IMPACT OF GREEN BUILDING DESIGN ON HEALTHCARE OCCUPANTS ------WITH A FOCUS ON HEALTHCARE STAFF

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ABSTRACT

IMPACT OF GREEN BUILDING DESIGN ON HEALTHCARE OCCUPANTS

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Previous studies have shown that indoor environmental factors such as ventilation, lighting, noise and contact with nature can influence the occupant perception of the working environments. But there is still hot debate over whether a green hospital is more comfortable to work in. Since the green healthcare design is increasingly adopted in practice, it's important to assure this new healthcare design addresses the needs of the staff, with the sustainability considered at the same time. There is evidence linking the working environments to the turnover rate of nurses, medical errors of the doctors and staff, and the overall care they deliver. Therefore it's very important to study the impact of built environment on healthcare staff and identify the factors that influence the perception of comfort and satisfaction.

This research adopts quantitative study using surveys. The participants are the healthcare staff including doctors and nurses from three hospitals, two of which are LEED-certified hospitals and the other is not LEED-certified with conventional designed. The results show significant difference between two types of hospitals studied. Staff working in the LEED-certified hospital feel more comfortable and show a higher satisfaction level towards their working environments. This study provides valuable empirical results to reveal the relation between the building design and the comfort and satisfaction of healthcare staffs, which will shed light on the future hospital design.

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Chapter 1 Introduction

1.1 Introduction

Our world is facing serious problems including energy crisis and environmental degradation. If the current energy consumption rate remains, oil and natural gas will be used up in 42 and 61 years, respectively (Kisslinger, 2004). Since buildings consume more than 70% of the electricity and a large part of materials, water, and generate 60% of non-industrial waste (National Institute of Building Sciences, 2010), green buildings become one of the mainstream practices. They are defined by some researchers as buildings based upon resource efficient, ecological design aimed at creating healthy indoor environment. In green buildings, the consumption of energy, water, and other resources are greatly reduced by adopting various methods such as using solar cells and collecting stormwater (U.S. Green Building Council, 2011). In addition, green buildings are known to provide healthier indoor environment. Air quality is improved by using low emission materials and better designed ventilation systems. Moreover, green buildings are expected to reduce significantly waste production and pollution, which impose much less pressure on the environment. Leadership in Energy and Environmental Design (LEED), a rating system developed by U.S. Green Building Council (USGBC), provided a third-party verification which assesses building projects based on the green building and performance standards (USGBC, 2011).

Hospital buildings are one important type of buildings. The United States is facing one of the largest hospital building booms in the U.S. history, as a result of the graying of the baby boom generation and the need to replace aging 1970s hospitals

(Ulrich *et al.*, 2008). Even as economy slows and construction is down nationwide, healthcare-related construction projects continue to grow. According to statistics from the U.S. Census Bureau (2008), $48.5 billion was spent on hospital construction in 2010, up 1.2% from the previous year. However, the current hospital design doesn't always meet the need to create the most effective environment for the patients to recover and for the staff to work in. As described by Institute of Medicine in 2001, "The frustration levels of both patients and clinicians have probably never been higher. Yet the problems remain. Health care today harms too frequently and routinely fails to deliver its potential benefits"(Institute of Medcine, 2001).

In the healthcare industry, approximately 6600 tons of waste is generated daily in the United States, 85% of which is nonhazardous solid waste such as paper, cardboard, food, glass, and plastics that can be recovered or recycled. The amount of waste and costs could also be reduced through efficiency. According to Environmental Protection Agency (2010), about 30% of the health sector's energy use could be reduced by switching toward renewable and more efficient energy sources. As a result, the concept of green hospital design is now increasingly adopted in practice in the healthcare industry. It's important to assure this new healthcare design indeed addresses the needs of the patient and staff, with the environmental sustainability considered at the same time.

Current studies on hospital design more often concentrates on the patient side. Less attention has been given to healthcare staff. According to the report of Bureau of Health Professions (BHP) (2004), the nurse shortage is growing from -6% in 2000 to -17% in 2010 and will keep growing to -36% in 2020, which directly threatens the

patients' safety. In addition, the existing nurse force is aging. Their age averaged more than 43 years old in 2002 and will increase to 50 by 2010 (JCAHO, 2002). Jones (1990; 2002) and Steel (2002) found that the turnover rate among nurses is more than double that for other professionals of comparable education and gender, which ranges from 17% to 36%. One of the major reasons why nurses plan to leave the field is because of the physical environments of workspaces (Steel, 2002). All of these call for more careful studies on the impact of built environment on healthcare staff, with the goal to improve the working conditions and ultimately the care they deliver.

1.2 Research Purpose and Objectives

The primary purpose of this study is to evaluate the impact of hospital design on the perceived staffs' comfort and satisfaction therein by comparing the data collected from LEED-certified hospitals and non-LEED-certified hospitals. This study aims to provide more insight about the post-occupancy evaluation and suggest better building design considerations for improving comfort and satisfaction of healthcare occupants in their working environments.

Based on the purpose, this study set the following objectives for the study:

1. To examine how the healthcare building design (LEED vs. non-LEED) might influence the perception of the comfort toward the workplace between the staffs from LEED-certified hospitals and non-LEED-certified hospitals.
2. To evaluate how the healthcare building design (LEED vs. non-LEED) might influence the satisfaction toward the workplace between the staffs from LEED-certified hospitals and non-LEED-certified hospitals.

3. To determine how the perception of comfort might influence the satisfaction toward the workplace among healthcare staffs.
4. If the answer is yes to objectives 3, identify the comfort categories which are responsible for the difference in the perception of satisfaction toward the workplace.
5. To suggest design considerations for the future green healthcare designs

1.3 Research Hypotheses

According to the purpose and objectives of this study, the following hypotheses will be tested:

1. Healthcare staffs from LEED-certified hospitals perceive their workplace more comfortable than those from non-LEED-certified hospitals.
2. Healthcare staffs from LEED-certified hospitals are more satisfied toward their workplace than those from non-LEED-certified hospitals.
3. The perception of comfort significantly influences the satisfaction toward the workplace among healthcare staffs.
4. Higher perception of comfort leads to higher degree of satisfaction among healthcare staffs.

1.4 Importance of the Study

Although green building design is known to have a number of benefits, it remains in question due to the lack of real data whether green building design really improves the perception of comfort and satisfaction among the occupants. Especially for healthcare facilities, even fewer studies have been done to answer this question. It is

necessary to generates valuable empirical results to reveal the relation between the healthcare design and the perception of comfort and satisfaction among healthcare staff, which provides invaluable implications in future healthcare design. Therefore, this study aimed to investigate the perceived comfort and satisfaction of healthcare staffs in LEED and non-LEED-certified hospitals and examine any significant differences. The entire data and results will provide evidence-based design suggestions for future healthcare designs.

1.5 Definition of Terms

For the purposes of this study, the following definitions will be used.

LEED refers to Leadership in Energy and Environmental Design. It is an internationally recognized green building certification system developed by the U.S. Green Building Council. It aims to provide a standard for evaluating whether a building is environmentally responsive, profitable and a healthy place to work. According to the U.S. Green Building Council, LEED promotes a holistic approach to sustainability by recognizing performance in five key areas of human and environmental health including sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality. LEED (USGBC) buildings are expected to improve health and safety for the occupants, reduce waste sent to landfills, save energy and water and improve indoor air quality. Buildings are rated as "certified", "silver", "gold", or "platinum" depending on the number of credits received.

Post-occupancy evaluation is defined as the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time (Preiser *et al.*, 1998). It assesses how well buildings match users' needs, and identifies

ways to improve building design, performance and fitness for the purpose.

Environmental Management System is a set of processes and practices that enable an organization to reduce its environmental impacts and increase its operating efficiency (U.S. Environmental Protection Agency, 2002). It brings together the people, policies, plans, review mechanisms, and procedures used to manage environmental issues at a facility or in an organization (U.S. Environmental Protection Agency, 2002).

HVAC refers to a Heating, Ventilation, and Air-Conditioning (HVAC) system (U.S. Environmental Protection Agency, 2010). It's designed to help maintain good indoor air quality through adequate ventilation with filtration and provide thermal comfort. HVAC systems are among the largest energy consumers in buildings. The choice and design of the HVAC system can affect many other high performance goals such as water consumption.

1.6 Structure of the contents

Chapter 2 of this thesis will review the literature related to the topic. Chapter 3 presents research methods adopted in this research including research subjects, data collection procedure, instrumentation and analysis design. Chapter 4 presents the research results based on statistical analyses and discusses the implications. Chapter 5 presents the summary, conclusion and the suggestions for future healthcare design and related research.

Chapter 2 Literature Review

There has been an increasing number of research focusing on the impact of building design on occupants' comfort and satisfaction. This chapter aims to give an overview of what kinds of studies have been conducted so far and provide a background for the research. Articles reviewed are grouped into three categories, including (1) the relation between built environment and comfort, (2) the relation between built environment and satisfaction, and (3) the impact of building design on the healthcare staff.

2.1 Built environment and occupant comfort and satisfaction

Increasing number of studies has been carried out focusing on evaluating the built environment quality, which is usually measured in terms of occupant comfort. Because there is evidence indicating that comfortable indoor environment can lead to improvements in productivity in the workforce and hence greater competitiveness for the company involved.

Studies on indoor air quality are far too vast to be covered fully in this thesis. However, the message is very clear: *indoor air quality* is one of the key factors affecting health, well being, perceptions of ambient conditions and work. For example, results obtained by Hummelgaard et al. (2007) indicated a higher degree of satisfaction and a lower prevalence of Sick Building Symptoms (SBS) among the occupants in the naturally ventilated buildings comparing to mechanically ventilated buildings. Menzies (2000) also found Sick Building Syndrome (SBS) symptoms were significantly

decreased in buildings with better ventilation system. These findings are consistent with an early study of occupants in newly renovated office buildings which found high levels of general symptoms and mucosal symptoms associated with odors and organic compounds in dust (Valbjorn, 1995). In a most recent article, the occupant sensation and satisfaction level towards their thermal and visual environment was found to be clearly better in a contemporary environmentally-concerned building compared to those in a conventional high-rise office block (Zhang *et al.*, 2011). Humidity is another factor showing a significant effect on the occupant comfort as well as the energy consumption (Simonson *et al.*, 2002). As described by Heerwagen et al. (2000), indoor air quality is greatly improved due to material selection, construction techniques, enhanced ventilation and inclusion of indoor nature settings in green buildings, which suggests green design could possibly improve the occupant comfort as well as satisfaction level.

