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An Evidence Based Design Guide for Interior Designers

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AN EVIDENCE BASED DESIGN GUIDE FOR INTERIOR DESIGNERS

by

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AN EVIDENCE BASED DESIGN GUIDE FOR INTERIOR DESIGNERS

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The intent of this thesis is to provide an introductory guide for interior designers wishing to conduct research on various aspects of the built environment. It is tailored toward designers working in the healthcare field, but the concepts discussed can be translated into any realm of interior design or architecture.

Research is important to the profession and should play a role in every design project, particularly in the healthcare market. Credible design research will continue to elevate the profession and strengthen the credibility of design practitioners and firms who can successfully conduct a research program. Among the key areas of challenge are the gap between the producers of scientific evidence and its intended consumers and the lack of standardized terms, definitions, metrics, and measurement tools that are commonly accepted and understood by designers. (Debajyoti 2011) These factors combined result in difficulty translating research findings into design knowledge, difficulty developing a centralized evidence base for design, and difficulty making informed predictions based on research findings.

It is hoped that the resulting guidelines for designers be straightforward enough to apply to interior design practice without sacrificing the elements essential for the thorough scientific evaluation of evidence.

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Introduction

Research into the impact of the healthcare environment on healthcare outcomes has been growing rapidly in recent years. Many scientific studies have collected empirical evidence demonstrating connections between the environmental design of healthcare facilities and outcomes that are important for patients, families, healthcare staff, and healthcare organizations (Ulrich, et al. 2008). As a result, there is a growing understanding that an appropriately designed built environment can help to improve patient outcomes and create a safe, nurturing, and positive work environment for caregivers. (Goertz, et al. 2008)

The Center for Health Design defines evidence-based design as the process of basing decisions about the built environment on credible research to achieve the best possible outcomes. (The Center for Health Design 2008) The current definition spans numerous disciplines, including architecture, medicine, interior design, landscape design, facilities management, and nursing. In order to further promote the development, translation, and use of EBD research to impact healthcare outcomes, it is necessary to break down the components of EBD into individual frameworks within which practitioners of each discipline can operate.

According to Zborowsky, our challenge as designers is to discover frameworks to help identify elements that create optimal healing environments within our own communities. (Zborowsky and Kreitzer 2009) In the course of their work, investigators develop concepts, formulate hypotheses, and test their ideas within these established frameworks. During a research project, investigators carry out activities in various sequences and combinations and in various ways. This complex activity is called “research.” (Lewin 2010) Interior designers can become researchers by doing normal, everyday things in an orderly way and for a specific purpose. The orderly way to do research can be learned. The ability to develop interesting concepts – to go

beyond the information given – can also be learned but it is a creative ability to be learned as one learns a skill. (Zeisel 2006)

Meta-analyses have been conducted across a broad range of architectural EBD elements; however, no such analysis exists relating exclusively to interior design. Furthermore, despite healthcare research growing exponentially in the past several years, there has not been a collective analysis of EBD measures and studies since 2008. As a response to the gap in research, this paper seeks to address contemporary challenges in EBD exclusively as they relate to interior design.

Chapter 1

History and Current State of EBD

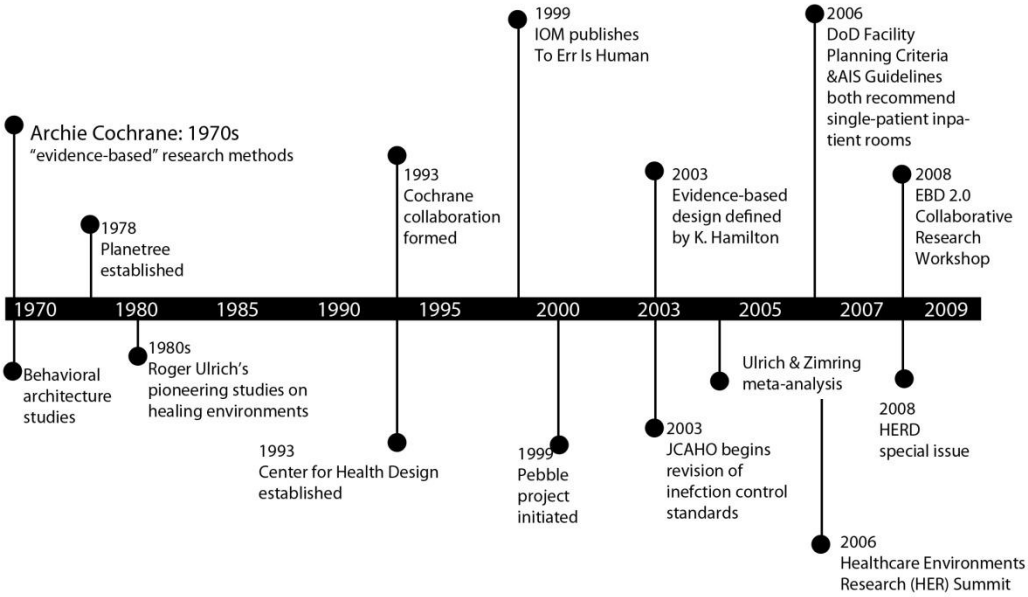


Figure 1. History and Current state of EBD (Adapted from The Center for Health Design 2008)

The Center for Health Design defines evidence-based design as the process of basing decisions about the built environment on *credible research* to achieve the best possible outcomes. (The Center for Health Design 2008) The term evidence-based design evolved from other disciplines that have used an evidence-based model to guide decisions and practices in their respective fields. Sacket, Rosenberg, Gray, Hanes & Richardson (1996) define evidence-based medicine as "the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients." The practice of evidence-based medicine means integrating individual clinical expertise with the best available evidence from systematic research. Evidence-based design is structured along the concepts of evidence-based medicine.

(The Center for Health Design 2008) Thus, the process is relatable to the medical practitioners who are often heavily involved in the EBD process.

The evidence-based design movement began in the 1970s with Archie Cochrane's book Effectiveness and Efficiency: Random Reflections on Health Services. It highlights his work to collect, codify, and disseminate the "evidence" gathered in randomized controlled trials relative to the built environment. (Debajyoti 2011) In 1984 Ulrich published his pioneering study on the effects of a natural view on patient healing. In the same year, the first Planetree hospital was constructed. (The Center for Health Design 2008) These events laid the groundwork for what has now become the discipline now known as evidence-based design.

