LIGHT EXPOSURE, SLEEP-WAKE PATTERNS, MOOD, AND PAIN IN HOSPITALIZED ADULT MEDICAL PATIENTS

by

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Dedication

I dedicate this work to the courageous patients who so graciously and unselfishly agreed to participate in this study despite their pain and uncertain circumstances. They represent a population of medical inpatients who are often overlooked when new research and treatment modalities for pain are being considered. May the insights gained through their participation lead to better care of those who follow them.

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Light Exposure, Sleep-Wake Patterns, Mood, and Pain

in Hospitalized Adult Medical Patients

Abstract

by

ESTHER I. BERNHOFER

For many patients, the hospital environment may contribute to discomfort by providing a lighting structure that interferes with circadian rhythmicity, sleep, mood, and pain. Using Nightingale's Environmental Theory and the Heitkemper/Shaver Human Response Model, this study described light exposure, sleep-wake patterns, mood, and pain in 40 adult medical inpatients. Over 72 hours, light exposure and sleep-wake patterns were continuously measured with wrist actigraph/light meters, mood was measured using the POMS Brief Form, and pain scores were obtained from participants' medical records. The convenience sample included 23 females and 17 males, mean age 50 years. Light exposure levels were low during the daytime (M = 104.8, SD = 131.13) and nighttime (M = 7.07, SD = 7.00). Sleep time (minutes) was also low during daytime 161.02 (M = 161.02, SD = 81.40) and nighttime (M = 236.35, SD = 72.27). Participants experienced significant pain on a 0-10 scale (M = 5.91, SD = 1.55). POMS total mood disturbance score was also high (M = 19.56, SD = 13.11). Fragmented sleep and low intra-daily stability (IS) scores showed restless sleep and little circadian synchronization with the low levels of hospital lighting (the external zeitgeber). The mood subscale of fatigue significantly predicted pain; light exposure significantly predicted fatigue. This study provides preliminary data, useful in developing and testing future lighting interventions to improve sleep-wake patterns and consequently, mood and pain in hospitalized adults.

Light Exposure, Sleep-Wake Patterns, Mood, and Pain in Hospitalized Adult Medical Patients

Chapter I

Hospitalization is a difficult time for adult medical patients. In addition to the problems that precipitated the acute care admission, patients often have trouble adjusting to the clinical in-patient environment (Dijkstra & Pieterse, 2006). Despite progress in hospital environmental design to enhance patient well-being, one aspect of the hospital's physical environment that may not yet promote patient health is the institutional lighting structure (Webb, 2006; Joarder et al., 2009; Pechacek et al., 2008). Although there is evidence on how environmental light exposure affects personal well-being, there is little indication that this evidence has been used to change lighting environments for hospitalized patients. For example, institutional hospital lighting may still be too muted to promote entrained sleep-wake rhythms (Higgins et al., 2007; Alzoubi et al., 2010) resulting in sleep-wake disturbances that have been shown to have a negative relationship with pain and mood (Roehrs & Roth, 2005; Raymond et al., 2001; Vandekerckhove et. al., 2010). Researchers have found positive correlations between light exposure and mood (Partonen, & Lönnqvist, 2000) and an inverse relationship has been demonstrated to exist between mood and pain (Villemure & Bushnell, 2009; Tang et al., 2008). Furthermore, one study found a significant relationship between light exposure and pain levels in patients recovering from spinal surgery (Walch et al., 2005). No studies, however, have examined the relationships among the four factors of light exposure, sleep-wake patterns, mood, and pain in hospitalized medical patients. Since these four factors are commonly experienced in this acute care population and are factors that may lead to complications

in healing, describing and understanding their association will be important to better patient outcomes.

Specific Aims

The specific aims of this study were to describe light exposure, sleep-wake patterns, mood, and pain in hospitalized adult medical patients and to investigate the relationships among these variables. The long-term goal of this program of research is to develop intervention studies involving manipulation of hospital lighting to treat sleep-wake patterns, mood, and pain.

There were five research questions answered for this study. Over a three day period, for hospitalized adult medical patients:

1. What were their light exposure patterns, sleep-wake patterns, mood levels, and pain intensity levels?
2. What were the correlations among their light exposure patterns, sleep-wake patterns, mood levels, and pain intensity levels?
3. Were there differences in their light exposure patterns based on geographical orientation of windows in the hospital room (north, south, east, and west)?
4. Were there differences in sleep-wake patterns, mood levels, pain intensity levels, and analgesic use based on age or gender?
5. Did light exposure patterns, sleep-wake patterns, and mood levels predict pain?

Previous studies indicated that three covariates are required in this study: age, gender, and geographical orientation of the bed. Age may be associated with diminished light exposure to the brain due to aging changes in the eyes (Shneerson, 1999). Pain perception and sleep-wake patterns also may change with the process of aging (Kelly,

2009; Martin et al., 2007). There may be gender-based differences in pain perception, pain expression, and mood (Trame & Rawe, 2009). Information regarding the geographical orientation of the hospital bed was gathered to account for naturally varying light levels based on window orientation. For example, window beds located on south side of a unit received significantly more measured light intensity than those on the east and north side (Alzoubi et al., 2010).

This study used a sample of adult patients admitted to an urban tertiary care hospital. All participants in the convenience sample had a medical diagnosis that involved treatment for pain. For 72 hours, participants wore a wrist actigraph with a light sensor to measure rest-activity rhythms and light exposure levels. The Profile of Mood States Brief (POMS™ Brief) was used to measure participants' mood on a daily basis. Participants' self-reported pain levels, using the pain numeric rating scale; amounts of analgesics used while hospitalized were obtained from the participants' electronic medical records. Bivariate regression analyses were conducted to examine the relationships among light exposure, sleep-wake patterns, mood, and pain, and comparisons to these variables were made using sample characteristics.

Background and Significance

Inadequate light exposure related to well-being has been studied in several patient populations and settings, but not in acute care medical patients (Joarder et al., 2009). Sleep-wake disturbance is an on-going problem for hospitalized patients but usually has been studied with regard to environmental disturbances in the hospital such as noise, interruptions, and bright obtrusive light (BaHammam, 2006). Patient mood also is often overlooked for hospitalized adult patients, but researchers have shown that depressed

mood is highly associated with sleep disturbances and pain (Tanga et al., 2008; Paterson et al., 2010). And inadequate pain management continues to be a problem for a high percentage of hospitalized adults despite increased pharmaceutical management and efforts to manage pain (Huang et al., 2001; O'Malley, 2005). Furthermore, pain in hospitalized adult medical patients has not been given as much research attention compared to other populations such as those experiencing post-surgical pain, cancer pain, or chronic pain (Helfand & Freeman, 2009).

Light Exposure and Sleep-Wake Patterns

Researchers in health care design have examined hospital lighting as an important component of the built environmental that can have implications for patient health outcomes; insufficient lighting or inappropriate light exposure over the 24-hour period can hinder proper circadian entrainment in the individual (Pechacek et al., 2008). Circadian entrainment occurs when the master internal clock in the suprachiasmic nucleus is synchronized with the naturally occurring light-dark patterns to create predictable 24-hour biochemical, physiologic, and behavioral responses (Rea, Figuerio, & Bullough, 2002). With the 24-hour light-dark cycle the dominant external stimulus in entraining, or synchronizing, human circadian rhythms (Rea, Figuerio, & Bullough, 2002), the eye's retinal receptors require significant changes in light-dark levels, which hospital lighting may not provide. Although there is adequate lighting in the hospital for visual acuity, it may be inadequate for circadian entrainment (Rea, Figuerio, & Bullough, 2002; Lee et al., 2004; Webb, 2006). Lighting may be too bright during the night inhibiting sleep, and yet artificial lighting may not be bright enough during the day to provide the contrast in lighting necessary for circadian entrainment; thus, when an adult

is hospitalized, even for a short stay, the inadequate lighting scheme may contribute to circadian disruption (Higgins et al., 2007; Auvil-Novak, 1997; Pechacek et al., 2008). This circadian disruption can be seen in sleep-wake disturbances in the hospitalized patient. Since circadian entrainment is critically important for the coordination of functions throughout the human body, sleep-wake disturbances may reveal a circadian misalignment which can lead to asynchronies within cell cycles and between organ systems (Rea et al., 2008) as well as an increase in blood pressure, levels of c-reactive protein, and stress markers such as cortisol (Lane & East, 2008). Impaired glucose tolerance, irritability, confusion, reduced neurocognitive function, depression, and pain can also be consequences of sleep-wake disturbances (Lane & East, 2008; Roehrs & Roth, 2005).

Mood

Mood changes in the acute care medical patient population have not been well studied. It makes sense, however, that changes in mood may accompany hospitalization and may take the form of depression, anxiety, and irritability, as health stressors have done in other populations (Katon et al., 2007). Depressed mood and increased anxiety can affect healing outcomes in the acute care patient through increasing the pain experience (Tanga et al., 2008; Katon et al., 2007), and inhibiting the healing process (Glaser et al., 1999). Mood disturbance has also been shown to be associated with sleep-wake disturbances, as well as being affected by light intensity (Partonen & Lönnqvist 2000).

Pain

Pain is described as one of the factors most feared during hospitalization (O'Malley, 2005). In a study by Warfield & Kahn (1995), 77% of adults reported having

pain after surgery with 80% of these stating the pain was moderate to extreme. Despite receiving medication, 71% of those who reported pain stated that they continued to experience unrelieved pain. Other studies indicate that 50-75% of all hospitalized patients do not receive appropriate pain relief (Huang et al., 2001; Chung & Lui, 2003). The physiological ill-effects of inadequate pain management have been well-documented and include impairment of cardiac, endocrine, and pulmonary function (Carr & Goudas, 1999). Pain can interfere with the body's ability to heal and can decrease the immune system's ability to ward off infections (McEwen, 2005; Yun & Doux, 2007). Although proper pain management is receiving more attention in hospitals, patients continue to get inadequate pain relief (Huang et al., 2001; American Pain Society [APS], 2008). Furthermore, medical patients have not received the same attention from pain researchers compared to post-surgical and cancer patients in the hospital. There is little published research investigating pain in this population; consequently medical patients continue to experience the untoward effects of poor pain management while hospitalized (Helfand & Freeman, 2009).

Theoretical Framework

The overarching theoretical framework for this study was Nightingale's Environmental Theory in nursing. In 1859, Florence Nightingale proposed that sunlight was critical to the healing of body and mind and that light exposure could be manipulated by the nurse to provide better healing for the patient (Nightingale, 1969). Although Nightingale did not understand the physiology of circadian rhythm and light exposure, she understood the positive outcomes of providing adequate light to the patient (Nightingale, 1969). Because circadian rhythm photobiology, sleep, mood, and pain

management are important factors of health (body and mind), and hospital light exposure is an important environmental factor, Nightingale's environmental theory was logical as a philosophical base for this proposed study.

The Heitkemper and Shaver Human Response Model (HRM) (Heitkemper & Bond, 2003) was the middle-range theory used to describe the relationships among the concepts of person, environment, and individual adaptation in the hospitalized medical patient. In this study, *person* was the adult medical patient, *environment* was the light exposure in the hospital, and *individual adaptation*s were sleep-wake patterns, mood, and pain. These three measures corresponded to the physiological, experiential, and behavioral domains of adaptation in the HRM model. The model for this study is presented in Figure 1.

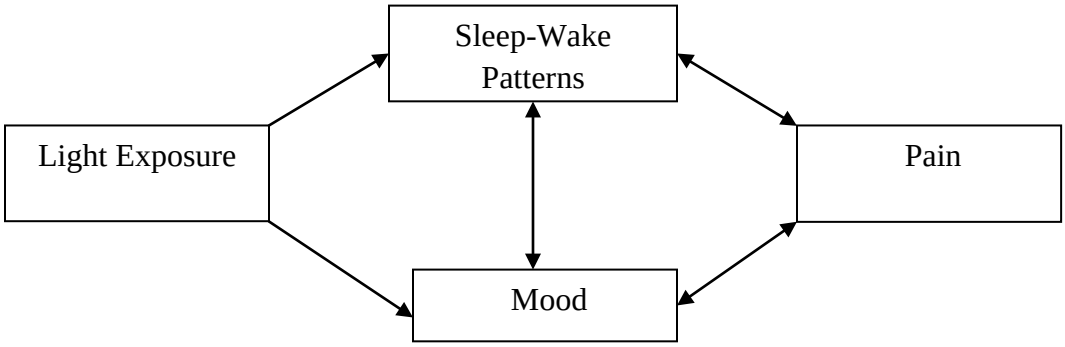


Figure 1. Model of the Research Study: Relationships among Light Exposure, Sleep-Wake Patterns, Mood, and Pain

Theoretical Definitions of Terms

Light exposure is defined as the intensity of available lighting surrounding a person or subject in the hospital environment whether by natural or mechanical sources (Dijk et al., 1995).

Sleep-wake patterns are defined as the rhythmic natural and periodically necessary state of rest of body and mind: a recovery state of the brain (McEwen, 2006). Sleep is described as a complex, regular, and easily reversible state of unconsciousness and physiological quiescence (Tranmer et al., 2003) which, when disrupted, may be a signal of circadian misalignment (Sack et al., 2007).

Mood is defined as the current psychological state of an individual person; it is the prevailing feelings and emotions and can include happiness, euphoria, anger, anxiety, depression, and any other emotional states (Clark, 2005).

Pain is defined by the International Association of the Study of Pain (IASP) as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or is described in terms of such damage" (Merskey et al., 1994, p.207). Furthermore, McCaffery (1968) has classically described pain as "whatever the experiencing person says it is, existing whenever the experiencing person says it does" (McCaffery, 1968, p.95).

The study concept terms are further described in Table 1.

Table 1

Study Concepts and Operationalization of Terms

Concept	Instrument	Variable
Light exposure	• Wrist actigraph light sensor	• Mean light levels in lux during day time (6a-10p) and night time (10p-6a)
Sleep-wake patterns	• Wrist actigraph motion sensor	• Mean # minutes of sleep during up time and down time • Sleep fragmentation index (FRAG) • Wake after sleep onset (WASO) • Intra-daily variability (IV) • Inter-daily stability (IS)
Mood	• Profile of Mood States Brief Form (POMS™ Brief)	• Total mood disturbance score (TMD) • POMS subscale scores: tension, depression, anger, vigor, fatigue, and confusion
Pain	• Numeric pain scale • Analgesic use	• Mean pain intensity score: 0-10 numeric pain scale score • Oral morphine equivalents of opioid use

Significance to Nursing and Healthcare

This study was framed by the nursing paradigm of person, health, environment and nursing. Studying the relationships among light exposure, sleep-wake patterns, mood, and pain in the medical inpatient has important implications for nursing science and practice. Nurses have always been involved in the management of pain and sleep since the beginning of the profession. In *Notes on Nursing*, Florence Nightingale writes, "… pain, like irritability of the brain, perpetuates and intensifies itself. If you have gained a respite of either in sleep, you have gained more than the mere respite...this is the reason why sleep is so all important" (Nightingale, 1969, p.44). Today's nurse has at his/her disposal many techniques and drugs to intervene for the maladies of disturbed sleep, mood, and pain. However, few nurses consider the associations among light exposure, and sleep, mood and pain.

This study is one of the first to describe these relationships in hospitalized patients and provides a basis for future nursing research studies and nursing education regarding utilizing light exposure in the treatment of sleep-wake disturbances, mood changes, and pain in the hospitalized adult patient. Patient satisfaction with hospital care, including sleep-wake disturbances and pain management, has received greater attention in recent years and is currently being evaluated by all hospitals in the United States (US Department of Health & Human Services, 2009). Understanding the relationships among hospital lighting that can be cost-effectively manipulated by the nurse in the healthcare system, and sleep-wake disturbances, mood, and pain, has the potential to lead to effective interventions for improved and more cost-effective patient care.

Assumptions

For this study, it was assumed that nurses could effectively manipulate the physical environment to maintain and improve patient health, and that manipulation and consideration of the environment, including lighting, is not only within the scope of nursing, but is part of the paradigm of nursing (although no lighting manipulation was done in this study). The hospital lighting environment varied and light intensity levels were experienced differently by different medical patients depending on room location and activities of the individual patient. Participants in the study continued to receive all usual care.

Summary

Adult medical patients experience four closely-related factors together during their acute-care hospitalization: hospital lighting, sleep-wake disturbances, mood changes, and pain. Sleep and mood disturbances as well as pain can all have profound implications on patient's healing, recovery, and satisfaction with their care. Research has shown that light exposure to individuals may affect sleep, mood, and pain. Although each of these factors has been studied individually in various populations, and some have been studied together, no investigations have included all four factors, describing their relationships in the medical inpatient. This study was the first known study to investigate all these factors in hospitalized adult medical patients, generating knowledge for further research on the benefits of manipulating lighting for better patient outcomes.

Chapter II

The literature review for this study provided an updated synthesis of published research investigating the concepts of light exposure, sleep-wake disturbance, mood, and pain. This section expounds upon the concepts, more fully explaining them, and how they have been studied in relationship to each other, especially in the hospital setting. What is known and what is yet unknown about the concepts are clarified. Also, literature that examines the adult medical acute care population chosen for this study is reviewed to ascertain how the study concepts affect them specifically. Evidence linking light exposure, sleep-wake disturbance, mood, and pain in the study population will demonstrate the importance of examining the relationships for further study.

Literature Review

Light Exposure

Light as a property. Visible light is defined in terms of electromagnetic radiation. Human eyes are only sensitive to a very small segment (about 350nm to about 800 nm) of the wavelengths of light in the electromagnetic spectrum (Light, 2008). Vision occurs when these wavelengths enter the eye and stimulate the rods and cones (photo-receptor cells) in the retina. A chemical reaction is created, creating an electrical impulse that is sent to the brain via the optic nerve enabling vision (Vision, 2008).

The brightness of light (luminance) in the environment that enables vision can be measured in different ways. Photographers use light meters as measurement tools, realizing that human vision is not reliable in detecting how bright the ambient light may be for the best photographic outcomes (Kripke, 1998). A foot candle is an older standard of measure used in some light meters by photographers and scientists to assess

luminance. One foot candle measures the illumination produced by one standard candle in a dark room, one foot away. The current measure used by modern photometers, however, is lux. One lux of light is about the brightness of one candle one *meter* away in a dark room. Due to light dispersion, the light illumination measured one meter from a candle is less than 1/10 the illumination of light of a candle a foot away so one lux is approximately 0.1 foot candles (Kripke, 1998). The human eye normally experiences a visual range of 0.01 lux (a moonless starry night) to 20,000-50,000 lux (a bright sunny day). Indoor lighting ranges from 20-50 lux in a common living room to 100 to 500 lux in a bright office (Kripke, 1998). Lux was the unit of measurement used to measure luminance in this study.

The luminance of environmental light (also known as ambient light), as essential as it is for human vision, is also important to the body for non-visual reasons. When electromagnetic optical radiation enters the eyes it also produces a non-visual circadian response (Rea et al., 2010). The light (optical radiation) enters the eyes and creates a signal that goes to the suprachiasmatic nucleus (SCN) in the hypothalamus of the brain which is responsible for the regulation of daily rhythms through links to the central nervous system (Kalsbeek et al., 2006). As noted in the previous chapter, environmental light to the eye is the primary synchronizer of the body's circadian rhythm with the 24-hour day (Rea, Figuerio, & Bullough, 2002). This proposed study was limited to investigating light to the eye for its non-visual effects on daily rhythms (circadian rhythms/ sleep-wake patterns), and its relationship with the central nervous system that includes mood and pain.

