Exploring the Connection Between the 14 Patterns of Biophilia and their Potential
Restorative Effects on ICU Nurse Burnout and Stress Levels

Thesis Report in Environmental Design

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ABSTRACT

Background: Nurses in the Intensive Care Unit (ICU) experience high levels of stress and burnout; a significant number of nurses leave after only one year. Several studies have suggested that hospitals need to take action to prevent future nurses from burnout to protect their health.

Objective: The objective of this study is to explore the use of biophilia theory (exposure to nature indoors) to increase positive sensory stimulation on ICU nurses to reduce burnout and stress levels. Method: To address these issues, this article analyzed current literature on the 14 patterns of biophilic theory through stress recovery theory and stimulation theory as catalysts to propose potential applications of biophilic theory in hospital settings in nurses facing burnout and stress.

Results: Using stress recovery and stimulation as catalysts, the literature on the 14 patterns of biophilia identified by researchers is analyzed to determine proposed benefits to physical, mental, and behavioral well-being that might be used to reduce nurse stress and burnout in ICUs. Next, designs are proposed that can benefit nurses and help reduce their stress and burnout. These designs are separated into four categories: courtyard, the layout of the surgical ICU, nurses’ workstations, and their breakroom. Conclusions: There is a conceivable cause between the physical environment and nurses' burnout and stress, as shown in theoretical assumption and lecturer review. The findings suggest that having biophilic patterns in the physical design of the ICU unit, workstation, and breakroom could play both a direct and indirect role in influencing emotion.

Keywords

Biophilic design, connecting to nature, stress recovery, stimulation, ICU nurses, stress, and burnout.
CHAPTER I: INTRODUCTION

Nurse burnout is a prevalent problem among nurses in the U.S (Mihandoust, 2019). Approximately 40% of nurses experience burnout, and one out of five nurses leave their work every year (Aiken et al., 2001). Burnout has many negative impacts on nurses’ personal and professional lives; it can impede the nurses’ quality of care delivery, job performance, even patients’ health and lead to medical errors. Personally, burnout affects nurses’ emotions, behaviors, relationships, well-being, and quality of life.

Several studies in healthcare report a relationship between stress and nurse burnout. Many nurses are under increasing stress due to a range of work-related problems, prolonged workplace stress, workload and lower job satisfaction (Applebaum et al., 2010), environmental factors such as “noise, air quality, light, toxic exposures, temperature, humidity, and aesthetics (Applebaum et al., 2010), integration between environmental factors with the increasing demand for safety, security, and physical and psychological comfort (Applebaum et al., 2010), with personal factors such as age, marital status, level of education, and exercise (Mihandoust, 2019).

A significant number of nurses leave their work after only one year (Cho et al., 2006). Cho et al indicated that 66% of newly graduated nurses suffered from burnout because of a negative workplace. Laschinger et al., (2010) found the same results and indicated that the burnout has continued to be a problem among nurses. Laschinger and Fida (2014) suggested that hospitals need to take action to prevent future graduating nurses from burnout in order to protect not only their health but also the patients and the organization; they can take action by designing a work environment that benefits the future nursing workforce, allows nurses to optimize work performance, and improves their well-being (Laschinger & Fida, 2014).
Evidently, studies show the relationship between stress and nature. How exposure to nature may help reduce stress level, lower blood pressure, relieve pain, accelerate healing, and improve staff behavior and performance that leads to a better relationship between staff and patients (Coles & Calabrese, 2018). Exposed to nature through biophilic design and applying their principles and patterns will optimize the same benefit of exposure to nature in the built environment to benefit individual’s psychological and emotional health.

However, literature suggested strategies to reduce nurse burnout in healthcare through limited biophilic patterns such as visual connection to nature (direct access to nature, access to nature through windows, image) and daylight. Biophilic design has fourteen patterns that could better assist with reducing stress and nurse burnout. This study explored the connection between using 14 patterns of biophilia and their potential restorative effects on intensive care units (ICU), nurse burnout, and stress levels in their workplaces and break areas.

**Purpose of study**

This study will discuss the detrimental effect of burnout on nurses for ICU nurses. Through investigating the effects of ICU nurses’ work environments and break areas on their performance and quality of care, the study has two main goals:

1- To describe the relationship between nurse burnout and stress.

2- Explore the relationship between environmental approach (exposure to nature through biophilic design) and reducing stress levels in ICU nurses.

**Research Question**

Nature positively affects humans’ emotions, productivity, and well-being. Which elements relating to biophilic design can be used to benefit ICU nurses to reduce burnout?
This question is divided into three sub-questions to trace a connection between the relationship among burnout (emotional exhaustion), stress level, and biophilic design:

- What is the relationship between nurse burnout and stress?
- What is the relationship between stress and biophilic patterns?
- How can biophilic patterns help reduce nurse burnout to assure better nurses’ outcomes and well-being?

**Theoretical Framework**

Biophilic theory gives the overall conceptual framework for the study. In addition, attention restoration theory, stress recovery theory, and stimulation theory are needed. This paper analyzes biophilic patterns from restorative, simulative, and stress recovery assessments in demonstrating the benefits of biophilic design for intensive care unit (ICU) nurses’ well-being and reduces stress levels and burnout.

**Biophilic Theory**

The biophilic conceptualization encourages the use of features that were inspired by nature into the built environment when people cannot surround themselves with nature. Features from nature provide individuals with much needed exposure to nature and well-being with the aims of making the built environments feel alive. Biophilic theory proposes that individual reflections on nature explores human connection and other forms of life (Gillis & Gatersleben, 2015). Nevertheless, individuals’ interactions with nature are often lacking in the built environment. Using biophilia indoors could fill the gaps and increase the ability to use nature for better health.

**Attention Restoration Theory**
Attention restoration theory demonstrated that natural environments have rich physical characteristics which are necessary for human recovery and stress relief, with nature being the preferred destinations for breaks and vacations (Kaplan, 1995). The concept this theory would help nurses’ focus by using the benefits of nature to cope with stress. Kaplan (1995) claimed that “human needs an alternative mode of attending that would render the use of directed attention temporarily unnecessary” (p.172). Many natural spaces are idyllic places for 'getting away’ such as seashores, forests, mountains, lakes, streams, and meadows (Kaplan, 1995). However, the opportunity for nurses to get away and visit these places is not an option while working. The use of biophilic design will offer a resource for relaxing and helping nurses to gain the benefits of nature.

Restoration, as described by Staats and Hartig (2004), is ’a process of renewal that replenishes a depleted social, psychological or physical resource. Olmstead (1865) argued that the reason nature is restorative is because it holds our attention without any effort, looking at nature is enjoyable, and it blocks out daily demands and stress. He stated that when one is exposed to a view of nature that, the attention is aroused, and the mind occupied without purpose (as cited in Gillis & Gatersleben, 2015). Evidence on restorative environments focused on the visual sense where auditory sense and olfactory sense are needed.

Stress Recovery Theory (SRT)

The stress recovery theory indicated that nature does a significant job in reducing stress, due to its attention-holding properties. Different outdoor environments can have different impacts on individuals; nevertheless, each environment still helps in stress recovery. Different outdoor environments can consist forests in the wilderness or parks in urban areas (Ulrich et al., 1991).
Stress recovery theory explains the importance of nature of basic human functioning. It is indicated in the theory that when individuals are stressed, natural settings can immediately reduce stress while urban settings limit recovery (Ulrich et al., 1991). Ulrich et al. (1991) investigated the psychological benefits of nature which subsequently generated much more research activity.

This theory states how mental fatigue is not an isolated feeling; it is usually accompanied with negative feelings and declined cognitive performance (Ulrich et al., 1991). Recovery is needed from extended mental exertion and stress, which can occur quickly in settings with low stimulating properties, such as complexity, movement, and intensity. When individuals are stressed, it has been found that they prefer settings with low levels of complexity. Natural settings tend to have lower stimulating properties than urban environments which makes them the preferred setting for stress reduction (Wohlwill, 1976).

**Stimulation Theory**

Stimulation theory conceptualizes the environment as a resource for sensory information that results in affecting the experience. The theory interprets the environment as a source generated from vision, smell, touch, and sound (Wohlwill, 1966), where each sense can be under-stimulation. The threshold is defined as the point of significance when either too much or too little stimulation happens. In the current study, connecting to nature through the fourteen patterns of biophilic design, consider as positive-sensory information that may result in stimulation and emotional restoration.

**Assumption**

Current literature has explored the relationship between stress and burnout, and between biophilic design and stress. Additionally, biophilic design has psychological benefits and seeks to
increase performance, productivity, and natural system overtime (Coles & Calabrese, 2018). This study assumes that biophilic design may assist in reducing nurse burnout and stress levels. Therefore, the fourteen patterns of biophilic design help to reduce human stress; thus, biophilic design may have restorative effects on ICU nurse burnout (emotional exhaustion) and stress levels.

**Definition of Terms**

**Burnout and Nurse Work Environment**

The concept of ‘burning out’ is an extreme ‘strain’ reaction (Payne, 2001). It is the prolonged emotional response to too much stress within a job (Wang et al., 2015) and is defined by three scopes: emotional exhaustion, depersonalization, and decreased personal accomplishment. Emotional exhaustion is a central quality of burnout and is the first that refers to decreased emotional experience related to work (Poghosyan & Clarke, 2010), and feeling emotionally exhausted when they have contact with others. Depersonalization refers to when nurses separate themselves from patients and their families (Laschinger & Fida, 2014; Wang, et al., 2015). Decreased personal accomplishment refers to achievement associated when working with people.

The concept of burnout was defined in the 1970s by Freudenberg. He described burnout as occurring when young adults have increased workloads, and they have to sacrifice their health to receive recognition or rewards from their work (Wang et al., 2015). Exhaustion is defined as general fatigue related to excessive energy and time spent on a task, typically that is not perceived as beneficial. In the hospital setting, emotional exhaustion can be caused by continued involvement in emotionally challenging and stressful conditions (Wei et al., 2017).
Stress is the psychological and physiological response to a situation that challenges or threatens a person’s well-being (Ulrich et al., 1991). The psychological aspect is the way we cognitively assess the situation through emotions such as anger, fear, and coping techniques. The physiological aspect is the way the systems of the body respond to the situation, such as the cardiovascular, skeletomuscular and neuroendocrine systems, which affect how the individual will handle the situation (Ulrich et al., 1991).

Nurses are exposed to a diverse number of stressors due to the nature of their work. Stress is defined as a mental, physical, or emotional strain on the body, which only occurs in response to a stressor. Applebaum (2008) described stress as a reaction when an individual does not have steadiness between the demand of their work and their ability to fulfill these demands, this results in poor health over time. The physiological symptoms of stress may affect heart rate, pain, dizziness, low concentration and retention, fatigue, and confusion, where the behavior makes individuals experience sleeping problems, and take up smoking, drinking, or changing in eating habits (Applebaum, 2008). Thus, the more nurses experience stress, the lower their job contentment (Applebaum et al., 2010).

In 1988, the concept of a healing environment was introduced to improve the healing process in hospitals by identifying the factors that could improve resources, increase the comfort level among staff, and offer flexibility in care delivery. Evidence in the literature supported that the physical work environment affect physical and psychological stress, staff fatigue, job satisfaction, performance, and staff behavior and communication (Applebaum et al., 2010).

Moreover, different researchers support that nature indoors (biophilic design) help reduce occupants’ stress, though applying the benefits of biophilic theory to hospital designs. Biophilic design is a way to design the indoor environment to connect with nature for the benefit of the
occupants. It incorporates elements from nature to enhance the indoor quality and user well-being.

Exposed to nature indoors is known as biophilia. In 1980, Edward Wilson defined biophilia as “the inherent human inclination to affiliate with natural systems and processes, especially life and life-like features of the nonhuman environment” (as cited in Totaforti, 2018, p. 3). Biophilia can influence people’s emotional well-being. The concept of biophilia is a complex concept that describes the connection between humans and nature, through their response to stimuli (Totaforti, 2018).

**Limitation**

This research primarily focuses on emotional exhaustion factors and not on personal accomplishment factors. Emotional exhaustion is the first sign of burnout. Information is gathered from the literature review and suggested application; real applications and results using human subjects still needed.