Role of EBD in the Interior Design Profession

Designers have always intuitively known the value of design decisions on the quality of human experiences. Social and behavioral scientists have added to this a body of research that increases our understanding of how design impacts these experiences. Now it is possible to use research to answer critical questions of why this happens and how designers can improve the human experience.

Over the years, a number of approaches to the EBD process have emerged as pioneering organizations have taken this knowledge and adapted it to their unique set of circumstances. (McCullough 2010) The common thread in all of these approaches is that EBD needs to be integrated into different stages of the building design process. In order to accomplish this, the EBD process needed to be broken down into steps that could coincide with traditional design stages. Listed below are the key steps that have emerged as the EBD process according to the

Center for Health Design. Tables 1-3 identify how these steps can be incorporated into the design process.

Key evidence-based design steps:

- Define evidence-based goals and objectives
- Find sources for relevant evidence
- Critically interpret relevant evidence
- Create and innovate evidence-based design concepts
- Develop a hypothesis
- Collect baseline performance measures
- Monitor implementation of design and construction
- Measure post-occupancy performance results

Design Tasks	EBD Step	EBD Tasks
Establish interdisciplinary team	1. Define EBD goals and objectives	Documents project vision Define Desired Outcomes
	2. Find sources for relevant evidence	Establish goals that link design to outcomes Gather evidence to inform project
Visioning	3. Critically interpret evidence	Evaluate evidence Create design concepts
Functional and space programming	4. Create EBD concepts	Translate project goals to research hypothesis Collect baseline data

Table 1. Pre-Design Stage

Design Tasks	EBD Step	EBD Tasks
Conceptual Design Schematic Design Design Development Construction Documents	5. Develop hypothesis 6. Collect baseline performance measures	Create and innovate design concepts Develop hypothesis Test conceptual diagrams Construct mock-up environments Integrate EBD features into design strategy

Table 2. Design Stage

Design Tasks	EBD Step	EBD Tasks
Bidding/Negotiation Construction of Project Commissioning Move-in Post-Occupancy Evalution	7. Monitor implementation of design and construction 8. Measure POE results	Assure design intent is directly linked to EBD goals Make sure selected design intervention and hypotheses are maintained during bidding and negotiation Monitor implementation of design & construction Communicate the interface between construction & research plan to construction team Prepare for post-occupancy Verify the building complies with the intent of the research plan, design, interventions & business case (during commissioning phase)

Table 3. Construction and Occupancy

(Table Sources: Center for Health Design: EBD Guide 1)

The incorporation of these steps into practice requires the collaboration of healthcare organizations, design firms, and research experts. The EBD process requires an understanding of the healthcare delivery system, research, and the design and construction process combined. "EBD infuses these principles, goals, and expected outcomes throughout all steps of planning, designing, and operating buildings. It reflects an organization's ability to change, and a willingness to measure and confront the results of measurement". (Debajyoti 2011)

As evidence-based design is becoming more widely adopted in the interior design field, distinctions need to be made in regard to the level of investigation conducted by designers. Kirk Hamilton divided the categories of investigation into Level 1, 2, 3, and 4 Practitioners.

Level one practitioners make an effort to stay familiar with the current literature in the design field and to design based on the findings of that literature. (Hamilton, 2010) The designer translates the evidence as it related to his or her design problem and makes a judgment as to the best design for that specific condition. (Ulrich, 2008) These designers are producing work that advances the profession because they are learning from others and developing new examples for others, while delivering better designs for their clients.

Level two practitioners stay current with literature in the field, but go a step further than level one practitioners. They use the literature to hypothesize the expected outcomes of design interventions and then actually measure and record the results. (Hamilton, 2010) At this level, the designer needs to understand the research, translate its results, and connect the design decision to a measurable outcome. This process helps to reduce the amount of uninformed design decisions and provides solutions linked to measureable evidence-based outcomes.

What distinguishes level three practitioners from other practitioners is that they report their results in the public arena. (Hamilton, 2010) There are various ways this can be accomplished, including speaking at conferences and seminars, publishing work, or lecturing at universities. In addition to sharing knowledge, these techniques also subject the designer's methods to the scrutiny of others. This contributes to the level of rigor and reliability in the research process and opens the discussion for alternate views and opinions on the subject at hand.

Level four practitioners engage in all of the activities discussed in previous levels, but take another step by publishing in peer-reviewed scholarly journals. (Hamilton, 2010) They may also collaborate with researchers in academic settings or other fields of study. These practitioners are designing and building healthcare facilities, while also advancing evidence-based design literature and standards.

Hamilton also states that there are "level zero practitioners," individuals who grasp the concept that the environment has an effect on those who are in it and that there is evidence to support various conclusions about those effects. However, these practitioners rarely engage in literature searches or evidence-based design practices. Hamilton also notes that inexperienced practitioners will find it difficult to make the leap from data about clinical conditions to the successful design of a patient room or visitor facility. (Hamilton, 2010) Thus, it is important that an interdisciplinary team is consulted before evidence-based conclusions are drawn.

Chapter 2

The Evidence-Based Design Process Overview

Interior designers often focus on visual media to understand space and a majority of their efforts are spent designing buildings. (Goertz, et al. 2008) This contributes to why few designers write articles and why there has been only a modest volume of literature specific to healthcare architecture. There is, however, a growing body of literature from interior designers regarding healthcare design. Ulrich claims that "the state of knowledge of evidence-based healthcare design has grown rapidly in recent years. The evidence indicates that well-designed physical settings play an important role in making hospitals safer and more healing patients, and better places for staff to work." (Ulrich, 2008) The challenge for practicing designers lies in their ability to distinguish evidence based design concepts from non-research based ideals, as well as to develop the tools to translate these concepts into their work.

Again, the Center for Health Design defines evidence based design as the process of basing decisions about the built environment on credible research to achieve the best possible outcomes. (The Center for Health Design 2008) The author has further developed the 8 EBD steps and definitions of their processes based on the guidelines set forth by the Center for Health Design. They are divided into two parts for the purpose of this thesis. The first 5 steps are involved in research preparation. The last 3 steps are involved in actually conducting a research project.