Light and circadian rhythm. Ambient light exposure to the eye is the driving force in circadian rhythm synchronization, or entrainment, with the 24 hour day (Rea, Figuerio, & Bullough, 2002; Czeisler et al., 1989). Light (electromagnetic optical radiation) enters the eyes, stimulates the retina, and creates a signal carried along the retino-hypothalamic tract (RHT) via intrinsically photosensitive retinal ganglion cells (ipRGCs), axons where optical radiation is converted to neural signals that are directly put into the master clock of the suprachiasmatic nucleus (SCN) in the hypothalamus of the brain (Berson, Dunn, & Takao, 2002; Rea et al., 2010). This master clock then synchronizes and organizes the timing of all rhythmic bodily daily functions from complex physiological processes to single cell functions (Rea et al., 2010). The master timing and synchronization of bodily processes (circadian rhythm) is adjusted based on *zeitgebers* (German for time-keeper), or external drivers, of which the 24 hour cycle of variation in light is the main zeitgeber (Auvil-Novak, 1997).

A number of studies have addressed circadian biological responses to light in relationship to patients' health and well-being in hospitals (Taguchi et al., 2007; Meyer et al., 1994; Walch et al., 2005; Walder, 2000; Beauchemin & Hays, 1998) and in nursing homes (Ancoli-Israel et al., 1997; Fetveit & Bjorvatn, 2005; Shochat et al., 2000; Sumaya et al., 2001). Not every study that measured light exposure, however, measured circadian entrainment. For example, Walch (2005) examined the relationship between light levels and pain but did not mention circadian rhythm. Beauchemin and Hays (1998) studied the correlation between light and cardiac patient outcomes, while Sumaya et al. (2001) looked at light and depression; neither researcher mentioned circadian rhythm in relation to light exposure. Light exposure, however, affects circadian entrainment and has been

linked to important human health aspects including the maintenance of cell cycles and synchrony between organ systems, digestion, neuroendocrine and neurobehavioral regulation, cardiac function, and perhaps cancerous tumor growth (Figueiro et al., 2006; Stevens et al., 2007; Rea et al., 2008).

Some studies, however, incorporated measurement of both light and circadian function. Taguchi and colleagues (2007) investigated circadian disruption related to bright light therapy for older post-operative patients to determine if circadian rhythms could be adjusted with bright light treatment to prevent delirium (a neurobehavioral phenomenon). Eleven subjects were randomized into either an intervention group (n=6) or a control group (n=5). The intervention group was exposed to 5000 lux of bright light therapy, 100cm from the eyes, for 2 hours from 7:30 to 9:30 am for 3 days, 2-5 days following surgery. The control group was placed in the usual lighting situation for that hospital population (10-300 lux over 24 hours). Circadian disruption was measured using an accelerometer placed on the participant's ankle, similar to a wrist actigraph, which measured rest-activity cycles. A significant difference was found ($p = 0.014$) in delirium scores (using the NEECHAM Confusion Scale) between the two groups on the third morning of bright light therapy vs. usual lighting: less delirium and activity between 2am and 4am was recorded in those in the experimental lighting group compared with controls (Taguchi et al., 2007). The major limitation with this study was the small sample size, but the researchers concluded that even in the short-term stay of the acute care setting, lighting may be beneficial in better patient outcomes, although more investigative studies with larger study groups are needed (Taguchi et al., 2007).

As in Taguchi's 2007 study, circadian entrainment or its converse, circadian disruption, is often measured using calculations that measure cross-correlations between light exposure and activity (Rea et al., 2008). Van Someren et al., (1999) noted the need for a better, more sensitive analysis method, however, in determining if there is an effect on circadian rhythm related to light exposure due to the characteristic non-sinusoidal waveform of rest-activity and light exposure wave data. Van Someren and colleagues looked at data collected from two separate studies that measured rest-activity patterns and light exposure of Alzheimer's patients in order to measure circadian disruption with increased sensitivity. Non-parametric tests, intra-daily variability (IV) and inter-daily stability (IS) were calculated and used to quantify the variability in the rest-activity data to determine its synchronization with light exposure data from participants. The IV statistic calculates the number of the transitions between rest and activity over a 24 hour period, indicating fragmentation caused by frequent night waking or day napping. The IS statistic calculates the synchronization of the rest-activity data of the subject with the 24 hour external ambient lighting of the subject's environment. In a re-analysis of the data from one study, after controlling for covariates, the IS method of analysis indicated that a bright light significantly affected rest-activity cycles [$F(2,6) = 8.51$, $p = .02$] (Van Someren et al., 1999). In the second study re-analysis, Van Someren and colleagues also found that IS was sensitive in showing the effect of bright light on rest-activity [$F(2,32) = 5.99$, $p = .006$] as well as less fragmented rest-wake activity over a 24 hour period according to intra-daily variability (IV) [$F(2,32) = 2.41$, $p = .10$] (Van Someren et al., 1999). This study calculated the IV and IS to measure circadian entrainment from light exposure data collected from the participants in the hospital.

Light in hospitals. Hospital lighting is part of an increased emphasis on the importance of the interior 'built' environment to benefit patient outcomes. Known as evidence-based healthcare design (Ulrich et al., 2008), research into better hospital design was facilitated by a now-classic study (cited 1,108 times to date) published by Ulrich (1984) who investigated the post-surgical outcomes of patients depending on their window view during recovery. Ulrich's study was a comparative retrospective study of 23 matched pairs of post-surgical patients (n=46). There was a significantly shorter length of stay between the patients who had windows with tree views and those whose windows faced a brick wall: 7.96 days compared to 8.70 days respectively. Analgesic consumption was also significantly less among the patients with a tree-view room and those in the brick-view room. (Ulrich et al., 2008).

Since Ulrich's study in 1984, the environmental aspects of hospitalization that affect patient well-being, including windows and ambient lighting, have been studied extensively (Ulrich, 2000; Martin, 2000; Caspari, et al., 2006; Webb, 2006; Stichler, 2007; Pechacek et al., 2008). Two such studies were conducted by Meyer et al. (1994) and Walder (2000) to investigate the relationship between light and sleep disruption. Meyer and colleagues noted that there were considerable differences in light exposure in intensive care unit rooms depending on window direction and shading. Mean daytime light levels ranged from 1602 to 5089.9 lux to nighttime means of 128 to 1445 lux at night (Meyer et al., 1994). Walder also measured light in an intensive care unit setting to evaluate whether clinical guidelines effectively reduced light at night in patient rooms (for better sleep) and found much lower light levels (mean lux between <5 and 23 lux) than in Meyer's study. Walch et al. (2005) looked at patients' light exposure based on

whether they resided in a “bright” or “dim” room on a regular (non-intensive care) post-surgical unit. Walch et al. calculated the luminance in rooms by measuring light levels (in lux), twice a day at 9:30am and 3:30pm in each patient’s room and multiplying the result by the number of morning (sunrise to noon) and afternoon (noon to sunset) exposure hours each day for each patient to achieve a cumulative daily sunlight exposure figure. These light measurements were taken from postoperative day one and continued every day until discharge, an average of 3.5 days. The results were that brighter rooms had a cumulative light measurement of 73,537 lux, exposing patients to 46% more light than dim rooms with 50,410 lux total exposure during hospitalization (Walch et al., 2005).

Beauchemin and Hays (1998) also measured hospital lighting in a cardiac intensive care unit (CICU) and examined its correlation with patient outcomes. The study was a natural history study that included 568 patients that had been directly admitted to the CICU for a first heart attack and did not have surgery, with 272 patients in ‘bright’ rooms (southern exposure with 1200-1300 average lux) compared to 296 patients in ‘dark’ rooms (northern exposure with 200-400 lux). The only additional patient information collected was age, gender, and whether the patient had died. Those patients in bright rooms stayed an average of 2.3 days compared to those in dark rooms who stayed an average of 2.6 days. Women stayed significantly longer in the dark rooms, 3.3 days compared to those in bright rooms staying 2.3 days. A 2-factor ANOVA, using light conditions and gender indicated a main effect of light on length of stay ($F = 6.5$, df 2; $p<0.006$). Age was not determined to be a significant factor with length of stay (Beauchemin & Hays, 1998).

When studying the effects of light on older adult patients in a Japanese hospital, Wakamura and Tokura (2001) reported ambient light intensities in north-facing patient rooms from 50 to 300 lux. Brighter light was provided for 5 hours mid-day by way of a light box attached to the head of the bed, exposing each participant to 3,000 lux of light at eye level for one week resulting in having statistically longer sleep times during the days of extra light exposure (Wakamura & Tokura, 2001).

Of the five studies reviewed, four (Meyer et al., 1994; Walch et al., 2005; Wakamura & Tokura, 2001; Beauchemin & Hays 1998) reported that light from windows was a significant contributor to measured luminance of their study. This study also considered geographical orientation of the window near the hospital bed in comparing the measurement of light exposure among patients in the hospital.

Different types of light meters were used to measure luminance in the aforementioned investigations. One report of instrumental research reviewed for this study looked at the difference between two light meters that may be used in research to measure luminance in hospital rooms. Higgins et al. (2007) compared the difference between two instruments used to measure light in a hospital setting. Higgins used 20, 24-hour light trials, collecting 480 light measurements from two different light meters: a stand-alone meter placed 5 feet from the patient's bed, and a light meter on a patient's wrist-worn actigraph watch. Statistical analysis, using Bland Altman plots (to compare the differences in the two techniques plotted against the means of the two techniques) was done to determine the similarity of measurement between the two instruments. Although differences in light measurements were found, when light was simultaneously recorded with both meters, variances remained within the pre-selected standard deviation

of 1.96 for the study. This indicated that both stand-alone light meters and wrist worn light meters (on the actigraph) could be used for light measurements in studies in the hospital setting with similar results (Higgins, 2007).

Most of the studies reviewed here included measurement of natural light from windows as well as artificial light sources. Luminance was measured from all sources and associations with various amounts of ambient light exposure were made with patient outcomes. These studies demonstrate the wide rang of light exposure in the hospital.

Light and sleep-wake patterns. Many studies that investigate light exposure in relationship to health outcomes measure the sleep-wake circadian rhythm. Sleep-wake patterns and light exposure are biologically linked. There is a connection between the suprachiasmatic nucleus (SCN) and the pineal gland which is responsible for the synthesis and secretion of melatonin, a hormone produced in correlation with the light-dark exposure to the eye (Reiter, 1991). Melatonin has a 24 hour production cycle, with higher levels produced in darkness at night. Melatonin levels usually peak between 2am and 4am and decline to daytime levels between 7am and 9am. Light exposure in the evening and at night can cause melatonin synthesis to rise at a slower rate and fall at a faster rate near morning (Figueiro et al., 2009). It is melatonin synthesis that is thought to be responsible for the biological link between light exposure and sleep-wake patterns.

Seven studies that investigated the relationship between light exposure and sleep are reviewed here. In a non-intervention study that measured light exposure and sleep-wake disturbances in an institutionalized older adult population, higher light levels predicted fewer night-time awakenings and daytime napping; increased day time light exposure correlated with peak activity levels among the study group (Shochat, et al.,

2000). Mishima et al., (2001) conducted a comparison study on the effects of daily ambient light exposure on the melatonin levels and sleep quality of nursing home residents, comparing those who had psychophysiological insomnia (n=10) with healthy nursing home residents (n=10) and young healthy non-resident subjects as control (n=10). An increased exposure of midday bright light to the insomnia group resulted in an increase in melatonin levels and improved sleep quality in study subjects to the levels found in the young control group (Mishima et al., 2001). These results were similar to a pilot study done with 11 participants, also in a nursing home, that reported that bright light exposure was effective in decreasing day-time sleep and increasing night-time sleep in older adults (Fetveit & Bjorvatn, 2005).

Another study that measured 66 older adults in a nursing home setting was done by Sloane and colleagues (2007) who measured the effect of an increase in light exposure for institutionalized older adults with dementia on their sleep patterns and circadian rhythms. A low-glare lighting system was installed, providing approximately 2,500 lux of light for 2.5 to 3.0 hours every morning, every evening, and all day (7am to 8pm) to the participants in the eating and activity areas of the nursing home. Three groups of 22 participants each were exposed to the different lighting times. Each lighting time period lasted one week for a total study time of 3 weeks. Night time rest-activity was measured with wrist actigraphy watches placed on the 66 older adult participants. Morning light and all day light was associated with the greatest increase in night-time sleep ($p<.05$) (Sloane et al., 2007). The researchers concluded that although findings were significant, the limitations of cost and extra heat (from the electrical light source) may not make it feasible for practice and more studies need to be done (Sloane et al., 2007).

Only one published research study was found that examined the effects of light exposure and sleep in hospitalized patients. Wakamura and Tokura (2001) reported the effects of exposing older hospitalized participants (n=7, mean age=67 years) to 3,000 lux of light from a fluorescent lamp fixed on the bed frame near the head of the bed for one week (light was on at 10am and off at 3pm). A pre-post test design was used. Findings were compared to baseline sleep levels measured 2 days before the study began and then during the last 2 days of bright light exposure. Results concluded that the bright light exposure intervention increased "Time in Bed" ($p<0.05$), increased "Immobile Minutes" ($p<0.05$), and delayed "Get up Time"($p<0.01$) (Wakamura & Tokura, 2001).

In a search for light exposure and sleep-wake disturbance research conducted outside of hospitals and nursing homes, two studies were found that looked at community-dwelling volunteers who were exposed to bright light conditions (2,500 to 5,000 lux) for the purpose of examining the effectiveness of bright-light therapy for better sleep (Lack et al., 2005; Takasu et. al, 2006). Lack et al. studied 24 otherwise healthy adults with insomnia and assigned 12 to light therapy with exposure to 2500 lux light boxes for 4 hours, with the control group assigned to 4 hours of dim (not specified how low lux levels were) light exposure. The bright light group had a significant reduction in wake time during the night, with the control group having little change over baseline insomnia (Lack et al., 2005). Takasu et al. (2006) had similar results after exposing the intervention group of 8 healthy volunteers in a community living facility to 5000 lux of light (by use of fluorescent ceiling fixtures in small closed, experimental windowless rooms) for 7 days, 8 hours a day, resulting in increased sleep time at night as measured by polysomnography and subjective sleepiness on the Questionnaire for Subjective

Symptoms 2002 (QSS2002) prior to baseline (Takasu et. al, 2006). Although this study was experimental and not done in any 'normal' living conditions, it provided similar results to other studies.

Whether among older nursing home residents, hospitalized persons, insomniacs, or young healthy adults, increased light exposure was correlated with fewer sleep-wake disturbances. Since the greatest gap in the research on light exposure and sleep-wake disturbances is in hospitalized patients, this study provided more knowledge to fill that gap in describing the relationship between light exposure and sleep-wake patterns in the adult medical inpatient.

Light and mood. The association between light and a positive mood has long been understood. Music and literature is filled with references to light (usually sunlight) as imparting a happy mood. Songs such as *You Are My Sunshine* and references to having *seen the light* indicate that light is a good thing that makes one happy and a *sunny disposition* means the person is cheerful.

The positive relationship between mood and light has also been well studied in the scientific community. Seasonal Affective Disorder (SAD), a depressive disorder associated with lack of ambient light, specifically in the winter months, was first described and studied in the 1980's (Rosenthal et al., 1984). Researchers have since found that a decrease in light exposure due to short day length and gloomy weather is a significant contributor to winter depression (Rot et al., 2008).

Due to positive effects on mood and depression for SAD sufferers obtained with light therapy (Sher et al., 2001), a number of studies have been undertaken to examine the effect of bright light treatment on other non-seasonal mood disorders (Golden et al.,

2005). A meta-analysis of the effect of light therapy on mood disorders was done in 2005 that included a pubmed search for articles published between January 1975 and July 2003 to look for randomized controlled trials of light therapy for mood disorders. A total of 64 investigative studies done in a non-geriatric adult population were found that met certain criteria: (a) placebo groups needed to receive a maximum of 300 lux of light exposure; (b) bright light treatment must consist of a minimum of 4 days of at least 3,000 lux-hours per day; and (c) dawn simulation studies must consist of increasing light exposure from 0 to 200–300 lux over one to two and a half hours (Golden et al., 2005). The result of this meta-analysis was that bright light therapy for non-seasonal depression was found to be as effective as most antidepressant pharmaceutical therapies in clinical trials. The authors stated that the limitations to all of the studies, however, included meeting rigorous clinical trial standards such as defining acceptable parameters for active treatment and control conditions as well as issues of safety and optimum dosing; they concluded that more research is still needed in the area of bright light therapy and mood disorders (Golden et al., 2005).

Two studies were found that examined the association between light and mood in adult patients admitted to psychiatric hospital units. Beauchemin and Hays (1996) compared the length of stay for depressed patients in sunny rooms with those in dim rooms. Occupants of the sunny rooms had an average length of stay (LOS) of 16.9 days compared to an average LOS of 19.5 days for those in dim rooms (Beauchemin & Hays, 1996). Similar results were obtained in another study done with psychiatric patients. Bipolar depressed patients residing in east-facing rooms that were brighter than those in west-facing rooms had a shorter hospital stay by an average of 3.67 days (Benedetti et al.,

2001). Both Beauchemin and Hays and Benedetti and colleagues concluded that length of stay was a parameter of effective treatment of depression and the significant decrease in length of psychiatric hospitalization demonstrated better mood and healing from depression associated with more environmental light exposure. However, an obvious limitation to this study remains that the authors did not measure other factors that may contribute to the length of stay of these patients.

When looking for published research regarding the association between light and mood in another population, hospitalized medical patients, no studies could be found. Two published studies, however, were found that examined bright light therapy in institutionalized older adults who may be at risk for chronic light deprivation and may experience depression (Sumaya et al., 2001; Riemersma-van der Lek et al., 2008). Sumaya conducted a placebo-controlled crossover design study with ten participants (n=6 women, n=4 men; mean age 83 years) living in a nursing home. These participants received 30 minutes of light treatment every morning: 5 days of 10,000 lux of light, 5 days of 300 lux (considered placebo), and 5 days of no treatment (control). There was one week between treatments. Results of mood were measured on the Geriatric Depression Scale (GDS) with baseline scores that showed that those who had been institutionalized longer had higher depression scores. Scores decreased significantly during the 10,000 lux treatment time but remained near baseline during placebo and control conditions, causing the researchers to conclude that bright light treatment for older adults may be useful in the nursing home setting (Sumaya et al., 2001). Riemersma-van der Lek et al. (2008) had similar results when studying 189 older adult residents in group care facilities in the Netherlands. Residents in the group homes (n=189) were

randomly assigned to bright (approximately 1000 lux) lighted areas for 9 hours per day for a mean time of 15 months (study lasted 3.5 years), or to the control of dimly lighted areas (approximately 300 lux) for the same duration. Results showed that depressive symptoms measured on the on the Cornell Scale for Depression in Dementia decreased by a modest but significant 19% during the course of the study leading the researchers to conclude that light exposure has a modest benefit to improving mood in this population (Riemersma-van der Lek et al., 2008).

In a unique physiological study of how light may be associated with serotonin, a biological indicator of mood, Lambert et al. (2002) examined circulating serotonin levels in healthy male volunteers (n=101) to determine if there was an association with bright light exposure, mood, and depression levels. Lambert proposed that the rate of serotonin (a hormone and neurotransmitter influencing mood) production by the brain was directly related to the duration of bright light exposure to the eyes. In Lambert's study, participants had venous blood samples drawn from a catheter positioned in the internal jugular vein to sample blood directly from the brain to examine serotonin levels. Each participant had one blood sample taken and the study spanned the course of a year to examine serotonin levels throughout the differing light exposures of the seasons. It was found that irrespective of the month of the year, controlling for other environmental factors, serotonin levels were affected by acute changes in current natural lighting with values of serotonin higher on bright days than on dull days. Serotonin levels did not correlate with sunlight levels on the previous day, but only with those light levels currently experienced by the study participant, concluding that serotonin levels must adjust quickly to sunlight levels on the morning of the study (Lambert et al.,2002). Study

limitations include that the researcher, although studying ‘healthy’ individuals, did not account for participant’s individual mental status, mood, and other factors that can contribute to fluctuation in serotonin levels. However, it was a unique method of measuring an important association between a biological influence of mood and natural light exposure.