**Significance of the Study**

In this study, connecting to nature through the fourteen patterns of biophilic design is considered as a positive sensory stimulation resulting in emotional restoration (Mihandoust, 2019). This study will examine how biophilic design may be applied, based on primary literature, to reduce nurse burnout. Using the patterns to reduce stress should have a wide variety of benefits on nurses’ physical, mental, and behavioral well-being [e.g., behavioral benefits including improved skills, attention, and awareness, and improved social interaction; improved fitness and health including lower blood pressure; mental benefits including increased motivation and lower stress and nervousness (Coles & Calabrese, 2018; Yin et al., 2018). Knowledge of the application of applying biophilic patterns in ICUs can benefit interior design educators and
practitioners to create a good environment for nurses to work. Most literature examining benefits of nature in hospital settings address patient stress and the relationship to biophilic aspects such as visual access to nature, non-visual connection with nature, dynamic and diffuse light, and natural materials. Fewer researchers have addressed nurse burnout.
CHAPTER II: LITERATURE REVIEW

Stress is a critical problem among intensive care unit (ICU) nurses who experience acute anxiety due to high patient illness and death (Moss et al., 2006). Stress has a negative impact on nurses’ well-being and performance and can result in burnout. Burnout is a psychological condition of “feeling hopelessness with difficulty coping with work and or performing one’s job effectively” (Jakel et al., 2016, p.613) and contains three symptoms: emotional exhaustion, depersonalization, and reduced personal accomplishment. Nurse burnout happens because of long-term stress. Among the top three factors of burnout, emotional exhaustion is the main reason and has a significant correlation with stress (Farquharson et al., 2013; Mihandoust, 2019).

Burnout impacts nurses’ performance, absenteeism, patients’ health, and can lead to medical error (Cesario, 2009). Literature indicates this problem is addressed through healthcare operative and management treatments (Pati et al., 2008), where the physical environment could help to modulate stress and play a significant positive effect on burnout, especially, emotional exhaustion (Berto, 2014; Cordoza et al., 2018). The physical environments of the ICU nurses’ workplaces and break areas may play an important role in enhancing healthcare delivery, patients’ health, nurses’ health, and the environmental features that may reduce stress levels of nurses and increase satisfaction.

Various studies in neuroscience, endocrinology, environmental psychology, and other related fields revealed how indoor spaces affect well-being. Especially when most of peoples’ time is spent indoors, this separates them from the benefits of nature for long periods of time (Yin et al., 2018). Evidence indicated that spending time in nature has affected human health positively. White et al. (2019) showed that individuals who spend two hours in nature per week reported better overall satisfaction and health than individuals who spent less time in nature. In
1979, Ulrich began exploring the relationship between psychological health and physiological responses when people are exposed directly to nature or even a view of nature (Soderlund & Newman, 2015).

Evidence shows when people experience biophilia indoors, it can potentially influence aspects related to emotional health (Totaforti, 2018), reduce stress levels (Gillis & Gatersleben, 2015; Yin et al., 2018; Gatersleben, 2015), lower blood pressure, reduce fatigue, and improves mood and performance (Coles & Calabrese, 2018) in addition to decrease negative emotions compared to those who experience non-biophilic contexts (Yin et al., 2018).

Some evidence indicates that designing an effective facility space can decrease the amount of stress among staff and promote productivity, and this will help them to improve the quality of care and job satisfaction (Ulrich et al., 2011). A 2001 Institute of Medicine reported the need for new facilities to be constructed in a way to enhance well-being and health of patients and staff (Cesario, 2009).

Thus, using biophilic design, integrating natural aspects and systems into indoor environments to provide human beings exposure to nature, can help to reconnect nurses with nature and receive its benefits. Using biophilia indoors simulates reality through its patterns to provide a variety of indoor settings that exposes natural aspects where access to nature may not possible (Cordoza et al., 2018). The positive benefits of nature exposure for nurses may give support to stress recovery theory (Berto, 2014; Gillis & Gatersleben, 2015; Yin et al., 2018) Restoration theory, and stimulation theory (Berto, 2014; Burnard & Kutnar, 2015; Gillis & Gatersleben, 2015).

In many healthcare settings, biophilic design is used to reduce patients’ stress and enhance patients’ health and well-being (Park & Mattson 2008; Totaforti, 2018). Ulrich et al.
(2011) suggested that evidence indicates the environmental features that impact patients’ health positively, such as natural views and daylight, can also affect nurse burnout. However, very little biophilic design patterns are used to reduce nurses’ stress. Studies have only focused on the importance of views to nature, daylight, and views through windows, while biophilic design is much more complicated than access to nature and outside views. In total, there are 14 elements of biophilic design that can potentially affect reducing human stress indoors (Browning et al. 2014).

The present literature review explores the three categories and 14 patterns of biophilic design that reflect being in nature indoors for the nature-health build environment. In a philosophical approach to the relationship between these patterns and reducing stress, and emotional exhaustion (subscale of burnout) in ICU nurses, the current study focuses on the biophilic patterns according to those which evidence has shown to reduce stress levels and increase health and well-being indoors (Totaforti, 2018).

1. Non-Environmental Approaches

1.1. Personal Interventions

Several varieties of stress management interventions have been recommended to manage nurses’ stress and reduce burnout. Most literature examined the impacts of mindfulness to control stress levels and reduce nurse burnout, while two of the readings examined yoga and meditation, and one reading addressed spirituality programs, and another addressed resilience programs.

**Mindfulness.** The Mindfulness Stress Reduction program (MBSR) was developed by John Kabat-Zin with the primary idea of “mindfulness,” that implies being completely present at the time with no resistance (Kabat-Zinn, 1990). Its training sessions include the practice of
mindful meditation, yoga, breathing exercises, the “body scan meditation,” and the use of music to center oneself (Cohen-Katz et al., 2004). Several studies examined the effectiveness of practicing mindfulness for reducing nurse burnout have yielded mixed results. The first research found that practicing mindfulness resulted in a decrease in emotional exhaustion (p< 0.05), depersonalization (p<0.05), and a decrease in personal accomplishment level (p=0.0004) as well as an increase in overall life satisfaction (Mackenzie et al., 2006). Another study shows significant results only on personal accomplishment (increase p=0.3) and achievement immediately following the study, but it decreased during a follow up study. There were no significant changes in emotional exhaustion nor depersonalization (Gauthier et al., 2015), while another study reported a significant reduction (p < 0.001) on burnout level (Slatyer et al., 2018).

Researchers examined the effect of using mindfulness meditation on nurse burnout. Research by Havezi (2016) asked nurses to practice ten minutes of meditation each day. The nurses received audio CDs to assist them in meditation for self-awareness, calmness, and relaxation for five days a week for a month. Paired t-test confirmed that nurses had decreased burnout rankings (p =0.003) after the intervention.

**Yoga.** Alexander et al. (2015) explored the influence of yoga practice on nurse burnout on 40 nurses for eight weeks. The yoga sessions consisted of yoga classes which included awareness exercises through breathing techniques, posture alignment, and mind monitoring. Participants received instructions for homework exercises including relaxation sessions. The study showed a significant improvement in emotional exhaustion (P = 0.008), and depersonalization scores (P = 0.007) for 20 participants (Alexander et al., 2015).

**Spirituality.** Yong et al. (2011) evaluated the effects of spirituality training programs on 51 mid-management nurses during a five-week program for 90-minute weekly sessions. The
spirituality program consisted of educational sessions addressing spiritual care, focusing, and repeating a holy word (“list of recommended words from several major religious traditions as well as nonreligious words that were deemed spiritually significant”) (p. 283), and integrating the practice in everyday life. The study showed significant results in 24 nurses: lower scores in burnout (P=.000) in comparison to the 27 nurses in the control group (Yong et al, 2019).

**Resilience.** Jakel et al. (2016) used Resilience Mobile Application (PRMA) to examine a sample of 25 oncology nurses for six weeks. PRMA monitored nurses and reminded nurses to practice mindfulness and self-care. The data were collected before the PRMA intervention and immediately after. The result of this indicated that there are no significant changes in nurse burnout in the treatment group after the intervention (Jakel et al., 2016).

Mindfulness is the most common intervention that has been examined to reduce nurse burnout, followed by meditation training, resilience, spirituality, and yoga, which are all subsection of mindfulness. Literature experimented with mindfulness of different departments of the hospital. Most of these showed significant results in emotional exhaustion level.

**1.2 Work Approach**

Two studies evaluated the impact of two long-term organizational interventions on nurse burnout for more than six months. The first study, by Rickard et al. (2012), examined the impact of decreasing workload, increasing employment opportunities and access to clinical supervision on nurse burnout. The intervention had a “pre-post design” and showed a significant decrease in emotional exhaustion level (P<0.01) (Rickard et al., 2012). Wei et al. (2017) investigated the effect of an active intervention termed “comprehensive management” on emergency department nurses for six months. Comprehensive management training sessions were implemented to develop communication skills, control conflict and emotions, and improve working skills. This
study reported a significant decrease in emotional exhaustion and depersonalization (p<0.05). The treatment group also had less significant decrease in personal accomplishment scores (Wei et al., 2017).

Perceived organizational support may reduce nurse burnout and stress levels. Evidence supports creating a positive feeling in nurses toward their work environment including supportive workplaces, educational programs, and coping techniques (Bobbio & Manganelli, 2015). Thus, supportive and healthy work environment are crucial factors for nurses’ well-being and satisfaction. Improved well-being in nurses’ workplaces and break areas can reduce nurse burnout (Wu et al., 2016), and other issues associated with nurse burnout. Literature mostly indicated organizational environment as a factor in the work environment that impacts nurse burnout, where the physical design features were only studied in the context to avoid medical error (Mahmood et al., 2011) and physical environmental hazards (Hu et al., 2015).

2. Environmental Approach

There are two studies on the effect of the environmental design on nurse burnout, and both show the significant impact of being exposed to nature on nurse burnout (Cordoza et al., 2018; Mihandoust, 2019). The first study, by Corodoza et al (2018), examined the effect of spending 15 minutes in the hospital garden during a break and compared it with spending break time indoors for 29 nurses. The results show that nurses who spend their break time in the garden had a significant decrease in both in emotional exhaustion (4.5 vs -0.2; P < .001) and depersonalization (1.8 vs 0.0; P = .02) scores, while there was no effectiveness for personal accomplishment (-0.6 vs -0.0; P = .55). The study suggested that taking a daily walk in the garden may positively modify nurse burnout.
The second study, by Mihandoust (2019), explored the relationship among nature views, nurse stress, and nurse burnout in 51 nurses in six intensive care units. The study indicated a minor negative correlation between the amount of being exposed to nature view and two categories of nurse burnout: emotional exhaustion and depersonalization. Nurses who experience natural view longer had lower levels of after shift stress as well as lower levels of emotional exhaustion and depersonalization (p<0.05) (Mihandoust, 2019). The study suggested making the ICU unit and breakroom access to exterior nature views easier to work as a consistent preventive intervention for nurse burnout.

Both studies demonstrated the positive effects of contact with nature for improving risk factors associated with nurse burnout. These results give support for using other aspects of connecting to nature indoors (biophilic patterns) to enhance ICU nurses’ performance and reduce burnout.

2.1 Biophilic Design

Biophilia was defined in 1980 by biologist Edward Wilson as, “the inherent human inclination to affiliate with natural systems and processes, especially life and life-like features of the nonhuman environment” (as cited in Totafori, 2018, p.g3). Biophilia encourages using natural elements and systems as design inspiration in the indoor environment (Gillis & Gatersleben, 2015). The idea behind this is to create a better indoor environment for people as living beings to improve people’s health and well-being (Coles & Calabrese, 2018). According to the evidence, connecting to nature positively affects individuals’ physiological and psychological health (Soderlund & Newman, 2015). In the biophilic hypothesis, individuals inherently respond positively when they connect with nature (Gillis & Gatersleben, 2015).
Evidence for biophilic design is mostly linked to one or more of the three overarching mind-body-systems: cognitive, psychological, and physiological. These three systems have been explored and tested to explain how humans’ health and well-being are affected by their environment and how the environment offers better emotional restoration (Browning et al., 2014) than non-biophilic aspects. Cognitive responses to nature include attention, concentration, emotion, and mood as well as overall physical comfort which includes influence to nature that affect restoration and stress management (Barton & Pretty, 2010; Hartig et al., 2003).

Biophilic design is needed to reconnect with nature after removing society from nature through buildings. Biophilic design developed into two theories in environmental psychology: Attention restoration theory (Kaplan, 1995) and stress recovery theory (Ulrich et al., 1991). Attention restoration theory states that individuals can concentrate better after spending time in, or even looking at nature (Kaplan & Kaplan, 1989), and stress recovery theory, looks at the psychological benefits of natural environments (Ulrich et al., 1991). Stress recovery theory is a part of the larger concept of restoration, which also includes recovery from under-stimulation and recovery from anxiety (Ulrich, 1993). Both theories, attention restoration theory and stress recovery theory, indicated that some indoor environments are stressful, and others enhance individuals’ recovery from stress and mental fatigue. Gillis and Gatersleben (2015) indicated environments that enhance a positive mood can also attract people’s attention without being stressful. Biophilic design indicates that the indoor environment could be made more restorative and stimuli by integrating natural elements into the design of the spaces.

