104 | 33.48 (9.43) | 20-64 |
| Number of children under 18 years of age living at home | 106 | .69 (1.22) | 0-9 |
| Years of nursing experience | 108 | 6.05 (6.61) | 0-29 |
| Years at current job | 108 | 4.28 (5.21) | 0-29 |

| Characteristic | *n* (%) |
|---|---|
| Gender (*n*=108) | |
| Male | 22 (20.4) |
| Female | 86 (79.6) |
| Living situation (*n*=108) | |
| Single, living alone: Usually (<50% of the time) **not** responsible for another (child, parent, or other) during non-working hours | 31 (28.7) |
| Single, living alone: Usually (>50% of the time) **do** have responsibilities for another (child, parent, or other) during non-working hours | 8 (7.4) |
| Married or living with significant other: Usually (<50% of the time) **not** responsible for another (child, parent, or other) during non-working hours | 32 (29.6) |
| Married or living with significant other: Usually (>50% of the time) **are** responsible for another (child, parent, or other) during non-working hours | 37 (34.3) |
| Number of children under the age of 18 living at home (*n*=106) | |
| None | 65 (61.3) |
| One | 21 (19.8) |
| Two | 16 (15.1) |
| Three | 1 (0.9) |
| Four | 2 (1.9) |
| Nine | 1 (0.9) |
| Highest nursing degree | |
| ADN | 43 (39.8) |
| BSN | 61 (56.5) |
| MN/MSN | 4 (3.7) |
| Nursing specialty certified | |
| None | 96 (88.9) |
| Medical-surgical certified | 10 (9.3) |
| Nurse Practitioner | 2 (1.9) |

Note: ADN = Associate Degree in Nursing; BSN = Bachelor of Science, Nursing or Bachelor of Science in Nursing; MN = Master's in Nursing; MSN = Master of Science in Nursing.

## Person Level Covariates

Person-level covariates were sleep, mental health status (operationalized by the BDI-II), intershift recovery, social support (operationalized as living situation), and exercise. Descriptive statistics of these person level covariates follows.

### Sleep and Mental Health Status

PSQI subscores had a potential range from zero (not during the past month) to three (three or more times a week). The nurses had the highest PSQI subscale scores in daytime dysfunction (*M* = 1.13, *SD* = .82), subjective sleep (*M* = 1.21, *SD*= .71), sleep latency or the ability to fall asleep quickly (*M* = 1.28, *SD* = .98), and sleep disturbances (*M* = 1.30, *SD*= .53) (Table 7). The participants reported that they had difficulty falling asleep soon after going to bed less than once a week (sleep efficiency; *M* = 0.41, *SD*= .76), used sleep medications less than once a week (*M* = 0.56, *SD*= .92), and had difficulty obtaining 7 hours of sleep duration less than once a week (*M* = 0.80, *SD*= .96). According to Buysse et al. (1989), a poor sleeper is one who scores greater than 5 in the summed global PSQI score. As a group, the nurses in this study perceived their overall subjective sleep quality in the past month as fairly good (*M* = 1.21, *SD* =.71); however, 56% of the nurses in this study had a summed score on the global PSQI greater than 5 (*M* = 6.63, *SD*= 3.61), which is categorized as poor sleep (Buysse, 1989).

Table 7
*Descriptive Scores on the PSQI*

| Subscale | *M (SD)* | Range[a] |
|---|---|---|
| Subjective sleep quality | 1.21 *(0.71)* | 0-3 |
| Sleep latency | 1.28 *(0.98)* | 0-3 |
| Sleep duration | .80 *(0.96)* | 0-3 |
| Sleep efficiency | .41*(0.76)* | 0-3 |
| Sleep disturbances | 1.30 *(0.53)* | 0-3 |
| Use of sleep medication | .56 *(0.92)* | 0-3 |
| Daytime dysfunction | 1.13*(0.82)* | 0-3 |
| PSQI Global Score | 6.63 *(3.61)* | 0-16[b] |

Note: PSQI = Pittsburgh Sleep Quality Index. [a] Values: 0 = Not during the past month; 1= Less than once a week; 2= Once or twice a week; 3= Three or more times a week.
[b]Calculated; is not a summed subscore total.

The participants' intershift recovery subscale score was 57.72 (*SD* = 22.51), which suggested a moderate/high ability to recuperate after a fatiguing day.

Mental health status was operationalized as the BDI-II (Table 8). The BDI-II subscales with the highest means scores were change in sleep patterns (*M* = 0.96, *SD*= .87), loss of energy (*M* = 0.84, *SD*= .60), and tired or fatigued (*M* = 0.74, *SD*= .64). The nurses scored lowest in BDI-II subscales of suicidal thoughts (*M* = 0.03, *SD*= .17), worthlessness (*M* = 0.10, *SD*= .36), and punishment (*M* = 0.10, *SD*= .39). According to established categories for the BDI-II total score (Beck et al., 1996), most nurses were minimally depressed (76%); 16% were mildly depressed; 7% were moderately depressed, and only one (1%) was severely depressed. No nurse scored high on questions suggesting suicidal thoughts or extreme pessimism about the future.

Table 8

*Descriptive Scores on the BDI-II (Descending Scores)*

| Subscale | *M* | *SD* | Potential Range |
|---|---|---|---|
| Change in sleep patterns | .96 | .87 | 0-3 |
| Loss of energy | .84 | .60 | 0-2 |
| Tired or fatigued | .74 | .64 | 0-3 |
| Change in appetite | .64 | .78 | 0-3 |
| Irritability | .57 | .69 | 0-2 |
| Self-critical | .46 | .60 | 0-2 |
| Loss of interest in sex | .44 | .69 | 0-3 |
| Loss of pleasure | .41 | .55 | 0-2 |
| Difficulty concentrating | .41 | .61 | 0-2 |
| Loss of interest | .39 | .58 | 0-3 |
| Self-dislike | .38 | .65 | 0-2 |
| Agitation | .38 | .54 | 0-2 |
| Guilty | .35 | .50 | 0-2 |
| Indecisiveness | .32 | .53 | 0-2 |
| Pessimism | .31 | .52 | 0-2 |
| Crying | .22 | .52 | 0-3 |
| Sadness | .19 | .44 | 0-2 |
| Past failure | .19 | .50 | 0-2 |
| Punishment | .10 | .39 | 0-3 |
| Worthlessness | .10 | .36 | 0-2 |
| Suicidal thoughts | .03 | .17 | 0-1 |

Note: BDI-II = Beck Depression Inventory II

Social support was operationalized as living situation. More than half (64%) of the participants were married or living with a significant other. Sixty-one percent reported they did not have children younger than 18 years living at home; two participants did not provide this information. The number of times the participants exercised for a minimum of 30 minutes a day ranged from zero to seven times a week with a mean of 2.38 ($SD$ = 1.70) times per week.

Organizational variables were shiftwork, extended work hours, and disruptions to circadian rhythm. Most participants were working the shift they typically work (96%); they were working their preferred shift (78%), and they were working their preferred shift length (83%).

Table 9
*Frequency Distributions of Educational and Job Characteristics (Categorical Variables)*

| Characteristic | Frequency (%) |
|---|---|
| Shift currently working | |
| 7 a.m. – 3 p.m. | 29 (27.6) |
| 3 p.m. – 11 p.m. | 37 (35.2) |
| 11 p.m. – 7 a.m. | 20 (19.0) |
| 7 a.m. – 7 p.m. | 6 (5.7) |
| 7 p.m. – 7 a.m. | 8 (7.7) |
| 5 a.m. – 3 p.m. or 3 p.m. – 1 a.m. | 4 (3.8) |
| 8 a.m. – 5 p.m. | 1 (1.0) |
| Exercise: Times per week exercise for 30 minutes a day | |
| Mean *(SD)* | 2.38 (1.70) |
| Range | 0-7 |

Taking a nap within the previous two hours was measured with a single question: “Have you taken a nap within the past two hours?” No participant had taken a nap within the last two hours; hence this variable was dropped from further analysis. Caffeine ingestion within the last two hours was reported by 29% of the participants.

In summary, this was a relatively young, well-educated group of nurses with moderate nursing experience. Most worked 8-hour shifts, were working their preferred shift, and working their preferred shift length. Most did not have responsibilities for children under the age of 18 during their non-working hours. They perceived their sleep quality to be fairly good, but more than half met the criterion for poor sleepers. They had adequate time to recover expended energy between shifts, and they exercised about twice a week. About one-quarter of the participants were mildly, moderately, or severely depressed. Caffeine use was low, and no one had taken a nap in the previous two hours.

**Specific Aim 1. To Describe Nurses' Levels of Fatigue and Executive Function**

Fatigue was measured multidimensionally using two separate instruments. The CIS20R measured subjective fatigue (affective dimension), motivation fatigue (behavioral), concentration (mental), and activity (sensory dimension). The OFER15 measured chronic fatigue and acute fatigue, which are temporal (perception, duration) dimensions of fatigue.

The CIS20R subjective subscore was categorized into three levels of fatigue (mild, elevated and severe) as described by Vercoulen et al. (1994). The subjective subscale was the only subscale to have referenced normed criteria for subjective fatigue categories. Higher scores on the motivation, concentration, and activity subscales indicated higher levels of fatigue; however, the authors of the subscale did not provide reference criteria for categorizing these subscales. The CIS20R total fatigue score was categorized into normed references of not prolonged fatigue or prolonged fatigue.

**CIS20R.** The subjective fatigue subscale mean score for this group of nurses was 30.56 (*SD* = 10.90), which indicated an overall moderate level of fatigue during the past two weeks (raw score range: 28-35) (Table 10). When categorized, 39% of the participants met the criterion for mild fatigue, 22% for elevated fatigue, and 39% for severe fatigue (Vercoulen et al., 1994).

A high score on the motivation subscale indicated low motivation, and the participants in this study had a mean motivation subscale score of 12.23 (*SD* = 4.46). With a possible range of scores between 4 and 25, the group mean score indicated a motivation level in the second quartile or that the participants were not experiencing a low motivation level.

A high concentration subscore indicated a high level of concentration problems. The mean concentration subscale score was 16.11 (*SD* = 6.26). With the possible range of scores on the concentration subscale ranging between 5 and 35, the mean score was in the second quartile, which suggested some difficulty in concentration but not a high level of concentration problems.

A high activity subscale score indicated a low level of physical activity. The mean activity subscale score was 7.52 (*SD* = 3.75). With a possible subscale range of 3-31, this score was very low, which indicated the participants had a relatively high level of physical activity.

Table 10
*Descriptive Scores on the CIS20R*

| Subscale | M | *SD* | Possible Minimum and Maximum Scores | Actual Minimum and Maximum Scores |
|---|---|---|---|---|
| Subjective fatigue | 30.56 | 10.90 | 8-56 | 8-45 |
| Motivation | 12.23 | 4.46 | 4-28 | 4-25 |
| Concentration | 16.11 | 6.26 | 5-35 | 5-34 |
| Activity | 7.52 | 3.75 | 3-21 | 3-18 |

Note: CIS20R = Checklist Individual Strength 20 Revised

A summed CIS20R score of greater than 76 indicated prolonged worker fatigue with a greater risk of use of sick time (Vercoulen et al., 1994). The CIS20R summed score for this group ranged from 24-119 with a mean of 66.43 (SD=20.32). Sixty-three percent of the nurses in this study (n=68) did not meet the cut point for prolonged fatigue; however, 35% of the nurses did have a CIS20R summed score that indicated prolonged fatigue.

**OFER15.** The participants in this study had a mean OFER15 chronic fatigue score of 39.57 (*SD* = 24.89), which corresponds to a score within the second quartile indicating a low/moderate level of chronic fatigue (score 26-50); however, the relatively large standard deviation indicated that participants ranged between low (0-25 score) to moderate high (51-75 score) categories (Table11). Participants in this study had an OFER acute fatigue mean score of 53.67 (*SD* = 17.11), which indicated a moderate level of acute fatigue. Intershift recovery mean score was 57.72 (*SD* = 22.51) which indicated a high level of intershift recovery which means participants probably had adequate time to recovery energy between shifts.

Table 11
*Descriptive Scores on the OFER15*

| Subscale | *M* | *SD* | Range |
|---|---|---|---|
| Chronic fatigue | 39.57 | 24.89 | 0-90 |
| Acute fatigue | 53.97 | 17.11 | 17-80 |
| Intershift recovery | 57.72 | 22.51 | 0-100 |

Note: OFER15 = Occupational Fatigue Exhaustion Recovery Scale 15

In summary, more than half the participants met the criterion for elevated or severe fatigue within the last two weeks, and one-third had prolonged fatigue of greater than two weeks. They had moderate motivation, had some difficulty in concentrating, and had enough energy for physical activity. According to the temporal measures of fatigue, the participants were acutely fatigued; however, some were chronically fatigued and some may have been able to recover their lost energy through adequate intershift recovery or exercise.

Executive Function (**WCST-64:CV2)**:  The WCST-64:CV2™ (the operationalization of EF) total errors, perseverative errors and nonperseverative errors were normed based on age and educational level, and I used these normed scores for reporting and analysis to aid in facilitation for comparing results to other studies and to avoid having to include age as a covariate.

Table 12 shows the mean number of total sorting errors was 16.30 (*SD* = 9.47) and the range of observed total errors ranged from 6 to 54. This indicated that across the entire test, participants made an average of 16 errors in the 64 card-sorting process. A participant who made six errors used more EF than the person who made 54 errors in the card-sorting process. Further exploration of additional WCST-64:CV2™ subscales helped explain specific deficits in EF.

Table 12
*Descriptive Scores of the Sample on the WCST-64:CV2™ (n=108)*

| Subscore | *M* | *SD* | Possible Scores Minimum-Maximum | Actual Scores Minimum - Maximum |
|---|---|---|---|---|
| Total errors* | 16.30 | 9.47 | 0-64 | 6-54 |
| Perseverative errors* | 8.08 | 4.46 | 0-64 | 3-30 |
| Nonperseverative errors* | 8.19 | 5.98 | 0-64 | 1-39 |
| Categories completed | 3.44 | 1.47 | 0-6 | 0-5 |
| Trials to complete first category | 17.59 | 13.44 | 0-65 | 10-65 |

Note: WCST-64:CV2™ = Wisconsin Card Sorting Test64™
*Corrected for age and educational level

The participants had a mean number of 8.08 perseverative errors (*SD = 4.46*; Table 12). Next, I completed a frequency analysis and grouped participant perseverative errors into quartiles (Table 13). This revealed that 78% of the nurses had adequate executive functioning and made 10 or fewer perseverative errors; however, 22% had difficulty discovering the sorting rule and made 11 or more perseverative errors. This was an indication that the card-sorting rule was not held sufficiently active in their working memory and they persisted in acting in a previously successful way that had had a higher mental activation level.

Table 13

*Frequency Distribution of Perseverative Errors on the WCST-64:CV2™(Collapsed and grouped into quartiles by number of perseverative errors; n=108)*

| Number of Errors | Number of Participants | Percentage of Participants | Cumulative Percentage |
|---|---|---|---|
| 3 to 10 (low number of errors) | 85 | 78.70 | 78.70 |
| 11 to 18 (moderate number) | 18 | 16.67 | 95.37 |
| 19 to 26 (moderately high number) | 4 | 3.70 | 99.07 |
| 27 to 30 (high number of errors) | 1 | 0.93 | 100.00 |

Note: WCST-64:CV2™ = Wisconsin Card Sorting Test 64™

A subset of the perseverative error subscale was the failure to maintain the set score, which was described as failure to correctly sort the next ten cards according to a rule once that rule had been discovered. Of the participants, 70% were able to maintain the set once the sorting rule had been discovered; however, approximately 30% were unable to do so (Table 14).

Table 14

*Number of Participants Unable to Maintain Categories and the Number of Categories with Errors on the WCST-64:CV2™(n=108)*

| Number of Categories with Errors | Number of Participants | Percentage of Participants | Cumulative Percentage |
|---|---|---|---|
| 5 categories with errors | 1 | .92 | .92 |
| 4 categories with errors | 1 | .92 | 1.84 |
| 3 categories with errors | 3 | 2.78 | 4.62 |
| 2 categories with errors | 5 | 4.63 | 9.25 |
| 1 categories with errors | 21 | 19.44 | 28.70 |
| Completed categories did not contain errors | 77 | 71.30 | 100.00 |

Note: WCST-64:CV2™ = Wisconsin Card Sorting Test64™

Participants had a mean of 8.19 (*SD* = 5.98) nonperseverative errors (Table 12). Nonperseverative errors are errors of exploration. When the sorting rule changes, the participant must explore what the correct sorting rule is. Nonperseverative errors result from either a lack of planning and/or short-term memory, and are an indication of lack of concentration, planning, organization, cognitive flexibility in shifting set, working memory, and a lack of inhibition of impulse responding. Most of the participants (64%) had seven or fewer nonperseverative errors; however, 34% of the participants had eight or more (Table 15). Six percent had between 18 and 39 nonperseverative errors, which indicated a high level of EF dysfunction.