In addition, there is evidence showing that *indoor lighting* is also closely related to the occupant comfort. Earlier studies also shown that people valued daylight and preferred to be near windows (Collins, 1975; Heerwagen *et al.*, 1986). Literature regarding occupant preferences and satisfaction with the luminous environment and control systems in daylit offices were reviewed by Galasiu et al. (2006) which showed a consistent strong preference for daylight. In green building design, daylignt has been used as the primary light source which reduces building energy demand and at the same time enhances indoor environment quality. A recent study showed generally high satisfaction was perceived with daylit work environment in a LEED Gold laboratory building (Hua *et al.*, 2010). On the other hand, as it's still necessary to have artificial lighting, energy efficient, high quality electric lighting not only reduces energy

consumption, but also reduces computer glare, increases visual comfort, and adds an aesthetic element that is good for the mood of the occupants (Boyce, 1998). Incidence of headaches was found to decrease significantly with the use of high frequency fluorescent lamps (Collins, 1993). These features have been used commonly in green buildings which are found to reduce headache, eyestrains, and can serve as a buffer to discomfort or stresses.

Moreover, it's found that being able to have *visual contact with nature* through window views, sitting in the sun or shade, and to walk in interior streets with natural settings enhances mood and promotes higher quality of life (Heerwagen, 2000). A study examining the effects of window view on perception of spaciousness, brightness and room satisfaction in a campus building revealed that rooms with open and natural window views at higher levels were perceived larger and rated more satisfied by the occupants (Ozdemir, 2010). A view of natural elements was also found to buffer the negative impact of job stress on intention to quit and to have a similar elect on general well-being (Leather *et al.*, 1998). The recovery from stress was found to happen within three to five minutes after encountering real or simulated nature settings (Parsons, 2000) and this change was even quickly reflected in physiological changes such as blood pressure and heart activity and producing a feeling of comfortable (Ulrich *et al.*, 1991). More specifically, indoor plant density was shown to bring psychological benefits which results in better occupant attitudes and higher perceptions toward the indoor (Bringslimark *et al.*, 2009; Larsen *et al.*, 1998).

Noise is another indoor environmental contributor that greatly affects occupant comfort. It has been well established that noisy environments are stressful, frustrating

and prevent people from doing their job to the best of their abilities (Bordass, 2000). Satisfaction was found to drop significantly with increasing noise, as revealed in a field study assessing disturbance by office noise among 3391 employees at 58 sites (Sundstrom *et al.*, 1994). Noise is a substantial problem particularly in green building design as a result of open plan configuration. Negative effects of acoustic environment increased significantly, including increased distraction, reduced privacy, increased concentration difficulties and increased use of coping strategies. Self-rated loss of work performance because of noise doubled (Kaarlela-Tuomaala *et al.*, 2009; Smith-Jackson *et al.*, 2009). It was also reported that office noise (with or without speech) affected the memory and mental arithmetic which were independent of the meaning of the irrelevant speech (Banbury *et al.*, 1998). The physics of buoyancy utilized in natural ventilation was found to aid the transmission of noise from one part of the building to another (Edwards, 2006). The need for contact with nature together with the need for cross ventilation opens the interior to exterior noise. Added to this, exposure of hard fabric surfaces for night-time fabric cooling also adds to potential noise levels in the workplace (Edwards, 2006). Strategies have been developed to reduce noise in green building design (De Salis *et al.*, 2002; Swift *et al.*, 2008) and LEED standard for indoor acoustical quality has been proposed (Jensen *et al.*, 2008).

Thermal comfort was also found to correlate strongly with perceived comfort of the workplace (Roulet *et al.*, 2006; Xie *et al.*, 2009). Higher temperature is found to correlate with higher microbial presence in the air and thus result in higher level of general symptoms such as nasal inflammation. A Swedish office study found the incidence of headache and other symptoms increased steadily from 10% at 20°C to 60%

at 24.5°C (Krogstad, 1991). Thermal condition is found to be another potential problem in green buildings. In order to reduce the energy consumption and construction cost, natural cooling and heating are commonly adopted instead of air conditioning in these buildings. The results of overheating in summer, under-heating in winder, and excessive variability of temperature could be detrimental to the occupants' comfort (Edwards, 2006). In fact, a study conducted in Australia (Paul, 2008) showed that people staying in a green library in summer perceived the indoor environment as warmer and less comfortable. This shows a potential issue of green buildings associated with thermal comfort caused by saving energy for heating and cooling.

2.2 Impact of built environment on healthcare staff

As demonstrated in a number of studies, healthcare staff especially nurses experience a high level of work stress, which were found to contribute to nurse burnout and an intention to leave the job (Billeter-Koponen *et al.*, 2005; Scully, 1980; Sharma *et al.*, 2008; Ulrich *et al.*, 2008). However, there are only a few studies exploring how the built environment contributes to staff stress and affects the comfort and satisfaction so far.

Regarding to indoor air quality, Jiang et al. (2003) found that good ventilation could significantly reduce the viral load of the ward and might be the key to prevent outbreaks of severe acute respiratory syndrome (SARS) among healthcare workers. Two other studies conducted by Smedbold et al. (2002) and Menzie et al. (2000) both found significant decrease in illness infection among healthcare staff was related to less fungus in the air with better ventilation supply. In addition, Cooper-Marcus et al. (1995) found

that many nurses and other healthcare workers used the gardens for achieving pleasant escape and recuperation from stress. There is also evidence that healthcare staff perceive higher sound levels generated by the equipments as stressful (Bayo, 1995; Norbeck, 1985). Noise-induced stress in nurses also correlates with reported emotional exhaustion or burnout (Topf, 1988). A study conducted by Blomkvist et al. (2004) also found lower noise levels were linked with a number of positive effects on staff such as improved quality of care for patients. Finally, a large scale study conducted by Buchanan et al. (1991) examined a correlation between the appropriate lighting level and reduction of medication dispensing error rates. They found that medication dispensing error rates were significantly lower at an illumination level of 1,500 lux (2.6%) than those of 450 lux (3.8%).

These previous studies emphasize the relationships between healthcare staffs' satisfactions and stress, ventilation, garden, noise, and lighting level. This study thus will include these physical elements and examine their relationships with healthcare staffs' perceptions of comfort and satisfaction in their working environments.

2.3 Supportive Design Theory and its implications in healthcare design

Traditional healthcare design mainly concentrates on creating buildings that reduce infection and succeed as functionally efficient delivery platforms for new medical technology. This emphasis on functional efficiency and the pathogenic conception of disease and health often results in institutional and stressful environments that are detrimental to care quality (Ulrich, 1992; Ulrich *et al.*, 1991). Very little attention is given to creating surroundings that address psychological and social needs

of the patients. Ulrich (1984) published his findings on the *Science* journal showing that postsurgical patients whose hospital rooms offered an outdoor view tended to recover more quickly. This pioneered a new perspective toward healthcare design, which is now known as supportive design and evidence-based design became prevalent along with the supportive design theory. A growing number of studies have been conducted which provide more and more evidence suggesting that aspects of the built environment have significant effects on clinical outcomes for patients, since then.

As an example, *noise* was found to produce widespread annoyance among patients and stress in staff (Bayo, 1995) and was detrimental to at least some outcomes such as producing sleeplessness and elevated heart rate (Hilton, 1985). Studies of critical-care patients found strong correlation between the absence of windows and high rates of anxiety and depression (Keep *et al.*, 1980). Patient rooms with sunshine rather than cloudy conditions were found to possibly foster more favorable outcomes (Beauchemin *et al.*, 1996, 1998).

The number of such studies on the links between environmental characteristics and outcomes is growing but many healthcare design questions remain unanswered. The Supportive Design Theory is brought up to provide guidelines for the design situations where knowledge is not sound. The term *supportive* here refers to environmental characteristics that support or facilitate coping and restoration with respect to the stress that accompanies illness and hospitalization (Ulrich, 1999).

The Theory takes advantages of a large amount of indirectly relevant research in health psychology, environmental psychology, behavioral medicine, and other health-related fields (Ulrich, 1999; Ulrich *et al.*, 1991). A lot of these studies examined how

humans respond to the environment. According to environmental psychologists, the premise is the biophilia hypothesis, which asserts that humans have developed a trait to be sensitive and responsive to the surroundings since the earliest evolutionary phases of human life (Bilchik, 2002). Based on this hypothesis, three broad categories of research have been developed to reduce environmental stress for patients and healthcare staffs: (1) fostering control and privacy, (2) improving social support, (3) and connecting to nature and providing positive distractions (Bilchik, 2002).

Results from these studies indicate that the capability of healthcare environments to improve outcomes is linked to their effectiveness in promoting stress reduction, buffering, and coping (Ulrich, 1999; Ulrich *et al.*, 1991). For example, it was found that in all settings (office, library, hospital, etc.) some extent of control over the environment reduces stress (Bilchik, 2002). In hospitals, patients who have control over the temperature and lighting in their rooms, the amount of privacy they have and the timing and content of meals will experience less stress and will likely heal more quickly. Similarly, positive distractions were found to reduce stress in measurable ways. The inclusion of indoor natural settings, interactive works of art and aquariums is thus becoming integral to healthcare design.

In practice, supportive healthcare design takes two steps. It begins by eliminating environmental characteristics that are known to be stressful or have direct negative impacts on outcomes such as noise. In addition to this, supportive design goes a major step further by emphasizing the inclusion of characteristics in the environment that could reduce stress and improve outcomes suggested by the research (Ulrich, 1999).

To summarize, as suggested by a number of studies, Supportive Design Theory

improves the patients' health outcomes by reducing stress and anxiety for patients, reducing pain, improving sleep quality, lowering infection occurrence, and improving patient satisfaction. There was also evidence that supportive design is beneficial for healthcare employees by reducing the workplace stress and improving satisfaction.

2.4 LEED for Healthcare

Healthcare facilities have their own characteristics such as all day long operating schedule, need for infection control, and a large amount of medical wastes. Moreover, sustainable healthcare facilities should be not only good for the environment, but also good for physicians, staffs, and the patients. It's not appropriate to apply the LEED rating system for general buildings on healthcare facilities. Therefore U.S. Green Building Council collaborated with the Green Guide for Health Care (GGHC) and established LEED standards for healthcare facilities in 2009 (USGBC, 2009).