Most literature that looked at the benefits of nature in hospital settings addressed patients’ stress and the relationship to some biophilic aspects such as visual access to nature, non-visual connection with nature, dynamic and diffuse light, and natural materials. Fewer researchers
addressed nurses’ stress. One research study, to the author’s knowledge, examined nurses’ direct access to a hospital’s garden to reduce their stress level (Corodoza et al., 2018). Two studies examined using window views (Pati et al., 2008; Mihandoust, 2019), and two studies considered both access to windows and daylight (Zadeh et al., 2014; Shamloo, 2019). One study used artwork and access to nature in their exploration and found that nature was more restorative than artwork (Nejati et al., 2016).

Numerous studies examined using biophilic patterns to reduce stress on other participants such as workers and students. Those studies explore biophilic aspects such as visual access to nature, non-visual connection with nature, non-rhythmic sensory stimuli, thermal and airflow variability, presence of water, dynamic and diffuse light, and natural materials and showed significant results on stress reduction. Fascinating research examined the influence of using auditory, haptic, olfactory, and visual stimuli from nature and found significant results on reducing individuals’ stress. One study examined the use of natural material (wood) indoors and its effect on workers’ stress positively. Research also examined natural stimulation to enhance health and well-being. Descriptions of these studies are categorized according to the aspects of biophilic design. The present research looked at psychological, physiological, as well as the physical environment to explore how biophilic design was used for better health and well-being.

**Nature in the Space**

Nature in the space explains the direct, physical and ephemeral (Browning et al., 2014) presence of natural elements in indoor places such as plant life, water, fresh air, and light, as well as breezes, sound, scents and natural elements from nature within the built environment. There are seven patterns from biophilic design related to this domain: (1) visual connection with nature, (2) non-visual connection with nature, (3) non-rhythmic sensory stimuli, (4) access to thermal
and airflow variability, (5) presence of water, (6) dynamic and diffuse light, (7) and connection with natural systems (Ryan et al., 2014).

**Pattern 1: Visual Connection with Nature.** Visual connection with nature can be directly achieved through outdoor gardens, views of nature, windows, artwork, and visual displays of nature scenes, and it has a strong effect more so than indirect exposure (Kahn et al., 2008). Nanda et al. (2017) indicated that natural scenes that have soothing aspects, such as trees and water, are more effective than other natural aspects. Visual connection with nature can improve individuals’ mood and self-esteem, and reduce stress (Ryan et al., 2014).

In the 19th century, Benjamin Rush introduced a new therapeutic implement in psychiatry, the concept of a garden, in the USA and the approach spread (Sahlin et al., 2014). A study by Biederman and Vessel (2006) indicated that exposure to nature, even scenes of nature, stimulates “a larger portion of visual cortex than non-nature scenes and triggers more pleasure receptors in the brain” (Ryan et al., 2014, p.65); and that repetitive viewing of real nature, contrasting with non-nature, does not reduce the participants’ stress levels over time.

Barton and Pretty (2010) claimed that people received a significant impact on mood and self-esteem in the first five minutes of experiencing a green spaces, while Brown, Barton, and Gladwell (2013) stated that exposure to nature for ten minutes will benefit people when the body is at rest (parasympathetic activity), reduce mental stress, and encourage heart rate variability (Ryan et al., 2014). Additionally, Tsunetsugu and Miyazaki (2005) revealed that exposure to natural forests for 20 minutes after a mental stressor, helped return rational blood flow, and helped the brain to relax. All three studies support that exposure to nature helps reduce individuals’ stress, however, the length of exposure to the green spaces differs.
Numerous studies investigate different effects of being exposed to nature on people who have stress-related mental disorders (Sahlin et al., 2014), and the benefit of interacting with nature in hospital settings. The result of using the visual connection with nature in these studies benefits the psychological well-being of users and improves their health (Totaforti, 2018). Research has demonstrated that 95% of patients and their families who were directly exposed to nature reported lower stress levels and increased coping ability (Biederman & Vessel, 2006). Ulrich (1980s) examined the ability of surgical patients to recover quickly when they were exposed to nature (Totaforti, 2018). Indoor plants or gardens in a hospital may positively affect patients’ psychological response to treatment as well as reduce levels of pain and fatigue (Biederman & Vessel, 2006). There is only one study, to the author’s knowledge, that examined the effect of daily walks for nurses in the hospital garden and found a significant result in the reduction of nurse burnout. This study will be discussed in the case study section.

*Connection to Nature via Windows.* Extensive studies have examined the positive impact of natural views through windows in patients’ rooms, residents’ rooms in rehabilitation facilities, employees in the work environments, and nurses’ workplaces. Previous studies have examined how nature views through windows affect people’s well-being and reduce stress.

The positive effect of natural views is also examined in work environments. Sop Shin (2007) indicated that employees who have windows with views of forests had lower stress and more satisfaction compared to those who did not. Another study by Aries et al. (2010) on Dutch Offices indicated that window views had increased workers’ physical and psychological comfort. Moreover, another study about work environments suggested that views of outdoor green spaces directly and positively impacted workers and increased their job satisfaction. The study claimed that natural views can influence intention leave; the study showed that workers who have more
access to nature had less desire to leave their job (Mihandoust, 2019). The third study by Kahn et al. (2008) tracked the heart rate recovery from lower stress levels of individuals working in office environments. The study used three conditions: a) window with natural views, b) video of the same natural view but through a plasma screen, and c) a blank wall. The study found that a window with natural views was on average 1.6 times more restorative than the other condition. Participants looked at the window and the plasma screen almost the same number of times duration of viewing periods was significantly better through the real window (median = 622.0 seconds) than the plasma screen (median = 491.5s) or even the blank wall (median = 55.5s) (Ryan et al., 2014).

Visual connection with nature through windows is an essential factor for indoor well-being, and since 1984, Ulrich has examined patients’ health care settings. Patients recovering from bladder surgery with window views of nature had shorter hospitalization time, and fewer complaints and stress compared to patients who saw a brick wall from their windows (Soderlund & Newman, 2015; Mihandoust, 2019). Three studies address the positive effect of connecting natural views to nurses. The first study by Pati et al. (2008) explored the relationship between exterior views and nurse stress. Mixed-methods research gathered from 32 nurses in 19 different units collected data on stress and alertness of nurses before and after their 12-hour shifts. The study also gathered information regarding the physical environment stressors (light, noise, and thermal), organizational stressors (workload), and personal characteristics. The result of this study indicated that being exposed to exterior views to nature had a positive effect on lowering nurses’ stress, suggesting that the physical design also, directly and indirectly, influenced patient health through nurse outcomes. It was reported that exposure to natural views and light could positively affect nurses by increasing their alertness during everyday work and job satisfaction.
Zadeh et al., (2014) explored the physiological and psychological influence of using windows and daylight on ICU nurses. The study examined two nurses’ stations that have similar environmental and organization situations, similar patient populations, but different availability of windows in the nursing stations. The findings of this study showed a positive influence on circadian rhythms (as suggested by body temperature), decreased blood pressure, improved oxygen saturation, and insignificantly decreased medication errors (p = 0.14). The study indicated using windows can increase nurses’ health and well-being.

Another study by Nejati et al. (2016) assessed restorative attributes of visual and physical access to the outdoors in hospital environments using visual stimulation with different design features: window views, daylight, artwork, and plants in nurses’ break areas. The design features were used in five nurse breakrooms, including: (a) window and balcony, (b) window, (c) artwork but no window, (d) plants but no windows, and (e) no windows, plants, or artwork. Findings suggested that nurses found direct access to nature and window views the most restorative. Nejati et al. (2016) suggested that improving restorative qualities through direct nature in nurse breakrooms significantly improved nurses’ satisfaction, reduced their stress, and led to better patient health.

Shamloo (2019) explored how nurses’ perceptions relating to the effect of natural views and daylight on their behavior including mood, stress, satisfaction, medical error, and efficiency. The results of the study demonstrated that outside views of nature and daylight enhance nurses' satisfaction, mood, and alertness while reducing medical error, fatigue, and stress. Lastly, a study by Mihandoust (2019) investigated the relationship between the visual access to nature through windows and nurse burnout in nurses’ work and break environments. The result of this study
suggested that access to nature views could be a consistent preventive intervention for nurse burnout.

*Images of Nature.* Providing images of nature allows an alternative way to be exposed to nature when actual exposure is not possible. Using an image of nature positively impacts indoor users and reduces their stress levels to both experiencing real nature and seeing images of nature (Grahn & Stigsdotter, 2010; Kahn et al., 2008; Hartig et al., 2003). Sahlin et al. (2014) indicated that the supportive value of the type of natural environments in the image is different. Using an image of nature was widely studied in environmental psychology, few studies found in patients’ health, and the researcher was unable to identify any studies that examined the effect of the nature imagery on nurses’ stress.

Gillis & Gatersleben (2015) claimed that, depending on the contact and the content of the image, it could be more restorative than real views of nature depending on the biophilic attributes; for instance, water will be perceived as high restorative in the built environment (direct and indirect experience from nature). If the content of the image includes presence of water and the direct nature without water, the image may consider more restorative than the real view of nature. Felsten (2009) asked students to imagine that they had mental fatigue and asked them to rate various images. Findings suggested that students perceived murals of nature and water the most restorative (Gillis & Gatersleben, 2015). Images that had natural views have more stress-reducing qualities than abstract paintings (Karnik et al., 2014).

In healthcare settings, a study by Ulrich et al. (1993) took heart surgery patients and randomly assigned them to rooms that either provided exposure to an image of nature, abstract images, or no image or nature. Results showed that images with a lake and tree caused less stress in patients, and consequently, required fewer doses of medication than the control group; patients
who were showed abstract artwork had more stress than the control group (Ulrich et al., 1993). Another study investigated the relationship between the effect of visual connection to real and artificial nature and stress reduction in a hospital waiting room. Findings showed that patients responded positively to both real and posters of plants compared to the control group. Thus, both real plants and posters of nature have the same stress decreasing effect (Beukeboom et al., 2012).

Artwork with natural views is considered a sensory information source that is stimulation and results in emotional restoration. A study by Karnik et al. (2014) in a hospital environment examined uses of contemporary artwork. 61% of the 826 participating patients reported that artwork (containing natural views) reduced their stress levels compared to no artwork, 73% reported that the artwork helped improved their mood, and 39% reported lower levels of pain. The study stated that the varieties of artwork in patient settings significantly resulted in increased comfort, better mood, stress reduction, and overall patient satisfaction (Karnik et al., 2014).

**Pattern 2: Non-visual Connection with Nature.** A non-visual connection with nature is an indirect experience with nature. Gillis and Gatersleben (2015) reported that this pattern is important, especially when a direct connection to nature may not be possible in some indoor environments such as in certain medical environments. Non-visual connections with nature create a positive link to nature, illustrated by auditory, haptic, olfactory, or visual stimuli that create a positive imitation of nature, living systems or processes of nature (Browning et al., 2014). Many researchers examined the non-visual pattern and reported the benefits from this pattern on reducing blood pressure and stress hormones (Hartig et al., 2003; Orsega-Smith et al., 2004; Ulrich et al., 1991). Hunter et al. (2010) claimed that when experiencing visual and non-visual connections with natural stimuli, non-visual senses are interpreted in the brain. When stimuli that are connected with nature are present, a large portion of the brain becomes more
excited and more effective (Ryan et al., 2014), and can have positive health effects (Alvarsson et al., 2010; Li et al., 2012).

Hunter et al. (2010) claimed that experiencing both visual and non-visual stimuli together changes where the brain interprets the non-visual senses. Whereas, if both stimuli are connected to nature, then even more of the brain shows an excited response than if the two stimuli were separate (Ryan et al., 2014). Alvarsson et al. (2010) stated that natural sounds enhance physiological and psychological restoration, which, in turn, enhance performance (Ryan et al., 2014).

The experiment by Alvarsson et al. (2010) looked at the effect of sound patterns on how individuals process the sounds. Each sound affects different portions of the brain depending on whether the individual is watching a video of waves or traffic. The research shows that natural sounds help with physiological and psychological restoration up to 37% faster after being exposed to a stressor rather than urban noise. In particular, sounds and views of water have proven to be restorative (Gillis & Gatersleben, 2015). Hunter et al. (2010) found that stimuli that related to nature made a large portion of the brain excited. The study participants exposed to the sound of ocean waves considered them pleasurable and enhanced the experience of the video, compared to watching a video of traffic. The study explained that participants processed different sounds, in different portions of the brain, depending on what they watched.