Table 15

*Frequency Distribution of Nonperseverative Errors on the WCST-64:CV2™(Collapsed and grouped into quartiles by number of nonperseverative errors; n=108)*

| Number of Errors | Number of Participants | Percentage of Participants | Cumulative Percentage |
|---|---|---|---|
| 1 to 7 (low number of errors) | 69 | 63.89 | 63.89 |
| 8 to 17 (moderate number) | 32 | 29.63 | 93.52 |
| 18 to 26 (moderately high number) | 6 | 5.55 | 99.07 |
| 27 to 39 (high number of errors) | 1 | 0.93 | 100.00 |

Note: WCST-64:CV2™ = Wisconsin Card Sorting Test64™

A completed category is described as a participant correctly determining the sorting rule and correctly sorting ten cards in succession. Of the participants, 59% were able to complete at least four sorting categories, which meant having at least 40 of the 64 cards correctly sorted as determined by the computer (Table 16); however, 24% completed only two categories; i.e., they correctly sorted ten cards in succession only twice. Six of the nurses were unable to complete a single sorting category, which could indicate severe impairment of working EF.

Table 16

*Frequency Distribution of Number of Categories Completed on the WCST-64:CV2™(n=108)*

| Categories Completed | Number of Participants | Percentage of Participants | Cumulative Percentage |
|---|---|---|---|
| 0 | 6 | 5.55 | 5.55 |
| 1 | 8 | 7.41 | 12.96 |
| 2 | 12 | 11.11 | 24.07 |
| 3 | 19 | 17.59 | 51.66 |
| 4 | 33 | 30.56 | 72.22 |
| 5 | 30 | 27.78 | 100.00 |

Note: WCST-64:CV2™ = Wisconsin Card Sorting Test64™

Using deductive reasoning and computer feedback, 66% of the participants were able to complete the first category within 12 trials or 12 cards; however, 34% needed more than 13 trials with computer feedback to learn the sorting rule and complete the first sorting category (Table 17).

Table 17
*Frequency Distribution of Number of Trials to Complete First Category on the WCST-64:CV2™(n=108)*

| | Number of Participants | Percentage of Participants | Cumulative Percentage |
|---|---|---|---|
| 10 (perfect or minimal number of trials) | 2 | 1.86 | 1.86 |
| 11-15 (high number of trials) | 75 | 69.44 | 71.30 |
| 16-65 (very high number of trials) | 31 | 28.70 | 100.00 |

Note: WCST-64:CV2™ = Wisconsin Card Sorting Test64™

In summary, most of the nurses learned the card-sorting rules, made appropriate perseverative and nonperseverative errors. and were able to correctly sort the 64-card deck into correct categories with computer feedback. However, approximately one-third of the nurses made so many errors that they had difficulty completing the card-sorting categories.

**Aim 2: To Identify Correlates of Fatigue in Working Nurses**

I identified the correlates of fatigue using the Pearson-Product Moment Correlation Coefficient, given that all of the potential correlated were measured on either a binary or an interval scale and fatigue was measured on an interval scale. Before performing these analyses, I tested the assumptions of correlation (normally distributed, linearity and homoscedasticity) and all assumptions appeared to have been met.

First, I explored the relationships of the sociodemographic variables of age, gender, length of nursing experience, and highest level of nursing experience with fatigue; the results are presented in Table 18. All sociodemographic variables were found to have non-significant relationships with fatigue ($r$ = -.17 to .18, $p$ > .05).

Table 18
*Correlations Between Sociodemographic Characteristics and Fatigue Measures*

| Fatigue Measure | Age | Gender | Highest Nursing Education | Advanced Certification | Years Nursing Experience | Years at Current Job |
|---|---|---|---|---|---|---|
| OFER15 Chronic fatigue | <- .01 | .08 | - .07 | .02 | - .02 | .12 |
| OFER 15 Acute fatigue | - .04 | .11 | .03 | - .13 | - .05 | .04 |
| OFER15 Intershift recovery | .05 | - .11 | .05 | - .07 | .06 | .01 |
| CIS20R Subjective fatigue | .05 | .13 | - .17 | - .06 | < .01 | .03 |
| CIS20R Concentration | - .16 | - .07 | - .06 | - .10 | - .17 | - .17 |
| CIS20R Motivation | - .05 | - .08 | - .09 | - .10 | - .05 | .08 |
| CIS20R Activity | - .17 | - .12 | - .10 | - .17 | - .01 | < .01 |
| CIS20R Total score | - .09 | - .05 | - .14 | - .15 | - .08 | - .04 |

Note: OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised. No correlations were significant at $p < .05$.

Next, I explored whether sleep, mental health status, intershift recovery, and amount of physical activity (exercise) were related to fatigue using Pearson correlations. PSQI subscales that were significantly related to more than four of the seven fatigue subscales were sleep latency (ability to fall asleep quickly), sleep disturbances, use of medications, subjective sleep quality, and daytime dysfunction (Table 19). The global PSQI score was also significant with all measures of fatigue. Overall, this meant that decreases in the quality and duration of sleep decreased was associated with increases in fatigue; and that increases in daytime dysfunction and the use of medications was associated with increases in fatigue. All subscales of the PSQI were significantly related to all OFER intershift recovery subscales, which indicated that decreases in all protective aspects of sleep were associated with increases in inadequate intershift recovery.

I measured mental health status with the BDI-II and found that the BDI-II summed global score was positively related to six of the seven measures of fatigue (OFER15 Chronic Fatigue, $r$ = .41; OFER15 acute fatigue, $r$ = .35; $r$ = .41; OFER15 intershift recovery, $r$ = -.37; CIS20R subjective fatigue, $r$ = .48; CIS20R concentration, $r$ = .48;CIS20R, $r$ = .40; and CIS20R motivation, $r$ = .41; $p < .01$). This indicated that increases in poor mental health status was associated with increases in chronic fatigue, acute fatigue, subjective fatigue, motivational effort, effort to concentrate, and associated with decreases in intershift recovery. The relationship between mental health status, specifically depression, and amount of energy available for activity was not significant ($r$ = .14, $p > .05$).

Table 19

*Correlations Between PSQI and Fatigue Measures*

| | PSQI Subscales | | | | | | | PSQI Global Score |
|---|---|---|---|---|---|---|---|---|
| | Latency | Duration | Efficiency | Disturbances | Medication Use | Subjective Sleep Quality | Daytime Dysfunction | |
| OFER15 Chronic fatigue | .20* | .20* | .19 | .26** | .10 | .33** | .36** | .35** |
| OFER15 Acute fatigue | .28** | .11 | .15 | .40** | .32** | .48** | .54** | .50** |
| OFER15 Intershift recovery | -.30** | -.35** | -.23* | -.31** | -.27** | -.60** | -.45** | -.55** |
| CIS20R Subjective fatigue | .35** | .32** | .13 | .44** | .34* | .56** | .53** | .59** |
| CIS20R Concentration | .32** | .17 | .12 | .25* | .16 | .35** | .42** | .39** |
| CIS20R Motivation | .29** | .17 | .18 | .23** | .24* | .37** | .42** | .42** |
| CIS20R Activity | .16 | .01 | .00 | .25** | .15 | .09 | .28** | .20* |
| CIS20R Total score | .39** | .26** | .17 | .41** | .30** | .52** | .54** | .57** |

Note: PSQI = Pittsburgh Sleep Quality Index; OFER15 = Occupational Fatigue Exhaustion Recovery 15 Scale; CIS20R = Checklist Individual Strength20 Revised.

* $p < .05$ (2-tailed)

** $p < .01$ (2-tailed)

Intershift recovery was negatively related to OFER chronic fatigue ($r = -.57$, $p < .001$); OFER acute fatigue ($r = -.68$, $p < .001$); CIS subjective fatigue ($r = -.65$, $p < .001$); CIS20R concentration ($r = -.45$, $p < .001$); CIS20R motivation ($r = -.38$, $p < .001$); and CIS20R total score ($r = -.60$, $p < .001$). Intershift recovery had a small relationship ($r = -.19$) that approached significance ($p = .051$) with the CIS20R activity subscale. This meant that decreases in adequate intershift recovery was associated with increases in fatigue.

Use of caffeine within the last two hours had weak relationships that failed to reach significance with all six subscale measures of fatigue. Engaging in exercise was negatively correlated to OFER15 acute fatigue ($r = -.20$, $p < .01$), CIS20R subjective fatigue ($r = -.34$, $p < .01$), CIS20R motivation ($r = -.26$, $p < .01$), and CIS20R activity ($r = -.19$, $p < .05$). This indicated that increases in frequency of exercise were associated with decreases in acute fatigue, subjective fatigue, effort for motivation, and effort for activity.

I also examined the relationships between shift typically worked, shift currently working, working preferred shift, and working preferred shift length to all seven measures of fatigue. None of these variables were significantly related to fatigue.

**Aim 3: To Test If Self-Reported Fatigue Is Significantly and Independently Associated with Executive Function in Working Nurses**

The five WCST-64:CV2™ EF subscales measured were total errors, perseverative errors, nonperseverative errors, number of categories completed, and trials to complete the first category. The raw score for EF total errors, perseverative errors, and nonperseverative errors scores was corrected for age and educational level. The EF total error raw score value was normally distributed and used in multiple regression. The EF perseverative error and nonperseverative error was not normally distributed, and the standardized score (t-score) was normally distributed so the standardized was used for multiple regression analysis.

The OFER15 chronic fatigue subscale was negatively associated with WCST-64:CV2™ total errors ($r$ = -.21, $p$ = .04) which means higher levels of chronic fatigue was associated with worsening EF total errors. EF chronic fatigue was not significantly associated with perseverative errors ($r$ = .22, $p$ > .05) and positively associated with nonperseverative errors ($r$ = .18, $p$ > *.05*). Chronic fatigue was not significantly associated with categories completed ($r$ = - .17, $p$ > .05), but positively associated with trials to complete the first category ($r$ = .23, $p$ = .02; Table 20). This suggests that higher levels of chronic fatigue was associated with fewer categories completed and an increased number of trials to complete the first category, which indicates worsening EF.

The OFER15 acute fatigue subscale was not significantly associated with EF total errors ($r$ = - .11, $p$ > .05) and categories completed ($r$ = - .07, $p$ > .05). Acute fatigue was not significantly associated with perseverative errors ($r$ = .13, $p$ > .05), nonperseverative errors ($r$ = .11, $p$ > *,05*) , or trials to complete the first category ($r$ = .23, $p$ > .05) .

Higher scores on the OFER15 intershift recovery scale indicate better recovery and conceptually potentially improving EF. The OFER15 intershift recovery was positively associated with EF total errors ($r$ = .20, $p$ = .04), but not significantly associated with categories completed ($r$ = .15, $p$ = > .05). Increases in intershift recovery was associated with increases in total errors. Intershift recovery was not significantly associated with perseverative errors (r = .18, $p > .05$), nonperseverative errors ($r = .16$, $p$ = > .05), but was negatively associated with trials to complete the first category ($r$ = - .26, $p < .05$), which meant that increases in intershift recovery was associated with decreases in trials to complete the first category.

The relationships between fatigue and EF are reported in Table 20 and are given here for descriptive characteristics of this sample, however very few relationships are significant. Most of the CIS20R correlations were weakly and not significantly associated with EF variables. Subjective fatigue (affective dimension) was negatively associated with EF total errors and categories completed, which suggests that increasing (worsening) subjective fatigue was associated with worsening EF total errors and fewer categories completed. Subjective fatigue was positively associated with perseverative errors, nonperseverative errors and trials to complete the first category, which suggests increasing (worsening) subjective fatigue was associated with more perseverative errors, nonperseverative errors and increasing number of trials to complete the first category.

CIS20R concentration (cognitive dimension of fatigue) was negatively associated with EF total errors, categories completed and trials to complete the first category, which suggests higher levels of concentration (worsening concentration) was associated with worsening EF total errors and worsening (fewer) categories completed. The relationship between concentration and trials to complete the first category was not in the expected direction (and not consistent with the direction of chronic and acute fatigue); however the magnitude was very small ($r$ = - .004, $p > .05$). Concentration has positively associated with perseverative errors and nonperseverative errors which suggest higher levels of concentration (worsening) were associated with more perseverative and nonperseverative errors.

Motivation (behavior dimension of fatigue) was negatively associated with EF total errors and categories completed, which suggests that higher (worsening) levels of motivation were associated with worsening EF total errors and fewer categories completed. Motivation was positively associated with perseverative errors, nonperseverative errors and trials to complete the first category. This means that worsening motivation is associated with increased number of perseverative errors, nonperseverative errors and increased number of trials to complete the first category.

Activity (physical dimension of fatigue) was positively associated with EF total errors and categories completed which suggests that higher levels of activity (more physical energy available) were associated with better levels of EF total errors and more categories completed. Activity was negatively associated with perseverative errors, nonperseverative errors and trials to complete the first category. This suggests that a higher level of activity, or physical energy available was associated with fewer perseverative errors, nonperseverative errors, and fewer trials to complete the first category.

The CIS20R total fatigue score was negatively associated with EF total errors and categories completed, which suggests higher total fatigue was associated with worsening EF total errors and fewer categories completed. Total fatigue was positively associated with perseverative errors, nonperseverative errors and trials to complete the first category. This suggests that higher levels of fatigue was associated with increased numbers of perseverative errors, nonperseverative errors, and increased number of trials to complete the first category.

Table 20
*Correlations Between Fatigue Measures and WCST-64CV2™*

| | OFER15 | | | CIS20R | | | | CIS20R Total Score |
|---|---|---|---|---|---|---|---|---|
| WCST-64CV2™ | Chronic Fatigue | Acute Fatigue | Intershift Recovery | Subjective | Concentration | Motivation | Activity | |
| Total Errors (standardized score) | -.21* | -.11 | .20* | -.18 | -.03 | -.06 | .12 | -.10 |
| Perseverative Errors (raw score) | .22 | .13 | -.18 | .18 | .02 | .10 | -.02 | .12 |
| Nonperseverative Errors (raw score) | .18 | .11 | -.16 | .21 | .01 | .05 | -.13 | .10 |
| Categories Completed (raw score) | -.17 | -.07 | .15 | -.19 | -.02 | -.05 | .09 | -.10 |
| Trials to Complete First Category (Log transformed score) | .23* | .21* | -.26** | .28** | < -.01 | .04 | -.11 | .14 |

OFER15 = Occupational Fatigue Exhaustion Recovery 15 Scale; CIS20R = Checklist Individual Strength20 Revised; WCST

* $p$ < .05 (2-tailed)

** $p$ < .01 (2-tailed)

**Aim 4. To Determine the Amount of Variance in EF Accounted for by Fatigue after Controlling for Covariates**

Hierarchical multiple regressions (HMR) were done to determine the amount of variance in each EF outcome variable accounted for by fatigue after controlling for age, gender, living situation, current shift working, sleep quality, mental health status, and frequency of exercise. Tests for multicollinearity as checked by the tolerance statistic indicated little collinearity in the data.

For each of the multiple regression analyses, the control variables were entered in two separate blocks based on the conceptual basis of the variable to evaluate their unique effect. Person-level covariates of gender, age (if not controlled for by t-score), living situation, start time of shift, and length of shift were entered into the first block. Person-level covariates of sleep, mental health status (depression), and exercise that are known to decrease or increase fatigue were entered into the second block. Fatigue variables were entered into the third block. The WCST provided a standardized t-score that adjusts for age and educational level for the first three outcomes (total score, perseverative error and nonperseverative error), so age was not included as a covariate in these models. Because there was some evidence for skewness, I performed sensitivity analyses before running models with log-transformed raw scores and t-scores. The results of these analyses produced similar results, so I used the untransformed t-score for the first three variables. The last two EF variables (categories completed and trials to complete the first category) did not have t-scores, so I used the raw scores for those two outcomes. Because the raw score for trials to complete the first category had some evidence of skewness, I performed a sensitivity analysis on before running models with the raw score and log-transformed scores. The log-transformed score reduced the skewness for trials to complete first category variable, so the log-transformed score was used for trials to complete the first category.

After evaluating the hypothesized models, I performed a post hoc analysis to determine whether predictor variables could be removed to improve model fit. First, I looked at the overall pattern of zero-order correlations. Any predictors that were associated with the outcome at a level of $r < .15$ were considered candidates for removal from the model. I sequentially removed each variable from the model and examined model fit ($R^2$, adjusted $R^2$, $R^2$ change statistics, F change statistics, F-change p-values, overall model p-values). If removing the variable resulted in no change or an improvement in model fit, it was excluded. If model fit decreased, then the variable was left in the model (even if its Beta value was non-significant). Permutations of the candidate predictors were then excluded simultaneously to arrive at a final model with optimal fit. The original regression model was titled MRX.1 and successive models MRX.2 etc until I arrived at the final regression model.

**Fatigue and WCST-64:CV2™ total errors.** In my examination of the frequency distribution for WCST-64:CV2™ EF total error scores, I did not find any cases with scores greater than 3 standard deviations from the mean, and the histogram appeared to have normal distribution. Thus, it was assumed that the normality assumption was met. I also examined scatterplots of the standardized residuals against the predicted values, and there did not appear to be any evidence of heteroscedasticity.

An initial multiple regression model regressed EF total errors on fatigue after controlling for age, gender, living situation (dummy coded with the category Single No

Kids serving as the reference group), start time of shift, length of shift, sleep, mental health status, and times-per-week exercised. The fatigue variables did not account for a significant amount of the variance in WCST-64:CV2™ EF total errors after accounting for the covariates ($\Delta R^2 = .05$, $F_{change(4,88)} = 1.22$, $p = .31$). Neither was the overall model significant: $R^2 = .15$, $F_{(13,88)} = 1.20$, $p = .29$ (Table 21).