In all of the aforementioned studies, light exposure was positively correlated with mood in several different populations, whether through experimental light studies or natural light exposure. However, no studies were done in the hospitalized adult medical population. Given that greater light exposure has been associated with better mood in every population studied, it makes sense that brighter light exposure at the right times may correlate with better mood among hospitalized adult patients as well. This proposed study was among the first to examine the relationship between light exposure and mood in an adult hospitalized medical population.

Light exposure and pain. In a search of published research, only two studies were found that investigated an association between light exposure and pain in the hospital (Ulrich, 1984; Walch et al., 2005). Both studies reported an inverse correlation between light exposure and pain through the measurement of analgesic consumption. In an early study, Ulrich (1984) was the first to associate levels of light in the hospital (measured only by “bright” or “dim” description) with pain (measured by analgesic consumption). Ulrich found a negative association between the brightness in patients’ hospital rooms and their use of analgesics: the brighter the room, the less analgesics consumed, interpreted as less pain experienced (Ulrich, 1984). Walch et al. (2005) conducted a similar study but actually measured light levels in patient’s rooms and

associated them with analgesic use in 89 patients following spine surgery on a post-surgical unit. Lux levels of light were measured twice a day, at 9:30 am and 3:30 pm and the results were multiplied by daytime exposure hours and then summed to get a cumulative daylight exposure in lux-hours. Those patients with brighter-facing windows (cumulative lux of 73,537) were exposed to 46% more light than the dim-facing windows (cumulative lux of 50,410) and required 21% less analgesic medication (Walch et al., 2005). No other published research was found that examined light and pain in acute-care hospitalized patients.

The study model for this proposed research does not include a direct link between light and pain, instead investigating the relationship between light and pain as it may exist indirectly through sleep-wake disturbance and mood. However, it is worth noting that when reviewing the literature, published research was found proposing that melatonin receptors in the thalamus, hypothalamus (directly related to light stimulation in the SCN), and dorsal horn can induce anti-nociceptive, pain modifying, effects with regard to acute, inflammatory pain as well as chronic neuropathic pain (Ambriz-Tututi, et al., 2009). Furthermore, the multiple influences of melatonin to the body (produced by the brain in relation to light exposure) may also include a role in the experience of pain (Budak, et al., 2007; Ebadi, et al., 1998; Barrett, Kent & Voudouris, 1999). One researcher has hypothesized a link between light processing through the eyes, projecting through the retinal ganglion neurons to the SCN, and influencing serotonin production and sensitization of the periaqueductal gray which plays a role in the descending modulation of pain perception (Deshmukh, 2006). Stimulation of the periaqueductal gray in the midbrain has long been known to activate pain suppression systems essential to

analgesia (Basbaum & Fields, 1978). Knowledge gained from this proposed study will contribute to other investigative studies in hospital populations experiencing pain to determine if there is a direct correlation between light exposure and pain.

Sleep-wake Patterns

Sleep-wake pattern disturbances have previously been defined as an interruption in the necessary complex, regular, and easily reversible state of unconsciousness and physiological quiescence (Tranmer et al., 2003) that is necessary for good health. Sleep-wake disturbances may signal circadian misalignment (Sack et al., 2007) and have been recognized as a large problem in those recovering in a hospital. Up to 70% of hospitalized patients experience some type of sleep-wake disturbance which are reported as troubling (Raymond et al., 2001; Lauri, Lepisto, & Kappeli, 1997; BaHammam, 2006). Research has been conducted on sleep-wake disturbances related to other environmental factors such as noise and bright light at night interfering with sleep (Lane & East, 2008; Tranmer et al., 2003), but there is a limited amount of research in hospitals examining light exposure and circadian rhythm related to sleep. However, it is important to establish that sleep-wake disturbances have been directly related to mood and pain (Lane & East, 2008; Hamilton, Cately, & Karlson, 2007) creating important links in this proposed study's model.

Sleep-wake patterns and mood. Anecdotally, most people will indicate that if they have not slept well, they experience a decreased (or depressed) mood. In healthy persons, sleep-wake disturbances and depressed mood have been linked in studies like the one conducted by Blagrove and Akehurst (2001) who recruited healthy university student volunteers to participate in a sleep loss study designed, in part, to measure sleep

deprivation and mood. Volunteers in the experimental, sleep-deprived group were stimulated for 29-35 hours to stay awake (n = 31, males = 15, females = 16, mean age = 21.4 years). The control group participants (n = 30, males = 15, females = 15, mean age = 21.5 years) were permitted to sleep normally throughout the 36 hours. Results of the study showed that the sleep deprived group had a significant increase in mood disturbance scores on Profile of Mood States (POMS) mood scale from baseline ($p <$ 0.001) causing the researchers to concluded that controlling for other variables, sleep deprivation was associated with significant deficits in mood (Blagrove & Akehurst, 2001). Another study looking at the relationship between sleep-wake disturbances and mood in healthy individuals was done with 47 medical intern volunteers (Rosen et al., 2006). Results of this study showed a significant positive correlation between sleep deprivation and depressed mood (p = .014) in the young doctors throughout the one-year longitudinal study (Rosen et al., 2006). Similarly, Baker, Simpson and Dawson (1997) looked at the relationship between sleep-wake disturbances and mood in menopausal and pre-menopausal women. Twenty-eight women were studied (n = 15, menopausal, n = 13 pre-menopausal) using wrist actigraphy to determine sleep-wake disturbances (rest-activity levels) and the POMS scale to measure mood. Menopausal women were found to have significantly higher levels of arousal time at night (greater sleep-wake disturbance) and lower mood scores, with a significant correlation between sleep-wake disturbances and negative mood (Baker, Simpson & Dawson, 1997).

When looking for studies on the relationship between sleep-wake disturbance and mood in the not-so-healthy population, no published research was found testing the association between mood and sleep-wake disturbances in hospitalized medical patients.

However, studies among cancer patient populations were found and indicated similar results to the studies done in healthy groups as far as finding a relationship between sleep-wake disturbances and mood (Stepanski et al., 2009; Carlson & Garland, 2005). One study in cancer outpatients who reported suffering from sleep disturbances, demonstrated that when sleep quality improved through an intervention (Mindfulness Based Stress Reduction), mood also significantly improved (p=.001) (Carlson & Garland, 2005). Stepanski et al, (2009) looked at patient-reported outcomes from 11,445 cancer patients being treated at a large clinic. Patient-reported symptoms for depressed mood and trouble sleeping were collected with other data of interest. Those patients with moderate to severe trouble sleeping reported significantly more depressed mood (Stepanski et al., 2009). The authors concluded that based on this finding, an intervention to improve depressed mood would also be expected to improve other symptoms including sleep-disturbances (Stepanski et al., 2009).

If there is a association between brighter light exposure and an improvement in mood as described earlier, then it makes sense to expect a relationship between brighter light exposure at the right times and less sleep-wake disturbance with improved mood; these relationships will be investigated in the proposed study.

Sleep-wake patterns and pain. A definitive reciprocal relationship has been found to exist between sleep and pain (Roehrs & Roth, 2005) and more attention has recently been shown to this association as evidenced by a recently published book, *Sleep and Pain*, edited by Lavigne et al. (2008), which is a compilation of basic science and clinical studies that link the phenomena of sleep-wake disturbances and pain.

Most research work undertaken to examine the relationship between sleep-wake disturbances and pain have focused on the chronic pain population (Davies et al., 2008; Smith et al., 2008; Hamilton, Cately, & Karlson, 2007). In a study on Chronic Widespread Pain (CWP) such as in fibromyalgia, Davies et al. (2008) investigated 679 subjects at a pain clinic to see if there was a relationship between their pain and sleep following pain treatment. At the end of 15 months of treatment, those whose pain had resolved to within acceptable levels described by the patient, had significantly less sleep disturbances. The results for the association between pain and restorative sleep were significant and after adjusting for psychosocial factors, age, and gender, restorative sleep remained significantly associated with less pain in those studied (Davies et al., 2008). Hamilton, Cately, and Karlson (2007) also had similar results when studying those with fibromyalgia and rheumatoid arthritis ($n = 49$). This study lasted only 2 consecutive days with subjects reporting their sleep and pain ratings in the morning. The level of sleep disturbance was found to modify the level of the pain experience in those participants, with those having less sleep disruption reporting less pain (Hamilton, Cately, & Karlson, 2007). Smith et al. (2008) studied chronic pain and sleep-wake disturbances in a different patient population, the burn injury patient. This study examined 333 subjects to determine whether acute sleep-wake disturbances in the hospital predicted the development of chronic pain. The research team found that those who were experiencing sleep-wake disturbances at discharge had significantly increased pain severity long-term ($p < .001$) indicating that sleep disruption may be involved in the pain experience, even affecting future pain. In addition, this study showed an association between severe pain at hospital discharge and increased sleep disturbance long term ($p < .05$) indicating to the

researchers a bi-directional relationship between sleep-disturbance and pain (Smith et al., 2008).

A comprehensive literature review of sleep-wake disturbances and pain was done by Menfee and colleagues in 2000. In this review the authors concluded that chronic pain conditions, musculoskeletal pain, rheumatic diseases, headache, and fibromyalgia were all associated with poor sleep, but they did not look at acute pain issues. These researchers also examined the literature on the neurochemistry of the possible links between pain and sleep-wake disturbance since both have a connection with serotonin production in the brain linking back to the positive relationship between light exposure and brain serotonin levels as studied by Lambert et al. (2002) and reviewed earlier.

The relationship between sleep and pain has been well established in many populations, but has not been researched as frequently in those with acute medical pain. It makes sense, however, that those who are experiencing acute pain issues in the hospital would also suffer from sleep-wake disturbances as those with chronic pain do. This proposed study looked at that relationship in the study model, examining it among the relationships of light exposure, sleep-wake disturbances, mood, and pain.

Mood

Mood is defined as the current psychological *state* of an individual person; it is the prevailing feelings and emotions and may include happiness, euphoria, anger, anxiety, depression, and any other emotional distress (Clark, 2005). Mood has already been discussed in this review in its documented relationships with light and sleep-wake disturbances. Like other concepts in this proposed research, the phenomenon of mood disturbance has not received much attention from researchers in the hospital medical

population. Nevertheless, mood can be a critical moderator for healing (Glaser et al, 1999; Katon et al., 2007) and was studied in this proposed research study in its relationships to light, sleep-wake disturbances, and pain in the adult medical population.

Mood and pain. Mood and pain have long been linked with the idea that inducing a positive mood decreases pain perception and inducing a negative mood increases the pain experience (Villemure & Bushnell, 2009). The well known gate control theory of pain was the first theory to scientifically describe the association between mood states and pain. The gate control theory states that a gating mechanism in the dorsal horn in the spinal cord opens and closes to allow or deny the transmission of signals to the brain from the periphery, resulting in the experience of pain (Melzack & Wall, 1965).What made this theory remarkable was the contention that emotional as well as physical mechanisms worked to control the gate in the dorsal horn that allowed the transmission of pain (Melzack & Wall, 1965). The experience of pain is now known to be an interaction between the biological somatic in-put (the biological cause of the pain), the psychological processing of the experience, and the social context associated with the pain (Turk & Okfuji, 2002). This theory put together earlier existing theories and data and gave medical credibility to what many cultures and peoples had known since mankind began: pain was as much an emotional state as a physical one and was influenced by both physical and psychological means (Luedtke & Nelson, 2009).

In keeping with the realization that there is an association between emotional states and pain, mood and pain have long been linked in chronic pain studies (Naughton, Ashworth, & Skevington, 2006; Tang et al., 2008; Menefee et al., 2000). Studies describing the association between mood and *acute* pain were more difficult to find,

however. Two current studies were found for this review that investigated the effect of emotions on acute pain in experimental pain studies (Yang et al., 2009; George et al., 2006). George et al's (2006) study included measuring anxiety, fear of pain, and coping strategies of acute pain perceptions. The healthy volunteers in this study underwent cold presser pain. The results indicated that pain intensity at both threshold and tolerance were significantly predicted by fear of pain only, not anxiety or coping strategies (George et al., 2006). Yang and colleagues (2009) induced pain in their subjects with electrical stimulation to the fingers and measured the pain using a visual analog scale (VAS). Happy and sad emotions were elicited using pictures and were also measured on a VAS. Brain activity was then measured via magnetic resonance imaging (MRI). Pain delivered during happy emotions resulted in significantly less activity than pain delivered during sadness. This study suggests that emotional mood states and acute pain perception in the brain may be related but that fear of pain was the only predictor of how much pain could be tolerated by the study participants (Yang et al., 2009). These studies, while useful, are limited due to the use of experimental and not clinical pain, but are helpful in understanding the emotional aspect of acute pain. Additional studies that investigate the relationship between actual clinical acute pain and emotional mood states, such as the one proposed herein, will add to the scientific knowledge of mood and acute clinical pain and provide a basis for future research.

Pain

Considering what is known regarding the acute pain experience, a pain definition for the 21st century, adapted from Carr and Goudas (1999), is that acute pain is the normal, predicted physiological response to an adverse chemical, thermal or mechanical

stimulus associated with surgery, trauma, or acute illness and is affected by the patient's beliefs, attitudes, and personality. (Federation of State Medical Boards of the United States, 1998; Carr & Goudas, 1999). In a review of the literature so far, pain in this study has been indirectly linked to light exposure (a stimulus), and directly linked in other studies to sleep-wake disturbances and mood (often having to do with beliefs, attitudes, and personality). Despite ongoing research that has been done involving factors associated with pain, the management of pain in acute care medical patients continues to be under-recognized and under-managed (O'Malley, P., 2005). This proposed research study, looking at describing the relationships among light exposure patterns, sleep-wake patterns, mood, and pain adds to the scientific knowledge and will prompt investigative studies that will lead to interventions for better pain management in the hospitalized adult medical patient.

The Hospitalized Adult Medical Population

The hospitalized adult medical patient was chosen as the population of interest for this study since there is a gap in research regarding the study concepts of light exposure, sleep-wake patterns, mood, and pain among them. Researchers may have avoided this population in the past due to their large range in diagnoses, ages, and co-morbidities. However, it is a ubiquitous population, comprising a large part of most hospital censuses: medical patients occupy up to 14% of the Cleveland Clinic hospital beds on any given day.

Although medical and surgical patients are often put together in terms such as '*med-surg nursing'*, referring to medical-surgical nursing as a specialty (Academy of Medical-Surgical Nurses, 2010), or '*med-surg units'* in a hospital, the diagnoses and

needs of medical inpatients differ from its counterpart, the adult surgical (or *post*-surgical) population. For example, admission to the hospital is often planned for surgical patients who elect surgery and have a definite day of admission and approximate discharge, while those suffering a medical crisis often experience emergent hospital admissions. Although anxiety can accompany any hospital admission, an unplanned life disruption resulting in admission to the hospital for an unspecified amount of time for the medical patient also can add to depressed mood and increased pain. There is a vast range of medical diagnoses that include pain such as Crohn's disease, pancreatitis, diabetes complications, vascular disease, dermatologic lesions, neuropathic and chronic pain syndromes, renal and hepatic diseases, major gastric disorders, non-surgically treated broken bones, complications following old surgeries, and genetic disorders.

Pain research in the acute care population has been prolific in studying post-surgical pain but medical patients with pain have not been given as much attention (Helfand & Freeman, 2009; Chang et al., 2010). Studies involving the mood states of hospitalized medical patients could not be found for this review, while studies looking at sleep-wake disturbances related to other environmental factors in hospitalized patients were plentiful (but related to nighttime disturbances such as noise and bright light). Hospitalized adult medical patients were also not sought out as participants in light exposure and circadian rhythm studies, with most of the institutional participants in these light studies being residents of nursing homes.

This proposed study begins to fill the knowledge gap in this population and provides useful information that will be generalizable to many medical inpatient settings and provide a basis for future intervention studies in this population.

Summary

The extensive literature review done in preparation for this proposed research demonstrated that although each of these concepts, individually, has an established body of research, no investigative studies were found that included all four concepts in any population. Investigating the relationships among the study concepts in the adult medical population was a novel idea, one which may lead to further intervention studies in the adjunct use of light for better management of sleep-wake disturbance, mood, and pain among hospitalized adult medical patients.

Chapter III

Investigation of the relationships among the concepts of light exposure, sleep-wake disturbance, mood, and pain were conducted with adults admitted to the inpatient medical units of the Cleveland Clinic Hospital. A predictive correlational design utilizing multiple methods of data collection and multivariate analyses were used to answer the five research questions.

Preliminary Study

In collaboration with her dissertation advisor, the unit manager, and the facilities engineer, the principal investigator (PI) conducted a study of the environmental lighting factors in a typical, semi-private room on a medical unit. Measurements were obtained for the patient room, the external wall window, type and number of lighting fixtures, and light exposure levels. Geographic coordinates were also obtained for the patient rooms in all units that could be possible sites for data collection.

Results

Semi-private room measurements are 17 feet x 12 feet 7inches with a curtain separating the two beds. The external tinted windows are 5 feet 8 inches in height, 5 feet 6 inches wide, and are placed 30 inches up from the floor. The window covering consists of a roller blind shade, Draper Manual Flex Shade EcoVison with a bark-colored mesh fabric providing approximately 3% opening in the mesh for light permeability (Draper Inc., 2009). Each patient bed has an overhead lamp which includes two 4 feet long fluorescent tube lamps, General Electric (GE) 32 watt cool white bulbs. Three lamp housings, each containing a single 13 watt Sylvania Delux compact fluorescent bulb (equivalent to a common 60 watt bulb in luminance) are in the small entry vestibule of

the patient room (10 feet x 4 feet) and in two work areas, one near the window and one on the wall opposite the window. All walls are painted bright white.

Hospital lighting. Using a scientifically calibrated light meter, the DT-1309 / Wide Range Professional Light Meter (DAS Distribution Inc., 2007), the researcher measured hospital light levels in unoccupied patient rooms. Over a one-hour period on a sunny August morning, the following measures were obtained with all overhead lights operating: 1) Lux levels in 3 patient rooms on the south side of the hospital averaged 240 lux at the pillow level on the bed, with 3000-4000 lux of light at eye level, 2 feet from the window, 4 feet from the floor (approximately patient seated height in a chair); 2) Lux levels in 3 patient rooms on the north side of the hospital averaged 93 lux on patient beds at pillow levels and 800 lux 2 feet from the window, 4 feet from the floor.

Conclusion. These measurements were similar to study results reported earlier in other hospitals (Wakamura & Tokura, 2001; Beauchemin & Hays, 1998) including recent results obtained from a study conducted in Jordan in a newly constructed hospital (Alzoubi et al., 2010). Recognizing the limitations of cross-sectional data to describe the 24-hour light-dark changes that are needed to stimulate the circadian system, the proposed study will measure light exposure data continuously for 72 hours. The preliminary study also provided information about the physical environment of care and helped determine inclusion/exclusion criteria: 1) The five hospital units where data collection will occur have patient rooms with either north, south, east, or west facing windows; 2) All subject's beds will be located next to the room window.

Setting and Sample

Setting

This study was conducted at the Cleveland Clinic, a 1400-bed, not-for-profit tertiary care medical center focused on patient care, research, and education. Five inpatient medicine units with 36 beds each (H80, H81, G80, G81, and G100) dedicated to the care of adult medical patients were the setting for this research study. These units have most patient rooms with a northern or southern exposure, and a few that have an eastern or western exposure. This setting was chosen since it houses the adult medical population of interest and has patient rooms with naturally occurring contrast in light exposure.