The LEED 2009 for Healthcare Green Building Rating System (USGBC, 2009) is a set of performance standards for certifying healthcare facilities. The intent is to promote healthy, durable, affordable, and environmentally sound practices in building design and construction. The rating system addresses seven topics including sustainable sites (SS), water efficiency (WE), energy and atmosphere (EA), materials and resources (MR), indoor environmental quality (IEQ), innovation in design (ID) and regional priority (RP). There are several prerequisites and credits under each topic. To earn LEED certification, the healthcare facility must satisfy all the prerequisites and quality for a minimum number of points. The LEED 2009 for Healthcare Project Checklist is summarized in Table 1.

Table 1 LEED 2009 for Healthcare Project Checklist

Categories	Items
Sustainable Sites	Construction Activity Pollution Prevention
	Environmental Site Assessment
	Site Selection
	Development Density and Community Connectivity
	Brownfield Redevelopment
	Alternative Transportation
	Site Development
	Stormwater Design
	Heat Island Effect-Roof
	Light Pollution Reduction
	Connection to the Natural World
Water Efficiency	Water Use Reduction
	Minimize Potable Water Use for Cooling
	Water Efficient Landscaping
Energy and Atmosphere	Fundamental Commissioning of Building Energy Systems
	Minimum Energy Performance
	Fundamental Refrigerant Management
	Optimize Energy Performance
	On-site Renewable Energy
	Green Power
	Community Contaminant Prevention – Airborne Releases
Materials and Resources	Storage and Collection of Recyclables
	PBT Source Reduction – Mercury
	Building Reuse
	Construction Waste Management

Table 1 (Continued)

	Sustainably Sourced Materials and Products
	Furniture and Medical Furnishings
	Resource Use – Design for Flexibility
Indoor Environmental Quality	Outdoor Air Delivery Monitoring
	Acoustic Environment
	Low-Emitting Materials
	Indoor Chemical and Pollutant Source Control
	Lighting
	Thermal Comfort
	Daylight and Views
Innovation in Design	Integrated Project Planning and Design
	Innovation in Design
	LEED Accredited Professional

Because they are in use night and day, with a high need for frequent air changes and a large amount of equipment, hospitals consume a lot of energy. Energy-saving techniques therefore are key characteristics for LEED healthcare facilities, including exterior sunshades to reduce heat loads, insulated glazing, highly reflective roofs, energy-conserving light fixtures, and high-efficiency HVAC systems (Bristol, 2007). Solar panels are becoming more popular to reduce the consumption of electricity.

LEED healthcare facilities are usually designed to maximize the use of daylight for interior spaces. Exposure to natural light has been shown to reduce depression among patients, minimize pain, shorten hospital stays, improve the ability to perform visual tasks, and enhance sleep (Boyce, 1998; Collins, 1993; Hua *et al.*, 2010). Glares and solar heat gain are the issues need to be taken care of in the lighting design.

More efficient ventilation system is another feature commonly adopted in LEED healthcare facilities. It allows the installation of a smaller HVAC system, keeping air fresh while lowering energy use (Southerst, 2002). With the highly efficient ventilation systems, air quality can still be compromised by the materials used for the interior (Bristol, 2007). LEED healthcare facilities usually use low emission low toxic paints, carpets, finishes, adhesives, and sealants to ensure a better indoor air quality.

As mentioned earlier, medical waste is one of the most significant pollutants produced by healthcare facilities (Zajac, 2007). LEED healthcare facilities deal with this issue by using green supplies and materials to reduce the amount of waste, and by recycling non-hazardous solid waste such as paper and cardboard.

Other than the categories described above, LEED for Healthcare Rating System also gives credits for any innovative design to reduce the consumption of energy and

other resources, and to reduce the negative impact of healthcare practices on the environment.

This study focused on the impact of these green design features on the staff's perception of comfort and satisfaction toward their workplace. The items to be included in the investigation are summarized in Table 2.

Table 2 Items that were studied in this study

Category	Item
Building design	Hospital Layout
	Wayfinding and signing system
Materials	Materials & colors of the carpet, wall, floor, and furniture
Indoor Environmental Quality	Lighting
	Acoustics
	Ventilation system
	Temperature
	Humidity
Connection with nature	Indoor natural settings
	Outdoor Lounge

2.5 Summary

Previous results show clear evidence that indoor environment quality influences occupant comfort and satisfaction in the healthcare environment. In a survey conducted by the American Society of Interior Designers, 90% of respondents believe that

improvements in building design can increase occupant satisfaction level (Wheeler, 1998). Comfort was identified to be one of the key factors related to worker satisfaction. Compared to conventional buildings, green buildings address a number of critical indoor environmental aspects such as air quality, noise, lighting, and contact with nature. Proponents of green design such as Browning and Romm (1995) support that these green technologies and design strategies will enhance interior environmental quality by making green buildings more comfortable and productive than buildings that use standard practices. A more recent study conducted in Europe observed clear difference of perceived comfort in between low and high energy buildings, which suggested that it's possible to design buildings that are healthy, comfortable and at the same time energy efficient (Roulet *et al.*, 2006). However, there is still little empirical evidence to support this belief. In the context of healthcare facilities, the empirical evidence is even more sparse and weak.

Chapter 3 Methods

3.1 Conceptual Framework

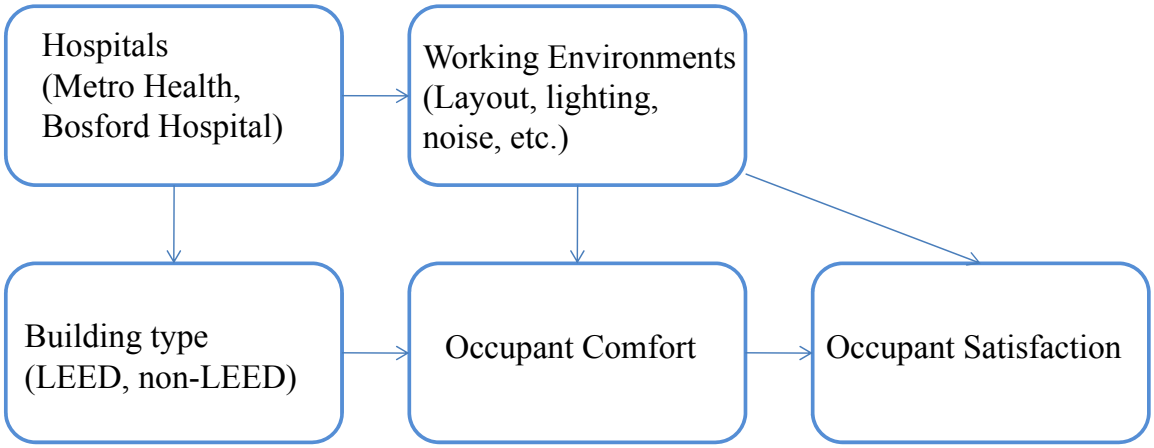

Figure 3.1 Causal diagram showing the effect of building type on occupant comfort and productivity

The causal model adopted in this study can be summarized in the diagram shown in Figure 3.1. This model is developed according to Edwin A. Locke's Range of Affect Theory (Locke, 1976). This theory considers satisfaction as determined by a discrepancy between what one wants in a job and what one has in a job.

Based on this model, different types of building design (LEED vs. non-LEED) give rise to differences in various working conditions such as hospital layout, lighting, and noise (As shown in Figure 3.1) By comparing what one expects and what the workplace offers, the occupants form perceptions of comfort toward their workplace. This occupants' perception of comfort then influences significantly their satisfaction toward the workplace. There is no direct relation between building types and occupant satisfaction, but there is a relationship expected between working environments and occupant satisfaction. This study will thus verify these hypothetical relationships.

3.2 Research Targets

To explore the relationships between working environments, either LEED - or non-LEED , and healthcare occupants' satisfaction and comfort, two types of healthcare facilities were targeted. Data were collected from the staffs from these two types. Due to the response number, this study included three hospitals: two LEED-certified hospitals (Metro Health and Botsford Cancer Center) and one non-LEED-certified hospital (Botsford Hospital main campus).

3.2.1 LEED Hospitals

1) Metro Health Hospital

Metro Health hospital is located at 5900 Byron Center Avenue in Wyoming in Michigan. The information on this hospital is based on the Metro Hospital website. It can be dated back to 1942 when a small group of osteopathic physicians committed their personal resources to build a 28-bed hospital dedicated to holistic and patient-centered care. The current advanced 208-bed medical center was open in 2007, sitting in the center of the 170-acre Metro Health Village. It's certified by LEED (certified) from the U.S. Green Building Council in 2009.

A number of green features are incorporated in the design of Metro Health hospital.

1. Water-saving features. Water-conserving fixtures, including waterless urinals and low-flow faucets are adopted to reduce the use of water. A microfiber mop system is used which cuts annual water use by 43,000 gallons and leads to a 90 percent reduction in chemical use.

Figure 3.2 Water-saving flush in Metro Health Hospital. For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this thesis.

2. Low emission materials & chemicals. Fabrics, furniture, paints, adhesives, sealants and carpets with low volatile organic compounds (VOCs) and low emissions are used to help maintain indoor air quality. Housekeeping chemicals are switched to Green Seal cleaning agents. All medical equipment containing mercury is eliminated. An Environmental Management System (EMS) is developed to identify and eliminate the use of harmful chemicals.

Figure 3.3 The interior of Metro Health uses low emission materials and paints.

3. Eco-friendly materials. Environmental friendly cups, compostable plates and glasses –known as bioware- are used in the cafeteria.

Figure 3.4 Eco-friendly plates in the cafeteria in Metro Health

4. Lighting. Motion-sensitive lights and the incorporation of natural light conserve energy.

Figure 3.5 Cafeteria in Metro Health showing the use of natural light

5. Medical waste reduction. Recycling programs for a wide variety of products including computers, paper, light bulbs, cardboard, X-ray film and batteries are established. Reusable needle box containers are used which reduced the annual medical waste by 7.8 tons.
6. Vegetation. A landscape plan that incorporates native and adaptive vegetation to reduce chemical inputs and irrigation requirements.
7. Rain gardens. These gardens (See Figure 3.6) filter pollutants from storm water runoff. Rain gardens are bio-retention systems that allow water to filter into the ground on-site so that it doesn't contribute to storm water runoff. Increased infiltration of water helps remove contaminates such as oil, grease,

and nutrients. It also reduces the volume of water flowing overland that will eventually enter a nearby stream, ditch, or storm sewer system.