Table 21
*Initial Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Total Errors T-Score)*

| Block | Variable | Beta | *p* (beta) | *R* | $R^2$ | $R^2$ Change | *F* Change | *p* (*F* Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .25 | .06 | .06 | 1.04 | .40 |
| | Gender (1=female) | -.03 | .75 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | -.21 | .27 | | | | | |
| | Partnered No Kids vs. Single with Kids | -.18 | .32 | | | | | |
| | Partnered with Kids vs. Single with Kids | -.24 | .21 | | | | | |
| | Length of Shift | -.18 | .10 | | | | | |
| | Shift Start Time | .02 | .82 | | | | | |
| 2 | | | | .32 | .10 | .04 | 1.44 | .24 |
| | Gender (1=female) | -.02 | .86 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | -.20 | .29 | | | | | |
| | Partnered No Kids vs. Single with Kids | -.17 | .37 | | | | | |
| | Partnered with Kids vs. Single with Kids | -.19 | .32 | | | | | |
| | Length of Shift | -.18 | .09 | | | | | |
| | Shift Start Time | .03 | .80 | | | | | |
| | **PSQI Global Score** | -.19 | .11 | | | | | |
| | **BDI II Global Score** | .13 | .30 | | | | | |
| | **Exercise** | .11 | .30 | | | | | |
| 3 | | | | .39 | .15 | .05 | 1.22 | .31 |
| | Gender (1=female) | .018 | .86 | | | | | |

| | | |
|---|---|---|
| Living situation | | |
| Single No Kids vs. Single with Kids | -.24 | .21 |
| Partnered No Kids vs. Single with Kids | -.19 | .31 |
| Partnered with Kids vs. Single with Kids | -.22 | .26 |
| Length of Shift | -.13 | .23 |
| Shift Start Time | .06 | .58 |
| PSQI Global Score | -.14 | .27 |
| BDI II Global Score | .17 | .23 |
| Exercise | .16 | .17 |
| **OFER15 Chronic Fatigue** | -.20 | .14 |
| **OFER15 Acute Fatigue** | .16 | .33 |
| **OFER15 Intershift Recovery** | .20 | .20 |
| **CIS20R Total Score** | .06 | .70 |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised.

Although there was a lack of strong multicollinearity among the variables, the number of variables that were included in the model may have used up too many degrees of freedom relative to the sample size available. This is apparent in the difference between the model $R^2$ and adjusted $R^2$ (e.g., .15 vs. .03 in the final model). Thus, I performed a sensitivity analysis to determine whether a more parsimonious model would reveal significant predictors.

I decided to sequentially remove variables from block 1 based on zero order correlations, semi-partial correlations, and theoretical importance to the model. With gender removed, the adjusted $R^2$ for the full model improved to .04 ($F_{(12, 89)} = 1.32$, $p = .22$) and there were no major differences in the regression coefficients for the remaining variables. With gender and living situation removed the adjusted $R^2$ improved to .05 ($F_{(9, 92)} = 1.59$, $p = .13$), without major differences in the regression coefficients for the remaining variables.  With gender, living situation, and shift start time removed the adjusted $R^2$ improved to .06 ($F_{(11, 90)} = 1.42$, $p = .18$) without major differences in the regression coefficients for the remaining variables. In the final model revision, with gender, living situation, shift start time, and the total fatigue scale, CIS20R, removed the adjusted $R^2$ improved to .07, without major differences in the regression coefficients for the remaining variables.

In this final model (MR1.5 Final, Table 22), chronic fatigue, acute fatigue and intershift recovery did not account for significant variance in WCST-64:CV2™ EF total errors ($\Delta R^2 = .04$, $F_{change\ (3, 94)} = 1.43$, $p = .24$) after controlling for length of shift, sleep, mental health status, and exercise. The final model was also not significant ($F_{(7, 94)} = 2.01$, $p = .06$).

Table 22

*Final Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Total Errors T-Score, MR1.5)*

| Block | Variable | Beta | *p* (beta) | *R* | $R^2$ | $R^2$ Change | *F* Change | *p* (*F* Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .21 | .04 | .04 | 4.47 | .04 |
| | Length of Shift | -.21 | .04 | | | | | |
| 2 | | | | .30 | .09 | .05 | 1.69 | .18 |
| | Length of Shift | -.20 | .04 | | | | | |
| | **PSQI Global Score** | -.20 | .09 | | | | | |
| | **BDI II Global Score** | .11 | .34 | | | | | |
| | **Exercise** | .12 | .24 | | | | | |
| 3 | | | | .36 | .13 | .04 | 1.43 | .24 |
| | Length of Shift | -.17 | .09 | | | | | |
| | PSQI Global Score | -.15 | .23 | | | | | |
| | BDI II Global Score | .17 | .18 | | | | | |
| | Exercise | .14 | .18 | | | | | |
| | **OFER15 Chronic Fatigue** | -.19 | .14 | | | | | |
| | **OFER15 Acute Fatigue** | .13 | .38 | | | | | |
| | **OFER15 Intershift Recovery** | .14 | .31 | | | | | |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised.

**Fatigue and WCST-64:CV2™ perseverative errors.** In my examination of the frequency distribution for WCST-64:CV2™ EF perseverative t-scores, I did not find any cases with scores greater than 3 standard deviations from the mean, and the histogram appeared to have normal distribution. Thus, it was assumed that the normality assumption was met. I also examined scatterplots of the standardized residuals against the predicted values, and there did not appear to be any evidence of heteroscedasticity. Recall that higher scores denote *better* executive functioning.

A second multiple regression model regressed EF perseverative errors on fatigue. The fatigue variables did not account for a significant amount of variance in WCST-64:CV2™ EF perseverative errors ($\Delta R^2 = .07$, $F_{change(4,88)} = 1.98$, $p = .10$) after controlling for gender, living situation (dummy coded with Single No Kids serving as the reference group), start time of shift, length of shift, sleep, mental health status, and times-per-week exercise. Neither was the model significant: $R^2 = .20$, $F_{(13,88)} = 1.71$, $p = .07$ (Table 23).

Table 23

*Initial Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Perseverative Errors T-Score, MR2.1)*

| Block | Variable | Beta | *p* (beta) | *R* | $R^2$ | $R^2$ Change | *F* Change | *p* (*F* Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .25 | .06 | .06 | 1.02 | .42 |
| | Gender (1=female) | .04 | .67 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | -.17 | .36 | | | | | |
| | Partnered No Kids vs. Single with Kids | -.20 | .29 | | | | | |
| | Partnered with Kids vs. Single with Kids | -.28 | .14 | | | | | |
| | Length of Shift | -.14 | .20 | | | | | |
| | Shift Start Time | .04 | .67 | | | | | |
| 2 | | | | .36 | .13 | .07 | 2.45 | .07 |
| | Gender (1=female) | .05 | .64 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | -.13 | .49 | | | | | |
| | Partnered No Kids vs. Single with Kids | -.17 | .35 | | | | | |
| | Partnered with Kids vs. Single with Kids | -.25 | .19 | | | | | |
| | Length of Shift | -.12 | .27 | | | | | |
| | Shift Start Time | .04 | .72 | | | | | |
| | **PSQI Global Score** | -.30 | .01 | | | | | |
| | **BDI II Global Score** | .09 | .46 | | | | | |
| | **Exercise** | -.02 | .87 | | | | | |
| 3 | | | | .45 | .20 | .07 | 1.98 | .10 |
| | Gender (1=female) | .09 | .39 | | | | | |
| | Living situation | | | | | | | |

| | | |
|---|---|---|
| Single No Kids vs. Single with Kids | -.18 | .34 |
| Partnered No Kids vs. Single with Kids | -.19 | .30 |
| Partnered with Kids vs. Single with Kids | -.28 | .15 |
| Length of Shift | -.06 | .59 |
| Shift Start Time | .08 | .47 |
| PSQI Global Score | -.26 | .05 |
| BDI II Global Score | .15 | .27 |
| Exercise | .03 | .77 |
| **OFER15 Chronic Fatigue** | -.27 | .04 |
| **OFER15 Acute Fatigue** | .20 | .19 |
| **OFER15 Intershift Recovery** | .21 | .16 |
| **CIS20R Total Score** | .06 | .71 |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised.

Overall Test of Model:
$F_{(13, 88)} = 1.71$, $p = .07$

Like MR1.1, the number of variables that were included in model MR2.1 may have used up too many degrees of freedom relative to the sample size available. This is apparent in the difference between the model $R^2$ and adjusted $R^2$ (e.g., .20 vs. .08). Thus, I performed a sensitivity analysis to determine whether a more parsimonious model would reveal significant predictors.

With gender removed, the adjusted $R^2$ for the full model improved slightly from .084 to .087 ($F_{(12, 89)} = 1.80$, $p = .06$) and there were no major differences in the regression coefficients for the remaining variables. With gender and start time of shift removed the adjusted $R^2$ improved to .09 ($F_{(11, 90)} = 1.94$, $p = .04$) without major differences in the regression coefficients for the remaining variables. With gender, start time of shift, and mental health status removed the adjusted $R^2$ did not change (.09) ($F_{(10, 91)} = 2.03$, $p = .04$) without major differences in the regression coefficients for the remaining variables. With gender, start time of shift, mental health status and times per week exercised removed the adjusted $R^2$ improved to .10 ($F_{(9, 92)} = 2.27$, $p = .02$) without major changes in the regression coefficients for the remaining variables. With gender, start time of shift, mental health status, times per week exercised, and living situation removed the final model had an adjusted $R^2$ of .108 ($F_{(6, 95)} = 3.03$, $p = .01$) without major changes in the regression coefficients for the remaining variables.

In this interim model (MR2.6, Table 24), the fatigue variables did not account for a significant amount of variance ($F_{\text{change}(4, 95)} = 1.60$, $p = .18$) WCST-64:CV2™ EF perseverative errors after controlling for length of shift, and sleep; however, the model was significant ($F_{(6, 95)} = 3.03$, $p = .01$). Although the model was significant, the block was not so I continued refining the model, removing variables based on regression coefficients.

Table 24

*Interim Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Perseverative Errors T-Score, MR2.6)*

| Block | Variable | Beta | *p* (beta) | *R* | $R^2$ | $R^2$ Change | *F* Change | *p* (*F* Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .18 | .03 | .03 | 3.48 | .07 |
| | Length of Shift | -.18 | .07 | | | | | |
| 2 | | | | .32 | .10 | .07 | 7.79 | .01 |
| | Length of Shift | -.16 | .11 | | | | | |
| | **PSQI Global Score** | -.27 | .01 | | | | | |
| 3 | | | | .40 | .16 | .06 | 1.60 | .18 |
| | Length of Shift | -.11 | .25 | | | | | |
| | PSQI Global Score | -.24 | .05 | | | | | |
| | **OFER15 Chronic Fatigue** | -.26 | .05 | | | | | |
| | **OFER15 Acute Fatigue** | .20 | .18 | | | | | |
| | **OFER15 Intershift Recovery** | .15 | .29 | | | | | |
| | **CIS20R Total Score** | .05 | .71 | | | | | |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised.

Overall Test of Model:

$F_{(6, 95)} = 3.03$, $p = .01$

I removed CIS20R total score from the model and the adjusted $R^2$ improved to .12 ($F_{(5, 96)} = 3.64$, $p < .01$) without major differences in the regression coefficients for the remaining variables. Removing intershift recovery did not change the adjusted $R^2$ ($F_{(4, 97)} = 4.29$, $p < .01$) and did not change regression coefficients. With shift length removed the adjusted $R^2$ changed to .11 without major changes in the regression coefficients of the remaining variables.

In this final model (MR2.9, Table 25), the chronic fatigue and acute fatigue accounted for 5.5% ($F_{\text{change}\,(2, 100)} = 3.17$, $p < .05$) of the variance in WCST-64:CV2™ EF perseverative errors after controlling for and sleep; and the model was significant ($F_{(3, 100)} = 5.03$, $p < .01$). Based on the regression coefficients, sleep and chronic fatigue were significantly contributed to EF perseverative errors..

Table 25

*Final Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Perseverative Errors T-Score, MR2.9)*

| Block | Variable | Beta | $p$ (beta) | $R$ | $R^2$ | $R^2$ Change | $F$ Change | $p$ ($F$ Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .28 | .08 | .08 | 8.38 | < .01 |
| | **PSQI Global Score** | -.28 | < .01 | | | | | |
| 2 | | | | .37 | .13 | .06 | 3.17 | < .05 |
| | PSQI Global Score | -.26 | .01 | | | | | |
| | **OFER15 Chronic Fatigue** | -.30 | .01 | | | | | |
| | **OFER15 Acute Fatigue** | .17 | .17 | | | | | |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale.

Overall Test of Model:

$F_{(3, 100)} = 5.03$, $p < .01$

**Fatigue and WCST-64:CV2™ nonperseverative errors.** A third multiple regression model regressed fatigue on EF nonperseverative errors after controlling for gender, living situation (dummy coded with the category Single No Kids serving as the reference group), start time of shift, length of shift, sleep, mental health status, and times-per-week exercise.

Whereas the raw score for EF nonperseverative errors was the number of nonperseverative errors, the t-score was now an indication of level of EF and changed the direction of the relationship between EF nonperseverative error and fatigue. In my examination of the frequency distribution for WCST-64:CV2™ EF nonperseverative t-scores  I did not find any cases with scores greater than 3 standard deviations from the mean, and this was supported by the histogram of score distribution. Thus, it was assumed that the normality assumption was met. I also examined scatterplots of the standardized residuals against the predicted values, and there did not appear to be any evidence of heteroscedasticity. Recall that using the t-score changed the interpretation of nonperseverative errors in that high level of nonperseverative errors denote *better* executive functioning.

The fatigue variables did not account for a significant amount of the variance in WCST-64:CV2™ EF nonperseverative errors ($\Delta R^2$ = .03, $F_{change(4,88)}$ = .69, $p$ = .60) after controlling for gender, living situation (dummy coded with Single No Kids serving as the reference group), start time of shift, length of shift, sleep, mental health status, and times-per-week exercise. Neither was the model significant, $R^2$ = .13, $F_{(13,88)}$ = 1.17, $p$ = .32 (Table 26).

Table 26

*Initial Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Non-Perseverative Errors T-Score, MR3.1)*

| Block | Variable | Beta | *p* (beta) | *R* | $R^2$ | $R^2$ Change | *F* Change | *p* (*F* Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .27 | .07 | .07 | 1.24 | .29 |
| | Gender (1=female) | -.10 | .34 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | -.28 | .14 | | | | | |
| | Partnered No Kids vs. Single with Kids | -.22 | .24 | | | | | |
| | Partnered with Kids vs. Single with Kids | -.30 | .12 | | | | | |
| | Length of Shift | -.15 | .17 | | | | | |
| | Shift Start Time | .08 | .87 | | | | | |
| 2 | | | | .35 | .12 | .05 | 1.66 | .18 |
| | Gender (1=female) | -.08 | .44 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | -.29 | .12 | | | | | |
| | Partnered No Kids vs. Single with Kids | -.21 | .29 | | | | | |
| | Partnered with Kids vs. Single with Kids | -.25 | .20 | | | | | |
| | Length of Shift | -.16 | .13 | | | | | |
| | Shift Start Time | .09 | .79 | | | | | |
| | **PSQI Global Score** | -.14 | .22 | | | | | |
| | **BDI II Global Score** | .16 | .18 | | | | | |
| | **Exercise** | .17 | .12 | | | | | |
| 3 | | | | .38 | .15 | .03 | .69 | .60 |
| | Gender (1=female) | -.05 | .65 | | | | | |

| | | |
|---|---|---|
| Living situation | | |
| Single No Kids vs. Single with Kids | -.32 | .09 |
| Partnered No Kids vs. Single with Kids | -.25 | .19 |
| Partnered with Kids vs. Single with Kids | -.29 | .15 |
| Length of Shift | -.13 | .25 |
| Shift Start Time | .06 | .58 |
| PSQI Global Score | -.10 | .45 |
| BDI II Global Score | .17 | .23 |
| Exercise | .21 | .07 |
| **OFER15 Chronic Fatigue** | -.09 | .50 |
| **OFER15 Acute Fatigue** | .11 | .50 |
| **OFER15 Intershift Recovery** | .21 | .18 |
| **CIS20R Total Score** | .09 | .59 |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised.

Overall Test of Model:
$F$ (13, 88) = 1.17, $p$ = .32

As with the previous regression models, the number of variables that were included in the model may have used up too many degrees of freedom relative to the sample size available. This is apparent in the difference between the model $R^2$ and adjusted $R^2$ (.15 vs. .02). Thus, I performed a sensitivity analysis to determine whether a more parsimonious model would reveal significant predictors.

With gender removed, the adjusted $R^2$ for the full model improved slightly from .021 to .03 ($F_{(12, 89)} = 1.26$, $p = .26$), there were no major differences in the regression coefficients for the remaining variables. With gender and living situation removed the adjusted $R^2$ did not change ($F_{(9, 92)} = 1.33$, $p = .23$), without major differences in the regression coefficients for the remaining variables. Living situation was added back in the model and start time of shift was removed, so with gender, and start time of shift, removed the adjusted $R^2$ improved to .037 ($F_{(11, 90)} = 1.35$, $p = .21$), without major differences in the regression coefficients for the remaining variables. With gender, start time of shift, and living situation removed the adjusted $R^2$ changed slightly to .034 ($F_{(8, 93)} = 1.44$, $p = .19$), without major changes in the regression coefficients for the remaining variables. With gender, start time of shift, living situation, and mental health status, removed the model adjusted $R^2$ decreased slightly to.032 ($F_{(7, 94)} = 1.47$, $p = .19$), without major changes in the regression coefficients for the remaining variables. Because the adjusted $R^2$ did not improve, mental health status was added back into the model and the total fatigue score (CIS20R) was removed. With gender, start time of shift, living situation, and total fatigue removed the adjusted $R^2$ improved to .041 ($F_{(7, 94)} = 1.61$, $p = .14$) without major changes in the regression coefficients for the remaining variables. Acute fatigue was removed to determine if the model could be improved further, and with gender, start time of shift, living situation, total fatigue, and acute fatigue the adjusted $R^2$ did improve to .048, without major changes in the regression coefficients for the remaining variables.