In a healthcare setting, a study by Kim et al. (2007) examined the effect of using aromatherapy after surgery. The study reported that patients who experienced aromatherapy used 45% less morphine and 56% fewer painkillers. In 2012, another study, by Li et al., found that smelling essential oils from trees has a positive effect on people as well.
**Pattern 3: Non-Rhythmic Sensory Stimuli.** Non-rhythmic sensory stimuli pattern is stochastic and have an ephemeral correlation along with nature which may not be precisely predicted but can be statistically analyzed. Meaning that using momentary exposure to the stochastic or unpredictable movement to natural sensory stimuli, such as periphery vision or the experience of scents or sounds that attract an individual’s attention, can help focus an individual from mental fatigue and stress.

Non-rhythmic sensory stimuli pattern is inclusive of all sensory systems that are commonly experienced at a subconscious level through unanticipated and brief exposure (Browning et al., 2014). The pattern can be naturally occurring, such as cloud movement, breezes, plants rustling, water babbling, birds chirping, fragrant flowers, trees, and herbs. The pattern could be simulated such as screen materials that can move or glisten with light or breezes, water reflection on a surface, shadow or spotted light that changes with the time or movement, and natural sounds spread at unpredictable intervals. Non-rhythmic sensory stimuli gives a sense of wonder, with fresh and interesting stimulation. Natural movement is typically seen as positive. If individuals are continuously exposed to a certain scent or a rhythmic motion is consistent, then they often lose interest with it in the long-term, unlike a stochastic movement, which draws one’s attention every time. This pattern aims to encourage the use of natural sensory stimuli to rejuvenate an individual’s focus from mental fatigue and stress. This is achieved through a design that has brief exposure to unpredictable movement, or periodic experience to sounds and scents (Browning et al., 2014).

Research indicates that using non-rhythmic sensory stimuli has a positive effect on stress reduction, such as heart rate, systolic blood pressure, and sympathetic nervous system activity (Li, 2009; Park et al., 2008; Ulrich et al., 1991). In 1982, Japan introduced the concept of forest
bathing trips for stress management and relaxation (Li, 2010). A study by Li (2010) examined using forest bathing trips on human function. The participants experienced smelling (wood essential oils). The study found that a forest bathing trip significantly decreased negative feelings, such as anxiety and anger, and provided a rejuvenated attitude. In addition, habitual forest bathing could help to decrease the risk of stress-related diseases. When individuals are in natural spaces, they frequently experience hearing birds chirping, leaves rustling, the faint scent of eucalyptus in the air (an instance of non-rhythmic stimuli). In this experiment, when participants were immersed in nature, they frequently experienced instances of non-rhythmic sensory stimuli including sight, sound, and smell. Browning et al. (2014) emphasized that many “gardens and certainly interior vegetation lack the qualities needed to support non-rhythmic sensory stimuli,” which should occur about every 20 minutes for about 20 seconds (p. 28); the most important factor is being the ephemeral and stochastic quality of these moments.

Ulrich et al. (1991) investigated the effect that views and sounds of nature through video had on stress recovery on 120 individuals. First, participants viewed a stressful movie and then were exposed to another video that showed views and sounds from one of six different outdoor settings (two natural and four urban). The first natural movie included vegetation, such as trees and plants, occasionally showing glimpses through the canopies, or breezes and bird sounds; while the second video included water with trees, and a fast-moving stream, with waves and ripples on the surface. The result indicates that individuals recover faster when exposed to either nature video rather than urban environment videos (Ulrich et al., 1991).

A researcher studied non-rhythmic sensory stimuli pattern on looking behavior, especially vision movement reflexes. Studies of the response to stochastic movements in nature through sounds and scents have been proven to help physiological restoration. When individuals
start to focus on a task, the lens of the eye becomes rounded with the contracting of the eye muscles. When these muscles stay contracted for more than 20 minutes, fatigue can occur, which results in eye strain, headaches, and physical discomfort. Lewis (2012) and Vessel (2012) stated that the muscles in the eye will relax, and the lenses flatten if there are brief visual or auditory breaks, non-rhythmic sensory stimuli, for greater than 20 seconds and at a distance of greater than 20 feet. This shows how connecting with the non-rhythmic stimuli may help individuals’ physiological restoration.

Non-rhythmic sensory stimuli have not been examined as much as direct visual connections to nature. No study, to the author’s knowledge, has been conducted in the hospital setting. Nurses may need to experience natural stimuli such as smelling essential oils and hearing natural sounds such as a bird or water movement during a work time to attract their attention from focusing on their work for seconds to reduced fatigue, eye strain, headaches, and physical discomfort, even in the break area to maximize benefits to help reduce their stress level and burnout.

**Pattern 4: Access to Thermal and Airflow Variability.** Access to thermal and airflow variability can be considered as ambient attributes such as air temperature, and relative humidity (Ryan et al., 2014). Researchers measured the effects of natural ventilation on workers and found that thermal variability positively influences workers’ thermal comfort, stress reduction, well-being, productivity (Heerwagen, 2006; Tham & Willem, 2005; Wigö, 2005), and satisfaction (Ryan et al., 2014). A study by Wigö (2005) indicated that a change in ventilation velocity could have a positive effect on occupants’ comfort and alertness. A study examined the effect of the gradient of the thermal condition in classrooms and showed that it can lead to better performances in students.
There is no study, to the author’s knowledge, in healthcare settings about how access to thermal and airflow variability can reduce stress. However, fresh air benefits could be applied to the study that examined nurses who take daily work breaks in a hospital garden; numerous nurses mentioned that they felt “less stressed after getting some fresh air” in the garden (Cordoza et al., 2018, p. 511). According to the previous studies on the work environment, access to natural ventilation assists nurses’ thermal comfort and stress reduction for well-being.

**Pattern 5: Access to Presence of Water.** The presence of water enhances users’ experience of spaces through seeing, hearing, or touching the water. Volker and Kistemann (2011) indicated that water was observed to be restorative (as cited in Gillis & Gatersleben, 2015), green landscape with water elements generated better improvement in self-esteem and mood than only green spaces without the presence of water (Pheasant et al., 2010).

Studies show how water can have a potential benefit on people’s health, comfort, stress level reduction, positive emotional responses and blood pressure (Gillis & Gatersleben, 2015). Karmanov and Hamel (2008) and White et al. (2010) reported that natural scenes without water have the same effect as urban scenes with water elements, where, usually, urban scenes have provoked less pleasurable or restorative effects. Additional support by Alvarsson et al. (2010) showed participants with perceived or potential tactile access to water reported reduced stress levels.

In healthcare settings, the presence of real water element will be impossible due to infection control (Clayton, 2012). Using a picture of water or sound could be an effective substitute and may have a similar impact as real water elements to influence people’s health as described previously in patterns two and three. In 2010, one Wisconsin hospital reported a problem with infection control in the hospital lobby. The health officials investigated to
determine the reasons and found the water-wall fountain in the hospital lobby caused 'Legionnaires' disease. The legionella bacteria can be contracted by breathing in mist or vapor from contaminated water; older and people who have weakened immune systems may more susceptible.

As a result, the presence of a water feature in ICU units might be dangerous. Thus, the space could include stimuli from the water such as picture view, the sound of water, colors, shapes or some ways to make the built environment be highly restorative as if it has the presence of water.

**Pattern 6: Dynamic and Diffuse Light.** Lighting is one of the core environmental stimuli that can affect human experience and mood (Abboushi et al., 2019). Researchers Beute and Kort (2013) and Zadeh et al. (2014) indicated that the restorative environment along with natural light have positively reduced stress and influenced daily work (Beckett & Roden, 2009; Gillis & Gatersleben, 2015), decreased blood pressure (Myers & Badia, 1993; Boyce, 1997), decreased heart rate (Smolders, de Kort, & Cluitmans, 2012), improved mood (Zadeh et al., 2014), enhanced alertness (Zadeh et al., 2014), and increased visual comfort (Elyezadi, 2012; Kim & Kim, 2007; Browning et al., 2014).

Natural light has been lauded by many different disciplines as it benefits both psychological and emotional well-being (Ulrich, 1991; Totaorti, 2018). In a study by Ulrich (1984), the effect of daylight on patient recovery was examined. The researcher found there was an increase in serotonin levels causing decreased feelings of pain, less use of pain treatment, and reduced time of hospitalization, as well as increased patient satisfaction, improved mood, and reduced stress (Gharaveis et al., 2019). In work environments, daylight and the effect of sunlight on workers were examined. A study by Beale et al. (1998) showed that sunlight had a significant
effect on workers’ job satisfaction and concluded either the view, or daylight, or both lower workers’ stress.

Artificial light could also be restorative similar to daylight; the variability of the level of the light, the natural color temperature, different size and shape of the artificial light in spaces could remind nurses of nature (Burnard & Kutnar, 2015). A study in a work environment showed that the color temperature of the light (Zadeh et al., 2014) can significantly create a visual comfort atmosphere that stimulates and influences workers’ mood, which leads to increased satisfaction and productivity (Abboushi et al., 2019). Research in laboratory environments confirmed that the artificial lights with characteristics similar to natural light improve workers’ mood, alertness, vigilance, and cognitive function (Postolache & Oren, 2005; Kent et al., 2010 as cited in Zadeh et al., 2014).

In healthcare settings, several studies have shown the positive benefits of using windows and daylight, mostly on patients’ health and well-being. However, only a few researchers examined the use of daylight for nurses. Studies reported that patients who experience access to nature, windows, and daylight had reduced pain, less pain medication consumption (Walch et al., 2005), and expedited recovery (Benedetti et al., 2001).

From research on restorative environments, Zadeh et al. (2014) and Gharaveis et al. (2019) examined the use of natural light and windows on nurses. The study showed a significant improvement in mood, sleep quality, stress, and communication among nurses. The result of this study indicated that access to daylight and windows may result in reduced blood pressure, increased oxygen saturation, reduced medical errors, and a more positive effect on daily work. Zadeh et al. (2014) concluded that a window with a view of nature and daylight is a way to
increase the health and performance of nurses. The study by Pati et al. (2008) claimed that both nurses that were exposed to natural view and nurses who were exposed to urban view reported improvement in their alertness and reduced stress; the study suggests that the natural light may help nurses’ health as well as the views.

**Pattern 7: Connection with Natural Systems.** Connection with natural systems is characterized as a seasonal pattern, wildlife habitats, and diurnal patterns. Biomimicry may also go under this pattern; it is an imitation of natural models, systems, processes, elements of nature for determination of solving a complex human problem in the built environments such as health, function, and energy (Aziz & El Sherif, 2016). Biomimicry used mostly in products and technology.

Browning et al. (2014) indicated that connection with natural systems pattern is very similar to pattern five (presence of water) which is presumed to enhance positive health with limited scientific documentation related to access to natural systems (Kellert et al., 2008). There is no research, to the author’s knowledge, on how connecting to natural systems can reduce stress in healthcare settings nor other disciplines. However, connection to natural systems could be beneficial to indoor environments to process fresh air and daylight. It could enhance changing indoor spaces to stimuli from outside environments, or pattern/color changes to create high stimuli indoor environments. Connection with natural systems pattern has potential applications that could be used and examined for nurses to reduce their stress levels and burnout and create better indoor spaces.

**Natural Analogues**
Natural analogues pattern is known as ornamentation, symbols, natural materials, biomorphic forms, (Ryan et al., 2014) that represent nature, remind individuals of it, and cause similar responses to real outdoor environments (Soderlund & Newman, 2015). Natural analogues pattern is divided into three patterns: (8) Biomorphic forms and patterns, (9) Material connection with nature, and (10) Complexity and order. Friedman et al., (2004) conjectured simulated nature could also have the same physiological effect as real exposure to natural elements or environments (Ryan et al., 2014). Natural analogs pattern is indirect experience of natural materials, patterns, and colors that are typical to the natural world (Totaforti, 2018).

**Pattern 8: Biomorphic Forms and Patterns.** Biomorphic forms and patterns is a pattern that occurs in nature and includes curved and angles of geometric shapes. The purpose of biomorphic forms and patterns is to allow individuals to create a more visual environment that connects to nature and enhances mental performance while assisting with stress reduction (Browning et al., 2014). The concept of biomorphic forms and patterns has been tested on how it can impact peoples’ stress or even well-being; it is only examined from view preference (Joye, 2007; Vessel, 2012).

**Pattern 9: Material Connection with Nature.** The material connection with nature pattern is another pattern that could benefit people in connecting to nature. Limited research within psychology explained the quantity and type of materials for perceived restorative value (Gillis & Gatersleben, 2015), and improved comfort (Tsunetsugu et al., 2007). Natural materials boost visual comfort and improve the immune system (Li 2010; Totaforti, 2018).