Figure 3.6 Metro Hospital rain garden

8. Green Roof. Instead of a traditional roof, the 48,000-square-foot roof of the hospital's main building is covered by living plants (see Figure 3.7), which requires less maintenance, provides greater insulation and offers a more therapeutic environment for patients.

Figure 3.7 Green roof on the main building of Metro Hospital.

Most of the patient rooms have a view of the roof and its vegetation, which changes with season. The plants selected can grow in just four inches of soil with no need for irrigation. They are drought resistant and also hold onto and store water. It's believed this green roof design could enhance human healing, improve air quality, minimize storm water runoff and cool down surrounding air.

9. Outdoor Lounge. An outdoor lounge that provides access to restorative and calming nature views which helps reduce stress.

Figure 3.8 Metro hospital outdoor lounge

2) Botsford Cancer Center (Green hospital)

The 30,000 square-foot 80-bed botsford cancer center is located on the north side of Grand River in Farmington Hills, MI, opened in January 2009. It's the first cancer center in Michigan by LEED (silver) (see Figure 3.9). Sustainability is achieved in a number of areas described below.

1. Open space. Landscaped open space consists more than 20% of the site.
2. Water management. Portable water use has been reduced by 28.7% by installing low-flow lavatories, kitchen sinks and exam sinks as well as dual-flush toilets. Stormwater management systems help to reduce stormwater runoff by 25%. Parking lot rainwater runoff is filtered before it goes into the sewer.

Figure 3.9 Rain garden in Botsford Cancer Center

3. Materials and resources. 21.3% of the building materials were manufactured using recycled substances. More than 20% of the building materials were comprised of components extracted, harvested, recovered or manufactured within 500 miles of the site. 95.79% of wood-based building materials were harvested in a socially and environmentally responsible manner. The whole construction project diverted 797.36 tons, or 86.7%, of onsite-generated construction waste from being dumped into a landfill.

Figure 3.10 Eco-friendly Building Materials are used in Botsford Cancer Center

4. Lighting. The lighting design in the entire site reduces light pollution significantly. The exterior lights are aimed down, limiting light shining into the sky. Natural light is maximized for interior spaces. Daylight is known to positively impact mood and productivity as well as save energy.

Figure 3.11 Natural lighting is maximized for interior spaces in Botsford Cancer Center

5. Energy. The heating system design reduces energy use by 21.5%。
6. Indoor environmental quality. The minimum oxygenated air quantities supplied to the site's HVAC equipment exceeds LEED's requirement. Prior to building occupancy, an air filtration system was installed, capturing about 80% of 1-micron particles at maximum dust loading. The products used in constructing the site including indoor adhesives and sealants, indoor paint and coating products, carpet systems, and indoor composite wood and fiber materials contains a very limited amount of volatile organic compounds. The cancer center is designed to maintain indoor comfort-temperature and humidity-within established ranges.
7. Healing garden. The healing garden gives patients, staff and visitors an outdoor space of respite to help them reconnect with the natural world.

Adjacent to the cancer center, the garden provides shaded seating areas that are wheelchair accessible, and is part of Botsford hospital's tobacco free campus.

Figure 3.12 Healing garden in Botsford cancer center

3.2.2 Conventional Non-LEED Hospital

1) Botsford Hospital

Botsford hospital main campus is located on Grand River Avenue in Farmington Hills, founded in 1965. It's a 330-bed health care facility serving communities in the southeast Michigan area. In 2009, there were totally around 2,500 employees including more than 600 medical staff.

Figure 3.13 Botsford hospital-main campus

In this hospital, no energy-saving or water-saving features are implemented. Conventional HVAC systems are installed to provide ventilation and to regulate indoor temperature and humidity. Artificial lighting is mainly used in all buildings with limited introduction of natural lighting. There is no rain garden or outdoor lounge in this campus. Additional information is not available because the hospital administration prohibited the investigator from taking photographs of the interior of the facility.

3.2.3 Climate

All the three campuses are located in Michigan, with similar latitude and elevation. All data were collected between November and February when it's winter in Michigan. According to the data from weather.com, the average maximum/minimum temperatures are the same for Farmington, MI and Wyoming, MI in these months: 8°C/-1°C (Nov); 1°C/-6°C (Dec); -1°C/-9°C (Jan); 1°C/-8°C (Feb). The average precipitation levels in these months for the two locations are also very similar. These weather similarities for the three hospitals studied rule out the possibility that the difference in the staff perceptions toward the working environments is due to the difference in the weather.

3.3 Survey Participants

The target population is the employees in three hospitals. Subjects were assigned to a building type (LEED or non-LEED) according to the type of hospital they were associated with at the time of study.

3.4 Data collection

This research is designed to be a quantitative study using surveys collected by purposive sampling according to the related hospitals. The IRB application was approved in September from Michigan State University. Data collection started in October. For the Botsford cancer center, questionnaires were distributed and collected at the end of the weekly staff meetings. For the Metro Health Hospital, a booth was set up with signs and introductions for the research. Responsess were collected from the staffs stopping by the booth. For Botsford Hospital main campus, questionnaires were

distributed and collected with the help of the human resource departments.

The questionnaire was accompanied with a cover letter explaining the purpose of the study and the need for honest responses. A consent form for participation was also attached. Responses to the questionnaire were voluntary and anonymous. There is no way to link a questionnaire to a specific respondent. All information collected will be kept private in locked file cabinets for five years after use.

This study adopted purposive sampling. A total of 20 responses were collected from Botsford Cancer Center, 34 responses were collected from Metro Health Hospital and 25 responses were collected from Botsford Hospital (main campus). Responses from the first two hospitals are grouped together to result in a total of 54 responses for green hospitals. The respondents and nonrespondents are assumed to be similar in the way they perceive comfort and satisfaction, so that the respondents fairly represent the entire population of the employees.

3.5 Instrumentation

The questionnaire was developed based on the previous research related to the occupant comfort and satisfaction in the work environment (Heerwagen, 2000; Lee *et al.*, 2008; Paul, 2008; Veitch *et al.*, 1998) and employee satisfaction questionnaire developed by Gastle (2006). In these previous studies on occupant work satisfaction, indoor air quality, lighting, thermal comfort, noise, connection with nature were used as primary items as presented in Table 3.

Table 3 Items in the previous studies to measure work satisfaction

Authors/Year	Items to measure work satisfaction
Heerwagen, J. H. 2000	Connection with nature; Lighting; Ventilation; Indoor air quality; Thermal comfort;
Lee, Y. S. & Kim, S. K. 2008	Layout; Furnishing quality; Thermal comfort; Indoor air quality; Lighting; Acoustics; Cleanliness & maintenance.
Paul, W. L. & Taylor, P. A.	Aesthetics; Lighting; Ventilation; Temperature; Noise; Humidity.
Veitch, J. A. & Newsham, G. R.	Aesthetic; Color; Lighting; Stress

Based on those studies, this study developed a questionnaire to measure perceived comfort and satisfaction of healthcare staffs which consists of four sections. Please see Appendix for the full questionnaire. Part 1 asks questions about the general information of the participants including age, gender, type of work and years worked. Part 2 asks the participants to rate their perception of the working conditions with regard to comfort on a 7-point scale, including hospital layout, wayfinding and signing system, materials and color, lighting, noise, ventilation, indoor natural settings, temperature, humidity, and outdoor lounge. Part 3 asks the participants seven questions about their perceived satisfaction. Part 4 asks a series of open questions which may reveal some important facts.

Table 4 Contents of the Questionnaire

Section	Items	Scale
Demographic Characteristics	Gender	Categorical
	Age	
	Type of Work	
	Years worked	
Perceptions of Working Environments	Hospital Layout	Nominal From very comfortable (+7) to very uncomfortable (+1)
	Wayfinding	
	Materials & Colors	
	Lighting	
	Noise	
	Ventilation	
	Indoor Natural Settings	
	Temperature	
	Humidity	
	Outdoor Lounge	
Satisfaction toward the workplace	Happy to Work	Nominal From very comfortable (+7) to very uncomfortable (+1)
	Like the Job	
	Department is well organized	
	Adequate Safety & Health Standard	
	Adequate Balance between Work and Personal Life	
	Overall satisfaction	

3.6 **Data analysis plan**

Data analysis is performed using SPSS 16.0. Questionnaire data is first coded into the format SPSS could recognize and analyze.

First, descriptive analysis was performed for the demographic and socioeconomic characteristics of the respondents including gender, age, type of work, years worked. Counts and frequencies for each categories and total numbers were calculated and summarized.

1) A comparison of occupant comfort perception between building types

There were 10 categories on Part 2 of the questionnaire designed to measure various aspects of perceived comfort. The mean for each category was calculated for LEED and non-LEED-certified hospitals and was compared using one-way ANOVA test. The purpose of this test was to see if there is indeed significant difference in each of the perceived comfort category between different building types. In other words, this test examined if the perceived comfort was associated with building types.

ANOVA, standing for analysis of variance, is used for a categorical independent variable (with two or more categories) and a normally distributed interval dependent variable. It assumes that the sampled populations are normally distributed. For one-way ANOVA tests, this study has hypotheses below.

Null hypothesis: The means among the respondents in two types of healthcare facilities are equal.

Alternative hypothesis: The means among the respondents in two types of healthcare facilities are not equal.

One-way ANOVA test calculates the p-value, and compares it with a significance level (usually choose 0.05 for 2-tailed test). If the p-value is smaller than the significance level, the null hypothesis is rejected which indicates a significant different between the means among the groups (NIST). Here in this study, the categorical

independent variable is the building type and the interval dependent variables are each of the 10 comfort categories.

2) A comparison of occupant satisfaction between building types

There were 7 questions on Part 3 of the questionnaire evaluating the occupant satisfaction from different perspectives instead of one general question (see Table 4). The mean for each question was calculated and compared for different building types using ANOVA test. Because the staff satisfaction toward the working environment could be influenced by factors other than the building types such as workload, type of work, and interpersonal relationship, these questions could help identify the satisfaction related to building types from those which are not. Then the responses for those satisfaction questions showing clear difference between green and non-green hospitals were summed and averaged to result in a new overall satisfaction parameter labeled as 'Caver'. The purpose of this test is to see if the overall perceived satisfaction was associated with building types.

3) Correlation between perceived comfort and overall satisfaction

Statistical relationship between overall satisfaction (*Caver*) and 10 comfort categories (B1-B10) were calculated for both green and conventional hospitals using Pearson Correlation Coefficients. The comfort categories that influence perceived satisfaction were identified.