In the final model (MR3.8, Table 27), chronic fatigue and intershift recovery did not account for a significant amount of variance ($\Delta R^2$ = .02, $F_{change(2,95)}$ = .92, $p$ = .40) in EF nonperseverative errors after controlling for length of shift, sleep, mental health status and exercise and neither was the model significant ($F_{(6, 95)}$ = 1.86, $p$ = .10).

Table 27
*Final Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Non-Perseverative Errors T-Score, MR3.8)*

| Block | Variable | Beta | $p$ (beta) | $R$ | $R^2$ | $R^2$ Change | $F$ Change | $p$ ($F$ Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .18 | .03 | .03 | 3.42 | .07 |
| | Length of Shift | -.18 | .07 | | | | | |
| 2 | | | | .30 | .09 | .06 | 1.94 | .13 |
| | Length of Shift | -.19 | .06 | | | | | |
| | **PSQI Global Score** | -.16 | .18 | | | | | |
| | **BDI II Global Score** | .14 | .22 | | | | | |
| | **Exercise** | .18 | .08 | | | | | |
| 3 | | | | .32 | .11 | .02 | .92 | .40 |
| | Length of Shift | -.17 | .09 | | | | | |
| | PSQI Global Score | -.10 | .43 | | | | | |
| | BDI II Global Score | .19 | .13 | | | | | |
| | Exercise | .18 | .08 | | | | | |
| | **OFER15 Chronic Fatigue** | -.06 | .63 | | | | | |
| | **OFER15 Intershift Recovery** | .12 | .35 | | | | | |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised.

Overall Test of Model:
$F$ (6, 95) = 1.86, $p$ = .10

**Fatigue and WCST-64:CV2™ categories completed.** The raw score for EF categories completed was used because a standardized score was unavailable. The distribution of scores appeared normally distributed on the histogram, so no transformation was performed. Age was included in the initial hierarchical regression because EF categories completed was not standardized for age and educational level as were the first three EF variables. A fourth multiple regression model regressed EF categories completed on fatigue after controlling for age, gender, living situation (dummy coded with the category Single No Kids serving as the reference group), shift currently working, sleep, mental health status, and times-per-week exercise. The control variables were entered in two separate blocks to evaluate the unique effect of age, gender, living situation, shift (block 1); and sleep, exercise, and mental health status variables (block 2).

In my examination of the frequency distribution for WCST-64:CV2™ EF categories completed I did not find any cases with scores greater than 3 standard deviations from the mean and histogram supported this finding. I also examined scatterplots of the standardized residuals against the predicted values, and there did not appear to be any evidence of heteroscedasticity.

The fatigue variables did not account for a significant amount of variance in WCST-64:CV2™ EF categories completed ($\Delta R^2 = .04$, $F_{change(4,87)} = .87$, $p = .49$), after controlling for age, gender, living situation (dummy coded with Single No Kids serving as the reference group), start time of shift, length of shift, sleep, mental health status, and times-per-week exercise. The overall model was not significant, $F_{(14,\,87)} = .82$, $p = .65$ (Table 28).

Table 28

*Initial Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Categories Completed, Raw Score,MR4.1)*

| Block | Variable | Beta | *p* (beta) | *R* | $R^2$ | $R^2$ Change | *F* Change | *p* (*F* Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .22 | .05 | .05 | 0.69 | .68 |
| | Gender (1=female) | -.04 | .72 | | | | | |
| | Age | -.00 | .97 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | -.22 | .25 | | | | | |
| | Partnered No Kids vs. Single with Kids | -.19 | .31 | | | | | |
| | Partnered with Kids vs. Single with Kids | -.20 | .31 | | | | | |
| | Length of Shift | -.16 | .14 | | | | | |
| | Shift Start Time | .02 | .87 | | | | | |
| 2 | | | | .29 | .08 | .03 | 1.08 | .36 |
| | Gender (1=female) | -.03 | .79 | | | | | |
| | Age | -.01 | .90 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | -.22 | .27 | | | | | |
| | Partnered No Kids vs. Single with Kids | -.18 | .34 | | | | | |
| | Partnered with Kids vs. Single with Kids | -.17 | .40 | | | | | |
| | Length of Shift | -.16 | .16 | | | | | |
| | Shift Start Time | .02 | .84 | | | | | |
| | **PSQI Global Score** | -.20 | .10 | | | | | |
| | **BDI II Global Score** | .12 | .31 | | | | | |
| | **Exercise** | .05 | .64 | | | | | |
| 3 | | | | .34 | .12 | .04 | 0.87 | .49 |

| | | |
|---|---|---|
| Gender (1=female) | -.02 | .87 |
| Age | -.03 | .79 |
| Living situation | | |
| Single No Kids vs. Single with Kids | -.26 | .19 |
| Partnered No Kids vs. Single with Kids | -.19 | .34 |
| Partnered with Kids vs. Single with Kids | -.17 | .40 |
| Length of Shift | -.12 | .27 |
| Shift Start Time | .03 | .75 |
| PSQI Global Score | -.16 | .22 |
| BDI II Global Score | .19 | .18 |
| Exercise | .08 | .49 |
| **OFER15 Chronic Fatigue** | -.19 | .18 |
| **OFER15 Acute Fatigue** | .20 | .23 |
| **OFER15 Intershift Recovery** | .10 | .53 |
| **CIS20R Total Score** | -.08 | .62 |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised.

Overall Test of Model:
$F$ (14, 87) = 0.82, $p$ = .65

As with the previous regression models, the number of variables that were included in the model may have used up too many degrees of freedom relative to the sample size available. This is apparent in the difference between the model $R^2$ and adjusted $R^2$ (.12 vs. - .03). Thus, I performed a sensitivity analysis to determine whether a more parsimonious model would reveal significant predictors.

With gender removed, the adjusted $R^2$ for the full model decreased from - .03 to - .01, there were no major differences in the regression coefficients for the remaining variables ($F_{(12, 89)} = .97$, $p = .48$). With gender and age removed the adjusted $R^2$ changed to - .004, without major differences in the regression coefficients for the remaining variables ($F_{(9, 92)} = 1.11$, $p = .36$). With gender, age and living situation removed the adjusted $R^2$ improved to .01 without major differences in the regression coefficients for the remaining variables ($F_{(8, 93)} = 1.23$, $p = .29$). With gender, age, living situation, and start time of shift removed the adjusted $R^2$ changed slightly to .018, without major changes in the regression coefficients for the remaining variables ($F_{(8, 93)} = 1.23$, $p = .29$). With gender, age, living situation, start time of shift, and exercise removed the model adjusted $R^2$ increased slightly to.026 without major changes in the regression coefficients for the remaining variables ($F_{(7, 94)} = 1.38$, $p = .22$). The additional removal of mental health status decreased the adjusted $R^2$ to .020 ($F_{(6, 95)} = 1.35$, $p = .25$). Because the adjusted $R^2$ did not improve upon removal, mental health status was added back into the model and the acute fatigue score was removed. With gender, age, start time of shift, living situation, exercise and acute fatigue removed the adjusted $R^2$ improved to .028 without major changes in the regression coefficients for the remaining variables ($F_{(6, 95)} = 1.49$, $p = .19$). Acute fatigue was returned to the model to determine if the model could be improved further, and with gender, age, start time of shift, living situation, exercise, total fatigue removed the adjusted $R^2$ did improve to .033, without major changes in the regression coefficients for the remaining variables.

In this final model (MR4.10, Table 29), chronic fatigue, acute fatigue and intershift recovery did not account for a significant amount of variance ($\Delta R^2 = .026$, $F_{change(3, 95)} = .90$, $p = .44$) in WCST-64:CV2™ EF categories completed after controlling for length of shift, mental health status, and sleep. After nine steps of model refinement the model remained non-significant ($F_{(6, 95)} = 1.57$, $p = .16$).

Table 29

*Final Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Categories Completed, Raw Score, MR4.10)*

| Block | Variable | Beta | *p* (beta) | *R* | $R^2$ | $R^2$ Change | *F* Change | *p* (*F* Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .18 | .03 | .03 | 3.25 | .07 |
| | Length of Shift | -.18 | .07 | | | | | |
| 2 | | | | .25 | .06 | .03 | 1.72 | .18 |
| | Length of Shift | -.16 | .10 | | | | | |
| | **PSQI Global Score** | -.21 | .07 | | | | | |
| | **BDI II Global Score** | .10 | .39 | | | | | |
| 3 | | | | .30 | .09 | .03 | 0.90 | .44 |
| | Length of Shift | -.13 | .19 | | | | | |
| | PSQI Global Score | -.20 | .12 | | | | | |
| | BDI II Global Score | .14 | .27 | | | | | |
| | **OFER15 Chronic Fatigue** | -.19 | .16 | | | | | |
| | **OFER15 Acute Fatigue** | .11 | .44 | | | | | |
| | **OFER15 Intershift Recovery** | .07 | .65 | | | | | |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised.

Overall Test of Model:
$F$ (6, 95) = 1.57, $p$ = .16

**Fatigue and WCST-64:CV2™ trials to complete the first category.** The EF trials to complete the first category violated the normally assumption of multiple regression (skewness – 2.721, kurtosis = 6.77), and the distribution histogram supported this finding. The EF trials to complete the first category was transformed with natural log. The histogram and skewness were now more normal, so I decided to use the natural log transformed score for the regression analysis. A sensitivity analysis done with the original variable did not result is major differences compared to the natural log variable. EF trials to complete the first category was also not standardized for age so age was entered into the initial regression model. A multiple regression model regressed EF trials to complete the first category on fatigue after controlling for age, gender, living situation (dummy coded with the category Single No Kids serving as the reference group), start time of shift, length of shift, sleep, mental health status, and times-per-week exercise.

With EF trials to completed log transformed, the fatigue variables did not account for a significant amount of the variance in WCST-64:CV2™ EF trials to complete the first category ($\Delta R^2 = .04$, $F_{change(4,87)} = .98$, $p = .42$) after controlling for age, gender, living situation, start time of shift, length of shift, sleep, mental status and exercise. The overall model was also not significant ($F_{(14, 87)} = 1.22$, $p = .28$ (Table 30)).

Table 30

*Initial Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Trials to Complete First Category, MR5.1)*

| Block | Variable | Beta | *p* (beta) | *R* | $R^2$ | $R^2$ Change | *F* Change | *p* (*F* Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .27 | .07 | .07 | 1.05 | .40 |
| | Gender (1=female) | .13 | .19 | | | | | |
| | Age | -.11 | .31 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | .08 | .66 | | | | | |
| | Partnered No Kids vs. Single with Kids | .17 | .37 | | | | | |
| | Partnered with Kids vs. Single with Kids | .18 | .36 | | | | | |
| | Length of Shift | .18 | .10 | | | | | |
| | Shift Start Time | .03 | .74 | | | | | |
| 2 | | | | .36 | .13 | .05 | 1.84 | .15 |
| | Gender (1=female) | .12 | .22 | | | | | |
| | Age | -.10 | .37 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | .06 | .75 | | | | | |
| | Partnered No Kids vs. Single with Kids | .15 | .43 | | | | | |
| | Partnered with Kids vs. Single with Kids | .12 | .52 | | | | | |
| | Length of Shift | .17 | .11 | | | | | |
| | Shift Start Time | .04 | .67 | | | | | |
| | **PSQI Global Score** | .24 | .05 | | | | | |
| | **BDI II Global Score** | -.09 | .48 | | | | | |
| | **Exercise** | -.08 | .47 | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 3 | | | | .40 | .16 | .04 | 0.98 | .42 |
| | Gender (1=female) | .08 | .44 | | | | | |
| | Age | -.09 | .40 | | | | | |
| | Living situation | | | | | | | |
| | Single No Kids vs. Single with Kids | .08 | .68 | | | | | |
| | Partnered No Kids vs. Single with Kids | .18 | .36 | | | | | |
| | Partnered with Kids vs. Single with Kids | .15 | .45 | | | | | |
| | Length of Shift | .13 | .22 | | | | | |
| | Shift Start Time | .02 | .83 | | | | | |
| | PSQI Global Score | .18 | .18 | | | | | |
| | BDI II Global Score | -.14 | .33 | | | | | |
| | Exercise | -.10 | .40 | | | | | |
| | **OFER15 Chronic Fatigue** | .12 | .37 | | | | | |
| | **OFER15 Acute Fatigue** | .02 | .88 | | | | | |
| | **OFER15 Intershift Recovery** | -.17 | .27 | | | | | |
| | **CIS20R Total Score** | -.09 | .57 | | | | | |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised.

Overall Test of Model 3:
$F$ (14, 87) = 1.22, $p$ = .28

Because the number of variables that were included in the model may have used up too many degrees of freedom relative to the sample size available, I again modified the model with the goal of improving fit (difference between observed $R^2$ and adjusted $R^2$ was .16 and .03, respectively).

With age removed, the adjusted $R^2$ did not change; there were no major differences in the regression coefficients for the remaining variables ($F_{(13, 88)} = 1.26$, $p = .26$). With age and living situation removed the adjusted $R^2$ changed to .05, without major differences in the regression coefficients for the remaining variables ($F_{(10, 91)} = 1.53$, $p = .14$). With age, living situation, and start time of shift removed the adjusted $R^2$ improved to .60, without major changes in the regression coefficients for the remaining variables ($F_{(9, 92)} = 1.71$, $p = .10$). With age, living situation, start time and gender removed the adjusted $R^2$ only slightly improved to .62 without major changes in the regression coefficients for the remaining variables ( $F_{(8, 93)} = 1.84$, $p = .08$). With age, living situation, start time of shift, gender and total fatigue removed the adjusted $R^2$ improved to .07 without major changes in regressions coefficients for the remaining variables ($F_{(7, 94)} = 2.08$, $p = .05$).

The final hierarchical multiple regression regressed log EF trials to complete the first category on fatigue (MR5.6, Table 31). Chronic fatigue, acute fatigue, and intershift recovery did not account for a significant amount of variance ($\Delta R^2 = .04$, $F_{change\ (3, 94)} = 1.55$, $p = .20$) after controlling for length of shift, sleep, depression and exercise; and the model was not significant ($F_{(7, 94)} = 2.08$, $p = .05$).

Table 31

*Final Hierarchical Multiple Regression of Fatigue Predicting Executive Function (Trials to Complete First Category, MR5.6)*

| Block | Variable | Beta | $p$ (beta) | $R$ | $R^2$ | $R^2$ Change | $F$ Change | $p$ ($F$ Change) |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | .16 | .03 | .03 | 2.77 | .10 |
| | Length of Shift | .16 | .10 | | | | | |
| 2 | | | | .30 | .09 | .06 | 2.29 | .08 |
| | Length of Shift | .15 | .12 | | | | | |
| | **PSQI Global Score** | .24 | .04 | | | | | |
| | **BDI II Global Score** | -.10 | .39 | | | | | |
| | **Exercise** | -.12 | .25 | | | | | |
| 3 | | | | .37 | .13 | .04 | 1.55 | .21 |
| | Length of Shift | .12 | .22 | | | | | |
| | PSQI Global Score | .17 | .19 | | | | | |
| | BDI II Global Score | -.18 | .14 | | | | | |
| | Exercise | -.12 | .25 | | | | | |
| | **OFER15 Chronic Fatigue** | .14 | .27 | | | | | |
| | **OFER15 Acute Fatigue** | .00 | .99 | | | | | |
| | **OFER15 Intershift Recovery** | -.14 | .31 | | | | | |

Note: Bolded variables indicate they were added in the block. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II; OFER15 = Occupational Fatigue Exhaustion Recover 15 Scale; CIS20R = Checklist Individual Strength 20 Revised.

Overall Test of Model:

$F_{(7, 94)} = 2.08$, $p = .05$

**Open-Ended Question Responses**

One open-ended question: “What do you think most contributes to your level of fatigue?’ was asked of all participants to solicit their understanding of contributors to their fatigue and to solicit their story or experience of fatigue. Space was provided for the participants to write in their response. Most participants gave short responses; however, even the short responses provided rich descriptions.

The open-ended question was located at the end of the pencil-and-paper survey (Appendix B). Of the 108 total participants, 104 provided written responses to the open-ended question. The qualitative responses provided additional information for possible variables not yet quantitatively measured, provided direction for further exploration on unexplained variance in predicting EF, and provided revealing insights into their experience of fatigue.

A phenomological approach was used to categorize the responses into themes with exemplar responses. These themes were often stated within one response, and this indicated that contributors to fatigue were complex and intertwined with other themes. Five themes emerged: sleep; the work of nursing; family and work-life balance; personal habits, choices, and attributes; and circadian rhythm. Appendix J provides more information on the themes.