<u>Preparing for Research</u>

1. Defining research goals and objectives
2. Finding reliable sources for relevant evidence

3. Analyzing relevant evidence
4. Creating relevant design concepts
5. Developing a hypothesis

Conducting Research

6. Understanding research methodologies
7. Understanding and creating research tools
8. Measuring post-occupancy performance results

Incorporating the key EBD steps in practice requires commitment and coordination between healthcare organizations, design and construction firms, and research expertise. The following is a breakdown of each step as it related to interior design with suggestions for implementation as well as resources and examples of tools and results.

Chapter 3

Preparing for Research

Defining research goals and objectives

During pre-design and design, researchers develop a hypothesis and obtain and translate evidence into design. (The Center for Health Design, 2008) During these stages of a project it is important to establish goals that will link the design to the desired outcomes. Guiding principles for the project are developed in order to set a framework for establishing these project goals and to help guide the decision making process. (Debajyoti 2011)

Questions to consider when defining research goals and objectives are:

- What is the overall vision of the project?
- What is the project trying to achieve?
- What are the design problems and how can EBD guide designers to a solution?
- Which design concepts should be considered to meet these goals and objectives?

After the goals have been established, designers will use them throughout the project to gauge the effectiveness of design decisions and EBD interventions. Designers must gather research about the design issues at hand as well as research about current evidence-based interventions. Designers traditionally use experiential knowledge and site visits to other facilities to gather this information and evaluate precedents. During the EBD process, designers must also look to current literature to ensure design interventions meet evidence-based standards. (Debajyoti 2011) A literature analysis will also help to evaluate existing design options and produce innovative design solutions.

Not to be confused with a book review, a literature review surveys scholarly articles, books, and other sources relevant to a particular research question or issue. (Lewin 2010) It is not an annotated bibliography, which lists each work alphabetically by author and then provides a short summary of the book or article. (Booth, Colomb and Williams 2008) Rather, a literature review provides a description and critical evaluation of each work as it is relevant to the subject or issue at hand. The purpose is to provide an overview of the existing knowledge published on a certain subject and to point out areas that may need further investigation.

According to the UCSC Library Guides, a literature review should be comprised of the following elements:

- An overview of the subject, issue or theory under consideration, along with the objectives of the literature review
- Division of works under review into categories
- Explanation of how each work is similar to and how it varies from the others
- Conclusions as to which pieces are best considered in their argument, are most convincing of their opinions, and make the greatest contribution to the understanding and development of their area of research

The literature review must contain reliable and relevant sources or it cannot be considered a valid research tool. The next section discusses how to find sources that are appropriate for a high level of design research.

Finding reliable sources for relevant evidence

With the technology that is available to us today, there is a plethora of resources and information available regarding any given subject. The challenge for designers is to distinguish what types of resources are valid and reliable. Since most interior designers are not trained in research, this task can be overwhelming. The following are tips on feeling confident that a piece of research is relevant to the subject at hand and comes from a credible source.

How to evaluate sources for relevance and reliability:

Relevance

Relevance is defined as the quality of being directly connected with and important to something else. (Merriam-Webster 2011) As discussed previously, once a designer has decided which topic to investigate, he or she will need to research the existing literature on that subject. It can be time consuming considering all of the information published on design research every year. When searching for evidence, consider using the following suggestions from Booth, Colomb, and Williams (2008) as a guide for determining relevance without having to invest a significant amount of time.

Books:

- Skim the index for your key words, and then skim the pages on which those key words appear.
- Skim prologues, introductions, and summaries
- Read reviews online if available

Articles:

- Read the abstract if there is one in the article.
- Skim the introduction and the conclusion
- Skim the section headings
- Look at the bibliography for other sources relevant to your topic.

Once you have determined that a source is relevant to your topic, you must determine whether it has come from a reliable source. If a piece of evidence is relevant, but not reliable, it should not be included in the research analysis. (Lewin 2010)

Consider the following questions when trying to determine reliability:

- Is the source published or posted online by a reputable press?
- Was the book or article peer-reviewed?
- Is the author a reputable scholar?
- If the source is available only online, is it sponsored by a reputable organization?
- Is the source current?
- If the source is a book, does it have a notes and a bibliography?
- Is the source is a Web site, does it approach its topic judiciously?
- If the source is a book, has it been well-reviewed?
- Has the source been frequently cited by others?

The Georgia Institute of Technology and The Center for Health Design established the following guidelines for use specifically in evidence-based design literature search.

In the first stage, word searches should be conducted to identify potentially relevant studies. It is up to the researcher to establish the number of words used and what environmental factors those words should refer to. An additional search should be conducted which includes articles referencing the term *evidence-based design* in the title or abstract. Multiple databases, such as Academic Search Premier, MED-LINE, PsycArticles, WorldCat, JSTOR, and Google Scholar should be utilized. Relevant studies from the reference lists of identified articles should also be investigated.

In the second stage, all identified references need to be screened using two criteria:

1. Whether the study was empirically based and whether it examined the influence of environmental characteristics on patient, family, or staff outcomes.

2. An evaluation of the quality of each study in terms of its research design and methodology and whether the journal was peer-reviewed.

Additionally, the criteria regarding methodology in the table below should be examined to ensure article validity. Studies that are not deemed satisfactory are not to be included in the analysis.

Source of Evidence	Peer-reviewed journal, peer-reviewed conference proceedings, academic dissertation
Purpose and Overall Method	A theory or framework is introduced within which the study is conducted.
Purpose and Overall Method	The research question and objectives are explained clearly.

Sampling	The document reports how the sample size was determined, for both quantitative and qualitative studies.
Research Design	The research design adopted is clear and understandable.
Measurements	The document reports how tools and measures were developed or adopted and validated.
Measurements	Important variables/concepts used are defined precisely in the document or sources are cited.
Analysis	The practical significance of findings is clearly articulated in the document.
Reporting	Appropriate sources were cited within the text and complete citations included at the end of the document.