A researcher from physiology indicated that variation in the wood ratio on indoor walls proceeds to different physiological responses (Tsunetsugu et al., 2007). A study by Sakuragawa et al. (2005) measured how material preference affects human blood pressure when individuals
The study asked participants about their feelings when they see steel and wood walls. For participants who prefer steel walls, their blood pressure remained unchanged when exposed to a steel wall, whereas participants who prefer the wood wall had increased blood pressure when exposed to the steel wall. While the research reported decreases in blood pressure for participants who like the wood wall during their exposure to it, whereas participants who dislike the wood wall, blood pressure neither increased nor decreased during the exposure to the wood wall. The study stated increasing the use of wood seeks to bring a positive effect on nature on health (as cited in Burnard & Kutnar, 2015). Another study, in psychophysiology, conducted on the effect of using wood material indoors has shown reduced stress responses comparing rooms with moderate or fewer wood finishes (Burnard & Kutnar, 2015). The study suggested that increasing wood use indoors would bring a positive effect of nature indoors.

In healthcare settings, limited studies have examined the use of wood material in patients’ rooms but have demonstrated that using natural materials helps patients’ health and foster quick healing (Totaforti, 2018). A study by Nyrud el al. (2014) examined the use of different quantities and layouts of wood in patients’ rooms. The most preferred was an intermediate amount of wood in the space including floor, one wall, and furniture made of wood.

In these studies, wood is the only material found in nature to be examined. There are more natural materials such as stone and leather that need to be explored as well as wood to address how these materials impact nurses’ stress and burnout.

**Natural Colors.** Color is an important aspect of psychological and physiological effects on visual stimulation. Colors can be divided into warm (reds, yellows, and oranges, which have longer wavelengths) and cool (blues, greens, and purples, which have shorter wavelengths).
Warmer colors are used to encourage activity or movement, while cool colors are used to stimulate growth and balance emotions.

How individuals perceive color is defined by previous events and connections they have made either through culture or subjective experiences. Research suggests that there is not a universal psychological response to color, which makes it difficult to choose a single color that will reduce stress for everyone (Applebaum, 2008; Clayton, 2012).

However, colors have always been related to human emotion in spaces. Research in the work environment has found that some workers react positively to their work environment, whereas others feel anxiety from visual stimuli at work. Color therapists have tried to determine what colors are perceived positively by the majority of people. A researcher found that green and blue are the most appropriate in the workplace (Applebaum et al., 2010). Green and blue are seen as calming and can balance emotions. Green may remind nurses of outside landscapes and green areas, while blue is the color of the sky and water. Both colors can remind nurses of outside nature, may enhance stimulation indoors, and benefit nurses through exposure to those elements. Both colors are seen as easy on the eyes and associated with growth (Applebaum, 2008).

**Pattern 10: Complexity and Order.** Complexity and order pattern is described by the apparition of rich sensory information that is shaped with congruent fractals and natural geometries as found within nature. Studies suggest that fractal patterns can have relaxing and restorative effects (Abboushi et al., 2019), increased navigation skills, and reduced stress (Abboushi et al., 2019; Taylor, 2006). A fractal is a complex, never-ending pattern (fractalfoundation.org) found in many natural aspects such as mountains, clouds, rivers, and trees (Vessel, 2012; Joye, 2007). Fractals happen when a “self-similar” pattern repeats as it gets smaller or larger across different scales (Gillis & Gatersleben, 2015, p.955). Fractals have been
examined in physiology, and research has found that fractals have a positive influence on both perception and physiology (Joye, 2007; Ryan et al., 2014; Taylor, 2006). In 1994, Taylor used a chaotic pendulum to create fractal and non-fractal patterns. Ninety-five percent of the participants preferred the fractal pattern. This highlights the potential of using fractals in art and architecture to reduce stress levels. Another study by Taylor (2006) explained the relationship between humans and fractals and why people are restored by nature. Accordingly, the analysis of certain images that have particular forms of fractal patterns might be used to reduce stress. In the study, the researcher mounted the pattern on a wall in front of the participants and found it significantly reduced stress “levels by 60%.

Using fractals could be useful for healing environments such as hospitals (Joye, 2007). Fractals could be used in many different applications in both ICU nurse work environments and break areas. Fractals can be applied on a wall, like an image or panel, or even on the surface of materials as patterns. Fractal patterns could be used in artwork, or in lighting, displayed in a way that shows movement and creates a feeling of nature in space.

Conversely, over-used complex design exposure to complicated fractals may result in discomfort (Browning et al., 2014), psychological stress, and even nausea (Heerwagen, 2014 as cited in Browning et al., 2014). The complexity and orders pattern needs additional considerations and balance when it is used indoors, especially with ICU nurses; the design of the space may need to be simple enough so they can focus on their tasks rather than the design.

**Nature of the Space Patterns**

Nature of the space is knowing how to affect human experience indoors through spaces and places (Totaforti, 2018), and how people responded psychologically and physiologically to different layouts in a space. Four patterns have been categorized: (11) prospect, (12) refuge, (13)
mystery and (14) risk/peril. These patterns are used in biophilic design as a guideline that assists in the design process (Burnard & Kutnar, 2015). The objective of specifying these patterns is to create clear connections among environmental factors, natural environments, and how individuals respond and benefit from these four patterns (Ryan et al., 2014).

**Patterns 11 and 12: Prospect and Refuge.** Research usually connects these two patterns. The objective of the prospect pattern is to offer individuals a situation suitable for considering the surrounding environment in a way that space feels open and free. Refuge pattern is important for supporting restoration; refuge provides individuals easy access, and a protective environment with aims to limit visual access into the refuge spaces such as nurses’ break areas. The ideal environment allows looking out and observing while being able to conceal oneself.

Prospect pattern helps space layout and orienting in corridors, break areas, and workstations with optimizing visual access to indoor or outdoor views, activity hubs, or destinations. Herzog and Bryce (2007) indicated that prospect pattern provides users a better sense of awareness, comfort, safety, and reduces stress (Grahn & Stigsdotter, 2010; Herzog & Bryce, 2007).

The function that is associated with refuge pattern is rest, relaxation, and privacy. Studies found that refuge provides a sense of protection, and improves awareness and attention (Browning et al., 2014; Grahn & Stigsdotter, 2010; Ulrich et al., 1993). Refuge pattern has not examined, to the author’s knowledge, in either psychology, physiology, or physical environments about how it can help reducing stress among indoor users. However, the refuge pattern may help ICU nurses in the design of the break area to provide privacy, relaxation, and comfort during the break. This may enhance nurses’ mood and comfort. Combining refuge
pattern with other biophilic patterns may help assist nurses with daily work and improve comfort and satisfaction.

The layout of the ICU units could use prospect and refuge patterns to help reduce nurses’ stress. An efficient nurse station layout along with patients’ rooms layout helps nurses’ visibility to patients, reduces the distance in decentralized medication rooms, and helps with noise reduction, which is a critical component in minimizing fatigue and stress among nurses (Chaudhury et al., 2009). Another goal in the ICU layout is to reduce nurses’ walking length. According to Chaudhury at al. (2009), walking between patients’ rooms, medical rooms and nurses’ stations is an important factor contributing to staff fatigue as well as medical errors. For nurses’ breakroom, the location of the room needs to be close to their work units.

**Pattern 13: Mystery.** Mystery is characterized by the potential of more information show by the presence of partially “obscured views or other sensory stimuli that fascinate and entice the individual to travel deeper into the environment” (Ryan et al., 2014, p.69). Kaplan and Kaplan (1989) stated that environment provides people with two needs to understand and explore the spaces, and this will achieve great pleasure response (Biederman, 2011; Ikemi, 2005). A study by Ikemi (2005) demonstrated that a good mystery situation persuading individuals to explore the spaces (see more of the incompletely hidden subject).

Mystery is essential to environmental preference. It may help assist nurses to overcomes their health problems if nurses use Virtual Reality Technology (VR) in breakrooms. VR technology is successfully used to boost relaxation and reduce stress which shows potential in enhancing and regulating emotional well-being (Pizzoli et al., 2019). It could be integrated into gardens outside the hospital, indoor gardens, or may possibly in nurses’ breakrooms.
**Pattern 14: Risk/Peril.** The risk/peril pattern is characterized to generate memorable experiences and should be used carefully. The concept come from when we experience nature the brain shifts to the different mood of processing where some of the higher cortical functions take a break and the person can experience through a state of “soft fascination”; when the individuals return to the work, they feel refreshed and focused (Browning, 2014, p. 30). Researchers claim that the risk/peril pattern assists people’s enjoyment responses (Browning et al., 2014).
## Table 1:

**Evidence of 14 patterns of biophilic design in the literature.**

<table>
<thead>
<tr>
<th>Biophilic Elements</th>
<th>Healthcare Setting</th>
<th>Decrease stress</th>
<th>Emotion, Mood &amp; Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Visual Connection with Nature</strong></td>
<td>Nurse</td>
<td>Lowered blood pressure and heart rate (Brown, Barton &amp; Gladwell, 2013; van den Berg, Hartig, &amp; Staats, 2007; Tsunetsugu &amp; Miyazaki, 2005) reduced stress (Ryan et al., 2014; Felsten, 2009; Kahn et al., 2008; Sop Shin, 2007), increased comfort (Veitch &amp; Newsham, 2010)</td>
<td>Positively impacted attitude and overall happiness (Barton &amp; Pretty, 2010)</td>
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<td></td>
<td>Patient</td>
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<tr>
<td></td>
<td></td>
<td>(Karnik et al., 2014; Sahlin et al., 2014; Biederman &amp; Vessel, 2006; Ulrich et al., 1993; Ulrich, 1991; Ulrich, 1984)</td>
<td></td>
</tr>
<tr>
<td><strong>Non-Visual Connection with Nature</strong></td>
<td>Nurse</td>
<td>Reduced systolic blood pressure and stress hormones (Park, Tsunetsugu, Kasetani et al., 2009; Hartig, Evans, Janner et al., 2003; Orsega-Smith, Mowen, Payne et al., 2004; Ulrich, Simons, Losito et al., 1991), enhance performance (Alvarsson et al., 2010; Hunter et al., 2010)</td>
<td>Perceived improvements in mental health and tranquility (Li, Kobayashi, Inagaki et al., 2012; Jahncke, et al., 2011; Tsunetsugu, Park, &amp; Miyazaki, 2010; Kim, Ren, &amp; Fielding, 2007; Stigsdotter &amp; Grahn, 2003)</td>
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<td></td>
<td>Patient</td>
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<tr>
<td><strong>Non-Rhythmic Sensory Stimuli</strong></td>
<td>Nurse</td>
<td>Positively impacted on heart rate, systolic blood pressure and sympathetic nervous system activity (Li, 2009; Park et al., 2008; Kahn et al., 2008; Ulrich et al., 1991), decreased psychosocial stress (Li, 2010)</td>
<td>Improved perception of temporal and spatial pleasure (allesthesia) (Parkinson, de Dear &amp; Candido, 2012; Zhang, Arens, Huizenga &amp; Han, 2010; Arens, Zhang &amp; Huizenga, 2006; Zhang, 2003; de Dear &amp; Brager, 2002; Heschong, 1979)</td>
</tr>
<tr>
<td></td>
<td>Patient</td>
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<td></td>
</tr>
<tr>
<td><strong>Thermal &amp; Airflow Variability</strong></td>
<td>Nurse</td>
<td>Positively impacted comfort, well-being and productivity (Heerwagen, 2006; Tham &amp; Willems, 2005; Wigó, 2005)</td>
<td>Observed preferences and positive emotional responses (Windhager, 2011; Barton &amp; Pretty, 2010; White, Smith, Humphries et al., 2010; Karmanov &amp; Hamel, 2008; Biederman &amp; Vessel, 2006; Heerwagen &amp; Orians, 1993; Ruso &amp; Atzwanger, 2003; Ulrich, 1983)</td>
</tr>
<tr>
<td></td>
<td>Patient</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Presence of Water</strong></td>
<td>Nurse</td>
<td>Reduced stress, increased feelings of tranquility, lower heart rate and blood pressure (Alvarsson, Wiens, &amp; Nilsson, 2010; Pheasant, Fisher, Watts et al., 2010; Biederman &amp; Vessel, 2006)</td>
<td>Effect human experience and mood (Abboushi, Elzeyadi, Taylor, &amp; Sereno, 2019; Zadeh, Shepley, Williams, &amp; Chung, 2014; Scott, 2000), increased visual comfort (Elzeyadi, 2012; Kim &amp; Kim, 2007 as cited on Browning et al., 2014).</td>
</tr>
<tr>
<td></td>
<td>Patient</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dynamic &amp; Diffuse Light</strong></td>
<td>Nurse</td>
<td>Positively impacted circadian system functioning (Abboushi et al., 2019; Figueiro, Brons, Plitnick et al., 2011; Beckett &amp; Roden, 2009) Increased visual comfort (Elzeyadi, 2012; Kim &amp; Kim, 2007), decreased blood pressure (Myers &amp; Badia, 1993; Boyce, 1997), decreased heart rate (Smolders, de Kort, &amp; Cluitmans, 2012), decreased stress (Beale et al., 1998)</td>
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<td></td>
<td>Patient</td>
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</tbody>
</table>