**Sleep**

Participants in this study identified *sleep* as a major contributor to their fatigue. The lack of sleep was a major theme and the reason most often given for their fatigue. Sleep quality, sleep duration, and sleep interruptions were also noted. Many had young families and said getting up to care for young children interrupted their sleep. Many participants stated they tried to take a nap before going to work, but this was not always possible. They often struggled with trying to stay on a sleep schedule conducive to their working schedule and the need to be on the family's sleep schedule. The nature of shiftwork and the timing of hospital shifts caused many disruptions to their sleep schedule. Working nightshift was often given as an explanation for fatigue: *"Having to continually accommodate my time to working night shift. Preparing for bed, meals (eating later) and trying to get things done all in a day on my day off (not going to bed on my day off in the am – don't want to waste my day sleeping."*

Many participants implied a lack of quality sleep ("*bad sleeping patterns," "hard to sleep on hot days")*. A lack of adequate sleep duration or restorative sleep was a recurring theme (*"inability to fall asleep," "not enough sleep"*). Many participants, particularly those working night shift, commented on sleep interruptions: "*Interruption to my sleep such as neighbor mowing lawn, dog barking…things like that"* and "*Odd hours of sleeping due to night shift hours and being woken by typical 'daily' activities such as lawnmowers, phone calls, etc."* Interruptions were not limited to the night shift, and many participants noted that family demands, especially young children, interrupted their usual sleep duration.

**The Work of Nursing**

Many of the participants stated or implied that nursing was hard work. Many participants stated the work was mentally exhausting, and several stated they ruminated about work on their off-time. Several participants stated disappointment that they were not able to provide the level of care they wanted or that the expectations of the job did not allow them to provide the level of care they wanted to provide (*"Many times I feel too stretched to do as good of job as I would like to"*). The physical demands of the work of nursing such as "*being on my feet"* and the "*need to care for obese patients"* were fatiguing. One participant stated that work was "*emotionally draining."*

Participants stated that inappropriate or unanticipated admissions, patient acuity, lack of support from co-workers, unexpected procedures, and the need to chart contribute to their fatigue. Participants noted that the nurse "*has to deal with´* inappropriate admissions; however, they also noted that patients being admitted have higher acuity than they have seen in the past.

> "*Having 5 patients that are difficult or heavy care. Noticed lately* [that approximately 40% of the patients] *either are not appropriate or not necessary to have been admitted. Just fill a bed with whatever and deal with it. This does not make a good working environment."*

Many participants commented that their workload was very heavy and the "*expectations of the job have increased (do more with less*)" and they were "*trying to do more than possible in a given day/time frame."* Another stated, *"Work in fast-paced unit, takes great effort to complete work in a particular shift."* The participants often stated they did not have adequate support from co-workers when needed. The work of nursing also meant assisting with or completing procedures that were unanticipated and this led to disruptions in their work flow. *"Multiple interruptions so tasks take much longer than they should & at times I feel fragmented (pulled in many directions)."* These disruptions or unanticipated procedures may have led to one participant to state: '*thoughts that I may have missed something"* contributed to his or her fatigue.

**Family and Work-Life Balance**

Sleep and the work of nursing were not the only contributors to the participants' fatigue. The participants stated that normal family demands, including being responsible for children or family members, being a part of a family, and the family being on a different schedule from work, contributed to their fatigue. Family/work balance and sleep were often stated together. *"Not getting enough sleep because of trying to balance family, boyfriend, work, fun and rest." "My 3 yr old son still wakes up at least once per night and both of my children wake up [between] 7 or 8:30. I don't always get to catch up on sleep before next shift."*

Many participants noted "*normal kid" and "family demands"* as contributors to fatigue, but they did not provide additional comments. Several participants noted *"child wake cycle is different from my wake cycle."* One participant sacrificed sleep for family involvement when he or she woke *"up in the early afternoon because I don't want to 'miss out' on family/friend time when I should still be sleeping."* Several participants commented on "*stress at home," "being responsible for household finances,"* and *"working nights – taking care of the kids during the day"* as fatiguing. Another participant was the caregiver for a family member with a chronic illness.

**Personal Habits, Choices, and Attributes**

Participants acknowledged that their personal habits (lack of exercise, poor eating habits), choices (commute), and health issues contributed to their fatigue. Many stated they had a "*lack of exercise," "less than I used to," or* I'm *"fatigued when I don't exercise."* A few struggled to fit exercise into their schedule and this seemed to imply that they recognized that exercise might help alleviate fatigue. One participant, however, stated "*exercise before work fatigues me."*

Poor eating habits contributed to fatigue, and participants noted that "*skipping meals leads to eating more later,"* that eating *"was not balanced,"* and that their eating was not *"managed for optimal energy."* Several participants noted that it was difficult to take a break or eat during the working shift. "*Stress from work-load, fast-pace of my shift no time for a break or time to relax and eat my dinner most of the time."* One participant acknowledged "*personal weight"* contributed to his or her fatigue.

Several participants noted that their commute either was fatiguing or contributed to fatigue. The commute required them to maintain a level of alertness to insure a safe commute. One stated a *"35 minute commute home forces me to stay awake and makes it difficult to unwind when I get home."* On the other hand, the length of the commute was cited by one participant as a potential danger: *"*[a] *1.5 hour drive home in heavy traffic after working 8 hours with demanding patients. I'm usually ok energy-wise until 30 minutes into my drive home*."

Several participants were dealing with health issues, which they stated contributed to fatigue. They noted contributors of *"medication," "increase in health problems," "chronic health issues,"* and *"history of cancer."* One had "*chronic back pain from a* *previous occupation"* in construction. A few participants declared stress in general, personal stress, life stress, or mental stress was fatiguing. One participant had complex family and health issues: *"Underlying autoimmune disease, stress over life & money. Vit B12 deficiency. Recent death of sister. I hate my job currently. I hate working weekends."*

**Circadian Rhythm**

The participants' circadian rhythm was stated in conjunction with other themes, and was also stated enough times separately that it was important to include circadian rhythm as a separate theme. Many participants noted that the time of work or shift work was not the same as their own circadian rhythm. *"Working nights, being on an opposite schedule as my circadian rhythm while also trying to go to school and keep fit."* This dysynchronicity was often stated in relation to sleep: ("*Not getting good sleep because I have to try to sleep during the day")*; however, it was also related to family schedules. One participant succinctly stated, *"Noc* [night] *shift. New baby."* An exemplar of the interconnectedness of circadian rhythm with other themes of a new job, mental demands, and physical demands was this: "*Having to wake before the sun. I am solar powered and crave the sun light. This new job is a lot to learn. It is like being in class 8 hours while also speed walking the entire time."* This participant was still in orientation, working day shift, so even working the day shift affected circadian rhythm.

Other individual responses were not mentioned often enough to warrant a theme but are important to mention. Several participants stated that "stress" contributed to their fatigue; however, they did not provide details. A few specifically noted *"personal," "life,"* or *"mental"* stress without further explanation that might have suggested inclusion into a previous theme. Several participants stated a challenge with *"time"* and *"trying to fit it all in,"* "*lack of time,"* or "*procrastination.*" Time was also interconnected with the work of nursing and even a disappointment or dissatisfaction with the job; one participant stated: " *sometimes work is so busy [that] I don't get the same pleasure from nursing as I do on less busy days and this is discouraging*." One participant seemed to suffer from ennui or a *"lack of motivation."* Many noted the demands of non-work activities such as school, just moved, or too much to do on the days off. Participants also stated that a "*lack of social life outside of work"* and that "*personal weight"* contributed to fatigue.

Overall, the participants noted a lack of restorative sleep. They stated that nursing was hard work, stressful, and fatiguing. The participants acknowledged incongruence between the level of care they wanted to provide and the level of care they were able to provide. The work of nursing, unanticipated admissions, unanticipated procedures, and charting, which are part of the normal work day, contributed to fatigue. The demands of family or trying to maintain a family/work-life balance added to individual fatigue. Many seemed to know exercise would alleviate fatigue and noted that a lack of exercise added to their fatigue level. Other personal habits, choices, or attributes that contributed to fatigue included poor eating, weight, the length of the commute to and from work, and new or chronic health issues. Circadian rhythm was mentioned several times and was integrated into responses related to sleep, the work of nursing, and family work-life balance. The themes revealed in the open-ended question on the sociodemographic questionnaire supported the quantitative results of the variables involving living situation and sleep; however, the themes provided more description about the work environment, family situations, and circadian rhythm that had not been captured in the quantitative surveys. The interconnectedness of the themes within individual responses revealed that even short responses are just verses in a song, and one must sing the whole song to get the story.

# CHAPTER 6

# DISCUSSION AND LIMITATIONS

## Interpretations of the Results

This study explored fatigue and executive function (EF) in nurses. Fatigue, sleep and mental health status had been previously studied in nurses. This study extended the knowledge of fatigue in nurses because it (1) employed two fatigue instruments to more comprehensively describe the multidimensionality of fatigue; (2) described EF in nurses; (3) examined the relationship between fatigue and EF; and (4) explored the unique contribution of fatigue to EF.

In this study I looked at the relationship between sociodemographic characteristics, sleep quality, mental health status, and characteristics of the work of nurses and fatigue and EF. Based on previous studies with nurses as the population (Kunert et al. 2007; Ruggerio, 2003), I hypothesized sleep and mental health status, specifically depression, to be strongly related to fatigue. I also hypothesized fatigue to be negatively associated with EF (Hockey, 1997; van der Linden & Eling, 2006; van der Linden et al., 2003). The results of this study supported these expectations as well as the results from the previous studies.

**Fatigue**. The theoretical framework for this study posited that fatigue was influenced by person-level variables (sociodemographic characteristics of the individual, sleep, mental health status, intershift recovery, and exercise) and organization-level characteristics (start time of shift, length of shift, extended work hours, and circadian rhythm). Chronic or prolonged fatigue occurs when fatigue lasts longer than two weeks, and it was theorized to be a result of acute fatigue (a normal phenomenon in response to depletion of energy) not resolved by adequate intershift recovery.

**Sociodemographic variables.** The majority of nurses in this study were relatively young, had a baccalaureate or higher nursing degree, worked primarily 8-hour shifts, did not have responsibilities for children during their non-working hours, had adequate non-working time for adequate intershift recovery, and engaged in exercise at least twice a week. They were also working their preferred shift and preferred shift length. Thus, this sample may be different from those previously reported. Because the average age of nurses in this study (33 years old) was much lower than the Washington State average (49 years old), the results may suggest that this younger sample prefers working fewer hours per day and was able to recovery energy during non-working hours. As the bubble of nurses who are baby-boomers prepares to retire, a return to 8 hour shifts may provide the between-shift recovery this sample has described.

Similar to results presented by Ruggerio (2003) and Winwood and Lushington (2006), age did not have a significant relationship to fatigue. Winwood et al. (2006a) found that age was negatively correlated to OFER intershift recovery, which suggested that older nurses may have better recovery between shifts than younger nurses. Gender was not significantly related to fatigue in the present study, similar to a study of Australian nurses (Winwood et al., 2006a). In this study, the relationships between living situation and fatigue were small and not significant, and the multiple regression analyses revealed living situation as not being a predictor of EF. It could be argued that age, gender, and living situation, as independent variables, have consistently been shown to not be significant predictors of fatigue, and that other independent variables are more important to measure, especially when considering measurement burden and feasibility.

Age, gender and living situation were also not predictors of EF, and this finding suggests these sociodemographic variables may not need to be included in future regression models.

Sociodemographic variables will always need to be measured for their importance to characterize the sample.

This study did not find significant relationships between level of nursing degree and fatigue, which is similar to the study with Australian nurses (Winwood et al., 2006a). This study also explored sociodemographic characteristics not explored by Ruggerio (2003) and found that shift currently working, shift preferred working, shift typically worked, and shift length did not have significant relationships with fatigue. Winwood et al. (2006a) found rotating shifts to be the most important factor in chronic fatigue; given that participants in this study did not rotate shifts, I could not test this relationship.

Nurse characteristics of education level, advanced certification, years of nursing experience, and years at the current job were also not found to have significant relationships to fatigue and EF. These results have not been reported in other studies, and the small sample size may have underpowered this current study. Future studies with larger sample sizes are suggested to further explore these relationships.

**Sleep.** The participants in this study had lower mean scores on the global PSQI than participants in other studies (Fang, 2008; Kunert et al., 2007; Ruggerio, 2003; Scott, 2010; Winwood et al., 2006a, 2006b). Several factors contributed to the lower global sleep score, and these factors were daytime dysfunction, sleep disturbances, decreased sleep efficiency, difficulty falling asleep quickly and low sleep duration.

The participants perceived they had had fairly good sleep quality over the past month; however, 56% met the criteria for poor sleepers. The sleep quality of participants in the current study is lower than in previous studies of nurses (Fang, 2008; Ruggerio, 2003, Scott, 2010). The current results may be because the nurses in this study on average were young, they exercised, they worked shorter shifts, and they did not rotate shifts; however, more studies are needed to support this assumption.

This study also supports significant relationships between sleep, and chronic fatigue, and acute fatigue (Fang, 2008; Winwood & Lushington, 2006; Winwood et al., 2006a, 2006b). This study did not find significant group differences based on shift working, sleep duration, use of sleep medication, and daytime dysfunction, which does not support the finding in Kunert et al. (2007).

**Mental health status**. Twenty-four percent of the participants in this study were mildly or moderately depressed, similar to the nurses in Ruggerio's (2003) study of critical care nurse fatigue (23%). Although this may seem alarming, this is consistent with the general population (Kessler, 2005). In addition, work environment characteristics of job strain (high demand and low decision latitude) and low social support have been found to be related to an elevated risk of subsequent onset of depressive symptoms (Bonde, 2008; Cohidon et a., 2010). Several participants stated the lack of co-worker support added to their fatigue, and this may have also been a contributing factor to their mental health status.

**Intershift recovery**. Few studies have explored intershift recovery; however, the results of this study confirm the results of other studies (Fang, 2008; Kant et al., 2003; Winwood et al., 2006a, 2006b) in that inadequate intershift recovery was positively associated with sleep problems, depression, acute fatigue and chronic fatigue.  In a difference from previously reported studies, fewer than 5% of the nurses in this study had maladaptive intershift recovery (Kant et al., 2003; Winwood et al., 2006a, 2006b). One possible reason for the level of adequate intershift recovery in this population may be that the majority of the participants were working eight hour shifts, which allowed for more recovery time between shifts compared to working 12 hour shifts.

**Physical activity/exercise.** Exercise frequency was negatively associated with acute fatigue, subjective fatigue, motivation, and activity similar to Winwood et al. (2006a). Based not only on these results, but on results from many other disciplines, efforts should be made to encourage nurses to engage in regular exercise to not only decrease fatigue but to increase overall well-being.

**Shiftwork/extended work hours/disruptions to circadian rhythm.** Currently working their preferred shift and working their preferred shift length did not have a significant relationship with fatigue potentially due to the homogeneity of the sample, who were nearly all working their preferred shift. Start time of shift had a negative relationship with depression and total fatigue; however, the relationship of start time of shift to sleep, chronic fatigue, acute fatigue and intershift recovery are unclear. Working 12 hour shifts may be related to less intershift recovery and possibly greater acute fatigue, however, there were few nurses in this study working 12 hour shifts so further conclusions on these relationships are not possible.

**Caffeine use.** Results showed nurses who worked day shift or night shift had higher caffeine use, but the relationship was weak. Caffeine had not been explored in previous studies, so comparisons are unavailable.

**Fatigue as an outcome.** Whereas Ruggerio (2003) operationalized fatigue as chronic fatigue, this study used two instruments to measure five of six dimensions of fatigue (Piper, 2004). Of the participants in this study, 51% met the criterion for elevated or severely fatigued *state* as measured by the CIS20R. Of the participants in this study, 37% met the cut point for prolonged fatigue, which is fatigue lasting greater than two weeks as measured by CIS20R; only 8% met the criterion for chronic fatigue (OFER15 chronic fatigue score greater than 80). Prolonged fatigue, as described by the CIS20R, and chronic fatigue, as described by the OFER15, had the same duration of fatigue lasting longer than two weeks; however, definitions may have been different enough from one another which resulted in the difference in the outcome of these measures for this sample.

Comparing the results of the current study to recent studies with nurses and the OFER15 measure of fatigue, the chronic fatigue rate (8%) in the current study is similar to Winwood et al. (2006a) which found a rate of 11%-15%. The nurses in the current study had lower acute fatigue scores and lower chronic fatigue scores than did other nurses in other studies (Barker, 2011; Fang, 2008). Fang reported the highest acute fatigue scores in nurses working intensive care, and highest chronic fatigue scores with nursing working oncology, so the lower acute and chronic scores in the current study may be partially explained by Fang sampling nurses in more diverse nursing units, or by unique organizational characteristics of the institution. Barker surveyed nurses by mail from various parts of the US and had a high percentage of nurses working shift lengths longer than eight hours which may be a partial explanation for the nurses in the current study having a lower chronic fatigue level because the majority of the nurses in this study worked eight hour shifts.

The results of prolonged fatigue in the current study as measured by the CIS20R are less comparable to other studies. In the current study 37% met the criteria for prolonged fatigue which is higher than the estimated 19%-20% of the general population experiencing chronic fatigue (Bultmann et al., 2002). Shiftwork and disruptions to circadian rhythm may help explain the higher percentage in the current study compared to the general population which may not be working shifts, and therefore is comparable to the report that fatigue is higher in healthcare populations (Hardy et al. 1997).