Sample

A convenience sample of 78 adult medical patients experiencing pain were recruited and a 10% attrition rate was expected. The attrition rate and level of missing data was greater than expected and is described in Chapter IV. A final sample size of 40 participants was analyzed.

Effect size. A medium effect size was chosen since no published studies were found that examined the relationships among all of the variables of light exposure, sleep-wake patterns, mood, and pain. Six studies examined light exposure and its relationship to one of the study variables of sleep-wake patterns, mood, and pain in correlational, descriptive studies (Sloane et al., 2007; Beneditti et al., 2001; Walch et al., 2005; Beauchemin & Hays, 1998; Higgins et al., 2007; Czeisler et al., 1989) but effect sizes were not reported in these publications. Cohen (1992) suggests that when effect size

cannot be determined from prior research, sample size for new research should be calculated using a medium effect size.

Power. The main research question (RQ) required multiple regression analysis and therefore all power calculations for sample size were based on calculations for this statistical analysis. According to G-Power 3.0 (Faul, Erdfelder, & Buchner, 2007), calculations for multiple regression with three predictors (light exposure, sleep-wake patterns, and mood) and one dependent variable (pain) with an alpha of .10 and a sample size of 40 attains a power of .61 providing for a risk of .39 (39%) of committing a Type 2 error and mistakenly accepting the null hypothesis. An alpha of .10 was used and indicates the maximum risk accepted (10%) for this study in committing a Type 1 error and mistakenly rejecting the null hypothesis (Cohen, 1992). Although the risk of committing a Type 1 error is higher than the customary cut point alpha of .05 or .01, this study was of low risk since all persons are exposed to ambient light daily and the relationships between mood, sleep, and pain in this study population have yet to be discovered. The power of .61 achieved in this study with a sample size of 40 is low and a sample size of 62 would have been necessary to achieve the more desirable power of .80 (Faul, Erdfelder, & Buchner, 2007). Even though the sample affords only a moderate effect size and low power, it serves as a preliminary study to provide a basis for future larger studies.

Inclusion criteria. All patients who matched the following inclusion criteria were approached for the study:

- Age 18 and older

- Hospitalized for a minimum of 8 hours but no more than 30 hours at time of recruitment. This 30 hour window provides flexibility for recruiting participants admitted overnight or who have extensive diagnostic tests on admission but it will also minimize the time of participant adaptation to hospital lighting.
- Expected to be hospitalized for ≥72 hours at the time of recruitment, which is the minimum time required to assess sleep-wake rhythms (Ancoli-Israel et al., 2003).
- Report a pain score ≥5 on a 0-10 numeric pain scale for two consecutive nursing pain assessments, considered to be moderate to severe pain (American Pain Society, 2008).
- Able to communicate adequately to provide informed consent, communicate responses, understand directions, and ask questions of the researcher.
- Occupying the window-side bedspace in semi-private rooms; this condition will provide less interference of disturbances such as hallway noise and traffic and help to standardize the participants' physical environment in terms of light exposure.

Exclusion criteria. Patients were excluded if:

- They were not oriented to person, place, and time, (as determined by the medical record and nursing staff) due to difficulty in reliable communication.
- They had undergone surgical intervention for their condition within the past 4 weeks or anticipated surgical intervention in the next week.
- There were no exclusions based on gender or ethnicity.

Study Variables and Instrumentation

Light exposure. Light exposure is defined as the intensity of available lighting surrounding a person in their environment whether by natural or mechanical sources (Dijk et al., 1995); it was measured in lux, a unit that measures the equivalent of one lumen of light per square meter (Ambulatory Monitoring, Inc. Ardsley, NY). Each participant's light exposure was measured using a wrist actigraph with light meter, Action W Actigraph Watch with Motion Logger–L®, (Ambulatory Monitoring, Inc. Ardsley, NY), hereinafter referred to as the actigraph watch. This actigraph watch is calibrated to an accuracy of $\pm$ 5% (Ambulatory Monitoring, 1999) and is approximately the size of a man's large wristwatch. It continuously measures light intensity from 0 to 4,000 lux by sensing light as a current, converting it to a voltage, and digitally storing it as a measurement (Horowitz & Hill, 1980). The lux level data obtained by the actigraph watch was used in this study to determine the light to which a participant was exposed for 72 consecutive hours, worn on the subject's wrist continuously throughout the duration of the study.

Light intensity was measured in one minute intervals, recorded, and graphically analyzed with Ambulatory Monitoring Inc. (AMI) software. Based on the hospital unit's usual routine, the data was digitally marked in order to examine light levels during different periods, e.g. 10pm- 6am (night or 'down' time). Light measurement data was then imported into SPSS as interval, continuous data for statistical analysis. This method enhanced reliability of the recording of the results, diminishing the chances of error in secondarily entering data by hand. The actigraph watch is waterproof and could be worn when bathing. It was easily cleaned while on the participant. Although one limitation of

the actigraph watch light measurement tool is the possibility of the watch being covered by clothing or bedding, one study showed that the wrist-worn light meter was dependable and comparable to stand-alone light meters (the current standard) for measurement of ambient light in hospital settings (Higgins, 2007).

Sleep-wake patterns. The concept of sleep-wake patterns is defined as a pattern between activity and the natural and periodically necessary state of rest of body and mind: a recovery state of the brain (McEwen, 2006). Sleep is described as a complex, regular, and easily reversible state of unconsciousness and physiological quiescence (Tranmer et al., 2003) which, when disrupted, may be a signal of circadian misalignment (Sack et al., 2007). Sleep-wake patterns will be operationalized through measurement by actigraphy, which interprets rest-activity patterns of the participant collected from actigraph data. The instrument used to measure sleep-wake patterns is the actigraph watch with light meter which will be worn by the subject to measure both light exposure and rest-activity patterns. The activity information on the actigraph watch was downloaded into the computer program at the same time as the light levels are downloaded. Actigraphy has been shown to be more reliable than subjective sleep logs and observation, correlated with the reliability of polysomnography (Littner et al., 2003).

Actigraphy will be used in this study to facilitate ease of use and cost effectiveness over polysomnography. AMI software will be used to interpret recorded wrist movement to determine sleep and wake time; when no movement is sensed over a short period of time, the software will record this time period as sleep; other recorded wrist activity movement will be interpreted as wakefulness. The AMI software used the proportional integral mode channel (PIM) (whose sensitivity to movement can be

selected as high or low enabling greater reliability of the instrument), to produce graphical data interpreting sleep-wake (Ambulatory Monitoring, 1999). PIM was used successfully in a recent study to produce statistical data interpreting sleep-wake patterns, disturbances, and sleep efficiency (Higgins et al., 2010). Clinical reliability of the Action W Actigraph Watch with Motion Logger–L® demonstrated a reliability coefficient of .98 indicating very good reliability in detecting wrist motion for activity (Tryon, 2005). The interval level data was imported into SPSS for data analysis.

Mood. The concept of mood is defined as the current psychological state of an individual person; it is the prevailing feelings and emotions and may include happiness, euphoria, anger, anxiety, depression, and any other emotional distress (Clark, 2005). Mood of participants will be operationalized by using the Profile of Mood States Brief Form (POMS™ Brief) scale to measure current mood states, an instrument that has been validated in a medical hospital based population (Curran et al.,1995). POMS Brief form is a 30-item questionnaire where each descriptive word regarding the participant's current feelings is evaluated on a 5 point Likert-type scale from 0 to 4. Each participant marked their current feelings about a word such as 'tense' on the scale where 0 = 'not at all', 1 = 'a little', 2 = 'moderately', 3 = 'quite a bit', and 4 = 'extremely. There are six subscales that make up the instrument: confusion, anger, depression, fatigue, tension, and vigor, with the higher the score, the higher the distressed mood. The box on the POMS Brief form which instructs subjects to respond about 'how you feel right now' was checked in order to obtain the current state of mood of the participant on that day (Curran et al.,1995).

The POMS Brief has demonstrated reliability comparable to the original Profile of Moods State (POMS) long form with 65 items. Correlations between the original POMS total mood disturbance and subscale scores and those on the POMS Brief all exceeded .95. The internal consistency scores on Cronbach's alpha range between .76 and .95 for the six subscales and .87 and .92 for the complete test (Curran et al., 1995). The brief form was chosen over the long form for its brevity and to minimize participant burden. This was a paper-and pencil test and administered every morning to study participants by the researcher during the 72 hour study time. Data obtained from the POMS Brief tool was entered into SPSS at interval levels to be analyzed with other variables in this study as an indication of mood of the participant.

Threats to internal validity with the measuring of participant mood repeatedly over 72 hours include repeated testing and maturation. This was taken into account and noted as a limitation of the study.

Pain. The concept of pain is described by the International Association for the Study of Pain (IASP) as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (Brooks & Tracey, 2005). Pain is dependent on diagnosis, treatment, and other individual factors, and is expected to vary throughout the study. Pain measurements were obtained by data abstraction from the patient record. Pain is measured subjectively by participant's self report of pain intensity on the well-validated Numerical Rating Scale of 0-10 with 0 being no pain and 10 being worst pain imaginable. Subjective numeric pain levels are obtained by the nurses from each patient at a minimum of every 8 hours, along with vital signs, per hospital protocol. The researcher recorded numeric scale pain levels taken

from the patient's electronic medical record for the duration of the study. Although it is the most commonly used measurement scale of pain intensity in hospitals because it is easy to administer and record, the reliability and validity of the numeric pain scale for pain assessment has not been investigated as well as other scales (Williamson & Hoggart, 2005). However, when correlated with the visual analog scale (VAS) for pain assessment, deemed to be highly reliable and valid, a significant correlation between 0.93 and 0.95 was found (Williamson & Hogart, 2005).

Analgesic consumption was also measured as an objective measure of pain. In order to maintain consistency in measurement, all analgesic consumption was converted to morphine equivalents using the Opioid Agonist Conversion module in the Cleveland Clinic's Pharmacy web page. Analgesic consumption has been used in other studies to measure pain (Ulrich, 1984; Walch et al., 2005; Cleeland, 2006), although the validity of measuring the consumption of pain medication as an indicator of pain has not been demonstrated. However, measuring the amount of analgesic that a subject consumes and comparing it to subjectively reported pain scores may reinforce the self report of pain. The average daily pain scores and the daily morphine equivalent amounts of analgesics used were entered into SPSS as an interval score.

Protocol for Conducting the Research

The principal investigator (PI) for this study is a registered nurse board-certified in pain management nursing. She has completed a five-day course at the National Institute of Nursing Research (NINR) Pain Methodologies Boot Camp. She is currently the Pain Education Specialist in Nursing Quality at the Cleveland Clinic and is familiar with the patient population, the nursing staff, physicians, and administrators and had

access to the potential participant population and their electronic medical record (EMR) to facilitate this study. Written approval to conduct this study was obtained from the Chief of Medicine/Hospitalists, the Nursing Director of the Medicine Institute, and the Unit Nurse Managers on the proposed study units.

Protection of human subjects. Following approval of the proposed study by the researcher's doctoral committee, approval from the Cleveland Clinic's Internal Review Board and Case Western Reserve University's Internal Review Board (IRB) for the protection of human subjects was obtained. The PI is certified by the Collaborative Institutional Training Initiative (CITI) program in compliance with the institution's educational mandates on the protection of human subjects (CITI, 2010). Protections provided to the research participants includes de-identification of any list of participants and storing all hard copies of data and other study lists and materials in a locked drawer in the locked PI's office. All electronic data will be stored in password -protected media.

Consent was obtained from study participants prior to initiation of data collection following IRB protocol and all study activities were conducted in accord with protection of human subjects in research. An information sheet that includes risks, benefits, procedures, and time frame of the study was provided to the potential participant. The participant was informed that the study is entirely voluntary and that they have the right to refuse any parts or to drop out of the study at any time. Confidentiality (protection of acquired participant information) including de-identification of all data will also be explained and included in the information sheet. Privacy of the participant was protected as much as possible, including interviewing of the participant (in semi-private room) with

curtain drawn and back of interviewer to the roommate, speaking in as low a voice as possible if the participant was not able to be moved to a private area for interview.

Study Protocol

Data collection began immediately after enrollment. The actigraph/light meter recorded data for 72 continuous hours and during this time, questionnaire data was collected every morning and medical record data was abstracted. The following protocol was followed to implement this study:

- **Study introduction.** The PI attended regularly-scheduled staff meetings (all shifts) in order to inform the nursing staff of the research taking place on the unit. A brief presentation was given to the nurses to inform them of the upcoming research study being conducted on the units where they work. The information provided to the nursing staff at these meetings included the purpose of the study, the planned duration of the study on their unit (approximately 1-2 months of data collection), the inclusion/exclusion criteria for participant recruitment, recruitment procedures, emphasis that the study would not interfere with any patient care, a description of the instruments (actigraph watch and questionnaire) used in the study, request of cooperation from the nursing staff in maintaining proper care/use of the actigraph on the participant patient, and contact information for the research team. The nurses were told that study results would be shared with them after final analysis.
- **Recruitment.** Most weekday mornings the researcher rounded on the nursing units to examine patient records and assess eligibility of potential participants. For patients who met inclusion/exclusion criteria, the PI approached them in a

private setting and explained the research, asking for their participation and consent. Time was allowed for the potential participant to read and ask questions regarding participation in the study. When all questions were answered, the researcher requested the participant to sign the consent form and become enrolled in the study. A copy of the study protocol and informed consent was left with the participant and included contact information of the research team. If the patient decided not to participate, the PI thanked the person for their time and recorded the encounter per the protocol in the subsequent section in this proposal entitled *patient refusal*.

- **Data collection with wrist actigraph.** Data collection began immediately upon enrollment. The wrist actigraph with light meter was synchronized with the computer, taken to the participant, and applied to the participant's wrist, face up, and snug enough to prevent it from slipping off, yet loose enough to prevent abrasion or discomfort. Either the right or left wrist was used for the actigraph watch, with the non-dominant hand preferred, but consideration was made for other medical devices on the hand/wrist (such as intra-venous access), and participant preference. The number of the watch, participant identification number, and the exact time of application to the participant's wrist (to the minute) was noted and recorded in a notebook maintained for this purpose. Following 72 hours of continuous data collection, the exact time of removal of the actigraph from the participant (to the minute) was recorded in the notebook as well. Any reported or observed incidents occurring during the time the actigraph watch was being worn by the participant was also recorded. Verbal instructions

were given to the participant and to the nurse regarding the use of the wrist actigraph: it was to be worn for 72 hours; in order to provide for 72 continuous hours of measurement of light-dark exposure and sleep-wake data; it was not to be removed at any time until the researcher removed it; kept face-up and uncovered as much as possible; it is waterproof so it will not interfere with bathing. Written instructions given to the patient and nurse caring for the patient, included aforementioned information regarding the research study, treatment of the watch, and researcher contact information. If the actigraph was uncomfortable/intolerable, or there was an emergency situation and it had to be removed, the researcher was to be called immediately and the actigraph watch would be placed in the nurse manager's office in a locked drawer until it could be retrieved by the researcher. The researcher's contact information was also printed on the back of the actigraph watch face.

- **Administration of mood questionnaire**. The POMS Brief questionnaire, a paper and pencil test with 30 adjectives for the participant to evaluate, was administered to the participant by the researcher on each morning throughout enrollment in the study to measure daily mood. This questionnaire took approximately 5-7 minutes to complete.
- **Data abstraction.** To obtain data on measurements of pain, the nurses' recording of the participant's pain scores (per hospital protocol) and analgesic use was abstracted from the patient's electronic medical record. Subjective numeric pain scores were recorded on the patient's medical record at a minimum of every 8 hours per hospital protocol and were easily found in the record.

Analgesic use was also easily found. All opioid analgesics used throughout the 72 hour data collection time were recorded by amount and time of use and were converted to morphine equivalents for consistency. Additional demographic data collected included: age, gender, primary diagnosis, and geographical orientation of the hospital bed. This information was useful in determining if there were any differences in the measured concepts among demographical differences and will be useful for further research in different demographic groups.

- **Patient refusal**. The number of patients approached, declined, and enrolled were tracked to describe any biases in enrollment procedures. Describing biases in sampling can help to determine if there is anything in the study design or recruitment process that could be changed to increase participation in future research studies. Basic information such as gender and age were obtained. If the patient volunteered a reason for declining, this was recorded, but no inquiry was made regarding the reason for deciding not to enroll. Any information collected from these patients, including any volunteered reasons for declining, were de-identified and filed in a *refusal* file on electronic media which were password protected and on hard-copy and filed with other study data in a locked drawer in a locked office.
- **Participant attrition**. Although subject burden was kept to a minimum, some participants did not remain in the study. Those who did not complete the study were replaced by other recruits until the minimum sample of 40 participants was met. Data collected from those who did not finish the study were not included for analysis, but were kept in a separate password protected electronic *withdrawn*

file with any hard copies of data kept in a locked file drawer in a locked office. The data were de-identified and reviewed in order to provide information concerning reasons for participant attrition and how amendments can be made to enable more participants to complete similar research studies in the future.

- **End of the study.** Upon completion of the study the wrist actigraph was removed, the time recorded (to the minute), and data were downloaded to the computer. All collected data are stored on a password protected computer in a locked office. Written hard copy records (POMS Brief questionnaire, sheets that include pain and demographic information, signed participant consent forms, and any other records) are stored in a locked file drawer. All data are password protected. Electronic backup data are also stored on a secured backup media which is only used for purposes of this study and is stored in the researcher's locked drawer in a locked office at the Cleveland Clinic.

Statistical Analysis

Collected data were entered, cleaned, and analyzed throughout this study, including ongoing analysis of graphical data supplied by the actigraph watch. Data were coded as follows: participants were assigned a number beginning with 101; the first participant was number 101, the 2nd participant was 102, and so on, and the participant number remained on all data collected from that participant.

Data were entered into SPSS as follows: (a) demographic data were entered by hand using double entry; (b) light exposure data and actigraph motion levels (sleep-wake) were downloaded directly into SPSS from the AMI software as continuous level (interval) data; (c) mood scores from the POMS Brief tool were entered by hand from

questionnaire sheets as continuous data and double checked; and (d) pain levels (interval) and opioid analgesic use amounts (converted to morphine equivalents and coded to interval levels) were also entered by hand and double checked. Decision tracking was done as data throughout the study was collected and entered in order to keep a clear record of necessary changes that were made throughout the data collection phase. Tracking of decisions were filed with all hard copies of data.

All data were entered into SPSS and double checked. A preliminary step to all of the analyses was to explore data to examine univariate characteristics: frequencies, means, medians, missing data, central tendency, dispersion, and distribution. These exploratory techniques were based on proportions (in the case of dichotomous variables), medians, and/or means (in the case of variables measured on an interval scale). The appropriate bivariate statistic test was utilized depending upon the scale of measure and the distribution of the variables being described.

Since parametric tests, including regression, were used to analyze data for this study, tests for assumptions of variability, normal distribution, influential cases, linearity, and constant error variance were conducted on the data set. Any problems with non-normal distributions, linearity, influential cases, and others were resolved through removing and transforming variables and data were retested. If results were similar, then original, untransformed and un-deleted data were used to maintain the integrity of the study (Fields, 2005; Norris & Aroian, 2004).

Missing data. It was expected that some data would be missing. Therefore, missing data were handled through the use of Expectation Maximization (EM) instead of

deleting missing data and cases when feasible (Musil et al., 2002). This assisted in better rigor of the study and its generalizability.