Table 1: (The Center for Health Design 2008)

**For a list of relevant sources compiled specifically for interior designers, see Appendix A.*

Analyzing relevant evidence

Understanding and Evaluating Evidence

After reliable and relevant sources have been found, it is important to be able to evaluate the evidence in a sound manner as it applies to a specific research question. Quality research and the application of research findings underpin the entire EBD effort, providing confidence and creditability to value-driven decisions made by leaders. (Debajyoti 2011) In this EBD step, the team must critically evaluate the individual studies, articles, and reports gathered in the literature review.

Researchers must be careful about drawing broad conclusions from literature that may not pertain to their specific design problem. It is important to consider the size, type, and location of the facility in the study as well as the demographics of the occupants before drawing conclusions. Just because an evidence-based intervention was successful in one type of facility, it does not necessarily mean the same results will hold true under different conditions. Researchers must consider all possible variables that may have an effect on the desired outcome before making any final design decisions.

It is important to document the specific interventions that have been extracted from the relevant evidence. Carefully recording all existing evidence used to inform the design intervention can help design researchers evaluate the evidence as it pertains to their unique circumstance. (EBD Guide 3)

Creating relevant design concepts

Design concepts serve as a baseline tool to support future design and research efforts relevant to a given situation. (McCullough 2010) During the pre-design and design phases, a variety of space and design concepts are developed to address the project goals, space program criteria, and EBD research used to inform the project. (The Center for Health Design 2008) Determining which concept is the best fit for the project can be difficult. Testing each concept against the guiding principles provides a consistent evaluation method that determines to what extent the planning and design concept addresses the original project goals. The guiding principles should be used continuously throughout the schematic design phase to test alignment between developing design solutions and project goals. (Debajyoti 2011)

During the conceptual phase of a design project, functional and space programs are coordinated with approved project budgets. The project team begins developing conceptual diagrams to express the design intent of each space. It is during this phase of the project that the evidence-based design interventions begin to develop physical characteristics. (McCullough 2010)

During design, the team refers back to the evidence and case studies collected during pre-design (such as the literature review) to inform new design interventions and ensure that the design follows the previously established guidelines. (EBD Guide 2)

It is very likely that new ideas for improving outcomes will be identified during the conceptual design phase and, as a result, new design hypotheses will be created. These new design hypotheses do not necessarily need to be researched. However, documentation of the new hypotheses linked to the desired outcomes will allow for future evaluation and study.

Testing Conceptual Diagrams

According to the Center for Health Design (2010), during the conceptual design phase, it is important that the interdisciplinary project team review each EBD feature to identify how the intervention aligns based on:

- Concepts: Does the EBD intervention support achieving a stated project goal or objective?
- People: Are considerations made for how the design intervention impacts staffing and provides the amenities needed to increase safety and satisfaction for patients, families, and staff?
- Systems: What technology and operational systems need to be considered during the development of the EBD intervention?
- Layout and operations: Will the layout cause changes in the operational model, requiring modifications in processes, staffing, and organizational culture?
- Physical environment: Does the EBD consider the added benefits of natural lighting and views, visibility and accessibility, environmental control for patients and staff, along with increased privacy and safety, different cultural preferences, and sustainable design components?
- Implementation: Will additional interdisciplinary project team members be needed to properly apply and integrate the design interventions? Have considerations been discussed about how the design intervention will be implemented while minimizing impact on infection-control risk and operational disruption?

In addition to using the guiding principles and design guidelines to evaluate the planning and design concepts, team members must consider other impacts the EBD intervention may have on other aspects of a project. These aspects might include:

- *Complexity of implementation:* What are the phasing requirements for the project? Are there make-ready projects that need to be completed first? What is the potential impact to critical care and emergency power?
- *Impact to operations and functional programs:* Will construction require a reduction in OR a bed capacity? Can circulation between departments be maintained? Does a department need to move temporarily?
- *Long-term flexibility:* Is there potential for long-term space and service expansion? Can technology equipment and systems be upgraded easily? What is the potential for reassigning the space with minimal architectural change?
- *Project costs:* What are the estimated project construction costs? What are the costs of make-ready projects? Is there a cost premium required to minimize impact to operations?
- *Operational costs:* Will additional staffing or equipment resources be required? What are the maintenance requirements? What is the potential for reduced staff turnover?
- *Schedule timeline:* Can the project be completed in the desired timeframe?

(EBD Guide 3)

Developing Hypotheses

Research provides deeper insight into a topic, better understanding of a problem, more clearly defined opportunities for and constraints on possible action, measurement of regularities, and ordered descriptions. (Maghoub, 1999) Presented with a problem, researchers draw on theory, training, accumulated knowledge, and experience to generate tentative ideas about how to solve it. (Groat and Wang 2002) Research questions and research hypotheses provide platforms for solving these problems.

A hypothesis is more specific than a research question, but the major difference between a research question and a hypothesis is that a hypothesis predicts an experimental outcome. (Goertz, et al. 2008) For example, a design hypothesis might state: "There is a positive relationship between the amount of sunlight in a patient room and patient satisfaction." A research question might be "Is there a relationship between lighting levels and patient outcomes?"

Hypotheses provide the following benefits:

1. They determine the focus and direction for a research effort.
2. Their development forces the researcher to clearly state the purpose of the research activity.
3. They determine what variables will not be considered in a study, as well as those that will be considered.
4. They require the researcher to have an operational definition of the variables of interest.

(Groat and Wang 2002)

Since the hypothesis is the basis of a research study, it is necessary for the hypothesis be developed with a great deal of thought and contemplation. There are basic criteria to consider when developing a hypothesis in order to ensure that it meets the needs of the study and the researcher. A good hypothesis should:

1. Have logical consistency. Based on the current research literature and knowledge base, does this hypothesis make sense? (Lewin 2010)
2. Be in step with the current literature and/or provide a good basis for any differences. Though it does not have to support the current body of literature, it is necessary to provide a good rationale for stepping away from the mainstream. (Booth, Colomb and Williams 2008)
3. Be testable. If one cannot design the means to conduct the research, the hypothesis means nothing. (Goertz, et al. 2008)
4. Be stated in clear and simple terms in order to reduce confusion. (Goertz, et al. 2008)

Chapter 4

Conducting Research

Understanding Research Methodologies

The following research methodologies are commonly used to gather information for evidence-based design studies.