According to the OFER15, which measures Piper's temporal dimensions (duration) of fatigue, the participants in this study were acutely fatigued after working; they usually had adequate recovery between shifts and they had low levels of chronic fatigue. According to the results from the CIS20R, the participants appropriately identified themselves as fatigued, yet they may have been able to summon the appropriate resources to be adequately motivated to accomplish a goal, to summon the appropriate resources to concentrate, and to summon enough resources for the necessary physical activity. Overall this means the work of nursing is related to acute fatigue, but with adequate time between shifts to rest, the nurse can return to work in a potentially baseline rested state or at least with less accumulated acute fatigue that would progress to chronic fatigue if unrelieved. There needs to be adequate time between work periods or shifts to regain the energy lost during the working shift. Working consecutive shifts, or being so busy during non-working time that intershift recovery is impeded, increases the possibility of accumulated acute fatigue progressing to chronic fatigue.

**EF and its Bivariate Relationships with Fatigue.** Although the WCST-64:CV2® has not been used with nurses, the results of this study showed that between 30-40% of nurses demonstrate difficulty with at least one aspect of EF as measured by the WCST-64:CV2®. Approximately one-third of these nurses made so many errors that they had difficulty completing card-sorting categories. Further studies are needed to support these findings; however, the artificial nature of completing a card sorting test may have resulted in the participants not being adequately motivated to perform their best. Although the test was conducted in the most quiet atmosphere available, overhead hospital announcements could still be heard and nurses are trained to listen to these announcements. In patient situations, nurses take notes of important information as a memory aid, and they did not while taking the WCST-64CV2. Had they taken notes, they would probably have accessed the notes to help remember what the previous sorting rule was and what the most immediate card decisions were. In addition, in most instances, nurses seek assistance from other nurses when they encounter unfamiliar situations and collaboration was not possible during the WCST-64CV2.

Fatigued individuals may have deficits in EF, and results of this study begin to support results of previous studies in working populations (Hockey, 1997; van der Linden & Eling, 2006; van der Linden et al., 2003) and extend the finding to the occupation of nursing. Previous studies had shown that fatigue primarily affects perseverative errors (concentration, planning and impulse control); however, this study showed that chronic fatigue and acute fatigue in nurses were negatively associated with total errors, and positively associated with the number of trials to complete the first category. These relationships are in the expected direction because higher chronic fatigue or acute fatigue was associated with worsening total errors and increasing number of trials to complete the first category. Total errors and trials to complete the first category are indicators of overall EF.

Intershift recovery was positively related to EF total errors and negatively related to trials to complete the first category. These relationships are in the expected direction in that higher levels of intershift recovery are associated with fewer total errors and fewer trials to complete the first category. These results were also confirmed by the inverse relationship between CIS20R subjective fatigue and perseverative errors.

**Unique Relationship of Fatigue with EF.** None of the five hypothesized regression models of EF was significant, and only the EF perseverative errors model was significant with post hoc revisions. EF nonperseverative errors, categories completed and number of trials to complete first category did not produce a significant model with major post hoc revisions. In van der Linden et al. (2004), perseverative errors were most sensitive to mental fatigue. In this study, chronic fatigue, acute fatigue and intershift recovery explained 5.5% of the variance in EF perseverative errors after controlling for sleep.

Participants' responses to the open-ended question provided substantial support for the measurement instruments chosen based on the fatigue conceptual framework, and provided additional results that work-life balance, the nursing work environment and circadian rhythm should be further explored to help explain nurse fatigue. The participants believed their lack of sleep quality affected their perception of fatigue. Their qualitative responses revealed their constant attempts to balance their working life and their non-working life. Many talked about the difficulty of their family or their neighbors being on a different work-sleep schedule than they were. This tension between schedules forced the nurses to make the choice to sacrifice sleep for family activities during a time when they would be sleeping after a shift. Sometimes the sleep interruption was due to non-family interruptions such as a barking dog, ringing telephone, or other normal daytime neighborhood activities during their sleep time. Of particular importance was the revelation that the work of nursing and specifically, the lack of peer support, was contributing to their fatigue. This is strong evidence that aspects of the nursing work environment should be explored for its relationship with fatigue.

## Limitations

**Design**. Temporal ambiguity (i.e., did the independent variable truly precede the dependent variable) is a limitation in correlational analysis where only relationships are described and, therefore, does not allow for conclusions regarding causal linkages. Selection bias is also a threat to internal validity because the participants in the study may differ in one way or another from those not volunteering; however, selection bias was somewhat mitigated by measuring and controlling for known covariates of fatigue such as depression and quality of sleep. Fatigued individuals are less willing to engage in effortful tasks (Gaillard, 2001), and the motivational aspect cannot clearly be differentiated from the pure cognitive effects of fatigue (Hockey, 1997). Of the nurses agreeing to participate, 10% did not complete the surveys and it is unknown whether their fatigue level was different from the sample. If the 10% were too busy with the work of nursing to complete the surveys, they may have been more fatigued and that data would have been useful. Experimental design comparing two groups with one experimental group with an intervention known to induce fatigue would help us better understand potential causal variables.

This study did not induce mental fatigue and that may have allowed confounding variables to be introduced. Inducing mental fatigue in one group of nurses and comparing it to a non-induced mental fatigue group would have helped mitigate this limitation. There are inherent ethical issues that must be considered when proposing to induce mental fatigue. The mental fatigue should be short enough duration for the study question and to ensure internal validity, and the sample would be voluntary which introduces selection bias. The researcher needs to also consider that the participant either needs adequate time to recover after the induced mental fatigue before engaging in activities that may be potentially harmful (such as driving home) or the participant needs to be transported to his/her home for adequate rest after the mental fatigue. The participant would also be fully informed about the nature and consequences of the mental fatigue and be able to contact the researcher if the participant felt the mental fatigue is affecting his/her ability to safely function. The researcher should have mechanisms in place to assist the participant to return to normal functioning such as transportation, rest facilities and food available.

The WCST is a valid and reliable test for EF, however, the artificial nature of the test compared to actual nursing functions may not have had sufficient motivation for the nurses to complete because they did not perceive the test on the same level of importance with their daily nursing decisions involving human lives. A design with nursing EF functions and tasks closely designed to nursing tasks such as physically demanding tasks (moving hospital beds) and mentally demanding tasks (dosage calculations) would yield more applicable results.

The sample was only medical surgical nurses, so the results have limited external validity because the results cannot necessarily be generalized to other departments of the hospital, nor can the results be generalized to other medical-surgical departments at other hospitals. Another limitation is possible model misspecification. Other important variables that are related to fatigue and EF, such as aspects of the nursing work environment (nursing leadership, nurse involvement in policy development, physician/nurse collaboration and staffing), were not measured and, therefore, could not be included in the model. Several reasons supported the decision not to measure aspects of the nursing work environment. First, the relationship between the nursing work environment and fatigue is unclear, and the relationship between the nursing work environment and EF is not known. Second, asking nurses to complete numerous surveys after a shift might have constituted a measurement burden, and I also did not want to induce more fatigue in the participants. Adding the nursing work environment would have introduced at least four additional variables in the model which would again use degrees of freedom. If the relationship among the nursing work environment, fatigue and EF was known, there may be indication for including this in future studies and future regression models.

It is unknown if and how characteristics of the nursing work environment contribute to a regression model of fatigue and EF. The qualitative responses identifying aspects of the nursing work environment as contributing to fatigue hint that the nursing work environment may be related to fatigue and EF.

**Sample**. The participants in this study were young, well-educated, and primarily working 8-hour shifts, which limits external validity to those working shift other than 8-hour shifts. All nurses working during the time of data collection were invited to participate, and thus attempts were made to maximize demographic and independent variable variability.

The sample size was also a limitation because it limited the number of independent variables I originally wanted to measure. The sample size was calculated from known effect sizes of fatigue (.3; Ruggerio, 2007) and EF (.3; van der Linden & Eling, 2006) and the sample size was achieved. The effect size estimates in the current study were between .08 to .3 for fatigue and .1 to .27 for EF. Thus, because fatigue and EF had smaller effect sizes in the current study than the studies used to calculate in the power analysis to calculate the sample size, the current sample size may not have adequate to provide the power needed to minimize a Type II error of rejecting results as non-significant when, in fact, they were significant.

**Measurement.** A limitation of self-report measures is reactivity or the natural inclination of participants to present themselves in a positive or socially acceptable way to the researcher (Stangor, 2004). To mitigate this, the directions emphasized that the purpose of the research was not to evaluate the participant personally and emphasized that the success of the research depended upon honest responses.

A limitation of the OFER15 and the CIS20R is the lack of evidence for validity and a lack of evidence of their use in the US (both instruments) or with working nurses (CIS20R). The CIS20R had not previously been used in a nursing population; however, it demonstrated similar reliability estimates as in previous studies (Vercoulen et al., 1994). It is a limitation that fatigue, a ubiquitous phenomenon, does not have one reliable and valid instrument with a solid history of use in apparently healthy populations or nursing populations.

The concentration, motivation and activity subscales of the CIS20R had weak relationships with other covariates and with EF. The weak relationships may have been due to the restricted range in measured fatigue, or may also be due to measurement items in the CIS20R not being valid for working nurses. In future studies, using triangulation for these subscales, such as an actometer to objectively measure physical activity, would provide information regarding the validity of this subscale.

## Clinical Relevance and Significance

Thirty-seven percent of the nurses in this study had prolonged fatigue; 24% were mildly or moderately depressed; and 56% met the criterion for poor sleeper – and this was a population of relatively young nurses, average age of 34 years. It was interesting to note that there was a negative association between exercise and the level of acute fatigue, the level of subjective fatigue, the level of motivation, and the effort needed for activity. This relationship suggests that increasing the frequency of exercise is associated with decreasing acute fatigue, decreasing subjective fatigue, increased motivation and increased physical activity; therefore, nurses should be encouraged and possibly rewarded for engaging in physical activity outside working hours.

It was not known what aspects of the nursing work environment contributed to the fatigue; however, responses to the open-ended question clearly demonstrated that the poor peer relationships contributed to individual fatigue. Nurses and nurse administrators should be aware that lack of co-worker support was given as a reason for individual fatigue and efforts should be made to increase interpersonal support and cohesiveness on nursing units. A healthy nursing work environment with good RN-to-RN relationships may decrease fatigue. Nursing departments have regularly scheduled staff meetings where administrative and clinical items are discussed. Including discussions at the staff meetings regarding the current nursing work environment and facilitating ways to improve or enhance the nursing work environment would be one strategy to address the RN-to-RN relationship.

Other aspects of the nursing work environment were implied in the open-ended questions and should be considered by the nursing administration.  Inadequate staffing, inadequate assistance during periods of increased activity (such as admissions, discharge and unanticipated procedures), and decreased satisfaction were all indentified as contributing to fatigue. These aspects of the nursing work environment can be discussed during staff meetings and suggestions solicited for solutions, or these aspects can be more formally measured on a regular basis with a reliable and valid measure, such as the Nursing Work Index or measurement tools for magnet status.

Nurses and nurse administrators need to be aware that nurses may be poor sleepers and actively seek ways to encourage improved sleep quality through nursing continuing education or through nursing unit inservices. Nurses new to shiftwork should be educated to the consequences of disruptions to circadian rhythm and also educated to strategies to mitigate the disruptions.

This study measured fatigue at one point in time. A better indication of whether fatigue is associated with errors would be to measure fatigue at the point of an error occurrence. The nurse would complete a fatigue questionnaire along with the error occurrence report, and the relationship between the two could be explored. The nursing profession should continue supporting an open acceptance of error-reporting so errors are accurately and comprehensively captured. With an accepting atmosphere of error-reporting, the assessment of nurse fatigue could also be enhanced.

This study documented deficits in EF, which are mental processes that are under high demand in complex changing situations. Fatigued nurses, as do workers in other occupations, rely on global processing, which is the “big picture,” and rely on what has worked in the past. This study demonstrated that approximately 30-40% of the nurses in this study had difficulty in at least one measurement of EF. The artificial nature of measuring EF, albeit with the WCST-64CV2 which is a gold standard for measurement of EF, may not translate to the same level of deficits in EF in the working environment where nurses often write down important information and frequently seek assistance from other nurses when faced with changing patient conditions. Because EF is comprised of several processes (concentration, planning, impulse control or inhibition, sequencing, and monitoring), when we know more about the relationship between fatigue and specific EF processes, we can recommend strategies to limit EF deficits.

Person-level clinical significant covariates suggest improving sleep quality, improving mental health status, and adequate social support are protective towards health. Nurses are taught to care for others.  It is important for nurses to 'care for' each other, recognizing when another nurse is fatigued and offer help or strategies enabling the nurse to recovery energy. One such example would be ensuring all nurses had the minimum number and time for breaks, and several nurses stated they often did not take breaks. Continuing education for nurses should include proven strategies for time management both during the working hours and non-working hours to ensure the best use of time. Many strategies exist for improving sleep quality and this should be an ongoing discussion in nursing especially where shift work and disruptions to the circadian rhythm are common. Nurses are also used to helping others, but they need to remember to help themselves by recognizing psychological or emotional exhaustion in themselves and seeking ways to regain emotional balance.

Clinical relevance and significance suggest that the nursing administration consider the differences between eight and 12 hour shifts, and the preference of the individual nurse. As this hospital does, some medical surgical departments are regularly scheduled with eight hour shifts and some with 12 hour shifts allowing the individual to choose a length that best fits their needs. The organizational level suggestion of adequate and positive peer support needs careful attention. Inadequate peer support in the workplace was mentioned several times by nurses in the current study as a contributor to their fatigue.

Nurses learn and advance their clinical knowledge through socially determined aspects of the work environment, including expertise of co-workers, social climate and team function, and sharing of experiences (Ebright, Urden, Patterson, & Chalko, 2004). Ebright et al noted that novice nurses, in order to decrease risk for errors, needed: a) consistent availability of other nurse expertise particularly in context of workload unpredictability, b) supportive social climate regarding expectations of novice nurses, and c) realistic expectations of novice decision-making ability during complex situations for up to a year after graduation. The demanding and complex work environment is not limited to novice and experienced bedside nurses, but also extends to nurse managers. Shirey, McDaniel, Ebright, Fisher, and Doebbeling (2010) found nurse manager stress was influenced by role expectations and communication demands. In addition, nurse managers need the resources not only to handle the complexities of the work environment, but to structure and influence a supportive work environment (Shirey, Ebright, & McDaniel, 2008). In times of mental fatigue, EF functioning occurs at a routine level or in ways that have previously been successful. Therefore, at times of mental fatigue all nurses, but particularly nurses in novice roles, whether in a bedside or manager role, perform at suboptimal levels. Ebright et al. (2004) advocated for a nursing work environment that was designed to decrease or eliminate environmental factors that contribute to errors and decrease quality. Complexity compression, or the continual assessment of priorities by nurses, underscores the need for nurses to be proactive in changing the nursing work system and acute healthcare system for optimal workflow and patient outcomes.

## Research Implications

Nurses, especially BSN prepared nurses with a foundation of research, were willing to participate in this study. Some found it challenging to find time during their shift or at the end of their shift to complete the surveys and one computer test. Several asked if the surveys were online. If the computer test had been available on the hospital server, more nurses could have accessed the program at one time; however, issues of testing fidelity would have needed to be addressed. A specific intent of the study was to measure the multidimensionality of fatigue, and this information is useful when considering specific nursing work environment adaptations to mitigate fatigue.

In addition, the WCST as a measure of EF may have been artificial and more natural experiments or simulations similar to the work of nursing may have results more indicative of true EF function in working nurses. Therefore, a design with an intervention more closely resembling the work of nurses is suggested. Simulation-based training may be the next step to explore EF. High fidelity simulation uses patient simulators that are programmed to respond to various interventions. The healthcare professional practices real-world situations using patient simulators to learn new skills, learn optimal sequencing of interventions, or refresh infrequently used but critical skills. Patient simulation, in a research design of EF, would use standard scenarios across the sample which would allow a more natural measurement of EF with better internal validity than the WCST for this population.

Simulation, however, is not without moral dilemmas. Simulation produces similar stress and suffering in the learner as does a real situation and there are moral obligations of the teacher or researcher to be aware of the potential stress and suffering (Taylor, 2011). In this regard, there is not a safe learning environment and safeguards need to be in place to adequately debrief the learner or participant to not only help frame the simulation as a learning tool or research tool, but also to return the learner or participant to pre-simulation (as much as possible recognizing one is forever changed by the simulation experience) baselines of stress, fatigue/energy, and suffering.

Because the WCST may not be an internally valid measure of EF in working nurses, more natural experiments or simulation should be considered. Natural experiments where the intervention is controlled into levels of low and high physical fatigue (pushing a bed without and with weight), low and high mental fatigue with utilization of EF (calculating simple and more complex dosages, questions regarding decision-making) combinations of each would allow greater internal validity and may more accurately measure fatigue and executive functions of concentration, planning, sequencing, and monitoring of the situation. One study to use simulated nurse work as the intervention and fatigue as the dependent variable found that physical exertion had a strong relationship with mental stress, but there was a small effect size on performance suggesting that either the simulated work needed to be increased in length (longer than 1-2 hours) or the tasks did not adequately affect performance (Barker & Nussbaum, 2011). The use of high-fidelity patient simulators, with scripted scenarios with a pre-test, post-test measurement design with naturally occurring nursing work and cognitive tasks, may yield results of EF with more internal validity and clinical relevance.