Analysis. The following analyses were planned for the proposed research questions: Over a three day period, for hospitalized adult medical patients:

RQ1. What were their light exposure patterns, sleep-wake patterns, mood levels, and pain intensity levels? Graphical analyses and descriptive analyses of light meter data were computed using the 72 hours of data collection time, parsed into 24-hour segments. Based on the hospital routine of the medicine units where the study is taking place, 10pm to 6am was considered night for purposes of delineating day-night patterns. Rest and activity data were obtained from the actigraph watches and computed and described in terms of sleep and wake time. Mood levels were entered into SPSS from the data on the POMS Brief tool, including total mood disturbance score, and the six mood factors of tension, depression, anger, vigor, fatigue, and confusion for each day within the 72 hours of data collection. The participant's subjective pain scores (0-10) and opioid use were obtained from the participant's electronic medical record and entered into SPSS.

For better understanding of sleep-wake patterns and circadian rhythm, intra-daily variability (IV), a non-parametric test specifically used to analyze actigraphy data were computed. The IV statistic provided information regarding any fragmentation of the transitions between rest and activity throughout the recorded 24 hour period with higher scores indicating more transitions between activity and rest, such as frequent waking at night (10pm to 6am for hospital routine as described earlier) or napping during the day (Van Someren et al. 1999). Inter-daily stability (IS), another non-parametric test, was computed to provide information regarding the synchronization of the rest-activity data

of the subject with the 24 hour external lighting, or zeitgebers, of the hospital day-night cycle in the course of the 72 hour study (3 days) (Van Someren et al. 1999).

RQ2. What were the correlations among their light exposure patterns, sleep-wake patterns, mood levels, and pain intensity levels? These data as described above were entered into SPSS and descriptive data, frequencies, means, and modes were analyzed. Correlations among the variables were analyzed and reported. These analyses were useful in describing and understanding the correlations among levels of light exposure patterns, sleep-wake patterns, mood levels, and pain intensity levels that the study participants experienced.

RQ3. Were there differences in their light exposure patterns based on geographical orientation of windows in the hospital room (north, south, east, and west)? Data were analyzed to determine if there were group differences in light exposure based on geographical orientation of windows in the hospital room (north, south, east, and west). Beds in rooms with north-facing and east-facing windows were grouped together (naturally occurring lower light levels) and south-facing and west-facing windows were grouped together (naturally occurring higher light levels) and an independent t-test was used to analyze the difference in light exposure patterns for each group.

RQ4. Were there differences in sleep-wake patterns, mood levels, pain intensity levels, and analgesic use based on age or gender? ANOVA and t test analyses were used to analyze the differences between age categories and sleep-wake patterns, mood disturbance levels, pain intensity levels, and analgesic use. Gender differences were examined using an independent t-test sleep-wake patterns, mood disturbance levels, pain intensity levels, and analgesic use. Independent t-tests also evaluated differences between

south-west, north-east geographical orientation of window beds and sleep-wake patterns, mood disturbance levels, pain intensity levels, and analgesic use.

RQ5. Did light exposure patterns, sleep-wake patterns, and mood levels predict pain? Following correlational analysis, all correlations with a statistical significance greater than $p = .10$ were used for analysis ($p <= .01$). Multiple regression analyses were conducted to determine if there was a predictive relationship among the independent predictor variables of light exposure patterns, sleep-wake patterns, and mood levels, and the dependent outcome variable of pain. Testing the effect of any mediating variable was implemented by including it and then excluding it from the regression model. Significant relationships among the variables were determined.

Summary

The protocol for conducting the research study described in this chapter contributed to its success. Proper collection and analysis of the data on light exposure, sleep-wake disturbance, mood, and pain helped to supply insight into the significance of the relationships among these concepts. This information provided preliminary knowledge on which to base future studies in specific population groups, hospital environment, light exposure, sleep-wake patterns, mood, and pain. The analyses of these statistics may provide the foundation for understanding how manipulating the ambient light environment may benefit hospitalized patients with sleep-disturbances, depressed mood, and pain.

Chapter IV

Results

The purpose of this predictive correlational study was to describe light exposure patterns, sleep-wake patterns, mood, and pain in hospitalized adult medical patients and to investigate the relationships among these variables (Figure 1).

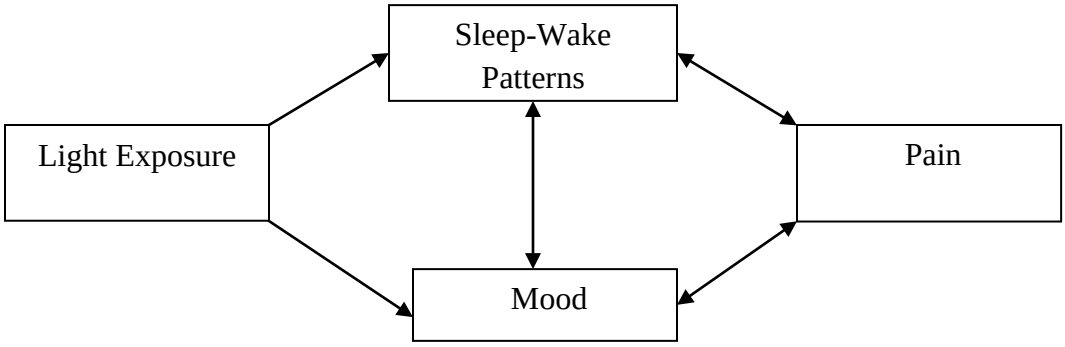


Figure 1. Model of the Research Study: Relationships among Light Exposure, Sleep-Wake Patterns, Mood, and Pain

A description of the study sample is provided in this chapter followed by the results presented according to the research questions. A predictive correlational design utilizing multiple methods of data collection and multivariate analyses was used to answer the five research questions: Over a three day period, for hospitalized adult medical patients:

1. What were their light exposure patterns, sleep-wake patterns, mood levels, and pain intensity levels?
2. What were the correlations among their light exposure patterns, sleep-wake patterns, mood levels, and pain intensity levels?

3. Were there differences in their light exposure patterns based on geographical orientation of windows in the hospital room (north, south, east, and west)?
4. Were there differences in sleep-wake patterns, mood levels, pain intensity levels, and analgesic use based on age or gender?
5. Did light exposure patterns, sleep-wake patterns, and mood levels predict pain?

Description of the Sample

Setting and Sample

Potential participants for this convenience sample were recruited from five adult inpatient medical units in a large tertiary care teaching hospital in Northeast Ohio. Each unit consisted of 32-36 beds, with private (single bed) and semi-private occupancy. Following approval for the study by the hospital's Institutional Review Board (IRB), eligible participants were recruited and enrolled in the 72 hour study. Throughout the year of data collection, 246 patients were identified that met the inclusion criteria and 78 were approached to participate in the study. Those who were not approached were either unavailable, their primary nurse or physician recommended that they not be approached, or the data collector found them ineligible due to discharge status. Of the 78 patients who were asked to participate in the study, 19 (24%) patients declined; a variation of "I don't want to bother" was volunteered as the predominant reason for not wanting to participate. Those patients who declined to be in the study had a slightly higher mean age (52.0 years) than the study participants and more males (n = 15) than females (n = 4) declined. Nineteen other cases were eliminated after enrollment leaving a total of 40 cases available for analysis. Figure 2 shows the process of sample selection.

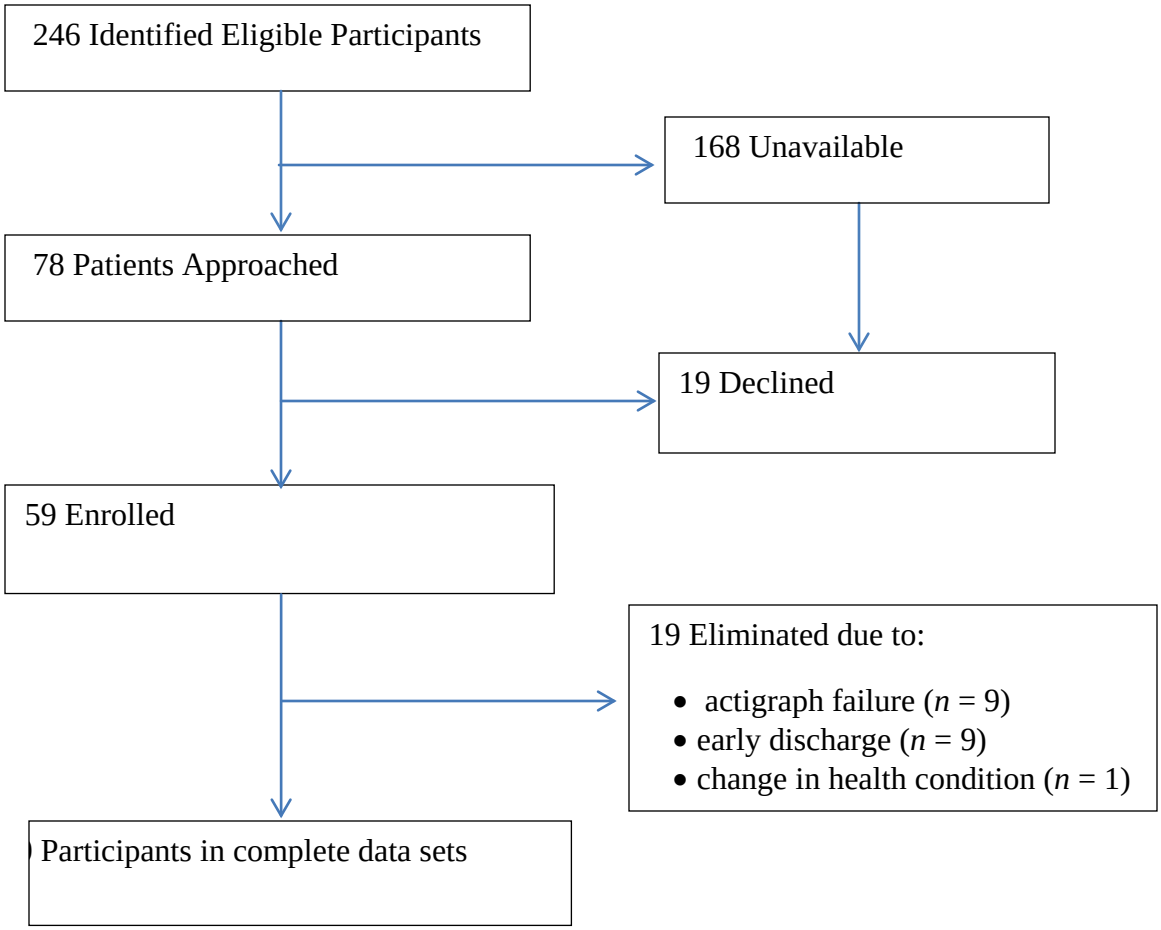


Figure 2. Sample Selection

Sample Description. Descriptive characteristics of the study sample are presented in Table 2. Forty participants, primarily Caucasian, with a mean age of 50.5 years were enrolled in the study.

Table 2

Demographics of the Sample (N = 40)

	M (SD); range
Age (in years)	50.5(14.7); 22-78
	n (%)
Gender	
Female	23 (57.5)
Male	17 (42.5)
Race	
African American	11 (27.5)
Caucasian	29 (72.5)
Admitting Diagnosis Category	
Digestive Disease	15 (37.5)
Wound/Vascular	8 (20.0)
Respiratory Disease	5 (12.5)
Infectious Processes	3 (7.5)
Spine Related	3 (7.5)
Head/Brain Disease	3 (7.5)
Urinary Disease	2 (5.0)
Endocrine Disease	1 (2.5)

Results

The concepts and operationalization of terms involved in this study were presented in Chapter I and are repeated here in Table 1 to assist in understanding results.

Table 1

Repeated from Chapter I: Study Concepts and Operationalization of Terms

Concept	Instrument	Variable
Light exposure	• Wrist actigraph light sensor	• Mean light levels in lux during day time (6a-10p) and night time (10p-6a)
Sleep-wake patterns	• Wrist actigraph motion sensor	• Mean # minutes of sleep during up time and down time • Sleep fragmentation index (FRAG) • Wake after sleep onset (WASO) • Intra-daily variability (IV) • Inter-daily stability (IS)
Mood	• Profile of Mood States Brief Form (POMS™ Brief)	• Total mood disturbance score (TMD) • POMS subscale scores: tension, depression, anger, vigor, fatigue, and confusion
Pain	• Numeric pain scale • Analgesic use	• Mean pain intensity score: 0-10 numeric pain scale score • Oral morphine equivalents of opioid use

Research Question 1

The first research question (RQ) regarding hospitalized adult medical patients hospitalized for a three day period was: *"What were their light exposure patterns, sleep-wake patterns, mood levels, and pain intensity levels?"* RQ1 was answered with data obtained from study participants' wrist actigraph with light meter: Action W Actigraph Watch with Motion Logger–L®, (Ambulatory Monitoring, Inc. Ardsley, NY), worn by study participants continuously for 72 hours. Participants also completed the Profile of Mood States (POMS) Brief questionnaire to obtain mood level scores. Subjective pain scores and opioid use were abstracted from the participant's electronic medical record.

Light exposure patterns

Light exposure data for 72 hours were analyzed utilizing the software provided for the actigraph device from AMI (Ambulatory Monitoring, Inc.). The variables for analyses were categorized according to 'day' light exposure (lux) defined as the period of time of most hospital activity, 6:01am to 10:00pm and 'night' light exposure (lux) defined as the period of time in the hospital deemed quiet or sleep time for most patients, 10:01pm to 6:00am. Light exposure also was categorized by seasonal differences (summer, winter, fall, and spring). The results are shown in Table 3.

Table 3

Light Exposure (in lux) of the Sample (N = 40)

Time	*n*	M	SD	Lowest	Highest
Daytime	40	104.80	131.13	9.72	707.24
Nighttime	40	7.07	7.00	0.31	29.83
Spring					
Day	12	109.23	104.51	16.40	367.99
Night	12	7.79	8.18	1.60	29.83
Summer					
Day	7	186.54	246.78	9.72	707.24
Night	7	2.54	2.18	0.83	6.82
Fall					
Day	8	98.25	122.99	15.46	338.15
Night	8	2.87	1.99	0.31	5.53
Winter					
Day	13	60.73	23.41	21.01	109.45
Night	13	11.43	6.97	1.39	26.60

Light exposure for participants during the day was extremely low, below the placebo range of 300 lux reported in other studies (Sumaya et al., 2001; Riemersma-van der Lek et al., 2008; Golden et al., 2005). Seventy-five percent of the participants were exposed to an average of less than 100 lux of light during the day. Only 7.5% (n = 3) averaged over 330 lux of light exposure during the day, with a maximum 72-hour average daily light exposure of 707.24 lux for one participant. Although this may have been due to blankets and clothing that occasionally covered the participants' wrist-worn light meters, light exposure readings in unoccupied rooms (described in the preliminary study, Chapter III) indicates that light levels also were in very low: mean of 166.5 lux during the day.

The high standard deviation (SD) of light exposure seen in Table 3 is an expected phenomenon since light exposure patterns, even in a controlled environment such as the interior of a large institution (hospital) is highly variable. Analysis of the light exposure patterns demonstrated that regardless of the time of day, study participants were exposed to very low ambient light throughout the study period. Although low ambient light at night is desirable for sleep, melanoreceptors in the eye also require exposure to bright light during the day for wakefulness. A review of intervention studies indicates that the average light exposure intensity during the day that provides for circadian entrainment is at least 1500 lux of light exposure for a minimum of 15 minutes a day in one study and up to 8 hours of 4000 lux of light exposure per day in another study (Duffy & Wright, 2005); data collected in this study showed that these levels of light exposure were never reached.

A univariate ANOVA was used to examine the differences in the means of light exposure among the seasons and results indicated that although there was a statistically significant difference among the means of light exposure during the seasons at night, $F(3, 36) = 4.69$, $p < .05$, there was no statistically significant difference among the seasons for light exposure during the day, $F(3, 36) = 1.46$, $p = .24$. One explanation is that the hospital is a controlled environment in which day time lighting is fairly consistent; night time differences may be explained due to the longer natural daylight hours in the early morning during the spring and summer (down time ended at 6am) coming through windows before artificial lighting is turned on.

Sleep-wake patterns

Sleep-wake patterns were interpreted from the 72-hour rest-activity data collected from the actigraph watches and analyzed using the AMI software and the (University of California, San Diego) UCSD sleep estimation method (Jean-Louis, Kripke, Mason, Elliot, & Youngstedt, 2001). Rest and activity patterns were interpreted as sleep and wake, respectively. Two variables were used to answer the research questions: mean sleep time in minutes during night time (10:01pm to 6am) for the 72 hour period and mean sleep time in minutes during day time (6:01am to 10pm) for the 72 hour period. Table 4 shows the sleep times during day and night hours.

Table 4

Sleep time (minutes) of the Sample (N = 40)

Time	M	SD	Lowest	Highest
Daytime	161.02	81.40	5.33	391.33
Nighttime	236.35	72.27	62.00	391.00

An examination of the frequency data for minutes of sleep during the day and night showed that the sleep times are further broken down into the following: 35% of the participants slept more than a total of 3 hours (>183 minutes) during the day and 50% of the participants slept less than 4 hours (<233 minutes) during the night.

Sleep fragmentation. The actigraph software also calculated night time sleep interruptions. Both fragmentation of sleep (FRAG) and wake after sleep onset (WASO) were examined in this sample for the eight hour period between 10p.m. and 6a.m. FRAG was determined by analyzing nocturnal movement: (the number of movement epochs -

time periods of one minute) which lasted four time periods plus the number of non-movement epochs which are less than a minute duration)/ (the number of non-movement epochs which are greater than one minute duration) x 100 (Mezick et al., 2009). Higher levels of FRAG indicate a greater number of sleep episodes, or worse sleep continuity. Among the participants in this study, the mean FRAG score was 9.37/8 hours (*SD* = 5.55) with a range of 2.0 -27.0. Twenty percent of the participants scored greater than 12.0 on the FRAG score indicating that their sleep was frequently interrupted. Stressful life events have been shown to have a high positive correlation with sleep fragmentation (Mezick et al., 2009) and pain can certainly contribute to stress. The subjective pain scores for this sample at night were high on a 0-10 scale (*M* = 6.02, *SD* = 1.99, range 1.33 to 9.33). Pain intensity in this population will be discussed further later in this chapter.

WASO is defined as the total amount of time awake after sleep onset throughout the night (down) time (Ambulatory Monitoring, Inc., 1999). The mean WASO time in minutes for participants in this study was 112.51 (*SD* = 48.67), range 28.00 – 228.33, an average of 1.87 hours each 8-hour night of the study. Fully 25% of the participants were awake 145 minutes (2.5 hours) their first sleep episode on the first night of the study. These data support previous studies: patients sleep poorly in the hospital and this may have a negative impact on their recovery (Raymond et al., 2001; Lauri, Lepisto, & Kappeli, 1997; BaHammam, 2006).

Intra-daily variability. Intra-daily variability (IV) was calculated from the rest-activity data provided by the actigraph watch. IV, which has a theoretical range of 0-2, describes the frequency and extent of transitions between rest and activity over a 24 hour period, indicating fragmentation of rhythm caused by frequent night waking or day

napping, with higher scores indicating more transitions between activity and rest. The higher the IV, the more fragmented the rest-activity throughout the 24 hour period. The actigraphy analysis that calculated IV was done by classifying each one minute epoch (period of time) based on activity score for that minute and applying an algorithm that weighs activity scores from surrounding minutes: it is a ratio of the mean squares of the difference between successive hours (first derivative) and mean squares around the grand mean (overall variance) (Mezick et al., 2009; Van Someren et al., 1997). The UCSD sleep estimation method was used in this calculation (Jean-Louis, Kripke, Mason, Elliot, & Youngstedt, 2001). Table 5 shows the results of the analysis on IV and IS.