Walkthroughs

The goal of a walkthrough is to quickly assess the physical condition of spaces and to note any areas which may prove problematic. (The Center for Health Design 2008) The duration of each walkthrough can be short because the primary focus is on the physical attributes of spaces, not behaviors and processes. Walkthroughs are valuable in helping designers understand qualities of space, but do not necessarily inform designers of occupant behavior or preferences.

Observation

Observation is the main type of measurement tool in the study of how human beings interact with the physical environment. (Sommer & Sommer, 2002) This methodology is more immersive and experience-focused than the walkthrough. Because people unconsciously display nonverbal behaviors, one of the advantages of observation over other measurement tools is that it may be the only way to detect these unconscious and nonverbal behaviors. (EBD Guide 2) Another benefit of observation is that it does not rely on a research subject's attention and memory, which can strongly influence the accuracy of other tools, such as interviews and questionnaires. (Sommer & Sommer, 2002)

Observation should be structured to allow the team to spend a significant time in the facility under review. Observing people to better understand their daily routines, interactions, and behavior in the context of the health care environment may take several site visits. These site visits should be scheduled to allow for observation over different times of day and with a variety of occupants if possible. Observation guides should be given to the team which describe how to observe building occupants with a goal of understanding their behavior and actions. If this is done in the actual environment in real time, researchers can better understand dynamics of staff, patients, and family relationships as well as the relationship between people and space. (Booth, Colomb and Williams 2008)

The outcome will be a qualitative description of the building occupants' points-of-view and behaviors based on what they actually do in a space versus what we think they do, which results in a deeper understanding of process and dynamics. (Groat and Wang 2002)

Shadowing

Shadowing is similar to observations but has the researchers following the footsteps of building occupants to understand their processes and journeys. In this methodology, the researchers are able to witness, and, to some degree, participate in the journey of an actual occupant. As a methodology, it is more closely engaged with the people being observed than passively witnessing their actions from afar. (Zeisel 2006)

Mock journeys, a more intensive form of shadowing, are designed to be immersive and experience-focused. This methodology provides researchers with emotional input in specific environments based on actual circumstances such as illness or injury. (Zeisel, 2006) The fundamental goal is to better understand through an “emotional experience” what a member or

patient has to do to accomplish a specific task. (Debajyoti 2011) For example, if a researcher were examining emergency department design, he or she might take a mock journey through the experience. Hospital administration and staff would need to agree to allow the researcher to participate in the emergency process in the same way an actual patient would. After arriving at the emergency department, the researcher would document how he or she felt in the environment as well as what he or she noticed about others' behavior.

Walkthroughs, observations, and shadowing may be recorded using various electronic devices but must be approved by the participating facility. These recordings should be compiled into a searchable database so that designers and researchers can then retrieve information by location, facility, date, and what was observed. (Groat and Wang 2002)

Focus Groups

A focus group is a small group of six to ten people led through an open discussion by a skilled moderator. (Eliot & Associates, 2005) Focus groups are conducted with building occupants, including both patients and staff. The purpose is to ask those being observed specific questions to clarify interpretations made by the researchers or to clarify a specific point of view. (Booth, Colomb and Williams 2008)

According to Eliot & Associates, twelve is the maximum number of questions for any one group. Focus group participants won't have a chance to see the questions they are being asked during the session. In order to ensure that participants understand and can fully respond to the questions posed, focus group questions should be unambiguously worded, non-threatening, and encourage open-ended responses. (Eliot & Associates, 2005)

Focus Group Example Questions:

Engagement question:
What is your favorite design feature in the hospital?

Exploration question:
In what ways does this facility help or hinder your job performance?
Tell us about the environment inside the facility (air quality, trash, clean-up, sun/shade, lighting, etc.)
How comfortable is this facility to be in?

Exit question:
Is there anything else you would like to say about the design of the hospital?

**For a complete list of healthcare design focus group questions developed by the author, see Appendix E.*

Environment and Experience

In addition to understanding research methodologies, it is important to understand the different types of environments humans experience and their responses to those environments.

Experience is a matter of the interaction of organism with its environment, an environment that is human as well as physical, that includes the materials of tradition and institution as well as local surroundings. (Dewey 1980) There is no experience in which the human contribution is not a factor in determining what actually happens. In an experience, things and events belonging to the world (the physical and social) are transformed through human perception. Simultaneously, humans are transformed and changed by the physical and social events of the world. (De Botton 2006) Thus, external stimuli are perceived differently by different individuals according to their previous experiences. These past experiences also affect an individual's behavior. (Zeisel 2006) This creates an intricate relationship between humans and their environments. Environmental researchers must recognize this complex relationship and

seek to gain an understanding of the different types of physical environments experienced by humans.

It is important to approach design research with an exploratory attitude, as the variables of human experience in the built environment are often difficult to pinpoint. After developing a hypothesis, carrying out a research program, and analyzing the results, one may find that numerous factors have contributed to a subject's experience. To understand how people relate to environments and to be able to make design decisions about those settings while controlling behavioral effects, we want to know how people respond to both abstract and actual environments.

Actual environments are physical environments, including objects in a setting; places; relations between places created by such things as walls, distance, windows, barriers, and adjacencies; and qualities of the setting, such as light and sound. (Bastea 2004) Abstract environments include both administrative and behavioral environments. Administrative environments include formal rules governing such things as use of setting, contractual arrangements for use, and required entry procedures, and informal rules about what is appropriate to do there. Behavioral environments include characteristics of people there, their activities there, and relationships between people. (Zeisel, 2006) Abstract and behavioral environments are more difficult for researchers to study, as many of the characteristics are intangible.

The more a researcher knows about how people see environments and what they know about environments, the more he or she will understand behavioral and emotional reactions to them. People make sense of their surroundings by observing them with all their senses and then organizing, interpreting and giving meaning to what they observe. (De Botton 2006) This

interpretation in turn has consequences for what people do in an environment and what they do to it. The better a designer understands this process, the better they are able to understand the effects of environmental design decisions they make.