Future research should include more organizational outcome variables such as absenteeism, increased turnover and decreased retention, staffing, and measures of the nursing work environment such as RN involvement in policy and decision making, interpersonal communication and nursing administration support. Suggested patient outcome variables might include indicators of patient safety. Because fatigue is known to affect learning, measures of fatigue in the nursing learning environment could also be considered. Fatigue is also related to increased risk of illness and increased risk of injury, so absenteeism specifically related to illness and injury would also yield results enhancing our knowledge and understanding of the complexity, multidimensionality, and outcomes of fatigue.

Future research into fatigue and EF should be designed to sample for greater variability in demographic, independent and dependent variables. For demographic variables, this can be accomplished through proportionate or disproportionate stratified sampling to ensure the sample is representative of the population. Suggestions for greater variability in fatigue might be to measure at a time with probability of less fatigue (beginning of shift or first shift in a series of working shifts) and at a time when increased fatigue is expected (end of shift or series of shifts, and situation known to be stressful or fatiguing such as just after a code situation). Results with wider variability of fatigue within one individual at more than one point in time would yield greater internal validity, and measurement of wider variability with different individuals would yield results with greater external validity. Suggestions for greater variability in EF might be measuring at different points in a learning situation or simulation. A larger sample size with wider range in demographics, independent and dependent variable would yield results with stronger relationships and yield a more accurate picture of the true relationships between the variables (Stangor, 2004).

**Theoretical implications.** This study described some of the variables empirically known to be related to fatigue and EF. The small sample size limited robust conclusions. Future research, with larger sample sizes should more comprehensively explore person and organizational level covariates. Physical illnesses, chronic illnesses, or comorbidities could be measured as covariates of fatigue and for its relationship to EF. Physical activity, in this study, was limited to one question, and this variable could be more comprehensively explored. It is known that other non-working recreational activities are related to improved mental health and future research could explore this variable. Intershift recovery may be a moderator of fatigue, and this relationship should be statistically tested. As stated before, the nursing work environment should be measured as an organizational-level variable to better understand its relationship to fatigue and determine if it is related to EF.

Consequences of fatigue to the individual such as risk of illness and risk of injury could be described in a larger study. Measuring individual fatigue at the time of an error, patient incident related to safety, or a critical incident would allow us to explore the potential relationship between individual fatigue and patient safety.  Finally, measuring individual fatigue and measuring individual absenteeism, intent to leave the organization, and resignation of nursing position would allow us to understand the relationship between fatigue and these organizational-level outcomes.

## Summary

This study was based on the theoretical foundations of Lazarus and Folkman’s revised model of stress and coping and Hockey’s cognitive-energetic framework on EF. This study described nurses’ level of fatigue, covariates of fatigue, the relationships between covariates, fatigue and EF, and it explored models to explain the unique contribution of fatigue to EF. This study extended the knowledge base on fatigue in nurses and explored EF in nurses for the first time. The responses to the open-ended question supported and enhanced the results with a rich textual description using the participants’ own words.

Age, gender, living situation, length of nursing experience, and highest level of nursing education were not found to be significantly related to fatigue. The current shift the nurse was working, sleep quality, and depression had moderate to strong relationships with fatigue.

When measuring fatigue, the OFER15 had stronger relationships with sociodemographic variables, person-level variables and organization-level variables than the CIS20R. The CIS20R did provide descriptions of four of the fatigue dimensions recommended by

Piper. The OFER15 captures aspects of shiftwork inherent to hospital nursing and the most relevant to EF. Overall, the researcher must balance measurement burden and feasibility especially in a study with fatigue and EF as the primary foci.

Fatigue elicits a diversity of behavioral and cognitive effects with important potential implications for patient safety. Results from this study provided the foundation for studying fatigue and EF in other health care professions where the occupation involves the responsibility for another's life.

Important clinical findings were as follows: Nurses in this study were acutely fatigued, had adequate intershift recovery, and did not have maladaptive chronic fatigue. These results may be partially explained by the fact that the nurses in this study were relatively young and most worked 8-hour shifts. Their level of chronic fatigue was lower than in other studies with nurses, their level of depression was similar to other studies with nurses, and they had better sleep quality. EF was impaired in up to 30% of the nurses in this study, and this has potentially important implications for patient safety. Nurses responded that the nursing work environment was a contributing factor to their fatigue.

Limitations of the study include limited generalizability, reliance on self-report, a descriptive correlational design which severely limits conclusions regarding causality, a self-selection of participants into the study, single-site data collection, and small sample size relative to the number of factors that were examined.

More studies need to be done in EF to better understand EF in nurses so the nursing profession can move toward intervention studies on fatigue counter measures to minimize deficits in EF caused by shiftwork, lack of quality sleep, and lack of intershift recovery.

Patient safety depends on further studies on fatigue and EF so sources or causes of fatigue and EF can be identified and modified to limit escalations in fatigue and limit deficits in EF.

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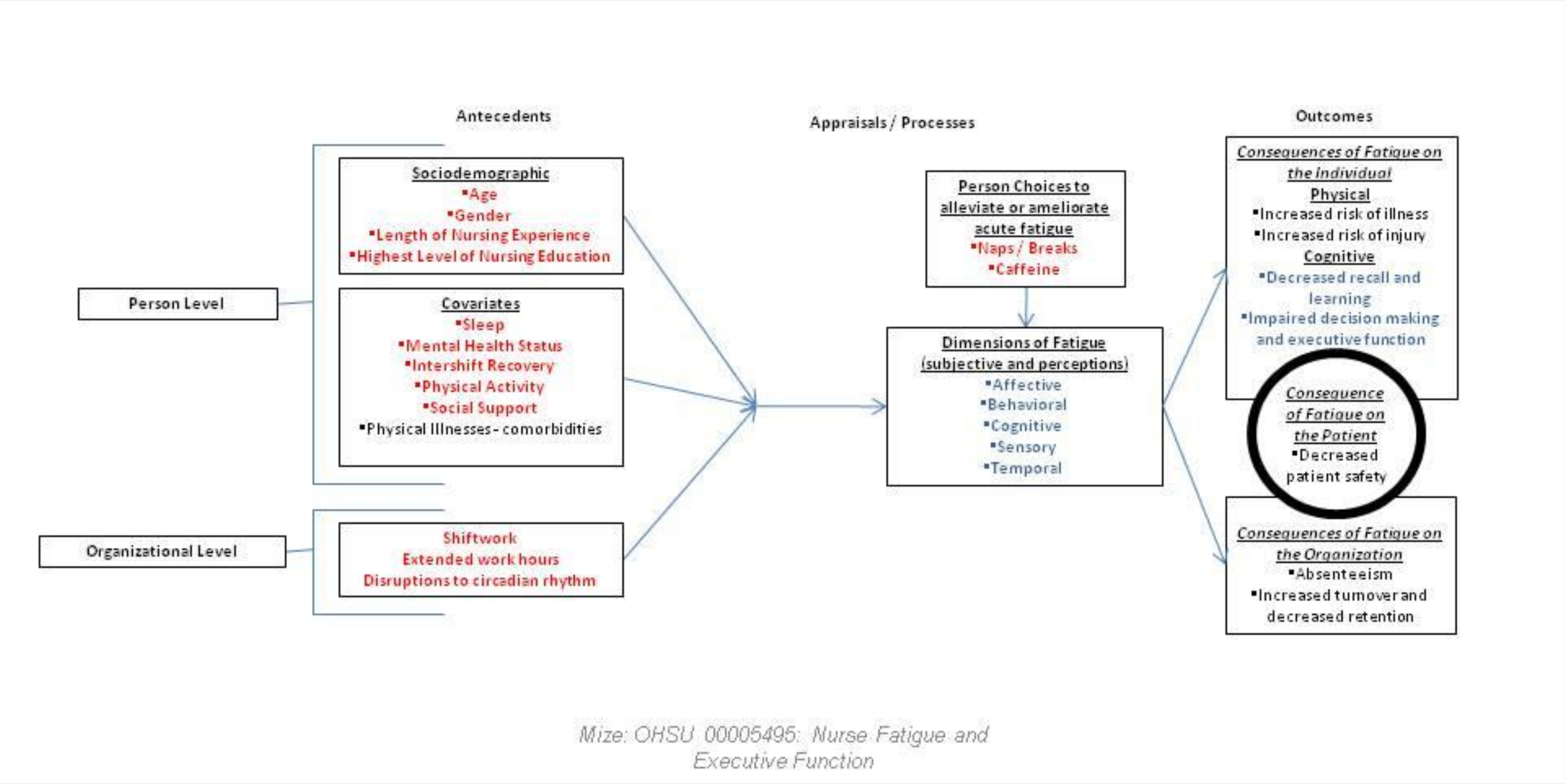
# Appendix A

## Conceptual Framework



# Appendix B

## Sociodemographic Questionnaire

### Sociodemographic Questionnaire

1. Gender: ☐ male ☐ female

2. Living situation (choose the closest description of your situation):

   ☐ single, live alone: usually (<50% of the time) **not** responsible for another (child, parent, or other) during my non-working hours

   ☐ single or live alone: usually (>50% of the time) **do** have responsibilities for another (child, or other) during my non-working hours

   ☐ married or living with significant other: usually (<50% of the time) **not** responsible for another (child, parent, or other) during my non-working hours

   ☐ married or living with significant other: usually (>50% of the time) **are** responsible for another (child, parent, or other) during my non-working hours

3. Number of children under 18 years of age still living at home? _____ children

4. Years of nursing experience: _______ years

5. Years of experience at current job: _______ years

6. Highest level of nursing education:

   ☐ Diploma

   ☐ ADN

   ☐ BSN

   ☐ MN/MSN

   ☐ PhD or DNP or EdD

7. Do you have any nursing specialty certifications (such as certified in med/surg, Clinical Nurse Specialist)

Please write out entire certification ______________________________

8. Shift typically worked:

Start time:_______ ☐ AM ☐ PM End time:_______ ☐ AM ☐ PM

9. Shift currently working:

Start time:_______ ☐ AM ☐ PM End time:_______ ☐ AM ☐ PM

10. Number of consecutive shifts currently working _________ shifts

11. Which shift of the consecutive shifts is this shift you are now working:___of_ __

12. Do you have another paid position other than is current FHS position

☐ no ☐ yes, if yes what level FTE ☐ >.5

☐ < 20 hours per week

☐ < 20 hours per month

13. Are you working your preferred shift? ☐ no ☐ yes

14. Are you working your preferred shift length? ☐ no ☐ yes

15. How many times a week do you usually engage in 30 minutes of exercise?

_________ times

16. What do <u>you think</u> most contributes to your level of fatigue? (Please write your answer below).

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

________________________________________________________________

Appendix C

Beck Depression Inventory II

**BDI-II**

Date:

Name: ______ Marital Status: ______ Age: ______ Sex: ______

Occupation: ______ Education: ______

**Instructions:** This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the **one statement** in each group that best describes the way you have been feeling during the **past two weeks, including today**. Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

**1. Sadness**

0 I do not feel sad.
1 I feel sad much of the time.
2 I am sad all the time.
3 I am so sad or unhappy that I can't stand it.

**2. Pessimism**

0 I am not discouraged about my future.
1 I feel more discouraged about my future than I used to be.
2 I do not expect things to work out for me.
3 I feel my future is hopeless and will only get worse.

**3. Past Failure**

0 I do not feel like a failure.
1 I have failed more than I should have.
2 As I look back, I see a lot of failures.
3 I feel I am a total failure as a person.

**4. Loss of Pleasure**

0 I get as much pleasure as I ever did from the things I enjoy.
1 I don't enjoy things as much as I used to.
2 I get very little pleasure from the things I used to enjoy.
3 I can't get any pleasure from the things I used to enjoy.

**5. Guilty Feelings**

0 I don't feel particularly guilty.
1 I feel guilty over many things I have done or should have done.
2 I feel quite guilty most of the time.
3 I feel guilty all of the time.

**6. Punishment Feelings**

0 I don't feel I am being punished.
1 I feel I may be punished.
2 I expect to be punished.
3 I feel I am being punished.

**7. Self-Dislike**

0 I feel the same about myself as ever.
1 I have lost confidence in myself.
2 I am disappointed in myself.
3 I dislike myself.

**8. Self-Criticalness**

0 I don't criticize or blame myself more than usual.
1 I am more critical of myself than I used to be.
2 I criticize myself for all of my faults.
3 I blame myself for everything bad that happens.

**9. Suicidal Thoughts or Wishes**

0 I don't have any thoughts of killing myself.
1 I have thoughts of killing myself, but I would not carry them out.
2 I would like to kill myself.
3 I would kill myself if I had the chance.

**10. Crying**

0 I don't cry anymore than I used to.
1 I cry more than I used to.
2 I cry over every little thing.
3 I feel like crying, but I can't.

______ Subtotal Page 1

Continued on Back

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**11. Agitation**

0 I am no more restless or wound up than usual.
1 I feel more restless or wound up than usual.
2 I am so restless or agitated that it's hard to stay still.
3 I am so restless or agitated that I have to keep moving or doing something.

**12. Loss of Interest**

0 I have not lost interest in other people or activities.
1 I am less interested in other people or things than before.
2 I have lost most of my interest in other people or things.
3 It's hard to get interested in anything.

**13. Indecisiveness**

0 I make decisions about as well as ever.
1 I find it more difficult to make decisions than usual.
2 I have much greater difficulty in making decisions than I used to.
3 I have trouble making any decisions.

**14. Worthlessness**

0 I do not feel I am worthless.
1 I don't consider myself as worthwhile and useful as I used to.
2 I feel more worthless as compared to other people.
3 I feel utterly worthless.

**15. Loss of Energy**

0 I have as much energy as ever.
1 I have less energy than I used to have.
2 I don't have enough energy to do very much.
3 I don't have enough energy to do anything.

**16. Changes in Sleeping Pattern**

0 I have not experienced any change in my sleeping pattern.
1a I sleep somewhat more than usual.
1b I sleep somewhat less than usual.
2a I sleep a lot more than usual.
2b I sleep a lot less than usual.
3a I sleep most of the day.
3b I wake up 1–2 hours early and can't get back to sleep.

**17. Irritability**

0 I am no more irritable than usual.
1 I am more irritable than usual.
2 I am much more irritable than usual.
3 I am irritable all the time.

**18. Changes in Appetite**

0 I have not experienced any change in my appetite.
1a My appetite is somewhat less than usual.
1b My appetite is somewhat greater than usual.
2a My appetite is much less than before.
2b My appetite is much greater than usual.
3a I have no appetite at all.
3b I crave food all the time.

**19. Concentration Difficulty**

0 I can concentrate as well as ever.
1 I can't concentrate as well as usual.
2 It's hard to keep my mind on anything for very long.
3 I find I can't concentrate on anything.

**20. Tiredness or Fatigue**

0 I am no more tired or fatigued than usual.
1 I get more tired or fatigued more easily than usual.
2 I am too tired or fatigued to do a lot of the things I used to do.
3 I am too tired or fatigued to do most of the things I used to do.

**21. Loss of Interest in Sex**

0 I have not noticed any recent change in my interest in sex.
1 I am less interested in sex than I used to be.
2 I am much less interested in sex now.
3 I have lost interest in sex completely.