Note: Sources include multiple studies cited in the table.
<table>
<thead>
<tr>
<th>Connection with Natural Systems</th>
<th>Enhanced positive health responses; Shifted perception of environment (Kellert et al., 2008)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomorphic Forms &amp; Patterns</td>
<td>Observed view preference (Vessel, 2012; Joye, 2007)</td>
</tr>
<tr>
<td>Material Connection with Nature</td>
<td>Improved comfort (Tsunetsugu, Miyazaki &amp; Sato 2007)</td>
</tr>
<tr>
<td>Material</td>
<td>Decreased blood pressure (Sakuragawa et al., 2005), reduced stress (Burnard &amp; Kutnar, 2015)</td>
</tr>
<tr>
<td>Awareness &amp; Help</td>
<td>Positively impacted perceptual and physiological stress responses (Salingaros, 2012; Joye, 2007; Taylor, 2006; S. Kaplan, 1988)</td>
</tr>
<tr>
<td>with Nature</td>
<td>Improved comfort and perceived safety (Herzog &amp; Bryce, 2007; Wang &amp; Taylor, 2006; Petherick, 2000) improves concentration and attention (Grahn &amp; Stigsdotter, 2010; Wang &amp; Taylor, 2006; Wang &amp; Taylor, 2006; Petherick, 2000; Ulrich et al., 1993 as cited on Browning et al., 2014)</td>
</tr>
<tr>
<td>Complexity &amp; Order</td>
<td>Reduced stress (Grahn &amp; Stigsdotter, 2010)</td>
</tr>
<tr>
<td>Prospect</td>
<td>Induced strong pleasure response (Biederman, 2011; Salimpoor, Benovoy, Larcher et al., 2011; Ikemi, 2005; Blood &amp; Zatorre, 2001)</td>
</tr>
<tr>
<td>Refuge</td>
<td>Resulted in strong dopamine or pleasure responses (Kohno et al., 2013; Wang &amp; Tsien, 2011; Zald et al., 2008)</td>
</tr>
<tr>
<td>Mystery</td>
<td></td>
</tr>
<tr>
<td>Risk/Peril</td>
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</tbody>
</table>
Case Studies


   The experimental study by Corodoza et al. (2018) examined the relationship between taking a daily work break in the outdoor garden and nurse burnout. The chosen hospital in this study has an attached small garden. The study compared nurses spending 15 minutes of break time in the hospital garden for six weeks. The research found that nurses who spent their break in garden had a significant decrease in emotional exhaustion (4.5 vs -0.2; P < .001) and depersonalization (1.8 vs 0.0; P = .02) scores. The research suggested that exposure to nature helps reduce nurse burnout.

   Nurses in this experiment exposed to three patterns of biophilia: (1) visual connection with nature, (4) thermal and airflow variability, and (6) dynamic and diffuser.

2. Case study: Effect of Using Forest Bathing Trip on Human Function

   A study by Li (2010) examined focus on the effect of using a forest bathing trip on human function. Forest bathing trips is a short relaxing visit to forest similar to “natural aromatherapy” (p.9). The trip involves visiting the forest to relax and breath smell (wood essential oils). The study found that a forest bathing trip significantly decreased anxiety, depression, and anger, and increased activity. Participants in this experiment exposed to six patterns of biophilia: (1) visual connection with nature, (3) non-rhythmic sensory stimuli, (4) thermal and airflow variability, (6) dynamic and diffuser, (7) Connection with natural systems, and (13) mystery. The result finds reduced anxiety, depression, and anger, and increased vigor.

Summary

This review of the literature showed that nine patterns of the 14 patterns in biophilic design have been demonstrated to reduce individuals’ stress levels indoors: visual connection to
nature, non-visual connections to nature, non-rhythmic sensory stimuli, thermal and airflow variability, the presence of water, dynamic and diffuse light, a material connection with nature, complexity and order, and prospect.

The other five patterns, connection with natural systems, biomorphic forms and patterns, refuge, mystery, and risk/peril, were found in literature to improve individuals’ emotions, moods, and preferences. This could imply that the five patterns may enhance restoration and stimulate indoor environments which is beneficial for nurses’ stress reduction and burnout, as found in the other nine biophilic patterns.

The various patterns offer a flexible approach to enhancing nurses’ experiences (Browning et al., 2014). These patterns give us opportunities to incorporate natural aspects to indoor spaces for health and stress benefits. Practicing biophilic design demands five principles:

1. Biophilic design requires a continuous engagement with nature.
2. Biophilic design works with the ways that humans have evolved in the natural world, by incorporating the advances that humans have made for people’s health, fitness, and well-being.
3. Biophilic design is meant to forge an emotional connection to certain settings and places.
4. Biophilic design forms a relationship between human and natural communities which encourages a sense of responsibility and respect.
5. Biophilic design encourages a mutual understanding, connection, and integrative architectural solutions (Coles & Calabrese, 2018).

Biophilic design can impact the connection between the hospital environment and nurses which creates positive effects on nurses’ health and the feeling of well-being. This evidence
directs us to conclude that connections to nature help increase positive emotions and reduce stress. They even lower diastolic blood pressure and stress hormones (Ryan et al., 2014).

The outcome of using biophilic design can be explained by stress recovery (Ulrich et al., 1991), Restoration theory (Kaplan & Kaplan, 1989), and simulation theory (Wohlwill, 1966).

The indoor environment impacts the populations’ health and cognitive function. The research showed that even being exposed to natural elements over virtual reality has the potential to reduce stress and improve cognitive function. This will be beneficial in indoor settings where access to nature may not be possible. For nurses, visual access to natural patterns and non-visual access to natural patterns have been examined and have significant results in reducing their stress level.

Most applications in biophilic design in healthcare settings focus on reducing patients’ stress and increasing their health through access to nature of views, and few focus on reducing nurses’ stress and burnout, while there is more aspect in nature (through biophilic patterns) could enhance better results on reducing stress and improving nurses’ well-being and health.

Giving this, it is important to consider all the nine aspects of biophilia, that examined in other participants’ stress, to potentially be stress-reducing. Additionally, the five aspects of biophilic design (show significantly improved in participants’ mood and preference) that have not been researching in relation to stress but may also have the potential to be stress-reducing and beneficial for nurses’ well-being. Thus, maximizing the use of various biophilic patterns indoors may increase nurses’ chance to overcome their stress overtime and may improve their health and well-benign.
As a result, this will assist nurses to be more satisfied in their work environment and may improve their quality-of-care delivery and outcomes. Table (2) summarizes the aspect that examined in experimental articles on nurses and other participants, as well as other, suggests strategies of implementation that could be considered as stress-reducing to be examined for future research.
<table>
<thead>
<tr>
<th>Biophilic Patterns</th>
<th>Examined in nurses</th>
<th>Examined in other populations</th>
<th>strategies of implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature in the space</td>
<td>Visual connection with nature</td>
<td>Garden, windows views to nature, images with a lake and tree</td>
<td>Garden, windows views of nature, - Images that had natural views - murals of nature and water</td>
</tr>
<tr>
<td>Non-Visual Connection with Nature</td>
<td>Smelling wood essential oils</td>
<td>Smelling essential oils, hearing natural sounds such as a bird or water movement during a work time to tack their attention from focusing on their work</td>
<td>Simulation of natural features (changing): natural shapes, colors, cloud movement, breezes, water babbling, birds chirping, fragrant flowers, trees, herbs, daylight, and shadows</td>
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<tr>
<td>Non-rhythmic sensory stimuli</td>
<td>Momentary exposure to the stochastic or unpredictable movement to natural sensory stimuli such as periphery vision or the periodic</td>
<td>Aromatherapy after surgery, auditory, haptic, olfactory, or gustatory stimuli that create a positive imitation of nature Effect of natural sound (ocean waves)</td>
<td>Sensory variability, gardening, haptic activities</td>
</tr>
<tr>
<td>Thermal &amp; airflow variability</td>
<td>Gradient of the thermal condition</td>
<td>Presence of waterfall, the sound of wave ocean</td>
<td>Multisensory natural color temperament, different sizes, and shapes of spaces remind individuals of nature</td>
</tr>
<tr>
<td>Presence of water</td>
<td>Exposure to daylight</td>
<td>Exposure to daylight</td>
<td>Multisensory contact habitats and ecosystem and information richness, biomimicry</td>
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<tr>
<td>Dynamic &amp; diffuse light</td>
<td>Connection with natural systems</td>
<td>Wood</td>
<td>using forms and patterns from nature such as fractal and dynamic symmetry</td>
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<tr>
<td>BIomorphic forms &amp; patterns</td>
<td>Material connection with Nature</td>
<td>The use of the complex pattern (fractal shape)</td>
<td>Patterned wholes, trees and column supports, arches, dynamic balance, fractals, hierarchically organized scales, biomorphic, natural materials, botanical motif</td>
</tr>
<tr>
<td>Material connection with Nature</td>
<td>Complexity &amp; order</td>
<td>The use of the complex pattern (fractal shape)</td>
<td></td>
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<tr>
<td>Natural analogs</td>
<td>Nature of the space patterns</td>
<td>Prospects conveying a sense of protection</td>
<td>The layout of spaces, Courtyards, terraces, transitional spaces</td>
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<td>Using VR Technology Garden, Sensory variability, transitional spaces, reflected light overhanging elements</td>
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CHAPTER III: METHODOLOGY

Research Question

Nature positively affects humans’ emotions, productivity, and well-being. Which elements relating to biophilic design can be used to benefit ICU nurses to reduce burnout, reduce stress?

This question is divided into three sub-questions to trace a connection between the relationship among burnout (emotional exhaustion), stress level, and biophilic design:

1. What is the relationship between nurse burnout and stress?
2. What is the relationship between stress and biophilic patterns?
3. How can biophilic patterns help reduce nurse burnout to assure better nurses’ outcomes and well-being?

Strategies

The problem in the study was addressed by reviewing data from 99 literature reviews, two scientific magazines, and three websites that examined patterns of biophilic theory through stress recovery theory and stimulation theory. The study used the biophilia as a framework in the first phase to conduct in the literature on the topic covering PubMed, Web of Science, and EBSCO database provided by the Texas Tech University Library and Google Scholar using keywords ‘nurse burnout’, ‘biophilia’, ‘connecting to nature’, ‘stimulation environment’, stress recovery, ‘and individuals’ stress indoors. In the second face, the study was analyzed and break the data based on the 14 patterns of the biophilic design framework to determine proposed benefits to physical, mental, and behavioral well-being that might be used to reduce nurse stress and burnout in ICU, which utilized as guidelines.

Data Collection Method and Analysis

This study concentrated data from literature reviews to understand the problem with nurse burnout and how the stress affects emotional exhaustion. Access and even exposure to
nature via windows are as an examined solution to reduce nurses’ stress levels and low scores for nurse burnout subscales (emotional exhaustion). Researchers indicated the concept of exposure to nature as a solution to reduce stress through biophilic design that aims to incorporate nature indoors through its fourteen patterns. Studies in nurse burnout just examined the use of two biophilic patterns: visual connection to nature (through testing walking in the garden, view through windows, and image from nature), and daylight. Whereas biophilia has more aspects found in other populations (patients and workers) including environmental design, psychology, and physiology literature that examined and had significant results in patients at hospitals and work environments. Data concentrates on interactions study between individuals and their psychological and physical environment (natural and built) which is beneficial for understanding biophilic design.

Nine patterns of biophilic design have been tested in empirical studies and had a significant result in reducing individuals’ stress and other aspects related to individuals’ well-being, where the other five patterns had a significant result in emotional aspects and feeling refreshed and focused. Where evidence examined only two patterns from biophilic design to reduce nurse burnout, nine of the fourteen patterns had significant results to reduce patients’ and workers’ stress. Given the possibility that different biophilic patterns may help ICU nurses reduce their stress and the emotional exhaustion subscales (nurse burnout) as well as and increase well-being, the other six biophilic design patterns should be considered in designing ICU nurse work environment and break area.