The attitudes people hold toward an object, person, situation, or environment also influence how they respond to it. (De Botton 2006) As mentioned previously, observing behavior allows you to understand how people interact with their environment, what activities are performed, and the consequences or implications of those activities. Asking people questions about their environmental behavior tells you other essential things, such as what effects they expect their action to have, what they intended to do but never did, and what they still intend to do. (Groat and Wang 2002) Comparing observational data with interview data about the same activity provides investigators with information that is unavailable when using only one method: the relation between a person's conscious perception of himself and its external expression. (Debajyoti 2011)

Therefore, evidence based design researchers should ask questions to discover people's existing opinions about their environment. These opinions will then lead to an understanding of people's values and ideals. Another reason to ask someone questions about their surroundings is to assess that person's knowledge. Knowledge questions inquire how much respondents know about a situation, how they found out about an event, and what they think occurred. To interpret the answers – to assess someone's knowledge – it is helpful to have used other methods to observe and find out about what happened. (Booth, Colomb and Williams 2008)

Understanding and Creating Research Tools

Standardized Questionnaires

Standardized questionnaires are one of the most common ways to gather research regarding the built environment. (Groat and Wang 2002) They are useful in collecting information from a large amount of respondents without sacrificing a large amount of time and resources. Standardized questionnaires or surveys can be used alone or in conjunction with other research tools, such as focus groups and interviews. (Booth, Colomb and Williams 2008)

Standardized questionnaires are used to discover regularities among groups of people by comparing answers to the same set of questions asked of a large number of people. (Zeisel 2006) Researchers begin the process of using standardized questionnaires to test and refine their ideas by creating hypotheses about which attributes relate to each other. The quality of questionnaire data depends on the thoroughness that design researchers apply to defining the problems they are studying.

Qualities of Standardized Questionnaires

Researchers structure questionnaires and control their administration. The researcher also defines what happens during the interview: how it begins, the ordering of questions and answers, and how it ends. (Booth, Colomb and Williams 2008) Some control is surrendered when a questionnaire is distributed by mail. Therefore, mail surveys are usually shorter and more tightly organized.

Repeating standardized questions the same way to many respondents enables researchers to easily compare answers from different respondents. When individual questionnaire items are

repeated in separate and similar studies, answers can be shared and compared to build a cumulative body of evidence. (Zeisel 2006)

Before going into the field researchers using standardized questionnaires must determine the level of refinement they want answers to achieve to solve their problem. There is little room for adjustment once data gathering begins. To avoid some of the side effects of control in any method and in any type of interview, researchers should carry out preliminary investigative research. (Debajyoti 2011) After the questionnaire is written, designers should pretest it with people who resemble the expected respondents. Pretesting is the process of administering a questionnaire to respondents while asking them to comment on the clarity and categories of the questionnaire. (Zeisel, 2006)

Quantitative analysis of questionnaire data not only contributes precision to knowledge, it can also make research data convincing to others. The apparent exactness and rigorousness of statistical analysis is sometimes misleading, however, as variables in respondent's answering are out of the researcher's control. (Groat and Wang 2002) One way to ensure that a questionnaire has a high level of rigor is to conduct a content validity test using experts in the fields of design, research, and survey administration.

**For instructions by the author on how to conduct a content validity index, see Appendix B.*

Questionnaire Organization

Introducing oneself and the purpose of the survey can establish trust clearly and honestly without threatening the respondent. (Booth, Colomb and Williams 2008) EBD research projects may be introduced to respondents as attempts to ask their advice on how to make future similar environments better, what could have been improved in a setting, or just what people like or

think. (The Center for Health Design 2008) Questions requesting positive responses, such as "what do you like best about this facility?" can start the survey on a friendly note. However, researchers must be careful not to probe respondents for positive or negative opinions, but to remain as neutral as possible.

Early questions can influence the way respondents will answer later ones. A good rule to follow is to go from general to specific questions so that questions asked later in the interview require greater specificity of information, intent, and purpose. (Zeisel 2006)

In the half hour or so during which a questionnaire is administered, interviewers often have to choose between gathering a great deal of information and not tiring out the respondent. To maximize information gathering and minimize fatigue, you can group questions that relate to a single topic, such as a neighborhood, an event, or a set of activities in one place. (Debajyoti 2011)

Filtering questions help you avoid inapplicable questions by not asking respondents questions that don't apply to them. Follow-up questions are used for explanation, specification, or clarification of intensity and are targeted only to the respondents to whom they apply. (Booth, Colomb and Williams 2008)

Environmental interventions are typically manipulated and measured on a categorical scale such as yes or no. Other environmental variables are measured on an interval/ratio scale. (Stichler 2010) No matter how researchers pose questions in a structured interview or questionnaire, they must record the answers and prepare them for counting and analysis. One should group similar responses together, in order to make responses comparable to one another and, therefore, easier to analyze. The process of deciding how to partition responses into groups

is called coding because researchers use a few responses to develop a category code, which is then applied to the rest of the responses in a study. (Zeisel 2006)

The three characteristics essential for coding survey categories are mutual exclusiveness, exhaustiveness, and single abstraction level. (Saldana 2009) Mutual exclusiveness means that responses clearly fall into either one category or another. There can be no overlapping, either numerically or conceptually. Exhaustiveness means that any possible response fits into some category. Researchers can include "other" as a category to achieve exhaustiveness on all questions. Single abstraction level means that response categories are conceptually parallel. (Saldana 2009) See example below.

Example Question: What do you like best about this hospital?

- Single-level abstraction response options: the patient rooms, the lobby, the cafeteria
- Multi-level abstraction response options: the patient rooms, the lobby, the aesthetics, the friendliness of staff

In the single level abstraction code, all answers are spatial areas within the hospital. In the multi-level abstraction code, the answers range from spatial areas to general concepts (aesthetics) and staff characteristics (friendliness).