Correlation refers to any departure of two or more random variables from independence, but most commonly refers to a more specialized type of relationship between mean values. It's useful for identifying the relationship between two or more

normally distributed interval variables. Pearson correlation is one of the most commonly used correlations, which is sensitive to a linear relationship between two variables (Howell, 2002). It's obtained by dividing the covariance of the two variables by the product of their standard deviations. It assumes that data is on a continuous scale and the values are normally distributed.

For Pearson correlation test, this study tested a null hypothesis below.

Null hypothesis: There is no correlation between each comfort category and overall satisfaction.

Alternative hypothesis: There is correlation between each comfort category and overall satisfaction.

When the p-value is less than 0.05, the null hypothesis is rejected which means there is significant correlation between perceived comfort categories and overall satisfaction.

4) The direct effect of perceived comfort categories on overall satisfaction

From the analysis described in 3), comfort categories correlated with overall satisfaction were identified. A simple linear regression was then performed to determine the degree of the effect for each comfort category on overall satisfaction. Simple linear regression fits a straight line through the set of *n* points in such a way that makes the sum of squared residuals of the model. The analysis in SPSS calculates a linear regression coefficient. A more positive coefficient indicates a stronger positive (increasing) linear relationship while a more negative coefficient indicates a stronger negative (decreasing) linear relationship. A coefficient of 0 indicates absolutely no relationship (Draper, 1998). The linear regression test also provided a significance test

which indicates whether the calculated coefficient significantly differ from zero. For example, although a linear regression test gives a positive coefficient, the 2-tailed p-value could be higher than 0.05 which means the error of the coefficient is comparable or larger than the coefficient itself so the coefficient is not significantly different from zero. This means there is no significant correlation between two variables.

Chapter 4 Results

4.1 Demographic and socioeconomic characteristics of respondents

4.1.1 Gender

The gender distribution of the respondents for two building types is shown in Table 5 below. In LEED-certified hospitals, 31.5% of the respondents were male. In non-LEED-certified hospitals, the number of male responses was smaller (= 8.0%).

Table 5 Gender distribution of the respondents

Hospital/type	Gender				Total	
	Female		Male			
	Freq	%	Freq	%	Freq	%
LEED	37	68.5%	17	31.5%	54	100%
Non-LEED	23	92.0%	2	8.0%	25	100%
Total	60	100%	19	100%	79	100%

4.1.2 Age

The age distribution of the participants is shown in Table 6 below. As can be seen from the data, all of the participants from the non-LEED-certified hospital were older than 40. In contrast, significantly more young staffs worked in the green hospitals.

Table 6 Age distribution of the respondents

Hospital /type	Age			Total
	Under 40	41-60	Over 60	
LEED	27	23	4	54
Non-LEED	0	23	2	25
Total	27	46	6	79

4.1.3 Job type

The summary of the job type distribution is shown in Table 7 below. The job type of "others" includes the healthcare staffs other than doctors, nurses or administrators, including surgical support staff, nutritionist, physical therapist and so on.

Table 7 Job type distribution of the respondents

Hospital /type	Job type				Total
	Doctor	Nurse	Nutritionist, Therapist, etc.	Administrator	
LEED	3	9	36	6	54
Non-LEED	0	20	2	3	25
Total	3	29	38	9	79

4.2 A comparison of occupant comfort perception between building types

Part 2 of the survey posted 10 questions to the participants concerning their perceptions of the comfort within their workplace. The respondents assess each of the categories on a 7-point scale, from least comfortable (score=1) to most comfortable (score=7). All the respondents completed this section so the sample sizes were 54 for LEED-certified hospitals and 25 for non-LEED-certified hospitals.

The means and the standard deviations for each comfort categories are shown in

Table 8 for LEED and non-LEED-certified hospitals. The comparison can be demonstrated more clearly with the profile plot shown in Figure 4.1. All the means for LEED-certified hospitals are higher than neutral (score=4) while most of the means for non-LEED-certified hospitals are equal to or less than neutral. Only *lighting* and *indoor natural settings* were rated higher than neutral among non-LEED occupants. *Noise* and *temperature* were the categories rated lowest by the occupants from both hospital types comparing to other categories. However, occupants from LEED-certified hospitals rated these two categories higher than those from non-LEED-certified hospitals.

Considering the variations of the responses, the difference in the means doesn't necessarily indicate the statistical difference. ANOVA tests were conducted to confirm whether there is significant statistical difference between the responses from two hospital types. The computed p-values for each question were shown in the last column of Table 8. As can be seen from the data, p-values for all 10 categories were less than 0.001, which means the null hypothesis that the means among two or more groups are equal was rejected. In other words, occupants from LEED and non-LEED-certified hospitals differed principally for all the examined comfort categories.

Table 8 Means and p-values for each comfort categories between LEED and non-LEED-certified hospitals

Comfort category	Items	LEED	Non-LEED	F-Value	P-value
Layout	Mean	**5.72**	**3.92**	**33.739**	**< 0.001**
	Std. deviation	1.204	1.441		
Wayfinding	Mean	**5.61**	**3.88**	**31.426**	**< 0.001**
	Std. deviation	0.979	1.764		
Materials, colors	Mean	**6.24**	**3.92**	**91.195**	**< 0.001**
	Std. deviation	0.845	1.288		
Lighting	Mean	**6.31**	**4.36**	**74.593**	**< 0.001**
	Std. deviation	0.722	1.287		
Noise	Mean	**5.54**	**3.16**	**55.991**	**< 0.001**
	Std. deviation	1.145	1.625		
Ventilation	Mean	**5.72**	**3.44**	**47.929**	**< 0.001**
	Std. deviation	1.188	1.685		
Indoor natural settings	Mean	**6.07**	**4.76**	**16.675**	**< 0.001**
	Std. deviation	0.988	1.877		
Temperature	Mean	**4.94**	**2.84**	**33.842**	**< 0.001**
	Std. deviation	1.472	1.546		
Humidity	Mean	**5.81**	**3.60**	**46.723**	**< 0.001**
	Std. deviation	1.117	1.732		
Outdoor Lounge	Mean	**6.20**	**2.92**	**95.479**	**< 0.001**
	Std. deviation	1.188	1.754		

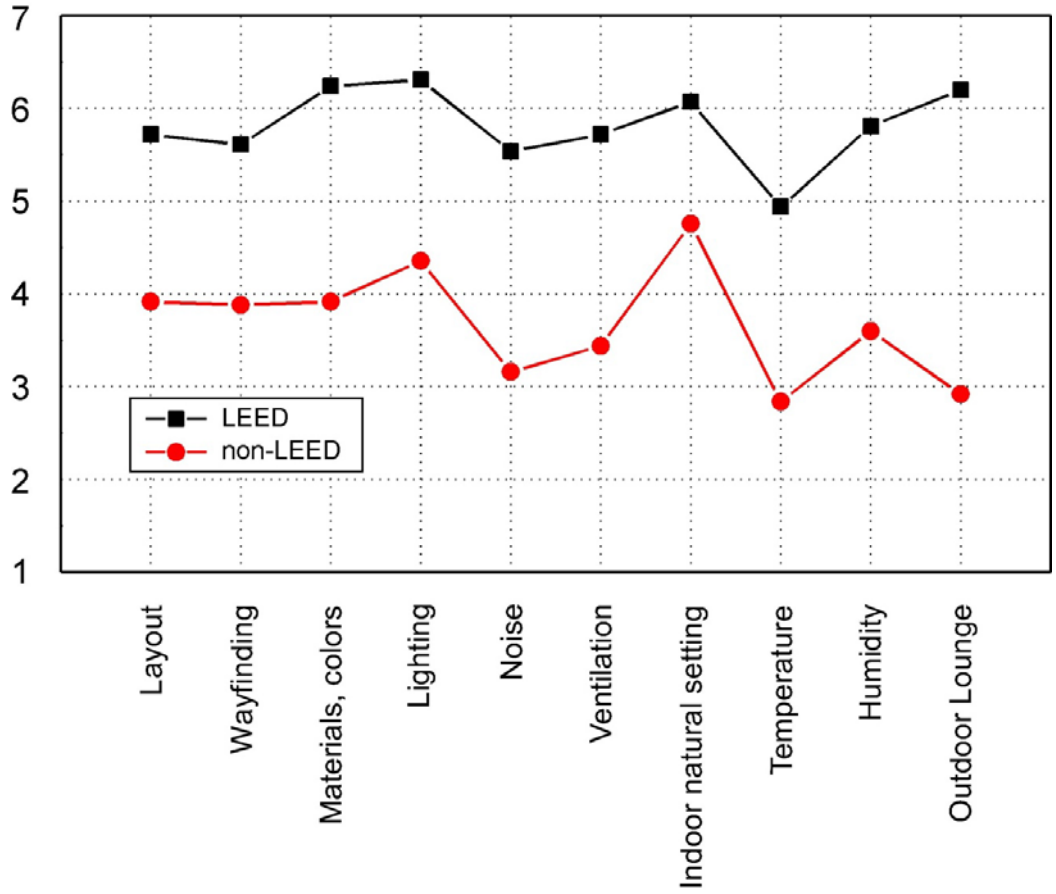

Figure 4.1 Profile plot of mean responses for 10 comfort questions for LEED (Black) and non-LEED-certified hospitals (Red).

4.3 A comparison of occupant satisfaction between building types

This research investigated the occupants' satisfaction toward their workplace with seven questions. The means as well as the standard deviation for each of the questions were presented in Table 9. A profile plot was also presented in Figure 4.2 to show the difference in the means more clearly.

To test the statistical difference in the responses from two hospital types, ANOVA test was performed and the computed p-values for each question were shown in the last column in Table 9. As can be seen from the results, three questions including *"Happy to work", "Adequate personal space", and "Excellent to work compared to other hospitals"* have p-values less than 0.05 and two questions including *"Adequate safety and health standards" and "Balance between work and personal life"* have p-values less than 0.001. All these five questions showed statistical difference among the respondents from two hospital types. The other two questions including "*like the job*" and *"department is well organized"* have p-values higher than 0.005, which indicates there was no significant difference for these two questions between respondents from two hospital types thus they were irrelevant for the topic we are interested in this study.

According to this analysis, a new variable-overall satisfaction or "*Caver*"-was computed by averaging the scores of the five relevant questions. *Caver* was then used as satisfaction perception for all the discussions beyond this point.