Usually, the highest IV value indicating excessive sleep-wake disturbance and fragmentation is 2.0. However, because rest-activity analysis is based on waveform analysis, values over 2.0 are found when there is extra 'Gaussian noise' due to excessive movement of the instrument recording the data (Van Someren et al., 1999). In this sample, IV values of 2.0 were frequently seen, but decreased from Day 1 to Day 3. On Day 1, 37.5% of participants had an IV score of > 2.0; and on Days 2 and 3, 10% of participants were >2.0. It is unclear if these results indicate that study participants 'settled in' after the first day of hospital admission or if there is some other explanation for the decrease in excessive disturbance such as better pain control.

Table 5

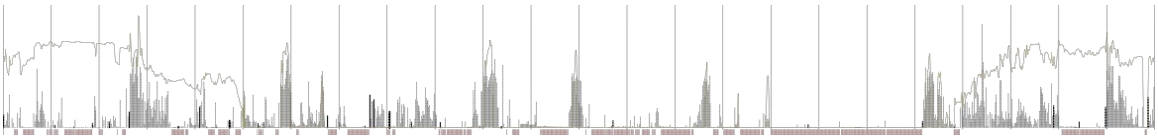
Intra-daily Variability (IV) and Inter-daily Stability (IS) of the Sample (N = 40)

	M	SD	Lowest	Highest
IV day 1	1.56	.63	.16	2.24
IV day 2	1.22	.67	.00	2.61
IV day 3	1.26	.57	.04	2.24
IS	.37	.13	.04	.76

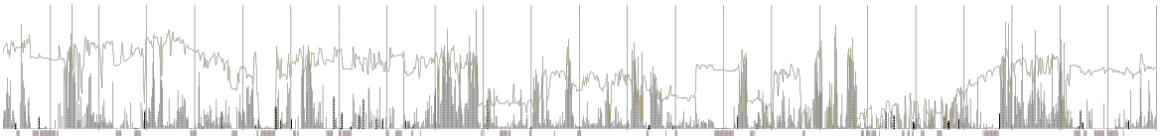
Inter-daily stability. The inter-daily stability (IS) statistic was calculated using rest-activity data and light exposure data over the course of the 72 hour study (Table 5). Inter-daily stability has a theoretical range of 0 – 1.0. The higher the IS value (maximum of 1.0 for perfect synchronization), the more closely a person's sleep-wake cycle is in alignment with the external light zeitgeber (German for time-giver), the naturally occurring light-dark cycles that sets the circadian rhythm (Auvil-Novak, 1997; Van Someren et al. 1999). In this study, the highest IS value among the participants was 0.76, achieved by one participant. Twenty five percent had an IS level of .28 or less indicating that their sleep-wake patterns were poorly aligned with the 24-hour light dark cycle.

There was a statistically significant positive correlation between IS and average sleep minutes at night ($N = 40$, Pearson $r = .41$, $p < .01$), indicating that the more nighttime sleep a participant received, the better aligned their sleep-wake cycle was with their external light exposure.

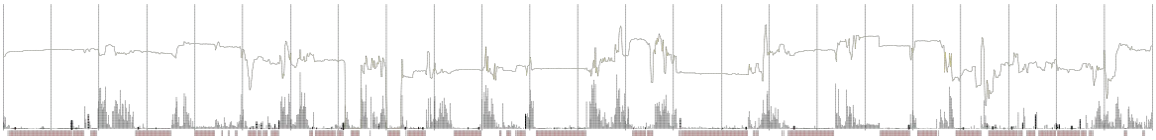
Examples of a 24-hour segment of graphical actigraphy data of three participants are displayed in Figure 3.



Subject 1: fair sleep after midnight with low light at night



Subject 2: little sleep and inconsistent light exposure with little contrast



Subject 3: fragmented sleep over 24 hours and consistent light on all night/day

noon midnight noon

Figure 3. Three samples of actigraphy graphical output for 24 hours with midnight at the center. Light exposure is represented by the upper jagged line superimposed on activity data which is represented by the lower hills and valleys: the higher the hills, the more activity. Rest (sleep) is indicated by flat lines underneath the x-axis.

Mood levels

Mood data were obtained from the POMS™ Brief questionnaire. All participants completed the 30-item questionnaire four times: baseline mood on day of enrollment and each day thereafter through day 3. The 30-item questionnaire consists of words that describe feelings people have. Each participant marks their current feelings about a word such as ‘tense’ on a 5 point Likert-type scale from 0 to 4 where 0 = ‘not at all’, 1 = ‘a little’, 2 = ‘moderately’, 3 = ‘quite a bit’, and 4 = ‘extremely. There are 7 scores: total mood disturbance (TMD) and six subscales: tension, depression, anger, vigor, fatigue, and confusion. According to the authors of the POMS Brief, normative data for each of

the POMS Brief factors have been established for healthy adults (McNair & Heuchert, 2005). These norms are included in Table 6 along with the daily mean scores of mood obtained from the study participants.

Table 6

Mood Disturbance Scores (N = 40)

	M	SD	Range		Normative Values	
			Minimum	Maximum	M	SD
TMD	19.56	13.11	-6.75	56.00	17.70	33.00
Tension	4.14	3.57	0.00	12.75	7.70	5.90
Depression	3.15	3.15	0.00	13.00	8.00	9.30
Anger	2.42	2.93	0.00	13.50	7.60	7.40
Vigor	2.31	2.52	0.00	11.00	19.30	6.70
Fatigue	7.90	4.43	0.00	17.00	8.00	5.90
Confusion	4.61	1.77	1.25	10.00	5.70	4.40

When comparing the study sample results to the normative data, it is unclear why hospitalized study participants' scores for tension, depression, anger, fatigue, and confusion are less negative than in the normative population. It is evident that this sample's scores are 'flattened', that is that they seem to indicate a flattened affect. This may be an artificial artifact, with participants unwilling to indicate their mood disturbances to the researcher while in their vulnerable condition. Conversely, it may be an accurate assessment of the mood exhibited by hospitalized adults who are overwhelmed with their diagnosis and treatment options and are consuming opioids for their pain.

It makes sense that the total mood disturbance in hospitalized patients with pain would be greater than in the healthy non-hospitalized adult population. A higher score in the subset of vigor in the healthy population over the hospitalized participants makes sense as well. It is worth noting that there is high variation in both the sample results and the normative results. And although the POMS instrument has published normative data for psychiatric outpatients, college students, a geriatric population, and healthy adults, there is no normative data for scores that includes acutely ill adults (McNair & Heuchert, 2005).

Pain intensity

The subjective pain intensity scores of the participants were abstracted from the electronic medical record. These scores were the self-reported pain levels reported on a numeric scale with a value of 0 to 10, 0 being no pain and 10 being the worst pain. According to hospital policy, nurses assess for pain and record subjective pain scores (0-10) in the hospital record at least once every 8 hours. If pain is present (any value over 0 on the numeric pain scale), nurses must assess and record pain scores every 4 hours and within one hour of providing an analgesic medication. Participants' mean pain levels for the duration of the study were high: 5.91 on the numeric (0-10) pain scale. Table 7 shows the breakdown of mean daily pain scores of study participants.

Table 7

Mean Pain Scores of the Participants During the Study (N = 40)

	M	SD	Minimum	Maximum
Morning (6:01am – 12 noon)	5.89	1.80	1.67	8.97
Afternoon (12:01pm – 5pm)	5.98	1.49	2.00	9.5
Evening (5:01pm – 10pm)	5.47	2.11	0.00	9.00
Night (10:01pm – 6am)	6.02	1.99	1.33	9.33
Total (24 hours)	5.91	1.55	2.75	9.26

There were no statistically significant differences in mean pain scores among the different times of day, however, a one-way repeated measures ANOVA indicated a significant difference between mean pain scores over the 3 Days of the study: $F(2,78) = 10.03$, $p < .001$ (Table 8). A post-hoc analysis of a paired samples t test indicated that there was a statistically significant difference in the scores for Day 1 ($M = 6.50$, $SD = 1.28$) and Day 3 ($M = 5.34$, $SD = 2.11$); $t(39) = 4.26$, $p < .01$. There was also a statistically significant difference between Day 1 ($M = 6.50$, $SD = 1.28$) and Day 2 ($M = 5.80$, $SD = 2.02$) times; $t(39) = 2.57$, $p < .05$).

Table 8

One-way Repeated Measures ANOVA: Pain Scores, 3 Days of the Study (N = 40)

Source	*SS*	*df*	*MS*	*F*
Days	27.35	2	13.67	10.03
Error	106.33	78	1.36	

Opioid analgesic use data was collected and the total of all opioid analgesics consumed over the 72-hour course of the study were recorded and analyzed. All opioids and dosages were converted to their equianalgesic oral morphine equivalents. Thus all reported values in this study for opioid consumption reflect grams of oral morphine for comparison. The mean grams of oral morphine equivalent of opioids used daily by study participants was 219.97 (*SD* = 370.71). After removing two cases with extremely high dosages (1,690 mg and 1,576 mg), the mean oral morphine equivalent use statistic was much lower (*n = 38*, *M* = 145.60, *SD* = 176.19). The large SD explains the high variation of use in opioids among the participants; this is expected since pain is experienced and treated differently among individuals. There was a positive, moderately strong correlation between participants' mean pain scores and the mean amount of opioids used ($n = 38$, $r = .46$, $p < .01$).

Non-opioid analgesics such as acetaminophen and ibuprofen were excluded from collection and analysis in this study since there is no method of accurately comparing usage and analgesic equivalency of different types of non-opioids. This is a study limitation, however, since multi-modal methods of pain management are often used to

treat pain in hospitalized adults and can contribute to subjectively reported pain intensity scores; this will be further addressed in Chapter V.

Research Question 2

The second research question asked, *"Over a three day period, for hospitalized adult medical patients, what were the correlations among their light exposure patterns, sleep-wake patterns, mood levels, and pain intensity levels?"*

Results of the Correlations

Appendix I shows the 2-tailed Pearson correlation matrix of the 12 variables that had a statistically significant correlation ($p < .05$) with at least one other variable: mean lux during the day, highest lux during the day, sleep minutes during the day, sleep minutes during the night, sleep fragmentation (FRAG), inter-daily stability (IS), total opioid use, total mood disturbance (TMD), and the subscale scores for anger, fatigue, confusion, and pain.

Total mood disturbance (TMD) had a significant, moderately strong negative correlation with the amount of light exposure during the day ($r = -.315$, $p < .05$). Subscales that had a statistically significant, moderately strong relationship were: a) day time light exposure and fatigue ($r = -.337$, $p < .05$) and b) day time light exposure and confusion ($r = -.323$, $p < .05$). Although light exposure levels throughout the study were low, the finding that light exposure during the day is negatively associated with fatigue and confusion is consistent with other light exposure and mood studies in institutionalized populations (Sumaya et al., 2001; Riemersma-van der Lek et al., 2008; Sloane et al., 2007). However, in this study population there was no statistically significant correlation between light exposure and pain. There was, however, a

moderately strong statistically significant positive correlation between pain and fatigue ($r = .336$, $p < .05$). Many studies support this finding (Roehrs & Roth, 2005; Lavigne et al., 2008).

Research Question 3

Research question 3 asked, *"Over a three day period, for hospitalized adult medical patients, were there differences in their light exposure patterns based on geographical orientation of windows in the hospital room (north, south, east, and west)?"*

Light meter data obtained from Action W Actigraph watches worn continually by the study participants (who occupied beds closest to the window for maximum light exposure) were used to answer this question. All data were screened to identify outliers and check for compliance with the assumptions of normal distribution, adequate variance of variables, and linearity and all data met the assumptions. Beds in rooms with north-facing ($n = 14$) and east-facing ($n = 2$) windows were grouped together (naturally occurring lower light levels) and south-facing ($n = 20$) and west-facing ($n = 4$) windows were grouped together (naturally occurring higher light levels).

After removing a case that included an outlier with an unexplainable extremely high light exposure level of 62,973 lux (possibly a technology error with the light meter), an independent samples t test was conducted to compare average light intensity between north-east facing window beds and south-west facing window beds during both the day and night. On average during the day, light intensity (in lux) was significantly greater in the south-west facing window beds than in the north-east facing window beds. At night, the average light intensity (lux) was almost exactly the same in both geographical

orientations: (M = 7.20 lux). See Table 9. During the day, there was a statistically significant difference between light exposure in the north-east facing beds and the south-west facing beds, $t(37) = -2.16$, $p < .05$.

Table 9

Light Intensity Comparisons Among Geographical Bed Orientations

	n	M	SD
South-West			
Day	24	130.86	150.94
Night	24	7.20	8.27
North-East			
Day	15	45.56	24.50
Night	15	7.20	4.73

Hospital lighting patterns collected with a free-standing light meter in the preliminary study described in Chapter III revealed that lux levels in unoccupied patient rooms over a one hour period during the day on the south side of the hospital (240 lux at the pillow level on the bed) averaged 158% higher than lux levels in patient rooms on the north side of the hospital (93 lux at pillow level). Light exposure data obtained from the actigraph watches worn continuously for 72 hours by participants in this study indicated that during the day, the average light exposure to patients located in the south-west oriented window beds was 187% higher during the day than those whose beds faced north-east.

There is a consistent difference in light exposure patterns between geographical window bed orientations that may have implications for future studies. It is also noteworthy that this study was done in window-bed inpatient rooms that received the

most natural and artificial light in the institution and the levels of ambient light were much less than in other hospital studies (Ulrich, 1984; Walch et al., 2005). In both the preliminary study and the current study, average light exposure for all geographical orientations of the hospital beds remained well below the currently reported necessary light level exposure of 1500 to 5000 lux several times per day for optimal circadian entrainment (Duffy & Wright, 2005; Taguchi, Yano, & Kido, 2007).

Research Question 4

Research question 4 asked, *"Over a three day period, for hospitalized adult medical patients, were there differences in sleep-wake patterns, mood levels, pain intensity levels, and analgesic use based on age or gender?* Prior to examining group differences, a Pearson correlation coefficient analysis was done to determine if there was a statistically significant relationship between the continuous variable of age and the variables of sleep-wake patterns, mood levels, and pain intensity. No significant correlations were found. The sample was then grouped into four categories (years of age): 18-30, 31-45, 46-60, and 61-80. A one-way ANOVA was conducted to determine if there were any statistically significant differences between age groups and the variables of sleep-wake patterns, mood levels, and pain intensity and there were none.

A t test was conducted to examine the mean group differences between gender and the variables of sleep-wake patterns, mood levels, and pain intensity levels; no statistically significant differences were found between males and females among the variables. In this study, therefore, age and gender had no relationship to sleep-wake patterns, mood disturbance scores, or subjectively reported pain intensity levels.

Research Question 5

The fifth research question asked, *"Over a three day period, for hospitalized adult medical patients, did light exposure patterns, sleep-wake patterns, and mood levels predict pain?* All data were screened to identify missing data, miscodes, and outliers and to ensure that the assumptions of normal distribution, adequate variance of variables, and linearity were met. All analyses were performed on normally distributed data that met the assumptions necessary to parametric testing.

As recommended by Hosmer & Lemeshow (2000), all variables with correlations of $p <= .20$ with pain were used in this multiple regression analysis. The nine predictive variables that met this criteria included: sleep minutes during the night, opioid use Day 1, opioid use Day2, opioid use Day 3, total opioid use, total mood disturbance (TMD), depression, tension, fatigue.

Evaluation for multicollinearity led to the elimination of the variables of opioids Day 1, opioids Day 2, and opioids Day 3.

Simultaneous entry multiple regression analysis was conducted to determine which remaining independent variables (sleep minutes during the night, total opioid use, TMD, depression, tension, and fatigue) were the predictors of pain. Regression results in Model 1 (with fatigue as the only independent variable) indicated that fatigue significantly predicted pain, $R^2 = .11$, $R^2_{adj} = .09$, $F(1, 38) = 4.84$, $p < .05$, demonstrating that fatigue accounted for 9% of variance in pain. In Model 2, mean opioid use was added to fatigue and this model also significantly predicted pain, $R^2 = .24$, $R^2_{adj} = .20$, $F(2, 37) = 5.89$, $p < .05$, accounting for 20% of variance in pain. It makes sense that opioid use would be a predictor of pain due to the highly significant correlation with pain. When

TMD was added to fatigue and mean opioid use in Model 3, there were also significant results, $R^2 = .25$, $R^2_{adj} = .19$, $F(3, 36) = 4.00$, $p < .05$, demonstrating that TMD, fatigue, and mean opioid use accounted for 19% of the variance in pain. The remaining predictors did not significantly predict pain in the follow-up models. In the final model, with all 6 predictors entered simultaneously, after controlling for all of the predictors, only opioid use, which was highly correlated with pain ($r = .46$, $p < .01$) still predicted pain, $b = .45$, $t (33) = 2.64$, $p < .01$). A summary of the regression models is presented in Table 10. Table 11 shows the predictors and coefficients for the models.

Table 10

Model Summary, Predictors of Pain (N = 40): 1 *= mean fatigue score, 2 = mean fatigue score, mean opioid use, 3 = mean fatigue score, mean opioid use, TMD, 4 = mean fatigue score, mean opioid use, TMD, mean depression score, total sleep minutes during the night, 5= mean fatigue score, mean opioid use, TMD, mean depression score, total sleep minutes at night, mean tension score*

Model	R	R square	Adjusted R Square	SE of Estimate
1	.34	.11	.09	1.48
2	.49	.24	.20	1.39
3	.50	.25	.19	1.40
4	.51	.26	.15	1.43
5	.54	.29	.16	1.42

Table 11

Predictors of Pain (N = 40)

Model	Variable	B	B SE	β	*t*	Sig.
1	Constant	4.97	.48		10.27	.00
	mean fatigue score	.12	.05	.34	2.20	.03
2	Constant	5.06	.45		11.12	.00
	mean fatigue score	.06	.05	.18	1.12	.27
	mean opioid use	.00	.00	.40	2.50	.02
3	Constant	5.07	.46		11.05	.00
	mean fatigue score	.10	.09	.30	1.20	.24
	mean opioid use	.00	.00	.41	2.55	.01
	TMD	-.02	.03	-.16	-.64	.53
4	Constant	5.58	1.02		5.45	.00
	mean fatigue score	.10	.10	.28	1.03	.31
	mean opioid use	.00	.00	.40	2.37	.02
	TMD	-.02	.05	-.15	-.38	.70
	mean depression score	.00	.15	-.01	-.02	.98
	total sleep minutes during night	.00	.00	-.09	-.56	.58
5	Constant	5.46	1.02		5.36	.00
	mean fatigue score	.14	.10	.41	1.42	.16
	mean opioid use	.00	.00	.45	2.64	.01
	TMD	-.06	.06	-.53	-1.07	.29
	mean depression score	-.06	.15	-.13	-.41	.68
	total sleep minutes during night	.00	.00	-.08	-.55	.58
	mean tension score	.18	.14	.41	1.27	.21

Although a further regression analysis examining a predictive association between light and fatigue (fatigue as the dependent variable) is not part of answering this research question, it is part of examining the relationships in the study model; is mood (fatigue) a mediator between light exposure and pain? Since the previously conducted correlation analysis showed a statistically significant negative correlation between mean fatigue mood score and light exposure ($N = 40$, $r = -.337$, $p < .05$) a regression analysis was conducted to examine if light exposure significantly predicted mean fatigue mood scores. Regression results indicated that the independent variable of mean light exposure significantly predicted mean fatigue scores, $R^2 = .11$, $R^2_{adj} = .09$, $F(1, 38) = 4.86$, $p < .05$. This model accounted for 9% of variance in pain. A summary of the model and coefficients are shown in Tables 12 and 13. Therefore, the greater the light exposure to the patient, the less fatigue they reported. With fatigue significantly contributing to pain in this study, there is sufficient reason to conduct further research examining this mediating relationship between light and pain in adult medical inpatients.