Survey Question Format

Remembering that most respondents to environmental surveys have little or no knowledge of interior design, researchers must format questions in a simple manner using terms that can be understood by the general public. (Fowler 1995) Other suggestions for simplifying questions include:

- Avoid double-barreled questions – Frequently researchers think they are offering respondents alternative response categories when they are actually combining two questions into one. (Saldana 2009)
- Use words and phrases within respondents' experience – This means that researchers must not use jargon. Professionals in environmental design and research often use terms that have little or no meaning to most people. Questions including these words or concepts may elicit misleading responses. (Booth, Colomb and Williams 2008)
- Do not assume respondents have much information. If a question requires information available only to some respondents, the answers will not reflect informed opinions. Answers will reflect an indistinguishable mixture of opinion and amount of knowledge. (Saldana 2009)

Exactness

Remember that respondents understand questions in different ways. The same word could hold multiple meanings depending on a person's background, education level, and culture. (Lewin 2010) Tips to keep survey questions precise are as follows:

Avoid complicated words with multiple meanings. We often use words that can be understood in various ways. Words such as territory, privacy, satisfaction, and bother mean different things to different people. (Groat and Wang 2002) To some, privacy means being able to be alone if one wishes. To others, it means not being overheard or seen by others - even by neighbors through thin walls.

Be specific about time and place. If researchers want to find out how often or where respondents do something, there are several types of questions they can ask. As a rule, the more specific are the response categories and the event being queried, the more likely respondents will be able to answer the questions and the more likely are the answers to be comparable. (Lewin 2010)

Objectivity

Researchers should avoid influencing the direction of respondents' answers. The way a question is worded can significantly affect the response of the question. (Lewin 2010) If a survey is worded negatively or positively, the answers to the questions will reflect this. It is important to remain as neutral as possible to avoid unintentional manipulation of survey responses. Researchers should not "lead" respondents by asking respondents to agree or disagree with only one side of an issue. (Lewin 2010)

Measuring Post-Occupancy Performance Results

The Post-Occupancy Evaluation (POE) process involves a systematic evaluation of opinion about buildings in use, from the perspective of the people who use them. (Preiser, Rabinowitz and White 1990) Coupled with qualitative information gathered via surveys, focus group discussions, methodical observation, and research of historical data it provides a truly comprehensive view of how well the building meets the needs of the user. (Shepley 2002) This social science based approach to design evaluation provides a comprehensive perspective on the consequences of past design decisions and the resulting building performance. (The Center for Health Design 2008) Organizations typically employ three types of POEs: Indicative, Investigative and Diagnostic. The type of POE utilized depends on client needs and building performance objectives. (Federal Facilities Council 2002)

Indicative POE

An Indicative POE indicates major strengths and weaknesses of a particular building's performance and provides data that supports the need for or against further in-depth evaluation. It is a relatively simple short term process that involves selected interviews, questionnaires, walkthroughs, and document evaluation. Investigative POEs Compare "big picture" building performance against existing criteria, design intent and the program. (Federal Facilities Council 2002)

Typical outcomes of an indicative POE include:

- Data is used to feed back into design guidelines, criteria and policies for the things that work well and should be carried forward to future projects.
- Identifies problems that require further study;
- Identifies the need for corrective actions for minor problems early in the building life-cycle;
- Lessons Learned are applied to future projects

Investigative POE:

Evaluation criteria such as a Program of Requirement, guidelines, performance standards or published literature on buildings are defined prior to initiation of a more in-depth evaluation. (Preiser, Rabinowitz and White 1990) This next level of evaluation was termed "Investigative" by the Federal Facilities Council.

Investigate POEs are typically performed after an indicative POE indicates that the building performance requires more in depth evaluation. An Investigative POE monitors specific aspects of building performance over a period of time and compares to existing criteria and design intent and evaluates these factors. The process involves more resources, more sophisticated data collection and analysis methodologies than an indicative POE. (Federal Facilities Council 2002)

Typical outcomes of an investigative POE include:

- Data is used to understand the cause and effect of issues in building performance.
- Data analyses are used to design corrective action plans
- Lessons learned are applied to future projects

Diagnostic POE:

Diagnostic POEs are performed post-investigative POE if further data collection or analysis is required to take corrective actions, or instead of an investigative POE if major design or operational flaws are discovered in the indicative phase POE. (Federal Facilities Council 2002) Conducting this type of POE involves data collection and comparison of many variables for a single facility or across facilities with similar function. This type of investigation typically requires a major investment of time, man power and resources. (The Center for Health Design 2008)

Typical outcomes of a diagnostic POE include:

- Systems analyses lead to recommendations for changing design criteria to improve facility performance for multiple facilities or types of facilities.
- Long term facility application of lessons learned to future projects.
- Improved performance knowledge base for comparison across buildings

Depending on the type of POE used the building performance elements should include but not be limited to: functionality, safety, comfort, security, aesthetics, efficiency, operations and occupant satisfaction. (Preiser, Rabinowitz and White 1990) If a POE will involve investigations of occupant behavior in the built environment and/or taking photographs of occupants, or taking specimens of any kind from an occupant, then informed consent may be required to protect individuals from risks and invasion of privacy. (The Center for Health Design 2008)

**For an example of an outpatient POE questionnaire created by the author, see Appendix C.*

Chapter 5

Evidence-Based Design and Healing Environments

● Indicates that a relationship between the design strategy and outcome is indicated by empirical evidence

Healthcare Outcomes \ Design Strategies or Interventions	Single-bed rooms	Access to daylight	Appropriate Lighting	Views of nature	Family zone in patient rooms	Carpeting	Noise-reducing finishes	Ceiling lifts	Nursing floor layout	Decentralized supplies	Acuity-adaptable rooms
Reduce hospital=acquired infections	●										
Reduce medical errors	●		●				●				●
Reduce patient falls	●		●		●	●			●		●
Reduce pain		●	●	●			●				
Improve patients' sleep	●	●	●				●				
Reduce patient stress	●	●	●	●	●		●				
Reduce depression		●	●	●	●						
Reduce length of stay		●	●	●							●
Improve patient privacy and confidentiality	●				●		●				
Improve communication with patients	●				●		●				
Improve social support	●				●	●					
Increase patient satisfaction	●	●	●	●	●	●	●				
Decrease staff injuries								●			●
Decrease staff stress	●	●	●	●			●				
Increase staff effectiveness	●		●				●		●	●	●
Increase staff satisfaction	●	●	●	●			●				

Source: (Ulrich et al. 2008)

Healing Environments

The term "healing environment" is used broadly throughout the design field to describe a place that both physically and culturally supports health, healing, and wellbeing. (McCullough 2010) As researchers, we must be careful not to confuse literature referring to "environment" as the culture of a hospital rather than the built environment. When we can eliminate confounding variables of the cultural environment we can better decipher the specific elements of the built environment that contribute to health and healing.