Table 9 Means and p-values for each satisfaction question between LEED and non-LEED-certified hospitals

Satisfaction questions	Item	LEED	Non-LEED	F-Value	P-value
Happy to work	Mean	**6.43**	**6.00**	**4.032**	**0.048**
	Std. deviation	**0.71**	**1.15**		
Like the job	Mean	**6.56**	**6.24**	**2.051**	**0.156**
	Std. deviation	**0.71**	**1.23**		
Department is well organized	Mean	**5.96**	**5.92**	**0.028**	**0.868**
	Std. deviation	**0.93**	**1.32**		
Adequate safety & health standards	Mean	**6.30**	**5.36**	**14.977**	**0.000**
	Std. deviation	**0.79**	**1.35**		
Adequate personal space	Mean	**5.76**	**4.96**	**4.548**	**0.036**
	Std. deviation	**1.41**	**1.81**		
Balance between work and personal life	Mean	**6.11**	**4.72**	**20.808**	**0.000**
	Std. deviation	**0.83**	**1.88**		
Excellent to work	Mean	**6.39**	**5.80**	**6.828**	**0.011**
	Std. deviation	**0.85**	**1.08**		

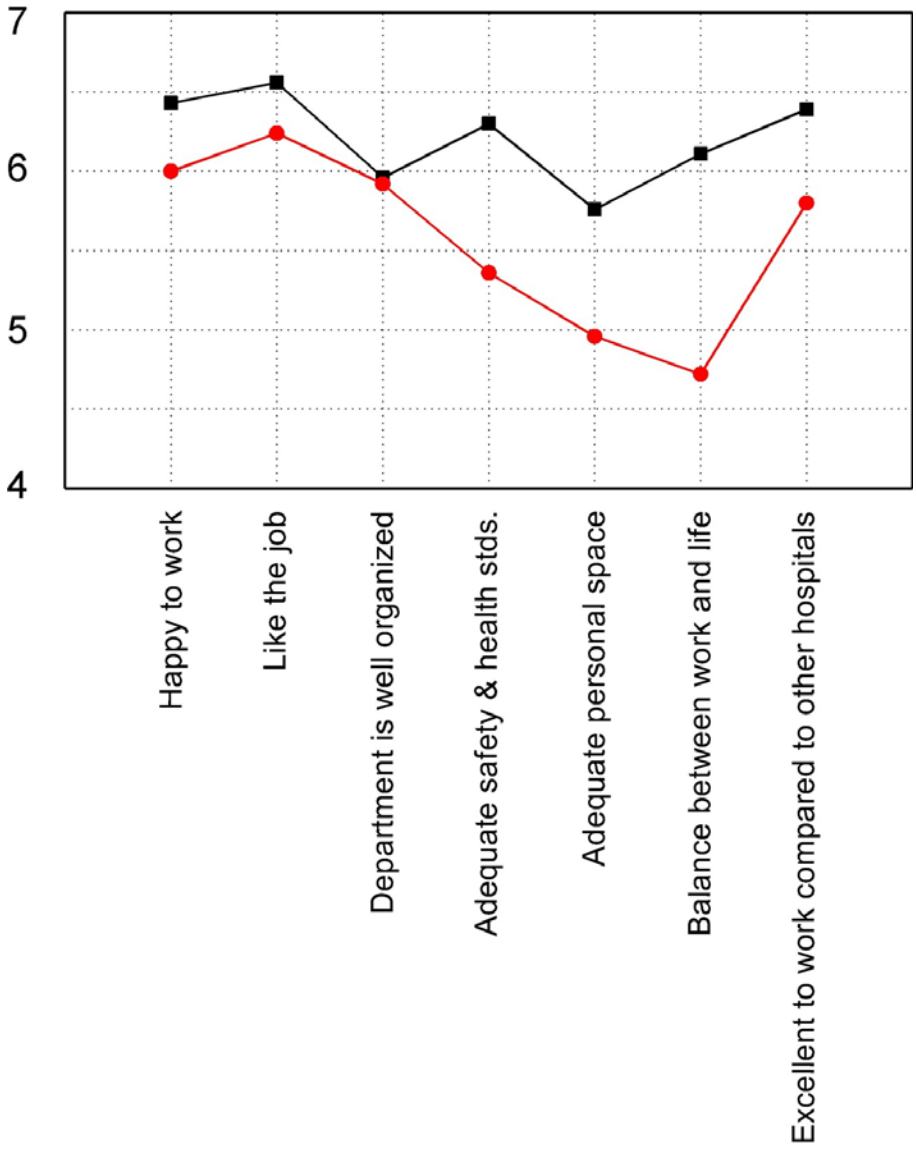

Figure 4.2 Profile plot of mean responses for 7 satisfaction questions for LEED (Black) and non-LEED-certified hospitals (Red).

4.4 Correlation between perceived comfort and overall satisfaction

Once it's confirmed there was statistical difference in the perception of comfort and satisfaction among the staffs between two hospital types, it was identified which comfort categories influenced the overall satisfaction toward their workplace and which didn't. Pearson Correlation analysis was then performed to test the correlation between each comfort category and the overall satisfaction. The computed p-values were shown in Table 10 for LEED-certified hospitals and Table 11 for non-LEED-certified hospitals.

Table 10 shows the correlation between each comfort category and the satisfaction as well as that between every two comfort categories for LEED-certified hospitals. The first line shows the correlation between each comfort category and overall satisfaction. As can be seen here, 7 comfort categories including *"hospital layout", "wayfinding", "materials and colors", "lighting", "ventilation", "indoor natural settings"*, and *"humidity"* showed higher correlation coefficient with p-values less than 0.05 which indicated positive strong correlation with overall satisfaction. On the other hand, *"noise", "temperature"*, and *"outdoor lounge"* gave p-values higher than 0.05 which indicated no significant correlation between them and overall satisfaction. In other words, in LEED-certified hospitals, the perception toward the seven comfort categories influenced their satisfaction toward their workplace significantly.

Table 11 shows the similar results as Table 10 but for non-LEED-certified hospitals. Interestingly, all 10 comfort categories showed p-values higher than 0.05 with satisfaction which means all the comfort categories were not significantly correlated with satisfaction. In other words, in non-LEED-certified hospitals, the perception of all ten investigated comfort categories didn't influence the perceived satisfaction toward

their workplace. From Table 8 we learned that all the comfort categories were rated mostly neutral by the staffs in non-LEED-certified hospitals. This might suggest the satisfaction in non-LEED-certified hospitals were more likely influenced by other factors other than comfort perception toward their workplace.

Table 10 Pearson correlation coefficients between overall satisfaction (Caver) and each comfort item for LEED-certified hospitals.

Item	Sat (Caver)	Hospital Layout	Way-finding	Material & color	Lighting	Noise	Ventilation	Indoor Natural Settings	Temperature	Humidity	Outdoor Lounge
Sat (Caver)	1.000	**.532****	**.344***	**.276***	**.354****	.109	**.531****	**.376****	.251	**.340***	.257
Hospital Layout	**.532****	1.000	**.483****	.141	.189	.097	.262	**.319***	.215	**.368****	.054
Way-finding	**.344***	**.483****	1.000	**.275***	**.363****	**.291***	.068	**.381*****	.024	.157	.151
Materials & colors	**.276***	.141	**.275***	1.000	**.461****	.117	.256	**.588****	-.050	.148	**.345***
Lighting	**.354****	.189	**.363****	**.461****	1.000	**.385****	**.434*****	**.337***	**.336***	**.378*****	.254
Noise	.109	.097	**.291***	.117	**.385*****	1.000	**.375****	.114	.052	.242	.154
Ventilation	**.531****	.262	.068	.256	**.434*****	**.375****	1.000	.243	**.315***	**.273***	.228
Indoor Natural Settings	**.376****	**.319***	**.381*****	**.588****	**.337***	.114	.243	1.000	.159	**.269***	**.437****
Temp	.251	.215	.024	-.050	**.336***	.052	**.315***	.159	1.000	**.567****	**.309***

Table 10 (continued)

Humidity	**.340***	**.368****	.157	.148	**.378*****	.242	**.273***	**.269***	**.567******	1.000	**.427*****
Outdoor Lounge	.257	.054	.151	**.345***	.254	.154	.228	**.437********	**.309***	**.427*****	1.000

The number of "*" following the correlation coefficients indicates the p-value and is defined as follows:
*: $0.01 < p < 0.05$ **: $0.005 < p < 0.01$ ***: $0.001 < p < 0.005$ ****: $p < 0.001$

Table 11 Pearson correlation coefficients between overall satisfaction (Caver) and each comfort category for non-LEED-certified hospitals.

Item	Sat (Caver)	Hospital Layout	Way-finding	Material & color	Lighting	Noise	Ventilation	Indoor Natural Settings	Temperature	Humidity	Outdoor Lounge
Sat (Caver)	1	0.112	-0.171	-0.13	0.033	-0.281	0.12	0.321	0.118	0.246	0.213
Hospital Layout	0.112	1	0.357	0.176	-0.051	0.273	0.29	0.07	0.443*	0.404	0.278
Way-finding	-0.171	0.357	1	0.454*	0.479*	0.516**	0.425*	0.381	0.497*	0.284	0.078
Materials & colors	-0.13	0.176	0.454*	1	0.32	0.484*	0.17	-0.112	0.37	0.321	0.2
Lighting	0.033	-0.051	0.479*	0.32	1	0.469*	0.577***	0.21	0.386	0.46*	0.087
Noise	-0.281	0.273	0.516**	0.484	0.469*	1	0.323	0.013	0.475*	0.32	0.034
Ventilation	0.12	0.29	0.425*	0.17	0.577***	0.323	1	0.153	0.556***	0.677****	0.308
Indoor Natural Settings	0.321	0.07	0.381	-0.112	0.21	0.013	0.153	1	-0.043	-0.044	0.133
Temperature	0.118	0.443	0.497*	0.37	0.386	0.475*	0.556***	-0.043	1	0.784****	0.164
Humidity	0.246	0.404*	0.284	0.321	0.46*	0.32	0.677****	-0.044	0.784****	1	0.318
Outdoor Lounge	0.213	0.278	0.078	0.2	0.087	0.034	0.308	0.133	0.164	0.318	1

4.5 The direct effect of perceived comfort categories on overall satisfaction

As can be seen from section 4.4, seven out of ten comfort categories were found to be significantly correlated with satisfaction among the respondents from LEED-certified hospitals. It would be also useful to rank these seven comfort categories in order to identify which categories influence the perception of satisfaction more than the others. In order to do this, simple linear regression was carried out between each comfort category and satisfaction. The regression coefficient A indicates the degree and the direction (positive or negative) of the correlation. C is the constant created by the regression. P-values were also computed which indicated whether the coefficient was significantly differ from zero.