Proposed Solutions

This research used UMC hospital floorplan (Surgical ICU) located in the main floor and address the following:
- Design consideration for Courtyard, ICU unit, ICU nurse workplaces, and break areas.

- Incorporate aspects of biophilic design to Courtyard, ICU unit, ICU nurse workplaces, and break areas.

- Design solutions can be used to range from economic change into major change.
CHAPTER IV: SOLUTION

Program

This research used the surgical ICU floor plan at the University Medical Center (UMC) Hospital located in Lubbock, Texas to apply the researcher’s solution to reduce nurse burnout and stress levels through the 14 biophilic patterns. The strategic solution is divided into four aspects: redesign a courtyard with biophilic sensors, redesign the unit (surgical ICU), redesign nurses’ workstations, and redesign and relocate nurses’ breakroom.

Figure 4-1: Floor Plan for UMC Health System Hospital Figure [PDF]. Lubbock, TX.
First Aspect: Courtyard with Biophilic Sensors

The first aspect of the strategic solution is to take advantage of the courtyard near the surgical ICU and redesign it as an indoor sensory garden with 14 biophilic patterns. The courtyard would be designed to encourage nurses to go for a walk during their break and relax as a way to reduce their stress and burnout; similarly, a study done by Corodoza et al. (2018) found that taking walks in the hospital garden significantly decreased burnout among the nursing staff.
View of the Existing Courtyard

Figure 4-3: UMC courtyard. Bazaid, R. (2020) UMC courtyard [Photographs]. Lubbock, TX.

According to the connecting with nature (biophilia) theory, having the courtyard include an indoor garden with biophilic sensors might be beneficial for reducing nurse burnout and stress levels. The indoor sensory garden could contain all the 14 aspects of biophilia to ensure nurses’ preferences would be met to provide positive experiences. This garden may have different green spaces, such as plants and flowers, that calm nerves and help nurses to relax; the garden has both actual and visual connection with nature (pattern one). Moreover, nurses would experience thermal and airflow variability, such as breeze (pattern four), and experience the presence of water (pattern five) such as a waterfall. As the aforementioned studies found, experiencing water aurally, which is considered a non-visual connection with nature (pattern two), positively benefits people. Nurses could be exposed to daylight (pattern six); because nurses work during the daytime or the nighttime, the garden may contain artificial light that is inspired by daylight in terms of color temperature, and there would be different sizes and shapes of light fixtures (pattern six).

The opportunity to walk in the courtyard indoor garden during breaktimes would help nurses connect to natural systems (pattern seven). The garden design and layout could create these complex systems when it is inspired by natural attributes. Being outside and experiencing
greenery, fresh air, and sensory stimuli from nature that are experienced with the four senses (touch, sound, sight, and smell), would help nurses feel as if they are in a forest. Taking a walk in the garden to clear their minds from any negative thoughts that they may face during their work (seeing people die or suffer) will not take their pain away, but at least it would help them feel better at the time. Connecting to natural systems may include watching plants grow, leaves changing colors, and falling leaves.

When the garden is designed from dynamic-natural forms, it would have forms or patterns from nature such as a fractal or dynamic non-symmetrical layout of the garden and patterns in the floor, and/or on furniture (pattern eight). These dynamic-natural forms, biomorphic forms, and patterns could possibly create complexity and order (pattern ten).

Figure 4-5: Example of dynamic layout or pattern. Galyna, P. Abstract Background inspired by nature stone shapes (March 2017) [Photographs]. Referred form https://www.istockphoto.com/vector/abstract-background-inspired-by-nature-stone-shapes-dynamic-emitted-particles-gm652734226-118561649

Figure 4-6: Example of complexity and order. Silver, S. (March 14, 2019) [Photographs]. Referred form https://thriveglobal.com/stories/why-i-kidnapped-my-daughter/

The garden would include natural materials in the floors, furniture, and shading systems such as wood, stone, and natural fibers (pattern nine). The nature of the space aspect, including prospect (pattern eleven), refuge (pattern twelve), mystery (pattern thirteen), and risk/peril (pattern fourteen), are achievable during the layout of the garden areas. These four patterns of the nature of the space could vary depending on the size of the garden and expected-use elements including paths, transitional spaces, sitting areas, and overhanging elements. Thus, the garden
could give nurses many different positive experiences with the aim to increase wellbeing and reduce burnout and stress levels.

**Table 3:**
*Strategies of implementation for the 14 patterns of biophilic design that could be used and examined in the future in the ICU courtyard.*

<table>
<thead>
<tr>
<th>Biophilic patterns</th>
<th>Strategies of implementation for the courtyard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature in the space</td>
<td></td>
</tr>
<tr>
<td>1- Visual connection with nature</td>
<td>Garden, views of natural elements</td>
</tr>
<tr>
<td>2- Non-visual Connection with Nature</td>
<td>Sensory variability (auditory, haptic, and olfactory)</td>
</tr>
<tr>
<td>3- Non-rhythmic sensory stimuli</td>
<td>Simulation of natural features (changing): natural shapes, colors, cloud movement, breezes, water babbling, birds chirping, fragrant flowers, trees, herbs, daylight and shadows, and natural sounds spread at unpredictable intervals Wind breeze</td>
</tr>
<tr>
<td>4- Thermal &amp; airflow variability</td>
<td>Presence of waterfall</td>
</tr>
<tr>
<td>5- Presence of water</td>
<td>Exposure to daylight, artificial light stimulated by daylight in terms of color temperature and different shapes and sizes</td>
</tr>
<tr>
<td>6- Dynamic &amp; diffuse light</td>
<td>Multisensory contact habitats and ecosystem and information richness</td>
</tr>
<tr>
<td>7- Connection with natural systems</td>
<td>Using forms and patterns from nature such as fractal and dynamic symmetry</td>
</tr>
<tr>
<td>8- Biomorphic forms &amp; patterns</td>
<td>Appling materials from nature such as natural stone, wood, and leather</td>
</tr>
<tr>
<td>9- Material connection with Nature</td>
<td>The use of the complex pattern (fractal shape)</td>
</tr>
<tr>
<td>Natural analogs</td>
<td></td>
</tr>
<tr>
<td>11- Prospect</td>
<td>Courtyards, transitional spaces</td>
</tr>
<tr>
<td>12- Refuge</td>
<td>Sitting areas</td>
</tr>
<tr>
<td>13- Mystery</td>
<td>Garden, sensory variability, transitional spaces, reflected light</td>
</tr>
<tr>
<td>14- Risk/Peril</td>
<td>Overhanging elements</td>
</tr>
</tbody>
</table>
Second Aspect: Layout of the Surgical ICU

The design of the surgical ICU layout should focus on nurses’ well-being and reduce the walking distance among nurse stations, patients’ rooms, and the supply room. In the surgical ICU, each nurse takes care of two patients, so each nurse station needs to be located between two patient rooms with full visual access to patients’ heads. In this floor plan, some nurse stations need to be redesigned for better visibility of patients’ heads. Moreover, the nurses’ breakroom needs to be relocated to be near the courtyard for easy access. Thus, this stage would apply the nature of the space patterns of prospect, refuge, mystery, and risk/peril. The design considers the distance between nurses’ stations and the supply room, giving the distance without changing the location of the supply room. This aspect needs to be noted; however, to the author’s knowledge, there is no research that addresses the ideal distance between them.

Existing Floor Plan

Analysis: Shows the locations of existing courtyard, nurses’ workstations and breakroom in the surgical ICU.
Table 4:

*Strategies of implementation for four patterns of biophilic design that could be used and examined in the future in the surgical ICU layout.*

<table>
<thead>
<tr>
<th>Biophilic patterns</th>
<th>Strategies of implementation for the layout of the surgical ICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of the space patterns</td>
<td>11 - Prospect The layout of spaces among nurses’ workstation, patients’ rooms, and the supply room</td>
</tr>
<tr>
<td></td>
<td>12 - Refuge Breakroom location, courtyard</td>
</tr>
<tr>
<td></td>
<td>13 - Mystery Sensory variability, transitional spaces, reflected light</td>
</tr>
<tr>
<td></td>
<td>14 - Risk/Peril Walking distances</td>
</tr>
</tbody>
</table>

**Third Aspect: Nurses’ Workstations**

In this stage, the design aims to maximize the biophilic aspects for nurses to experience along with the visibility of patients’ heads. Most importantly, biophilic aspects need to be infection controlled.
Views of the Two-existing Nurse’ Workstations

Figure 4-7: Views of the Two-existing patient’s room and two types of nurses’ workstations. Bazaid, R. (2020). Surgical ICU [Photographs]. Lubbock, TX.

From the author’s analysis and knowledge, nurses’ workstations could include eight patterns of biophilia: visual connection with nature (1), non-visual connection with nature (2), non-rhythmic sensory stimuli (3), daylight and diffuse light (6), connection with natural systems (7), biomorphic form and pattern (8), material connection with nature (9), and complexity and order (10). Nurses could visually see both patients' heads and views of nature (through windows).
As examined in the study by Mihandoust (2019), all patient rooms in the surgical ICU have window blinds that could be opened and could benefit nurses by allowing them to see views of nature. This would achieve a visual connection with nature (pattern one) and daylight (pattern six). Moreover, as the analysis shows in proposal perspective design for nurses’ workstations, nurses could have a visual access to images from nature, artwork (pattern one), and digital displays (pattern two, pattern seven, and/or pattern eight). A digital display could contain visual and nonvisual connection with nature (pattern two) when images change in shape, color, light, and sound. It could include a connection with natural systems (pattern seven) if those changes show scenes such as plants growing, falling water, leaves changing colors, etc., and/or contains biomorphic forms and patterns (pattern eight).

Figure 4-8: Example of digital display. Daniel Canogar. Courtesy of Mark Moore Gallery [Photographs]. https://wsimag.com/art/60589-daniel-canogar
The finishing materials could be natural materials or materials that have a natural look and/or colors (pattern nine), such as vinyl material that resembles wood. Moreover, using natural colors such as green and blue could help nurses recall natural environments such as forests, ocean, etc. The complexity and order (pattern ten), that involved rich sensory information that remains to those faced in nature, could be achieved in many ways: the complexity of the design elements, dynamic balance, fractals, biomorphic and botanical motifs, and/or visual access to trees.

These biophilic patterns would take nurses’ attention from their task (observing patients) for less than a second to relax their eyes and give a sense of being in nature, as shown in the study done by Lewis (2012) and Vessel (2012). Thus, the use of biophilic patterns in nurses’ workstations may increase nurses’ attention to their work and decrease their stress level (natural stimuli and connecting to nature).
Table 5:
Strategies of implementation for eight patterns of biophilic design that could be used and examined in the future in the ICU nurses’ workstations.

<table>
<thead>
<tr>
<th>Biophilic patterns</th>
<th>Strategies of implementation for the ICU workstations</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature in the space</td>
<td>- Window views of nature</td>
<td>Noise</td>
</tr>
<tr>
<td>1-Visual connection with nature</td>
<td>- Images with natural views (lake and tree)</td>
<td></td>
</tr>
<tr>
<td>2- Non-visual connection with nature</td>
<td>- Murals of nature and water</td>
<td></td>
</tr>
<tr>
<td>3-Non-rhythmic sensory stimuli</td>
<td>- Sensory variability (auditory, haptic, and olfactory)</td>
<td></td>
</tr>
<tr>
<td>6- Dynamic &amp; diffuse light</td>
<td>- Momentary exposure to the stochastic or unpredictable movement to natural sensory stimuli</td>
<td></td>
</tr>
<tr>
<td>7- Connection with natural systems</td>
<td>- Smelling wood essential oils</td>
<td></td>
</tr>
<tr>
<td>7- Connection with natural systems</td>
<td>- Hearing natural sounds such as a bird or water movement during work time to attract their attention so they can refocus on their work</td>
<td></td>
</tr>
<tr>
<td>7- Connection with natural systems</td>
<td>- Simulation of natural features (changing): natural shapes, colors, cloud movement, breezes, water babbling, birds chirping, fragrant flowers, trees, herbs, daylight, and shadows</td>
<td></td>
</tr>
<tr>
<td>7- Connection with natural systems</td>
<td>- A screen that can change with different light or time such as cloud movement and/or natural sounds spread at unpredictable intervals</td>
<td></td>
</tr>
<tr>
<td>9- Material connection with Nature</td>
<td>- Exposure to daylight</td>
<td></td>
</tr>
<tr>
<td>9- Material connection with Nature</td>
<td>- Multisensory natural color temperature, different sizes, and shapes of spaces remind individuals of nature</td>
<td></td>
</tr>
<tr>
<td>9- Material connection with Nature</td>
<td>- Multisensory contact habitats</td>
<td></td>
</tr>
<tr>
<td>9- Material connection with Nature</td>
<td>- Ecosystem and information richness</td>
<td></td>
</tr>
<tr>
<td>9- Material connection with Nature</td>
<td>- Biomimicry</td>
<td></td>
</tr>
<tr>
<td>8- Natural analogs &amp; Biomorphic forms &amp; patterns</td>
<td>- Using forms and patterns from nature such as dynamic symmetry</td>
<td></td>
</tr>
<tr>
<td>10- Complexity &amp; order</td>
<td>- Appling materials from nature such as natural wood, stone, and leather</td>
<td>Infection</td>
</tr>
<tr>
<td>10- Complexity &amp; order</td>
<td>- Botanical motifs on the finishing (wall, floor, workstation, chair)</td>
<td></td>
</tr>
<tr>
<td>10- Complexity &amp; order</td>
<td>- Patterns of nature, dynamic balance, fractal patterns, hierarchically organized scales, biomorphic shapes, botanical motifs</td>
<td>Infection and vision</td>
</tr>
</tbody>
</table>
Views of Existing Nurses’ Breakroom

Figure 4-10: Views of existing nurses’ breakroom. [Photographs]. Bazaid, R. (2020). Surgical ICU [Photographs]. Lubbock, TX.