____ Subtotal Page 2
____ Subtotal Page 1
____ Total Score



22 23 24 25 26 27 28 29 30 A B C D E

# Appendix D

**The Pittsburgh Sleep Quality Index (PSQI)**

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

**During the past month,**

1. When have you usually gone to bed? ________________________

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

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

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

| 5. During the past month, how often have you had trouble sleeping because you… | Not during the past month (0) | Less than once a week (1) | Once or twice a week (2) | Three or more times a week (3) |
|---|---|---|---|---|
| a. Cannot get to sleep within 30 minutes | | | | |
| b. Wake up in the middle of the night or early morning | | | | |
| c. Have to get up to use the bathroom | | | | |
| d. Cannot breath comfortably | | | | |
| e. Cough or snore loudly | | | | |
| f. Feel too cold | | | | |
| g. Feel too hot | | | | |
| h. Have bad dreams | | | | |
| i. Have pain | | | | |
| j. Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s): | | | | |
| 6. During the past month, how often have you taken medicine (prescribe or “over the counter”) to help you sleep? | | | | |
| 7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity? | | | | |
| 8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done? | | | | |
| | Very good (0) | Fairly good (1) | Fairly bad (2) | Very bad (3) |
| 9. During the past month, how would you rate your sleep quality overall? | | | | |

Appendix E
Sample CIS20R

********* CIS20R *********

**Checklist Individual Strength**

**University Medical Center Nijmegen, The Netherlands**

**Dept. of Medical Psychology**

Instruction:
On the next page you find 20 statements. With these statements we wish to get an impression of how you have felt during <u>the last two weeks</u>. For example:

**I feel relaxed**

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

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| I feel relaxed | **yes**, that is true | X | | | | | | | **no**, that is not true |

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

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| I feel relaxed | **yes**, that is true | | | | | | | X | **no**, that is not true |

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:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| I feel relaxed | **yes**, that is true | | | X | | | | | **no**, that is not true |

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 think I do a lot in a day. | 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 think I do very little in a day. | 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. | I get little done. | 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 |

# Appendix F

## OFER15

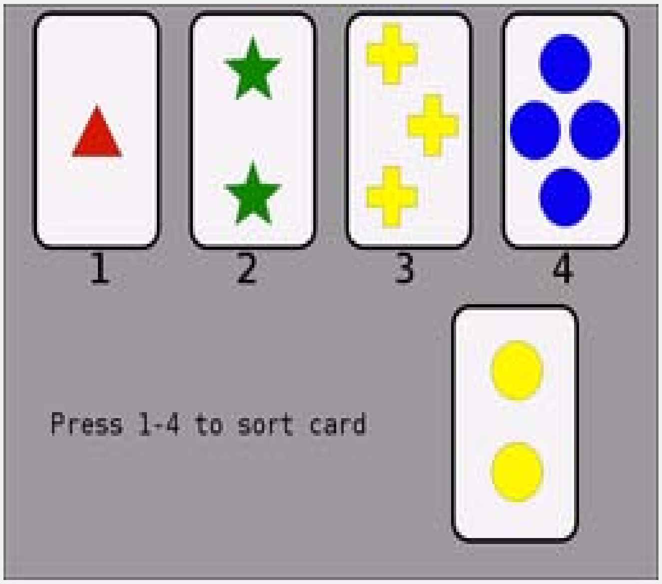
### Occupational Fatigue Exhaustion Recovery (OFER 15) Scale

**These Statements are about your experience of FATIGUE and STRAIN at Work and Home**
**OVER THE LAST FEW MONTHS**
**Circle a number from 0-6: "Strongly Disagree" to "Strongly Agree" which best indicates your response.**

| | Strongly Disagree | Disagree | Slightly Disagree | Neither Agree or Disagree | Slightly Agree | Agree | Strongly Agree |
|---|---|---|---|---|---|---|---|
| 1) I often feel I'm 'at the end of my rope' with my work | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 2) I often dread waking up to another day of my work | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 3) I often wonder how long I can keep going at my work | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 4) I feel that most of the time I'm just "Living to Work | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 5) Too much is expected of me in my work | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 6) After a typical work period I have little energy left | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 7) I usually feel exhausted when I get home from work | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 8) My work drains my energy completely every day | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 9) I usually have lots of energy to give to my family or friends | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 10) I usually have plenty of energy left for my hobbies and other activities after I finish work | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 11) I never have enough time between work shift to recover my energy completely | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 12) Even if I'm tired from one shift, I'm usually refreshed by the start of the next shift | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 13) I rarely recover my strength fully between work shifts | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 14) Recovering from work fatigue between work shifts isn't a problem for me | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 15) I'm often still feeling fatigued from one shift by the time I start the next one | 0 | 1 | 2 | 3 | 4 | 5 | 6 |

# Appendix G

## Sample WCST-64:CV2™




http://pebl.sourceforge.net/battery.html

Source website states release into public domain: "All screenshots found on this page are released into the public domain, and can be used for whatever purpose without copyright assignment, including in academic papers."

Appendix H
FHS MREC Application



**MEDICAL RESEARCH EVALUATION COMMITTEE**
St. Joseph Medical Center, St. Clare and St. Francis Hospitals,
St. Elizabeth, Franciscan Medical Group, and Franciscan Hospice

**PROTOCOL APPLICATION**

**Date:** April 27, 2011

**Title of Study:** Nurse Fatigue and Executive Function

**Principal Investigator:** Sheila Kodadek, PhD, RN, (Professor, OHSU School of Nursing)

**Sub-Principal Investigator:** Emily Mize, MN, RN (PhD Candidate, OHSU School of Nursing)

**Address: Emily Mize:** 7308 97th Ave SW, Lakewood, WA 98498

**Phone Number / Email:** 253.589.1229 (home) 253.380.6870 (cell) mizee@ohsu.edu

**Name of Institution or Group Submitting the Study:** N/A

**Sponsor, If any:** n/a

**Objective of Study:**
The purpose of this study is to learn more about the type and level of fatigue that nurses' may experience. It is also to learn about what may contribute to the fatigue and what may be an effect of fatigue. Objectives are:

(a) describe working nurses fatigue and EF and covariates of fatigue: depression, quality of sleep and demographic variables
(b) describe the relationships between depression, sleep and demographic variables and the outcome variables of fatigue and EF;
(c) describe the relationship between the outcome variables of fatigue and EF and
(d) explore the unique relationship between fatigue and EF after controlling for depression, sleep and any other potential covariates

**Devise Study Risk Determination: SR ________ NSR___x____**
*For Device Studies a risk determination of Significant Risk (SR) vs. Non-Significant Risk (NSR) must be designated by the Investigator. Please include the FDA's IDE approval letter which includes risk determination or other applicable Risk determination documents.

*Please set forth below, the page number of the submitted protocol that refers to the following Information:*
*(D=dissertation, Chapter 4; ASP= Abbreviated Study Protocol)*

1). Subject Eligibility — Page No. D:85; **ASP:1**
This should set forth the qualifying and disqualifying requirements for the subject.

2). Procedures for Entering a Subject in the Study — Page No. D:85, 97; **ASP: 1**
This section should state whether subjects are entered into the program in a random or nonrandom method, whether the study is double-blind, and methods of distinguishing between subjects.

3). Treatment Plan — Page No. **ASP: 2**
This should include the regimen for treatment, a description of the treatment and a description of any medications or devices used in the treatment.

4). Risks and Benefits — Page No. D: 87, 97; **ASP: 4**
This should include a description of the possible risks and benefits to the subjects involved in the study.

5). Response Criteria — Page No. N/A
What is the basis for documenting the response to the treatment? This should include criteria and methods of measuring the response.

6). Method for Monitoring Subjects — Page No. N/A
This should be a discussion of how subjects are followed in their treatment to determine the effect of treatment and methods of monitoring for adverse reactions.

7). Criteria for terminating or modifying the protocol. — Page No. N/A; **ASP: 5**
This should set forth guidelines for determining if a subject's treatment should be modified or terminated because of adverse reactions to treatment. The method for removing a subject from treatment should be specified.

8). Plan for evaluation of data — Page No. 97-102; **ASP: 5**
This should include a discussion of the method for evaluating the data to be obtained through the study.

9). Record keeping — Page No. **ASP: 8**
This should set forth the name, address and telephone number of the person/ institutions keeping records and study data.

10). Informed Consent — Page No.
This should include all of the elements set forth in chapter 2(b) of the Procedures Manual.

Do you (the Principal Investigator) your spouse, or your dependents, in the aggregate, have an ownership interest (stock, stock options, and/or debt, security or capital holding) in the sponsor of the proposed project, or any other entity related to the proposed project consisting of (a) stock with a current market value of more than $10,000 or (b) more than 5% of the equity of the company [not to include mutual funds or TIAA/CREF holdings]?

Yes ______ No ______

If yes, please submit a Financial Disclosure Form along with this protocol application.
* In addition, the Principal Investigator and/or Sub-Investigator(s) must report this financial disclosure should their financial status with the sponsor change after submitting the protocol.

**INVESTIGATOR SIGNATURE:**_______________________________________

**INVESTIGATOR NAME** *(print)*:_______________________________________

**DATE:**______________________

Do you (the or Sub-Investigator), your spouse, or your dependents, in the aggregate, have an ownership interest (stock, stock options, and/or debt, security or capital holding) in the sponsor of the proposed project, or any other entity related to the proposed project consisting of (a) stock with a current market value of more than $10,000 or (b) more than 5% of the equity of the company [not to include mutual funds or TIAA/CREF holdings]?

Yes ______ No ______

**Sub- INVESTIGATOR SIGNATURE:**__________________________________

**INVESTIGATOR NAME** *(print)*:_______________________________________

**DATE:**______________________

Appendix I
FHS MREC Approval Letter

CATHOLIC HEALTH INITIATIVES®

# Franciscan Health System

May 27, 2011

***Emily Mize MN, RN***
***Sheila Kodadek, PhD, RN***
***7308 97th Ave SW***
***Lakewood, WA 98498***

Re: Protocol- ***Nurse Fatigue and Executive Function (OHSU Study # 00005495)***

Dear Ms. Mize:

The Franciscan Health System Medical Research Evaluation Committee (St. Clare and St. Francis Hospitals, St. Joseph Medical Center, St. Elizabeth Hospital and Franciscan Medical Group Clinics), in compliance with the GCP/ICH/21 CFR 50 and 56, reviewed and approved the following documents, as outlined in the cover letter dated May 26, 2011, via expedited review by Michael J. Bonck, R.Ph, on May 27, 2011. A full committee review of this approval will be held on June 28, 2011.

<u>Cover letter dated May 26, 2011:</u>

1. *Informed Consent( Version A, May 2011) with track changes*
2. *Informed Consent (Version B, May 2011)*

This approval expires May 24, 2012. A status report is required prior to the expiration date, and a final report is due at the end of the study. Forms for the annual review will be mailed to you two months prior to the expiration date. Should the study end before that time, please notify us and provide any information regarding number of patients enrolled, findings and conclusions.

If you have any questions, please contact the MREC office, St. Joseph Medical Center, 426-6257.

Sincerely,

Michael J Bonck RPh

Michael J. Bonck, R.Ph.
Chair, Medical Research Evaluation Committee
MJB: pt

*A mission to heal, a promise to care.*

1717 South J Street P.O. Box 2197 Tacoma, WA 98401-2197
Phone 253.426.4101 www.FHShealth.org

ST. JOSEPH MEDICAL CENTER • ST. CLARE HOSPITAL • ST. FRANCIS HOSPITAL • ST. ELIZABETH HOSPITAL
ST. ANTHONY HOSPITAL • FRANCISCAN MEDICAL GROUP • FRANCISCAN HOSPICE AND PALLIATIVE CARE
FRANCISCAN OCCUPATIONAL HEALTH • FRANCISCAN FOUNDATION

Appendix J

Open-Ended Response: Themes and Exemplars

| **Sleep:** | **Sleep** |
|---|---|
| amount<br>Kids keeping me up<br>lack of✓✓✓✓✓✓✓✓✓✓✓✓✓✓✓✓<br>disruptions✓✓<br>family has different sleep schedules✓✓<br>family demands so can’t get enough sleep<br>quantity, quality, inability to fall asleep✓✓<br>disrupted circadian rhythm<br>rotating from non-day shift work schedule to family demands on day off<br>too little<br>unable to nap before work<br>bad sleeping patterns<br>hard to sleep on hot days<br>lack of consistent sleep schedule✓✓<br>not enough<br>interruptions from normal daytime activities outside the home (mowing lawn) | *“Having to continually accommodate my time to working night shift. Preparing for bed, meals (eating later) and trying to get things done all in a day on my day off (not going to bed on my day off in the am – don’t want to waste my day sleeping.”*<br><br>*“Interruption to my sleep such s neighbor mowing lawn, dog barking…things like that.”*<br><br>*“Odd hours of sleeping due to night shift hours and being woken by typical ‘daily’ activities such as lawnmowers, phone calls, etc.”* |

| | |
|---|---|
| **Workload:** ✓✓✓✓✓<br>patient acuity✓✓✓✓✓✓✓✓✓✓<br>lack of staff support✓✓✓<br>negative staff interactions<br>Schedule different than my circadian rhythm<br>Many shifts in a row<br>Normal fatigue<br>unanticipated procedures✓<br>paperwork/charting ✓✓<br>not enough time to provide care✓<br>Doing doubles<br>physical✓✓✓✓✓<br>mental✓<br>demands<br>nights✓✓✓✓✓✓✓✓<br>changing assignments<br>increasing disappointment<br>inappropriate admits and nurse has to deal with it<br>unreasonable<br>disconnect between what want to do and what can be done – satisfaction✓<br>lack of breaks due to work demands✓✓<br>12 hour shifts<br>hate my job, hate weekends<br>heavy (obese) patients<br>ruminating about work all the time, even when not at work<br>thoughts that I may have missed something<br>fast paced✓✓<br>the need to maintain positive patient interactions<br>in Orientation, rotating shifts<br>multitasking for others<br>not enough staff<br>emotionally draining✓✓<br>stressful, undifferentiated<br>rotating shifts, lack of consistent schedule<br>too many hours worked over a short period of time | **The work of nursing**<br>"*Support or lack of from other staff (charge RN or CNA)."*<br><br>*"Problems with personell"*<br><br>*"Many times I feel too stretched to do as good of job as I would like to".*<br><br>"*being on my feet "*<br><br>"*emotionally draining"*<br><br>"*has to deal with´* inappropriate admits,<br><br>"*Having 5 patients that are difficult or heavy care. Noticed lately pt's being (40%) admitted either are not appropriate or not necessary to have been admitted. Just fill a bed with whatever and deal with it. This does not make a good working environment."*<br><br>"*expectations of the job have increased (do more with less*)"<br><br>"*trying to do more than possible in a given a given day/time frame"*<br><br>*"Work in fast paced unit, takes great effort to complete work in a particular shift".*<br><br>*"Multiple interruptions so tasks take much longer than they should & at times I feel fragmented (pulled in many directions)".* '*thoughts that I may have missed something"* |
| **Family:**<br>kids keeping me up<br>normal kids / family demands✓✓✓✓✓✓✓✓<br>Stress undifferentiated | **Family and work-life balance**<br>*"Not getting enough sleep because of trying to balance family, boyfriend, work, fun and rest."* |

<table>
<tr>
<td>different schedules✓✓✓✓<br>demands✓✓✓<br>demands on day off<br>housework<br>responsible for household finances<br>sacrifice sleep to participate in family activities<br>chronic illness in family and I'm the caregiver</td>
<td>"My 3 yr old son still wakes up at least once per night and both of my children wake up b/w 7 or 8:30. I don't always get to catch up on sleep before next shift".<br><br>"normal kid" [demands]<br>"family demands"<br><br>"child wake cycle is different from my wake cycle".<br>"wake up in the early afternoon because I don't want to 'miss out' on family/friend time when I should still be sleeping."<br><br>"stress at home",<br>"being responsible for household finances"<br>"working nights – taking care of the kids during the day"</td>
</tr>
<tr>
<td>Exercise<br>Lack of ✓✓✓✓✓✓✓✓<br>Less than I used to<br>normal fatigue✓✓<br>undifferentiated<br>fatigued when I don't exercise<br>trying to fit it in<br>exercise before work fatigues✓ me</td>
<td rowspan="3">Personal habits, choices and attributes<br>"lack of exercise",<br><br>"exercising less than I used to"<br><br>"fatigued when I don't exercise".<br><br>"exercise before work fatigues me."<br><br>"skipping meals leads to eating more later", eating "was not balanced"<br>[eating was not] "managed for optimal energy".<br><br>"Stress from work-load, fast-pace of my shift no time for a break or time to relax and eat my dinner most of the time".</td>
</tr>
<tr>
<td>Eating<br>skipping meals leads to eating more later<br>not balanced<br>not managed for optimal energy<br>poor eating habits✓</td>
</tr>
<tr>
<td>Health✓<br>medications<br>increase in health problems<br>chronic back pain from previous occupation<br>chronic health issue✓✓✓✓<br>grief from recent death of sister<br>Hx of cancer,</td>
</tr>
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<tr>
<td>Weight:<br>personal weight</td>
<td rowspan="3">“personal weight” contributed to his/her fatigue.<br><br>“medication”,<br>“increase in health problems”<br>“chronic health issues”<br>“history of cancer”<br>“chronic back pain from a previous occupation”<br><br>“Underlying autoimmune disease, stress over life & money. Vit B12 deficiency. Recent death of sister. I hate my job currently. I hate working weekends.”<br><br>“found it difficult to unwind when I get home”, a ” 35 minute commute home forces me to stay awake and makes it difficult to unwind when I get home”<br><br>“1.5 hour drive home in heavy traffic after working 8 hours with demanding patients. I’m usually ok energy-wise until 30 minutes into my drive home.”</td>
</tr>
<tr>
<td>Stress<br>undifferentiated✓✓✓<br>personal<br>life<br>mental</td>
</tr>
<tr>
<td>Commute✓✓<br>trying to stay awake<br>Difficult to unwind when I get home<br>I unwind during the commute home and that’s not always a good thing</td>
</tr>
<tr>
<td>Circadian rhythm:<br>work schedule different than my circ rhythm<br>staying up later than prefer<br>disruptions✓<br>different from family</td>
<td>Circadian rhythm<br>“Working nights, being on an opposite schedule as my circadian rhythm while also trying to go to school and keep fit.”<br><br>“Not getting good sleep because I have to try to sleep during the day.”,<br><br>“Noc shift. New baby.”<br><br>”Having to wake before the sun. I am solar powered and crave the sun light. This new job is a lot to learn. It is like being in class 8 hours</td>
</tr>
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<table>
<tr><td></td><td>while also speed walking the entire time.”</td></tr>
<tr><td>New job</td><td rowspan="10">Miscellaneous Interconnected Themes<br>“new job”<br><br>“lack of time”<br><br>“trying to fit it all in”<br><br>“trying to go to school and keep fit”<br><br>“unorganized planning”<br><br>“lack of social group outside of work”<br><br>“Trying to do more than possible in a given day/time frame”<br><br>“Part-time – BSN”</td></tr>
<tr><td>Time<br>lack of<br>Trying to fit it all in<br>procrastination<br>doing more activities than usual<br>disconnect between expectations and able to accomplish<br>non-work activities flow into work time<br><br>Motivation<br>lack of</td></tr>
<tr><td>Depressed</td></tr>
<tr><td>School✓</td></tr>
<tr><td>unorganized</td></tr>
<tr><td>Age✓✓</td></tr>
<tr><td>Intershift recovery ✓</td></tr>
<tr><td>Social life outside of work<br>lack of ✓</td></tr>
<tr><td>Second job</td></tr>
<tr><td>Just moved</td></tr>
</table>