The results are shown in Table 12. As can be seen, the p-values for noise, temperature, and outdoor lounge were larger than 0.05 indicating the coefficient for these categories did not differ from zero. This is consistent with the results shown in Table 10. These results combined all the responses from all the buildings due to the small sample size.

Table 12 Simple linear regression between overall satisfaction (Caver) and each comfort categories.

Independent Variable	Coefficient	Constant	P-value
Indoor Natural Settings	0.227[4]	4.838	**0.005**
Outdoor Lounge	0.129	5.414	0.060
Lighting	0.292[1]	4.371	**0.009**
Materials & colors	0.194[6]	5.002	**0.044**
Noise	0.057	5.901	0.434
Ventilation	0.266[2]	4.690	**0.000**
Temperature	0.101	5.713	0.068
Humidity	0.181[7]	5.159	**0.012**
Hospital Layout	0.263[3]	4.709	**0.000**
Way-finding	0.209[5]	5.040	**0.011**

Note: Dependent Variable = Overall Satisfaction

Chapter 5 Discussion

5.1 Staff perception of comfort

We measured ten aspects of comfort in this study and found that for all of the questions, the healthcare staffs from the LEED-certified hospitals rated higher or feel more comfortable than those from non-LEED-certified hospitals. Given very similar climate in all of the hospitals during the study, this evidence does support the hypothesis that green hospitals outperform conventional buildings in terms of aesthetics, serenity, lighting, ventilation, acoustics and humidity.

In LEED-certified hospitals, *hospital layout* was scored 5.72 in average. As suggested by a few studies (Shepley, 2002; Trites *et al.*, 1970), the type of unit layout (radial, single corridor, double corridor) influences amount of walking among nursing staff, and time saved from walking was translated into reduced stress and fatigue. Radial layout was found to reduce walking up to 50%, and was preferred by a majority of the staffs (Trites *et al.*, 1970). Well designed layout improves work flow and reduces medical errors, which again reduces stress (Pierce *et al.*, 1990). From Table 10, we could see that the perception towards *hospital layout* was correlated with *wayfinding* and *indoor natural settings*. This may suggest that in the LEED-certified hospitals studied, *hospital layout* design is such that it facilitates the wayfinding system and increases the chances of encountering an indoor natural setting. In the non-LEED-certified hospital, hospital layout had an average score of 3.92, almost neutral. The difference indicates a significant improvement on the layout design in the LEED-certified hospitals which was appreciated by the staffs.

In LEED-certified hospitals, *wayfinding* had an average score of 5.61. The problems of wayfinding system in hospitals were found to be costly and stressful and have particular impacts on outpatients and visitors, who are more unfamiliar with the hospital. The stress to the staffs comes from the direction for the visitors giving by them other than information staff, which occupied a significant amount of time (Zimring, 1990). Other than the *layout design* discussed previously, the perception of wayfinding by the staffs also correlated strongly with *materials & colors, lighting, noise, and indoor natural settings* as shown in Table 10. *Materials & colors and indoor natural settings* could add some coordinated elements in addition to the signage for wayfinding. For example, change in flooring material could convey the message that the individual is moving from one area into another. Better lighting should improve the visibility of the signage to the visitors and patients. And lower noise level should reduce the stress for the visitors and patients, which increases their chances of finding the correct way to their destinations using the wayfinding system rather than asking a staff. All of these could reduce the load for the staffs to answering wayfinding questions raised from visitors and patients which helps to reduce the stress for them. The average score for wayfinding in non-LEED-certified hospitals was 3.88, a little worse than neutral (=4.0), indicating a slightly negative perception toward wayfinding system in the non-LEED-certified hospital.

In LEED-certified hospitals, *materials & colors* had an average score of 6.20. The use of low toxic & low emission materials significantly reduces indoor pollutant loads thus improves indoor air quality. The color schemes used for interior design and the colors introduced by natural plants help the staffs to recover from stress. This could be

the reason of strong correlation between the perception of *materials & colors* and *outdoor lounge*. The average score of *materials & colors* was 3.92 for non-LEED-certified hospitals indicating a nearly neutral perception.

In LEED-certified hospitals, *lighting* was scored 6.31 in average, which is the highest among ten comfort categories under study. The introduction of more natural light and the green features of the artificial lighting design not only reduce the energy consumption but also are favored by the staff because they increase visual comfort and reduce glare, which could have positive effect on the mood of the staffs. The comfort lighting levels also improve staff effectiveness while performing critical tasks such as dispensing medical prescriptions. It's interesting to see from Table 10 that the perception toward *lighting* was also correlated to *noise, ventilation, temperature and humidity*. This is probably due to "spirit lifting", as suggested by Boyce (Boyce, 1998). High quality lighting eliminates distractions and discomforts, provides appropriate conditions for the context, and adds an aesthetic element which may promote emotional functioning and serve as a buffer to discomforts or stresses. The lifted spirit may then be reflected in the higher perception of the overall indoor environment. The average score of *lighting* for the non-LEED-certified hospital was 4.36, one of the highest among the ten categories; although it's significant lower than that for LEED-certified hospitals. *Lighting* in the non-LEED-certified hospital may not offend or distract the staffs, but apparently fails to lift the human spirit.

In LEED-certified hospitals, *noise* had an average score of 5.54, one of the lowest rated categories. However, it was still rated significantly higher than neutral. As discussed in numerous studies in literature, higher sound levels were perceived as

stressful. Hospitals usually are excessively noisy due to numerous noise sources including alarms, moving bedrails, telephones, trolleys, pneumatic tubes etc. In addition, the sound-reflecting surfaces as well as badly designed layout cause noise to propagate considerable distances, traveling down corridors and into staff offices. Generally several environmental interventions could be used to reduce the noise level including installing high-performance sound absorbing ceilings, adopting noiseless systems, and providing single-bed rather than multi-bed rooms. Other than *lighting* and *wayfinding* discussed previously, *noise* was also found to correlate with *ventilation*. LEED buildings were found to have worse noise level due to open plan offices and spaces than non-LEED buildings in literature (De Salis *et al.*, 2002; Edwards, 2006; Swift *et al.*, 2008). However, this is obviously not the case in the LEED-certified hospitals studied. Comparing to the average score of 3.16 in the non-LEED-certified hospital, the performance of the LEED-certified hospitals were perceived significantly better by the staffs.

For *ventilation*, the staffs in LEED-certified hospitals rated an average score of 5.72. High quality ventilation systems will reduce the viral load of the ward, reducing the chances of airborne infection for the staffs. Ventilation was found to be correlated significantly with *temperature* and *humidity* which suggests adequate ventilation could be critical for maintaining good indoor environmental quality including *temperature* and *humidity*. In the non-LEED-certified hospital, the average score for *ventilation* was only 3.44, which is worse than neutral and significantly worse than that of LEED-certified hospitals.

In LEED-certified hospitals, *temperature* had an average score of 4.94, the lowest

among the ten categories, indicating the staffs felt least comfortable in temperature comparing to other categories. However, the score was still higher than neutral and significantly higher than that from the non-LEED-certified hospital, which was 2.84 in this case. *Temperature* was also found to strongly correlate with *humidity*. This is not surprising because it was found that the perception of temperature is affected by the relative humidity (Balaras *et al.*, 2007; Wolkoff *et al.*, 2007).

Humidity was scored 5.81 in average in LEED-certified hospitals. It was rated significantly higher than that from the non-LEED-certified hospital. In the non-LEED-certified hospital, humidity had an average of 3.60, which was worse than neutral.

The *indoor natural settings* was rated 6.07 in average in LEED-certified hospitals. Many studies of populations other than hospital staffs showed strong evidence that even fairly brief encounters with real or simulated nature settings can elicit significant recovery from stress (Parsons, 2000). The result obtained in this study confirmed the same observation for the healthcare staffs. The correlation between *indoor natural settings* and *outdoor lounge* could be easily understood since they are very similar in nature. In the non-LEED-certified hospital, *indoor natural settings* had an average score of 4.76, which is the highest among the ten categories for the non-LEED-certified hospital. However, the score from the LEED-certified hospitals studied is significantly higher.

5.2 Staff perception of overall satisfaction toward the workplace

As shown in Table 9 and Figure 4.2, the staff perception of overall satisfaction was statistically higher in the LEED-certified hospitals studied than that in the non-LEED-certified hospital studied. This suggests that building type is related to the

satisfaction among healthcare staffs and green hospital design may have positive effects resulting in higher level of satisfaction.

Although the perceptions of all the ten comfort categories under study were found to show significant difference between two groups of staffs in LEED - or non-LEED-certified hospitals, according to Table 12, only seven of them (*hospital layout, wayfinding, materials and colors, lighting, ventilation, indoor natural settings*, and *humidity*) showed significant correlation with satisfaction among the staffs from LEED-certified hospitals. *Noise, temperature* and *outdoor lounge* were the three categories that showed no correlation with satisfaction which means they didn't influence the staffs' satisfaction toward their workplace. The perception of the other seven categories were found to directly influence the staff satisfaction and they were sorted by the degree of influence from higher to lower as: *lighting > ventilation > hospital layout > indoor natural settings > wayfinding > materials & colors > humidity*.

Chapter 6 Conclusion and Suggestions

This study measured perception of ten comfort categories and satisfaction of the staffs from two LEED-certified hospitals and one non-LEED-certified hospital and compared between the two hospital types, in order to answer the questions that whether the building design of the hospitals influences the occupant perception of comfort and satisfaction, and if yes, which comfort categories were responsible for the difference.

The results from this study showed that for all the ten comfort categories examined, staff from the LEED-certified hospitals studied rated higher than those from the non-LEED-certified hospital studied. Seven of the ten comfort categories were found to correlate with the satisfaction level. *Noise*, *temperature* and *outdoor lounge* were found to be irrelevant to the satisfaction level, although they perform significantly better in the LEED-certified hospitals than the non-LEED-certified hospitals examined. Direct effect was also identified between the building design of the hospitals and the occupants' satisfaction level.

6.1 Limitations of the study and suggestions for future studies

One limitation of this study, as described earlier, is the relatively small sample size. For future studies, it would be more convincing to have a larger sample size including the number of staffs participated and the number of hospitals studied.