Fourth Aspect: Nurses’ Breakroom

In this stage, the design of the breakroom aims to maximize the biophilic aspects for nurses to take a break, relax, and connect to biophilic patterns during their down time. Also, relocating the breakroom would give direct access to the indoor garden through the breakroom.

From the author’s analysis and knowledge, the nurses’ breakroom could include eleven biophilic patterns: visual connection with nature (1), non-visual connection with nature (2), non-rhythmic sensory stimuli (3), thermal and airflow variability (4), daylight and diffuse light (6), connection with natural systems (7), biomorphic form and pattern (8), material connection with nature (9), complexity and order (10), prospect (11), and refuge (12).

Nurses could see natural views through windows; moreover, the nurses' breakroom could use patterns similar to those in the nurses' workstation. Additionally, nurses could be exposed to daylight (pattern six) through operable windows to get fresh air (pattern four). Also, the breakroom could have natural materials and colors (pattern nine) in the floor, wall(s), and
furnishing(s), and this pattern could be complex when they see natural views and systems. Additionally, they could use advanced technology such as virtual reality (VR) that could represent being in nature and/or aspects of nature. Nurses could experience natural systems and complexity via multisensory contact habitats and ecosystems and information richness such as watching flowers grow (pattern ten). The layout of the furnishings and areas in the breakroom would promote nurses’ relaxation. The refuge in this space could be achieved by using a specific area in the breakroom for relaxation. The relaxation area may include a reclining chair for better rest and use VR enhanced technology.

Table 6: 
Strategies of implementation for eleven patterns of biophilic design that could be used and examined in the future in the ICU nurses’ breakroom.

<table>
<thead>
<tr>
<th>Biophilic patterns</th>
<th>Strategies of implementation for the nurses’ breakroom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature in the space</td>
<td>1-Visual connection with nature                                                                                               - Windows views of nature (green and water)</td>
</tr>
<tr>
<td></td>
<td>2- Non-visual connection with nature                                                                                          - Images with natural views, lake, and tree</td>
</tr>
<tr>
<td></td>
<td>3-Non-rhythmic sensory stimuli                                                                                               - Murals of nature and water</td>
</tr>
<tr>
<td></td>
<td>- Repeated natural stimuli that are known (Sensory variability, auditory, haptic, olfactory)</td>
</tr>
<tr>
<td></td>
<td>- Using technology such as VR</td>
</tr>
<tr>
<td></td>
<td>- Momentary exposure to the stochastic or unpredictable movement to natural sensory stimuli such as periphery vision or the periodic</td>
</tr>
<tr>
<td></td>
<td>- Smelling wood essential oils</td>
</tr>
<tr>
<td></td>
<td>- Hearing natural sounds such as a bird or water movement during work time to tack their attention from focusing on their work</td>
</tr>
<tr>
<td></td>
<td>- Simulation of natural features (changing): natural shapes, colors, cloud movement, breezes, water babbling, birds chirping, fragrant flowers, trees, herbs, daylight, and shadows</td>
</tr>
<tr>
<td></td>
<td>- A screen that can change with light or time different, cloud movement, natural sounds spread at unpredictable intervals</td>
</tr>
<tr>
<td></td>
<td>4-Thermal &amp; airflow variability                                                                                               - The windows are operable to catch natural ventilation and wind breeze</td>
</tr>
<tr>
<td></td>
<td>6- Dynamic &amp; diffuse light                                                                                                   - Exposed to daylight</td>
</tr>
<tr>
<td></td>
<td>7-Connection with natural systems                                                                                               - Natural color temperament, different sizes, and shapes of spaces remind individuals of nature</td>
</tr>
<tr>
<td></td>
<td>- Multisensory contact habitats</td>
</tr>
<tr>
<td></td>
<td>- Ecosystem and information richness</td>
</tr>
</tbody>
</table>
Biomimicry that could be received from technology and watching flowers grow
- Using forms and patterns from nature such as dynamic layout and natural
- Finishing patterns

Using forms and pattern from nature such as dynamic layout and natural finishing patterns

- Appling materials from nature such as natural wood, and leather.
- Botanical motifs on the finishing (wall- floor- tables – chairs-sofa)

- Patterned wholes, trees and column supports, arches, dynamic balance, fractals, hierarchically organized scales, biomorphic, natural materials, botanical motif

The layout of spaces in the breakroom among sitting area, eating, enjoying, and relaxing
- The spaces in the courtyard

Concept
The design solution aims to enhance the ICU unit with spatial variation of the 14 biophilic patterns and maximizes nurses’ benefit of connecting with nature (biophilia). This paper will show all the possible ways, from the author’s perspective and knowledge, that could be used in the ICU unit to reduce nurses’ burnout and stress. The concept focuses on bringing nature indoors via the 14 biophilic patterns and increases the possibility of nurses experiencing nature with four senses (touch, sound, sight, and smell).

Drawing and Design

First Aspect: Courtyard with Biophilic Sensors
The layout of the indoor sensory garden is inspired by the shape of ocean waves. Using these complex shapes, the garden is divided into walking paths, green spaces, and relaxing, shade, and waterfall areas, all of which have natural stimuli. The layout of the indoor sensory garden considers the walking paths from the garden access, maximum experience of stimuli from nature, and how nurses would see the garden from their workstations and breakroom.
The indoor sensory garden (courtyard) has multiple sitting areas (1, 3, and 4), relaxing spaces, and walking paths for different experiences and preferences. The proposed design of the sensory garden would include all 14 patterns of biophilia as described in Table 3.
Proposed Design for the Sensory Garden

Key:
1 - Sitting area
2 - Flowers
3 - Bench
4 - Comfortable sitting
5 - Water element
6 - Shading system
7 - Pergola
8 - Walking path
9 - Flagstone material (Flooring)
10 - Different types of native and adopted trees
11 - Green spaces
Second Aspect: Layout of the Surgical ICU

In the surgical ICU unit, the breakroom needs to be relocated near to the courtyard. Nurses’ workstations need to be designed for visual visibility of patients' heads and biophilic elements. The solution considers the distance between nurses’ workstations and the supply room without changing the location of the supply room; there is no research, to the author’s knowledge, to address the ideal distance. For one trip to the supply room and back to the workstation, the shortest distance is 8’, and the longest distance is 108’, with an average of 61’.
Proposed Design for Surgical ICU
Third Aspect: Nurses’ Workstations

The nurses' workstations consider both view of patients’ heads and views of nature through windows, as shown in the floor plan.

Proposed Perspective Design for Nurses’ Workstations

Nurses’ workstations could include eight patterns of biophilia, as discussed in the third stage of the solution: visual connection with nature (1), non-visual connection with nature (2), non-rhythmic sensory stimuli (3), daylight and diffuse light (6), connection with natural systems (7), biomorphic form and pattern (8), material connection with nature (9), and complexity and
order (10). Nurses could see both patients' heads and natural views (through windows) as well as experience the eight biophilic patterns.

*Proposed Perspective Design for Nurses’ Workstation*

This perspective shows the possibilities of using biophilic aspects for better nurse experience and connection to nature indoors, as shown in Table 5.

**Fourth Aspect: Nurses Breakroom**

The nurses’ breakroom considers view and access to the sensory garden (courtyard), in addition to 12 biophilic patterns: visual connection with nature (1), non-visual connection with nature (2), non-rhythmic sensory stimuli (3), thermal and airflow variability (4), daylight and diffuse light (6), connection with natural systems (7), biomorphic form and pattern (8), material connection with nature (9), complexity and order (10), prospect (11), and refuge (12), as shown in Table 6. The layout of the breakroom considers giving nurses spaces to eat, rest, relax, and sleep if needed.
Proposed Perspective Design for Nurses’ Breakroom

Door for direct access to the courtyard

Possible for a picture of nature or digital display of nature

Relaxing Room
Proposed Perspective Design for Nurses’ Breakroom

These perspectives show the possibilities of using biophilic aspects for better nurse experience and connection to nature indoors, as shown in Table 6.
CHAPTER V: CONCLUSION

Conclusion

Nurse burnout is a considerable and prevalent problem among nurses in the U.S. Research indicates the relationship between stress and nature, and how exposure to nature may assist in decreasing stress level, lowering blood pressure, relieving pain, hastening recovery, and improving staff behavior and performance, which leads to a better relationship between staff and patients (Coles & Calabrese, 2018). Exposure to nature through the 14 biophilic patterns indoors would provide the same benefit as exposure to outdoor nature to benefit nurses’ psychological and emotional health.

Limited research exists regarding nurse burnout and the benefit of biophilic design, and it has been restricted to visual connection to nature, such as direct access to nature, access to nature through windows, and images, in addition to daylight. Biophilic design has 14 patterns that could well support reducing stress and nurse burnout. This study investigated the connection between using the 14 patterns of biophilia and their potential restorative effects on intensive care unit (surgical ICU) nurse burnout and stress levels in four different solutions in a healthcare setting: courtyard, layout of the unit, nurses' workstations, and nurses' breakrooms.

Future Research

Burnout and job stress affect nurses' performance and wellbeing; however, limited research covers these topics and further studies are needed. The content of this area of exploration has revealed various new and important questions that could be directions for future research. By evaluating studies looking at biophilic patterns, there is a lack of studies regarding nurse burnout. This study shows that many aspects of biophilia need to be examined in future research, which could take place in a hospital courtyard, a hospital garden, layout of units, nurses’ workstations, and/or nurses’ breakrooms.
Future research could focus on the use of sensory gardens and how exposure to the 14 patterns of biophilia would reduce emotional exhaustion in burnout. Further studies could focus on the layout of the ICU unit and how it is designed to meet nurses' work needs and reduce their walking distance. Future research could focus on restorative environments to examine the effects of biophilic aspects in the ICU work environments and break areas. Future studies may consider exposing nurses to natural stimulation, such as auditory and olfactory stimuli, to examine their effects on nurse burnout. Another study may look at natural materials and colors in the ICU nurse work environment and break area, and how they enhance nurses’ health and wellbeing while reducing their burnout and stress level. Research could look at how nurses experience their work environment and break areas to analyze the positive and negative impacts of the existing environment, and to replace the negative aspects with new solutions from biophilia. Non-rhythm patterns may be a good fit to consider when investigating treatments such as smells from particular plants or sounds of falling water, ocean waves, or birds chirping at unexpected times. Research may go further by investigating how technology could help nurses to relax and reduce burnout by enhancing the restoration of the breakroom environment and using technology to follow nurses’ thoughts and imagination.
REFERENCE


https://doi.org/10.1016/j.jenvp.2018.12.005


https://doi.org/10.1097/NNA.0b013e3181e9393b


https://doi.org/10.1177/1937586719851271


https://doi.org/10.3390/buildings5030948

affordances as a health-promoting tool in a therapeutic garden. *Innovative approaches to researching landscape and health, 1*(5), 116–154.


Totaforti, S. (2018). Applying the benefits of biophilic theory to hospital design. *City, Territory*


Vessel, E. A. (2012). New York University Center for Brain Imaging. *Personal communication with the authors.*

https://doi.org/10.1111/ijn.12216


Wei, R., Ji, H., Li, J., & Zhang, L. (2017). Active intervention can decrease burnout in ED


https://doi.org/10.1016/j.buildenv.2018.01.006


https://doi.org/10.3928/00220124-20101201-04


https://doi.org/10.1177/193758671400700405