Table 12

Model Summary, Predictor of Fatigue (N = 40): mean light during day

Model	R	R square	Adjusted R Square	SE of Estimate
1	.337	.113	.09	4.22

Table 13

Predictor of Fatigue (N = 40): mean light during day

Variable	B	B SE	β	*t*	Sig.
Constant	9.09	.86		10.58	.00
mean light exposure during day	.00	.00	-.34	-2.20	.03

Summary

Examination of the data provided rich descriptions of light exposure patterns, sleep-wake patterns, mood disturbances, and pain experienced by adult medical inpatients, much of which has not been described in this study population and provides insight on health indicators that will provide a basis for future research. Additionally, in response to the research questions, the analyses indicate that there are statistically significant relationships among some of the concepts in the study model. Further interpretation and discussion of these relationships will be discussed in Chapter V.

Chapter V

Discussion

This chapter will provide an interpretation of the findings of this study. The study model will be evaluated and limitations of this study discussed. Suggestions for future research in the areas of light exposure, sleep-wake patterns, mood, and pain in hospitalized adult medical patients will be explored.

Sample Description

The sample of 40 medical inpatient participants with moderate to severe pain was primarily Caucasian and middle-aged although participant ages ranged from 22 to 78 years. The sample was made up of approximately 60% females and 40% males and there was a diverse set of admitting medical diagnoses with digestive diseases accounting for almost 40% of cases. Compared to their counterparts with post-surgical acute pain, few research studies have focused on medical inpatients with pain (Helfand & Freeman, 2009; Chang et al., 2010). Also, this is one of only a few recent, studies to examine pain in association with other key clinical factors in this population and it is the first known study to describe the phenomena of light exposure, sleep-wake patterns, and mood as they relate to pain. The findings provide a rich database for future investigations in this population.

Light Exposure Patterns

Light exposure levels for study participants were low whether during the day or night, and regardless of season. This study's design specifically required participants to occupy a window bed to standardize the physical environment of light which resulted in participants occupying the patient-bed areas of the hospital that received the most light.

These overall low levels of light exposure in the brightest hospital rooms on regular nursing units are similar to light measurements (50-300 lux) obtained in other studies involving hospital lighting in the areas of non-intensive care beds during the day (Wakamura & Tokura, 2001; Taguchi et al., 2007). The result of this investigation emphasized the nature of institutional light exposure: even the brightest patient-bed rooms have very low ambient light during the day or night in all seasons, thus eliminating the photic stimuli (bright-dark contrast) that the human retina's melanoreceptors require to help maintain circadian rhythm.

Most of the literature has reported that higher levels of light intensity (1000 – 10,000 lux for 30 minutes to 9 hours daily) are required for changes in mood and sleep-wake patterns (Hood, Bruck, & Kennedy, 2004; Sumaya et al., 2001; Riemersma-van der Lek et al., 2008; Golden et al., 2005). An interesting finding in this study, however, showed that although mean day light levels throughout the year were low (mean of 104.80 lux during the day), there were statistically significant negative correlations between light exposure levels during the day and total mood disturbance (TMD), fatigue (a mood subscale), and confusion (a mood subscale), all of which were lower when light levels were higher. Thus, even in lower light situations, changes in light exposure levels may be associated with differences in mood, fatigue, and confusion in hospitalized patients. Similarly, lower light levels than previously thought were effective in changing circadian entrainment in an experimental study conducted by Wright, Gronfier, Duffy, & Czeisler (2005): 34 healthy adult volunteers were exposed to an average of 150 lux of light (average indoor light levels) during the day for 2 days and then an average of 450 lux of light (similar to a bright office) for 6 days in a controlled environment. In these

controlled experimental conditions, phase shifts in subjects' circadian rhythm (as measured by plasma melatonin levels) were seen: a significant phase delay of 1-hour and 12 minutes was seen after exposure to ~150 lux of light for 16 hours per day for 2 days, and a more significant phase delay of 2-hours and 5 minutes was seen after exposure to ~450 lux of light for 16 hours per day for 6 days indicating that changes in circadian entrainment can be achieved even when light exposure, the circadian synchronizer, is at much lower levels than previously thought, and within shorter time frames (2 or 6 days). There are no known experimental studies regarding the levels of light exposure necessary to affect changes in circadian entrainment (sleep-wake patterns), and potentially mood and pain in the hospitalized adult compelling further research in this area.

In this sample, the only predictive relationship was between light exposure levels during the day and fatigue. These findings may be useful in providing preliminary data to support a hospital lighting intervention study to examine lighting 'doses' that in combination with effective pain management, will elicit better patient outcomes such as better sleep at night, better overall mood, and less fatigue and confusion: common problems in all hospitalized adults and especially those in pain. It may be that increasing average daytime light exposure for hospitalized patients in comfortable (not too bright) doses heretofore thought ineffective could lead to less fatigue and better sleep-wake patterns at a reasonable cost. Further research is necessary in the adult medical inpatient population to determine if changes in hospital room lighting could be effective as a novel adjunct treatment for pain by way of managing circadian entrainment and fatigue.

Sleep-wake Patterns

The data describing sleep-wake patterns in this study indicate that participants' sleep was short in duration and interrupted during both day and night times. Intra-daily variability (IV) calculations that measured fragmented rest-wake patterns over a 24-hour period (both night and daytime sleep) indicated high levels of interrupted sleep. It is well known that the hospital environment is very disruptive and not conducive to having long periods available for sleep without interruptions; this is supported by the findings that 50% of the participants slept less than 4 hours (<233 minutes) during the night. Furthermore, 20% of the participants scored greater than 12.0 on the FRAG score indicating very fragmented sleep and 25% of the participants were awake 145 minutes (2.5 hours) during the first night of their hospital stay. It is understandable that there are many variables that may contribute to fragmented sleep in the hospital including noise, physical disturbances, co-morbid conditions such as sleep apnea, and medications (including opioids). This is the first known study to investigate and describe the sleep fragmentation of this medical inpatient population, whatever the cause, providing data that can be used in further investigations of sleep-wake patterns and health concerns.

In this study, inter-daily stability (IS), a calculation based on sleep minutes and light exposure levels for the total 72-hour duration of the study, was used to determine circadian alignment. The IS measurement, as described by Van Someren et al. (1999), is a variable with a high sensitivity to the effect of light exposure on the 24-hour sleep-wake circadian rhythm. The IS calculation is a valid measure of the strength of the alignment between light and circadian rhythm; it is useful when an invasive procedure such as serum melatonin collection is not feasible. In this sample without a biomarker, it appears

that IS is a good indicator of disrupted sleep patterns: a significant positive relationship was found between sleep minutes at night and IS indicating that hospitalized patients in pain are awake much of the night.

IS calculations are also based on light exposure patterns. The light levels in this study, however, were much lower than those used to initially calculate IS in Van Someren's (1999) analysis of two Alzheimer patient population studies (2000 lux). Van Someren's study populations had mean IS values of ~0.48 in one study and ~0.50 in another study (same population demographics) prior to experimental light exposure; this was much higher than the mean IS of 0.37 in the participants representing medical inpatients with pain in this study. Van Someren then exposed his subjects to experimental lighting conditions of ~2000 lux of light for 2 hours daily x 2 weeks and the mean IS values increased significantly to 0.62 and 0.65 respectively in his study populations. More research is necessary to determine what level of experimental doses of light would increase IS values (to help establish better circadian alignment) in hospitalized adult medical patients.

Circadian entrainment is critically important for the coordination of functions throughout the human body with substantial circadian misalignment leading to asynchronies within cell cycles and between organ systems (Rea et al., 2008) contributing to confusion, reduced neurocognitive function, depression, and pain (Lane & East, 2008; Roehrs & Roth, 2005). Minutes of sleep, whether during the day or night, did not significantly correlate with any mood disturbances in this study, which contradicts the clinical expectation that less sleep is associated with greater mood disturbances. And although sleep minutes were few and fragmented, there was also no significant

correlation between any of the sleep-wake pattern variables and pain. It is possible that ‘no pattern’ is the typical ‘sleep-wake’ pattern for hospitalized patients with pain; that is, mood disturbances, pain, relief, and sleep occur over relatively short, unpredictable cycles which lengthen and become more rhythmic and regular as the pain is brought under control and the patient recovers. Both intra-daily variability (IV) and pain levels decreased significantly between Day 1 and Day 3 indicating less sleep disturbance and a movement toward recovery from acute pain issues. Future studies regarding circadian entrainment in this population may benefit from extending the study to include time after the patient is discharged and recovering at home. Biological markers such as serum melatonin and/or cortisol levels may be helpful to investigate circadian disruption in the hospital environment followed by IS and IV calculations that can be used as a viable alternative to biological markers after hospital discharge. Continuing circadian alignment studies in the home after discharge can help determine the participant’s intrinsic circadian alignment with varying environmental light conditions and how they correlate with the health outcomes of sleep-wake disturbances, mood, and pain.

Mood

The Profile of Mood States (POMS™ Brief) tool was used to measure participant’s mood disturbance. Results indicated that overall mood levels varied greatly among study participants which were consistent with the great variation of mood norms of the general population. It is understandable that hospitalized patients would have higher total mood disturbances than the general healthy adult population. It also makes sense in this study that the mood disturbance subset of ‘lack of vigor’ is also much higher

than the general healthy adult population, since few hospitalized persons would describe a feeling of overall vigor while ill.

Curiously, however, the subsets of tension, depression, anger, fatigue, and confusion had lower disturbance scores among study participants than in the published measures of the normative population (McNair & Heuchert, 2005). After reviewing all raw data and calculations, the researcher did not have an explanation for these results, although it is worth noting that that developers of the POMS Brief do not report normative measurements among acutely physically ill adults and it may be that the responses to a mood questionnaire in this population are muted due to overwhelming pain and distress during hospitalization. Using the Hospital Anxiety and Depression Scale (HADS) to measure mood disturbance was considered as an alternative to the POMS Brief when designing this study, but was rejected in deference to the POMS Brief since, despite its name, HADS was validated in outpatient settings (Zigmond & Snaith, 1983). In future studies, an instrument such as the Memorial Symptom Assessment Scale Short Form (MSAS-SF) could be more useful when measuring mood in this acutely ill population. The MSAS-SF measures 32 items with physical (pain), psychological, and global distress subscales and has been validated in acutely ill cancer patients (Chang, Hwang, Feuerman, Kasimis, & Thaler, 2000). And although the participants in this study did not represent a hospitalized cancer population, it was a population more similar to acutely ill cancer patients than the psychiatric outpatient, healthy adult, college student, or healthy geriatric population which was used to determine the validity and reliability of the POMS Brief (McNair & Heuchert, 2011).

When examining the scores of total mood disturbances, fatigue, and confusion, there were statistically significant correlations among these variables, light exposure, and sleep at night. The mood subset of fatigue also had a positive statistically significant correlation with pain. It is important to note, however, that although fatigue was measured in this study as a subscale of mood, fatigue is more often considered associated with disturbed sleep and it may be a better indicator of problems with sleep-wake patterns rather than mood. Although there is no cause and effect implied, it is worthwhile to continue investigations regarding the mood (and fatigue) of hospitalized adults with pain to better understand its impact on the health outcomes of this hospitalized population.

Pain

Moderate to severe pain, indicated by a participant's subjective pain intensity score of ≥5 on a 0-10 numeric pain scale for two consecutive nursing pain assessments, was an inclusion criterion for this study. And pain levels remained high for most of the participants throughout their hospitalization. Although there was a statistically significant drop in pain from an average of 6.50/10 on Day 1 to 5.34/10 on Day 3, the average pain score still remained within the moderate to severe range (5+) after 3 days of treatment with opioids. It is worthwhile considering that these study participants may also have had ongoing chronic pain which influenced their reported pain levels and maintained high scores in this study. A history of chronic pain was not collected from participants, which is a limitation to this study.

The analysis showed that there was no statistically significant difference in mean pain scores among the different times of day, among males and females, and among age groups. This is in contrast to other studies which reported that patients may experience

pain differently according to time of day (Auvil-Novak, 1997), gender (Trame & Rawe, 2009), and age (Kelly, 2009). This study population of medical inpatients with moderate to severe pain may, indeed, not experience these differences and may become a more homogeneous population when hospitalized with acute medical illnesses. As stated previously, it may be that 'no pattern' is the pattern in adult medical inpatients and so the usual associations among pain, age, and gender do not exist in the same way as in post-surgical patients or community-dwelling populations with pain and may account for the difficulty in adequately treating medical inpatients with pain: a unique and restless population that does not respond to treatment in expected ways.

All participants received treatment for their pain with opioids. Data on type of opioid and dosages consumed was collected from the participants' electronic medical records and dosages were converted to their equianalgesic oral morphine equivalents for proper comparison. In the clinical setting, it is common to find a wide variation in analgesic (opioid) use among patients with pain, and that was reflected in the large standard deviations in analgesic dosages found in this study. Not surprisingly, a strong statistically significant correlation was found between participants' mean pain scores and the mean amount of opioids used which is consistent with at least one other study that investigated hospitalized adult's pain, use of opioid analgesics, and light exposure (Walch et al., 20015). Those who describe more pain use more opioids in an attempt to relieve the pain. Information regarding non-opioid pain medication and non-pharmaceutical methods of pain treatment were not collected. It may be beneficial in future studies, however, to gather information on all methods used to manage pain in order to identify any associations among sleep-wake patterns, light exposure, mood

changes, and pain relief with the method of pain relief chosen by the patient and medical staff and to examine if there were any patterns noted in choices of pain relievers by adult medical inpatients.

The Study Model

The study model for this predictive correlational research study depicted relationships between the four variables of light exposure, sleep-wake patterns, mood, and pain in medical inpatients. The model did not provide for a direct association between light and pain, but only as it may exist indirectly through sleep-wake patterns and mood. There is evidence in the findings of this study to support parts of the study model, presented in both Chapters I and IV.

There was a statistically significant negative relationship between light exposure and mood (total mood disturbance and the subsets of fatigue and confusion), which serves as a mediator between light exposure and pain: aspects of mood (fatigue and confusion) were statistically significantly associated with pain. Light exposure, however, was not significantly associated in this study with the variable of sleep-wake patterns unless, as mentioned earlier, fatigue were to be considered a disturbance in the sleep-wake pattern rather than a mood disturbance. Sleep-wake patterns, as described in this study, were not significantly associated with pain in these findings, which contradicts other research that links the reciprocal relationship between pain and sleep: the more sleep, the less pain (Roehrs & Roth, 2005). It is unclear whether this study's findings have to do with the characteristics of the hospitalized study population, which is the pattern of 'no-pattern', or if a larger sample size would have revealed a different outcome similar to previous research, but further investigation in this population is warranted.

Finally, the proposed association between mood and sleep-wake patterns was also not significant. The researcher's speculation that the better one slept, the lower the mood disturbance, was not supported by this study's outcomes. Characteristics of the study population as described earlier and the overall paucity of sleep experienced by the participants may have prevented levels of wakefulness that would have impacted mood.

Limitations

One limitation to this study was that light exposure data was being collected with a wrist-worn device that could be covered with clothing or bedding thus giving inaccurate light exposure measurements. Although participants were provided with an information sheet upon enrollment that encouraged them to keep the watch and light meter exposed and face up, it was not known if, and for how long, any of the participants had their wrists with the light meter hidden under blankets or clothing, unable to record room lighting. Interestingly, however, the mean light levels in the study corresponded well with the light level data collected in the preliminary study which used a free standing light meter placed at the head of the bed, at pillow level. These results are also congruent with a study of light measurement in hospital rooms conducted by Higgins et al. (2007) who found that light exposure data collected from a free standing light meter was statistically comparable with light exposure data collected at the same time from patient-worn wrist actigraphs with light meters.

A high attrition rate resulted in the lower than expected sample size of 40 participants which provided another limitation to this study. While the sample size is too small to be generalizable, these study results serve to provide preliminary data that will be useful in many follow-up studies in the same population or in others.

Although pain scores were easily obtained from the patient's electronic medical record and are believed to be accurate since self-report of pain is the most valid method of assessing pain (McCaffery, 1968), information regarding the presence of underlying chronic pain conditions was not collected. The presence of chronic pain may have had an influence on the reported pain scores and provides a possible limitation in the accuracy of the measurement of pain in this sample. It is recommended that future studies include assessing participants for the presence of chronic pain, differentiating between the intensity score of acute or chronic pain.

Another limitation to this study is that medications such as sedatives, anxiolytics, and sleep medications were omitted from analysis. These drugs may influence sleep-wake patterns, mood, and pain and should be accounted for in future studies.

A major limitation in this study was the lack of the measurement of any biological markers, such as serum melatonin or salivary cortisol which would have added to the findings on circadian entrainment and mood. Melatonin secretion is the most reliable method of determining circadian entrainment (Duffy & Wright, 2005) and that was not feasible for this study. Salivary cortisol has also been determined to be useful in assessing sleep-wake and mood disturbances (Backhaus, Junghanns, & Hohagen, 2004) and would have provided additional information regarding those variables. It is recommended that future similar studies include the measurement of serum melatonin and cortisol in experimental investigations of light exposure, sleep-wake patterns, mood, and pain in hospitalized adults.

Implications for Practice and Policy

Light and Mood

This study demonstrates that environmental hospital lighting is consistently low, even in the patient bed areas of the hospital that receive the most light exposure. Despite these low light exposure levels, there was a significant, negatively correlated difference in total mood disturbance, fatigue, and confusion between those who were exposed to higher levels of light and those who were exposed to lower light levels. While the results of this single study cannot be cause for policy or official protocol changes regarding lighting in the hospital setting, it is appropriate to consider these findings as a basis for further investigation into this phenomenon to see what levels of increase in light exposure, however modest, would have a significant impact on a patient's mood disturbance and thus pain. Depressed mood, fatigue, and confusion are often problems in hospitalized adults and can lead to complications in care, increased pain, longer hospital stays, poorer outcomes, and higher medical costs. Until further studies can be conducted, however, exposing hospitalized patients to more light during the day by raising a curtain or locating a patient's chair closer to the window may be beneficial and certainly within the scope nursing practice and may have a potentially significant positive impact on a patient's mood and pain.

Sleep is Poor

The descriptive data obtained in this study reveal that participants experienced short bouts of fragmented sleep during the 72 hours of the study. Recognizing that sleep is important to healing, many hospital nursing units across the country are working on efforts to improve sleep for inpatients (BaHammam, 2006). Fatigue was the subset of

mood that was most significantly correlated with pain. The results of this study further underline the need for hospital policies that promote undisturbed time for patients to sleep and to investigate low-cost and effective methods to promote proper sleep-wake patterns such providing day time light exposure for patients that are found to be effective for circadian entrainment.

Pain is Prevalent

Pain remains a significant problem in the hospitalized adult medical population. The descriptive data in this study showed that participants remained in significant pain throughout the study time despite high opioid usage. Opioid use among this population was highly correlated with pain levels and did not recede as pain levels diminished over the 72-hour course of the study. The participants in this study with non-surgically-related pain represented an often overlooked population in pain research studies because their acute pain is often more complex despite continued use of opioid analgesics (Helfand & Freeman, 2009; Chang et al., 2010). Attention to pain in this population should remain a priority for nurses and for those who make hospital policy; additional research regarding effective pain management, especially in areas that can potentially affect mood and sleep as avenues to better pain control, continues to be warranted in this population.

Recommendations for Future Research

The results of this study provided preliminary data for future studies exploring the hospital lighting environment and its correlation with sleep-wake patterns (circadian rhythm), mood, and pain in the hospitalized medical patients. Much of the descriptive information and their associations among the variables in this study have never been explored in a medical hospitalized population together until now. Even with the

limitations that this study experienced, the correlations between light exposure and fatigue, which was a significant predictor of pain, cannot be ignored.