Moreover, given that the two LEED-certified hospitals examined were built after 2000 while the non-LEED-certified hospital examined was built in 1960s, it's possible that some difference is due to the incorporation of new building design features which may be also adopted in newly built non-LEED-certified hospitals. To reach a more

convincing conclusion that LEED-certified hospital design does improve the staff perception of comfort and satisfaction, results from comparing newly built LEED-certified hospitals and newly built LEED-certified hospitals will be needed.

In addition, the research presented in this thesis did not study the impact of built environment on staff productivity which is critical for the quality of care delivered. Actually the direct relation between built environment and occupant productivity has been studied by a few researchers. For example, a research conducted in Denmark assessed the impact of a 20-year old carpet on work performance (Wargocki, 1999). Results shown that worker performed 6.5% better on a text entry task when the carpet was absent. This study is significant for showing a direct effect of air quality on performance. Menzies et al. (1997) also observed the workers' productivity was increased by 11% when the air velocity was tripled. Other than air quality and thermal factors, lighting is found to be an important contributor to work performance. Hedge et al. (Hedge, 1995) reported increased self productivity ratings with indirect lighting, while Veitch show increased objective productivity with a parabolic louver system (Veitch *et al.*, 1998). It was estimated by Fisk et al. (1997) that productivity gains from improvements of lighting can be as high as $125 billion annually. In addition, noise is found to be particularly detrimental to high level cognitive work that requires logical thinking, continuous access to working memory, and concentration (Heerwagen, 1990; Sims, 1998). There are relatively few studies conducted for healthcare staffs. It would be very valuable to provide solid data supporting the hypothesis that green design of the healthcare facilities does improve the productivity of the staffs and the quality of care they deliver.

6.2 Implications for future hospital design

The results obtained from this study suggested that the green features implemented in LEED healthcare facilities may have positive effect on the staff perception of comfort and satisfaction. For all the categories studied, staffs from the LEED-certified hospitals examined rated "comfortable" while those from the non-LEED-certified hospital examined rated mainly neutral.

In Metro Hospital, radial layout design is adopted which is known to reduce the amount of walking by the staffs. In addition, the radial design also helps to maximize the introduction of natural light into most patient rooms and offices. The better perception of the layout design by the staffs from the LEED-certified hospitals suggests that the radial layout design is beneficial and should be recommended in the future design.

Better wayfinding and signing system could reduce stress possibly because of fewer questions from the patients and visitors about the route. In the LEED-certified hospitals studied, the floor materials or the color of the carpets are different in different areas. This adds some coordinated elements in addition to the signage for wayfinding. The carpet patterns are the same throughout the entire hospital in the non-LEED hospital studied. The difference in the perception of the wayfinding system suggests the future hospital design should consider using different floor materials and/or floor colors to aid wayfinding.

Indoor environment in the LEED-certified hospitals studied is significantly better and is reflected by the higher perception of the comfort. The lighting design in the LEED-certified hospitals maximizes the introduction of natural light. This not only

saves energy, but also helps to reduce stress. In contrast, in the non-LEED-certified hospital studied, very limited natural lighting is available in the building. In Botsford Cancer Center (LEED-certified), a filtration system is installed in the ventilation system to filter 80% the particles smaller than 1 μm. And in both LEED-certified hospitals, materials and chemicals with very low emission are used. All these features significantly improve the indoor air quality and are greatly appreciated by the staffs working in the environment. In future hospital design, it would be beneficial to incorporate these features which help to provide healthier indoor environments.

Both the LEED-certified hospitals studied have a healing garden which is not found in the non-LEED-certified hospital. Healing garden not only helps the recovery of the patients but also provide an outdoor for the staffs to relax and to connect with the nature, which significantly reduces the stress and fatigue of the staffs. As indicated by the results from this study, healing gardens should definitely be incorporated in future hospital design.

Appendix

Appendix A. Questionnaire

Impact of green building design on healthcare occupants

------with a focus on healthcare staff

Previous studies have shown that indoor environmental factors such as ventilation, lighting, noise and contact with nature can influence the occupant perception of the working conditions. But it remains unclear till now that **whether a green hospital is more comfortable to work in**. Since the green healthcare design is increasingly adopted in practice, it is important to **ensure the staff needs are being addressed** and the claims of performance are warranted. This questionnaire aims to research the **impact of built environment on the comfort and satisfaction among healthcare staffs**. Your response will be used only for this research and will be coded. Your information will never be exposed.

There is no correct or wrong answers. If you honestly answer these questions based on your usual thoughts and perceptions, it will be helpful in collecting accurate data. You can voluntarily participate and answer any questions or not. You may stop at any point without any penalty.

Thank you so much for your cooperation.

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CONSENT FOR PARTICIPATION IN A RESEARCH PROJECT
MICHIGAN STATE UNIVERSITY

PI Name: **Suk-Kyung Kim, Ph.D.**
Co-PIs: **Ying Huang**
Study Title: **Impact of built environment on healthcare occupants------with a focus on healthcare staff**

You are invited to participate in a survey research study that will take approximately 15 minutes and will ask your perceptions of your building environment

This survey is for a research study entitled "**Impact of built environment on healthcare occupants------with a focus on healthcare staff**." The purpose of this survey is to investigate the impact of built environment on the comfort and satisfaction among healthcare staffs. The survey will ask you about your personal information, perceptions to your working environments, and perceptions of your satisfaction. The respondents of this survey should be healthcare staffs working in a hospital. This study will take approximately 15 minutes.

1. Risks and Benefits

There will be only minimal risk associated with the participation in this study. There is no monetary compensation for participating in this survey. But, your response is scholarly valuable because the analysis of the responses from participants including you will be analyzed for building place attachment theories.

2. Confidentiality

All information about you and your participation in this study will be confidential and your file will be kept private in locked file cabinets for the next 5 years, after which time the files will be destroyed. Published results from this study will not mention any names of participants and all associated information will be treated confidentially to the extent allowed by law. The records of this study will be kept private. No identifiers linking you to the study will be included in any sort of report that might be published. Research records will be stored securely and only Dr. Suk-Kyung Kim, and Ying Huang will have access to the records.

3. Voluntary Participation

Participation in the study is voluntary. If you agree to be in the study, but later change your mind, you may drop out at any time. Your decision whether or not to participate will not affect your current or future relations with Michigan State University. If you decide to participate, you are free to refuse to answer any of the questions that may make you uncomfortable. You are free to withdraw at any time without any penalty.

Questions

If you have any questions about this survey, please contact Dr. Suk-Kyung Kim at kimsk@msu.edu or 517-353-9367, or Ying Huang at huangyi9@msu.edu or 517-282-2468. If you have questions or concerns about your role and rights as a research participant, would like to obtain information or offer input, or would like to register a complaint about this study, you may contact, anonymously if you wish, the Michigan State University's Human Research Protection Program at 517-355-2180, Fax 517-432-4503, or e-mail irb@msu.edu or regular mail at 202 Olds Hall, MSU, East Lansing, MI 48824.

By completing and returning this survey you are agreeing to participate in this research.

Thank you so much for your time.

Part 1: Background information

1. What is your gender?
   a) Female b) Male

2. What is your age?
   a) 20 years or under b) 21-30 years
   c) 31-40 years d) 41-50 years
   e) 51-60 years f) over 60 years

3. What is the type of your work?
   a) Doctor b) Nurse
   c) Administrator d) Other

4. Please specify the department you are working for (surgical, internal medicine, e.g.)

5. Are you working independently or with patients?

6. How long have you worked in the building? __ years ___months

Part 2: Perception of the working conditions

Please rate your working condition on each of the following scales
1 means strongly disagree and 7 means strongly agree.

1. Hospital layout is well designed: furniture are pleasant:

1	2	3	4	5	6	7

2. Wayfinding and signing system is effective:

1	2	3	4	5	6	7

3. The painting material, color and the pattern of the wall, floor and

1	2	3	4	5	6	7

1	2	3	4	5	6	7

4. The color and brightness of lighting are comfortable:

1	2	3	4	5	6	7

5. The noise level is low:

1	2	3	4	5	6	7

6. The ventilation system is effective:

1	2	3	4	5	6	7

7. Indoor natural settings and gardens help reduce stress:

1	2	3	4	5	6	7

8. I never feel too hot during the summer nor too cold during the winter in the building:

1	2	3	4	5	6	7

9. The humidity is comfortable all the time through the year:

1	2	3	4	5	6	7

10. Outdoor lounge is available and comfortable:

Part 3: Perception of your satisfaction towards your working conditions
(1 means strongly disagree, 7 means strongly agree)

1. I am happy to work in this hospital.

1	2	3	4	5	6	7

2. I like my job and the work I do.

1	2	3	4	5	6	7

3. My department is well organized for the work it does.

1	2	3	4	5	6	7

1	2	3	4	5	6	7

4. The hospital has adequate safety & health standard

1	2	3	4	5	6	7

5. I have adequate personal space working on my job.

1	2	3	4	5	6	7

6. I can keep a reasonable balance between work and personal life.

1	2	3	4	5	6	7

7. All things considered, the hospital is excellent to work compared to other hospitals you know about.

Have you worked for another non-green hospital before? If yes, please answer the following questions (1 means strongly disagree and 7 means strongly agree). If not, please go to part 4.

1. Compared to the previous hospital, hospital layout in current hospital is better.

1	2	3	4	5	6	7

2. Compared to the previous hospital, the wayfinding and signing system in the current hospital is better.

1	2	3	4	5	6	7

3. Compared to the previous hospital, the painting, color and material used in current hospital is better.

1	2	3	4	5	6	7

4. Compared to the previous hospital, in current hospital I have more room to work for my job.

1	2	3	4	5	6	7

1	2	3	4	5	6	7

5. Compared to the previous hospital, I can keep a better balance between work and personal life.

1	2	3	4	5	6	7

6. Compared to the previous hospital, the color and brightness of lighting in current hospital are better.

1	2	3	4	5	6	7

7. Compared to the previous hospital, noise in current hospital is lower.

1	2	3	4	5	6	7

8. Compared to the previous hospital, ventilation in current hospital is more effective.

1	2	3	4	5	6	7

9. Compared to the previous hospital, temperature in current hospital is more comfortable throughout the year.

1	2	3	4	5	6	7

10. Compared to the previous hospital, humidity in current hospital is more comfortable.

Part 4: Open questions

11. Describe any changes to your workplace that would make you feel more comfortable.

_____

_____

_____

12. Describe any suggestions to improve the work environment in your hospital.

_____

_____

_____

13. What is it that you are not comfortable with in you job right now?

_____

_____

_____

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