As described throughout this chapter, future research must involve experimental studies that investigate lighting interventions in the hospital as an adjunct treatment for patients' sleep-wake and mood disturbances in order to provide effective pain relief. These intervention studies should include experimenting with different 'doses' of light exposure for participants and measure mood, sleep-wake patterns, and pain. The biological markers of serum melatonin and salivary cortisol should also be collected as indicators of circadian entrainment and stress. It may be beneficial and more feasible to conduct this type of future study in a controlled research hospital unit instead of a regular nursing unit. Results from such studies may provide evidence that will help nurses and policy-makers develop lighting interventions that offer unique, cost-effective ways of using light to take better care of patient's sleep, mood, and pain.

Another direction for future research based on these study findings include light exposure intervention studies among persons with chronic pain in the community setting. Mood and sleep disturbances are major issues for those with chronic pain (Naughton, Ashworth, & Skevington, 2007) and no known lighting intervention studies have been done targeting this growing population of pain sufferers. Often persons with chronic pain are home-bound and may be exposed to low light levels in their own homes; knowledge gained from community-based studies would be useful in designing low-cost adjunct treatments in the home for those suffering with chronic pain.

Conclusion

Over a century ago, Florence Nightingale maintained that sunlight was critical to the healing of body and mind and that it was the nurse's job to position the patient for the best possible exposure to sunlight to provide for better healing (Nightingale, 1969). Nightingale expounded on the common intrinsically held wisdom that a sunny day is better for mood than a cloudy day and that light somehow had healing properties. And although at the time it could not be scientifically measured, nurses understood that somehow bright light and good mood were intertwined with good health.

With today's highly technical instruments, researchers have the ability to precisely measure light levels and sleep-wake patterns, yet accurately measuring the highly personal and subjective variables of mood and pain remains a challenge, as it was in this study. Although significant relationships among all of the four variables of light exposure, sleep-wake patterns, mood, and pain were not found in this study as anticipated, certain significant associations were found, among them light/fatigue and fatigue/pain. In all, the rich compilation of descriptive data obtained in this study that heretofore had not been collected in any study involving hospitalized adult medical patients will serve as a basis for future studies investigating the important element of light in the care of hospitalized patients, especially those with pain. This researcher believes Florence Nightingale would approve.

Appendix A: Informed Consent Document

Cleveland Clinic
Consent to Participate in a Research Study

Study Title: Light, Sleep, Mood, and Pain in Medical Inpatients
Principal Investigator: Esther Bernhofer, PhD(c), RN-BC

Carefully review this consent document. The purpose of a consent document is to provide you with information to help you decide whether you wish to participate in research. Your decision is completely voluntary and will not affect your medical care if you choose not to participate. It is important for you to ask questions and understand the research risks, benefits and alternatives.

Please note:

- **You are being asked to participate in a research study**
- **Carefully consider the risks, benefits and alternatives of the research**
- **Your decision to participate is completely voluntary**

****

1. INFORMATION ON THE RESEARCH

Why Are You Being Asked To Take Part In This Research?
You are being asked to participate in this research study because you are an adult admitted to the hospital and you have non-surgical pain.

Why Is This Study Being Done?
This study is being conducted as part of the investigator's doctoral dissertation at the Frances Payne Bolton School of Nursing, Case Western Reserve University. Ms. Esther Bernhofer, the primary investigator of this study, is working under the direction of the Chair of her Dissertation Committee, Patricia A. Higgins, RN, PhD. Dr Higgins can be reached at her office phone, 216-368-8850**.**

The purpose of this study is to help researchers understand relationships among lighting in the hospitalized patient's environment, mood, sleep-wake disturbances, and pain.

How Many People Will Take Part In The Study?

About 78 people are sought for enrollment in this study.

What Is Involved In The Study?

This study involves wearing an actigraph, a watch-like device, on your wrist for 72 continuous hours. This device is powered by a small watch battery and measures your surrounding light levels as well as your rest and activity levels. This study also involves answering questions on a survey regarding your current mood. The study investigator will visit you once every day for 3 days – the same time period that you are wearing the actigraph watch – and ask you questions about how you feel and the quality of your sleep the night before. If you agree to participate in this study, the following data will also be recorded from your medical record: age, gender, primary diagnosis, your bed location on the unit, self-reported pain scores during data collection and the type and amount of pain medication administered.

How Long Will You Be In The Study?

Your participation in this study will last a minimum of 72 hours, including 3 nights.

2. RISKS AND DISCOMFORTS

What Are The Risks Of The Study?

This is a minimal risk study. Wearing the actigraph watch may cause the same discomfort that wearing any watch may cause.

There are no physical risks associated with the questionnaire portion of this study. There is, however, the potential risk of loss of confidentiality. Every effort will be made to keep your information confidential, however, this can not be guaranteed. Some of the questions we will ask you as part of this study may make you feel uncomfortable. You may refuse to answer any of the questions if you choose.

3. BENEFITS

There is no personal benefit to you by participating in this research study. The knowledge to be gained from this research may be beneficial for other patients, society, or science.

4. ALTERNATIVES

The alternative is not to participate.

5. PRIVACY AND CONFIDENTIALITY

The medical and research information recorded about you for this research will be used within the Cleveland Clinic and/or disclosed outside the Cleveland Clinic. A note that you are participating in this research study will be placed in your medical record. The information recorded about you as part of this research will be maintained in a confidential manner.

Upon completion of the study, you may have access to the research information as it is contained in the medical record. During the study, your access to research information about you will be limited. Preventing this access during the study keeps the knowledge of study results from affecting the reliability of the study. This information will be available should an emergency arise that would require your treating physician to know this information to assist in treating you.

Federal regulations require that you authorize the release of any health information that may reveal your identity. The persons and entities that you are authorizing to use or disclose your individually identifiable health information may include the study staff, Cleveland Clinic monitors/auditors, the Institutional Review Board (IRB), and the Department of Health and Human Services (DHHS). Because of the need to release information to these parties absolute confidentiality cannot be guaranteed. The Cleveland Clinic also may use and disclose this information for treatment and payment reasons. The Cleveland Clinic must comply with legal requirements that mandate disclosure in unusual situations. Once your personal health information is released it may be re-disclosed and no longer protected by federal privacy laws. The results of this research may be presented at meetings or in publications; however, your identity will not be disclosed in those presentation.

Your research information may be used and disclosed indefinitely, but you may stop these uses and disclosures at any time by writing to Esther Bernhofer at The Cleveland Clinic, 9500 Euclid Avenue, G80-51, Cleveland, Ohio 44195. If you do so, your participation in the research will stop, but any information previously recorded about you cannot be removed from the records and will continue to be used as part of the research. Also, information already disclosed outside the Cleveland Clinic cannot be retrieved. Even if you ask us to stop outside disclosures, information collected about you will be disclosed as required by state and federal law.

The Cleveland Clinic will not use or disclose the information collected in this study for another research purpose without your written permission unless the Cleveland Clinic Institutional Review Board gives permission after ensuring that appropriate privacy safeguards are in place. The Institutional Review Board is a committee whose job is to protect the safety and welfare of research subjects.

By signing this informed consent form, you are authorizing such access to your medical records. If you choose not to sign this consent form, you will not be permitted to participate in this research study.

6. COSTS

There are no costs to you for participation in this research study. The cost for routine tests and services that would normally be performed even if you don't participate in the study will be billed to you or your insurance provider.

7. VOLUNTARY PARTICIPATION

What Are Your Rights As A Participant?

Participation in this research study is entirely voluntary and you may drop out at any time.

If you have any questions, concerns or complaints about the research, or develop a research-related problem, contact Esther Bernhofer, Principal Investigator, at 216-445-2038. After hours, please call 216-244-6974. If you have questions about your rights as a research subject, you should contact the Institutional Review Board at (216) 444-2924.

8. SIGNATURE

Statement of Participant

I have read and have had verbally explained to me the above information and have had all my questions answered to my satisfaction. I understand that my participation is voluntary and that I may stop my participation in the study at any time. Signing this form does not waive any of my legal rights. I understand that a copy of this consent will be provided to me. By signing below, I agree to take part in this research study.

_____

Printed name of Participant

_____ _____

Participant Signature Date

Statement of Person Conducting Informed Consent Discussion

I have discussed the information contained in this document with the participant and it is my opinion that the participant understands the risks, benefits, alternatives and procedures involved with this research study.

_____

Printed name of person obtaining consent

_____ _____

Signature of person obtaining consent Date

Appendix B: Participant Demographic and Information Sheet

Research Study: Light, Sleep, Mood, and Pain in Medical Inpatients

Principal Investigator: Esther Bernhofer

Participant Demographic Information ____Participant did not complete study
* see reason below

Participant Study ID: _____

Gender: male ___ female ____ Age: _____

Primary diagnosis: _____

Unit: _____

Room orientation facing: north south east west

Did the participant occupy a window-bed during the entire time of the study? Yes No

If not, indicate when the patient moved to a different location _____

Dates and times of study participation:

Began at _____am/pm on _____

Ended at _____am/pm on _____

Pain Scores Abstracted from Medical Record:

(list all scores in correct block separated by commas)

	Morning scores (6am to noon)	Afternoon scores (1pm to 5pm)	Evening scores (6 pm to 10pm)	Night scores (11pm to 6am)
First 24 hours				
24-48 hours				
48-72 hours				

Comments:

_____

_____

*Reason for not completing study

_____

Pain medication use from medical record:

(list all pain medications whether opioid or non-opioid)

First 24 hours:

Name of medication	Dosage and route ordered	Frequency ordered	Amount actually taken	Comments

Second 24 hours:

Name of medication	Dosage and route ordered	Frequency ordered	Amount actually taken	Comments

Third 24 hours:

Name of medication	Dosage and route ordered	Frequency ordered	Amount actually taken	Comments

Appendix C: Subjective Sleep Questionnaire

Research Study: Light, Sleep, Mood, and Pain in Medical Inpatients

Principal Investigator: Esther Bernhofer

Participant Study ID: _____

1. When did you turn out the light to sleep for the night and when did you wake for the day in the morning?

Night 1 _____

Night 2 _____

Night 3_____

2. Please rate your quality of sleep last night:

Night 1

1. Very good
2. Fairly good
3. Neither good nor bad
4. Pretty bad
5. Very bad

Night 2

1. Very good
2. Fairly good
3. Neither good nor bad
4. Pretty bad
5. Very bad

Night 3

1. Very good
2. Fairly good
3. Neither good nor bad
4. Pretty bad
5 Very bad

Appendix D: Actigraph Use Instructions

Research Study: Light, Sleep, Mood, and Pain in Medical Inpatients

Principal Investigator: Esther Bernhofer

Participant Study ID: _____

Instructions on use of Actigraph Watch for study purposes

The actigraph watch:

- Is a device commonly used in clinical settings to measure the surrounding light exposure and rest/activity levels of the wearer.
- The same weight and feel of a man's common watch.
- Can be worn on either wrist, where it is most comfortable and convenient.
- Should be worn face up on the wrist so it has maximum exposure to room light
- Should be uncovered at all times – please try to keep sleeves, clothes, blankets, and bed linens away from the face of the watch so it can measure light in the room.
- Should not be removed throughout the time of this study, until the researcher removes it, approximately 72 hours.
- Is waterproof and can be used while bathing or showering.
- Is impact resistant, but please be careful not to bang it too hard or it can break like any watch.

If the actigraph watch must be removed for any reason, such as a medical test, please make a note as to the time it was removed and when it was re-applied and leave this information for the researcher with the nurse manager if the researcher is not available.

If it must be removed because the participant drops out of the study for any reason, it is to be given to the nurse manager for safe-keeping in a locked office and the Principal Investigator must be called as soon as possible.

Contact information for the Principal Investigator is:

Esther Bernhofer
Office phone: 216-444-2185
Alt phone: 216-244-6974

Appendix E: Actigraph Watch with Light Meter Information

Actigraph Watch with Motion Logger–L®,
(Ambulatory Monitoring, Inc. Ardsley, NY)

Information from Ambulatory Monitoring: www.ambulatory-monitoring.com/pdf/29ede7a4.pdf

731 Saw Mill River Road ■ P.O. Box 609 ■ Ardsley, New York 10502-0609
Tel: 1.800.341.0066 / 914.693.9240 ■ Fax: 914.693.6604
info@ambulatory-monitoring.com
www.ambulatory-monitoring.com

Motionlogger

AMI offers an actigraph to fit all budget and protocol requirements. Various model Motionloggers offer applications that include basic sleep estimation; simultaneous environmental data collection; and time-of-day features. A range of recording capabilities exist including four validated sleep algorithms, PLM analysis, and a suite of circadian rhythm analyses. Software for device operation and data analysis is available for Windows 2000/XP and comparable systems – and our ActMe Operational Software allows for quick, easy download of actigraph data into the Fatigue Avoidance Scheduling Tool ("FAST") Program. All models are Lithium battery powered for long use and come with a full one-year warranty.

Basic Motionlogger

BASIC MOTIONLOGGER **26.000**

Features include event marker; audible feedback; 2MB memory; 2-3 Hz filter; sensitivity .01G at mid band; Zero Crossing (ZC), Time-Above-Threshold (TAT), ZC/TAT Dual, and Proportional Integrating Measure (PIM) modes of operation and Tri-Mode PZT (ZC, TAT, and PIM, simultaneously); water resistant (shower safe); and easy coin cell battery exchange (60-day battery life) via compartment isolated from sealed interior electronics. Epoch lengths are adjustable from one second to minutes.

BASIC MOTIONLOGGER-L **26.000L**

Contains all of the features of Cat. #26.000 above as well as a photo optic light sensor nominally set up for 1 LUX resolution and 0-4,000 LUX range.

BASIC MOTIONLOGGER INTERFACE with ACT Operational Software Powered by 9-V Battery **25.111PS**

This Interface is compatible with the above actigraph units; and it comes with an optional A/C power supply. For initializing and downloading data.

(Analysis Software sold separately.)

ACCESSORY AND REPLACEMENT ITEMS FOR MOTIONLOGGER® ACTIGRAPHS

Motionlogger Disposable Duracell Batteries (set of 6)	**21.196**
Motionlogger One-Piece Velcro Wrist Strap	**21.193**
Motionlogger One-Piece Ribbon Wrist Strap with Adjustable Buckle	**21.194**
One piece, single-use plastic, hospital-type wrist strap (set of one dozen)	**21.192**
Two-Piece buckled, plastic wrist strap	**21.199**
Serial Port Tester	**21.198**

Device to test communications between Interface and computer. Identifies integrity of the communication port.

Motionlogger Web Belt with Pouch **21.199**

Black nylon pouch and quick release buckle belt (fitting waists up to 42") with tamper proof wrap-around enclosure for applications where activity measurements of general locomotion are the goal. Trunk activity measurement has been employed in ADHD and energy expenditure studies. Specify **Micro** or **Basic Pouch Size**

Appendix F: IRB Approval Letter

Cleveland Clinic

Institutional Review Board

AAHRPP Accredited

March 30, 2011

Esther Bernhofer, PhD(c), RN-BC / G80-51

RE: IRB # 11-269: Light, Sleep, Mood, and Pain in Medical Inpatients

Dear Ms Bernhofer:

Your new study application received on 3/21/2011 was **approved** under the expedited review process for the period of **3/21/2011 through 3/20/2012.** This research was determined to be minimal risk research and classified as Category #4 : research involving the collection of data through noninvasive procedures routinely employed in clinical practice, excluding procedures involving x-rays and #7: survey research involving minimal risk.

You are approved to conduct this research in accordance with Application received on 3/21/2011, Protocol Version 1.0 3/8/2011, Informed Consent Version 1.0 3/31/2011, Motion Logger Information 12/1/2010, Questionnaire, Data Sheet, Instructions Version 1.0 3/31/2011.

A copy of the approved Informed Consent, Instructions and Questionnaire with IRB stamp approval for the period of 3/21/2011 to 3/20/2012 are available online under the Stamped Documents tab.

You may not continue this research beyond the study expiration date 3/20/2012 unless a renewal application is approved by the IRB. Any changes or amendments must be reported and approved by the IRB prior to implementation. Any study deviations and unanticipated problems, including adverse events must be promptly reported to the IRB.

Sincerely,

Daniel Beyer

Daniel Beyer, M.S., MHA, CIP

Executive Director, IRB and Human Research Protections

DB: lrd

Institutional Review Board AAHRPP Accredited **Expiration Date: 3/20/2012**

Appendix G: IRB Amendment Approval Letter

Cleveland Clinic

Institutional Review Board
AAHRPP Accredited

August 23, 2011

Esther Bernhofer, PhD(c), RN-BC / G80-51

RE: IRB# 11-269: Light, Sleep, Mood, and Pain in Medical Inpatients

Dear Ms Bernhofer:

Your amendment form received on 8/22/2011 for the request to change the inclusion criteria, to allow recruitment from private rooms as well as semi-private rooms was **approved** under the expedited review on 8/22/2011.

The date for continuing review and study expiration remains unchanged at 3/20/2012.

Sincerely,

Daniel Beyer

Daniel Beyer, MS, MHA, CIP
Executive Director, IRB and Human Research Protections

DB: lrd

Expiration Date: 3/20/2012

Appendix H: IRB Renewal Approval Letter

Cleveland Clinic

Institutional Review Board
AAHRPP Accredited

March 22, 2012

Esther Bernhofer, PhD(c), RN-BC / G80-51

RE: 11-269: Light, Sleep, Mood, and Pain in Medical Inpatients

Dear Ms Bernhofer:

Your study renewal application received on 3/19/2012 was reviewed under expedited review on 3/22/2012 and **approved for the period of 3/22/2012 to 3/20/2013.**

This study was determined to be minimal risk

You are approved to continue this research with the use of the Consent Version 2.0 3/15/2012, Instructions Version 2.0 3/15/2012, Participant Demographic Information Version 2.0 3/15/2012, Questionnaire and Data Sheet.

The stamp-approved Consent, Demographic Sheet and Questionnaire are available

online under the Stamped Documents tab. Written consent is required to document that

each person enrolled in this research has been informed about this research and voluntarily agrees to participate prior to any involvement in the research.

Any changes or amendments require IRB review and approval prior to implementation. Unanticipated problems including adverse events and deviations are to be reported in accordance with IRB Policy 60: Adverse Events and IRB Policy 70: Unanticipated Problems.

This study may not continue beyond the approved expiration date. To request continuation, submit a renewal application 30 days prior to expiration or a completion report for closure.

Sincerely,

Daniel Beyer

Daniel Beyer, M.S., MHA, CIP
Executive Director, IRB and Human Research Protections

Expiration Date: 3/20/2013

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1 Lux day	1											
2 High lux	.488**	1										
3 Sleep day	-.160	.038	1									
4 Sleep night	.130	-.037	.398 *	1								
5 FRAG	.055	.143	-.219	-.715**	1							
6 IS	.227	.015	.058	.406**	-.123	1						
7 Opioid use	-.062	-.029	.000	-.230	.081	-.096	1					
8 TMD	-.315 *	-.371*	.091	-.251	-.002	-.213	.417**	1				
9 Anger	-.223	-.163	.312 *	-.091	-.037	-.159	.529**	.707**	1			
10 Fatigue	-.337 *	-.287	-.025	-.284	.059	-.131	.409**	.815**	.355*	1		
11 Confuse	-.323 *	-.370*	.171	.071	-.093	-.344*	-.201	.488**	.119	.346*	1	
12 Pain	.098	.001	-.087	-.218	.042	.145	.465**	.254	.206	.336 *	-.137	1

*Light, Sleep, Mood, and Pain: Correlations of sample using 2-tailed test (N = 40) Variables identified with numbers 1 through 12 in left column correspond with variable numbers 1 through 12 across top. Note.*p < .05 level, 2-tailed, **p<.01 level, 2-tailed*

Appendix I: Correlation Table

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