Dellinger defines healing environments in general as:

- A place to heal the mind, body, and soul
- A place where respect and dignity are woven into everything
- A place where life, death, illness, and healing define the moments and the building supports those vents or situations. (McCullough 2010)

Malkin (1992) describes the basic components of a healing environment as:

- Air quality
- Thermal Comfort
- Privacy
- Light
- Views of Nature
- Visual serenity for those who are very ill
- Visual stimulation for those who are recuperating

Over the last decade, those working with healing environments have expanded this list to include:

- Access to nature
- Positive Distraction
- Access to social support
- Options and choice (Control)

- Elimination of environmental stressors such as nose, glare, and poor air quality (Beggs 2003) (Debajyoti 2011) (McCullough 2010)

The evidence based design techniques described in this thesis are intended to contribute to the creation of an overall healing environment. Some argue that using EBD techniques alone will not necessarily produce an environment conducive to healing. (Malkin, 2008) In order for the design team and organization to ensure that the setting is a "healing environment", they must have the ability to translate their EBD findings into design solutions relevant to their particular problem.

Each design project will contain unique characteristics that may be of interest to design researchers. When conducting both pre-design and post-occupancy research, it is important to reflect back upon the project's vision and guiding principles. In pre-design research, these will serve as a baseline for investigating methods to physically capture those principles. In a post-occupancy evaluation, the physical design is investigated in order to evaluate whether or not those principles have been captured.

Ulrich and Zimring's sentinel literature review commissioned by The Center for Health Design in 2004 provided a framework that linked hospital design with clinical outcomes. The team identified more than 600 studies, most from peer-reviewed journals, that provide strong evidence confirming the certain design characteristics impact patient and staff outcomes in four key areas:

- Reduction in staff stress and fatigue
- Improvement in patient safety

- Reduction in patient stress
- Improvement in overall healthcare quality

Ulrich completed a second analysis of the literature from 2004 to 2007 that included an extensive search for empirical studies linking the design of the physical environments of hospitals with healthcare outcomes. The authors screened all identified references using several criteria. The studies had to be empirically-based and peer reviewed. They identified three main categories of outcomes:

- Patient safety issues, such as infections, medical errors and falls;
- Other patient outcomes, such as pain, sleep, stress, and depression, length of stay, spatial orientation, privacy, communication, social support, and overall patient satisfaction; and
- Staff out comes, such as injuries, stress, work effectiveness and satisfaction.

The researchers found few of these randomized controlled trials that directly linked design interventions to healthcare outcomes. Because there are so many environmental features that are impacted by physical changes, co-founding variables are created – making it difficult to link the impact on the healthcare outcomes to one independent effect.

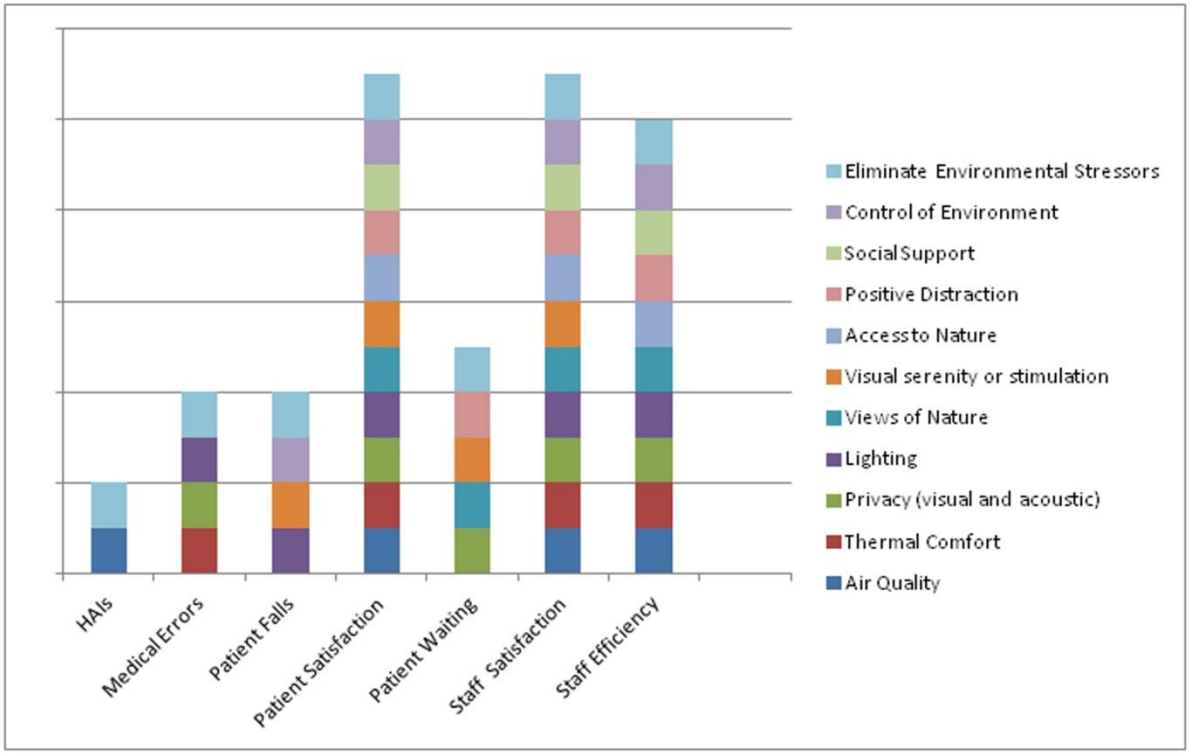
Specifically, Ulrich (2008) stated:

"Although many studies may not be well-controlled, the strength of the evidence is enhanced by the fact that, in the case of certain environmental factors, reliable patterns of findings across several studies emerged with respect to outcome influences. These patterns were broadly consistent with predictions based on established knowledge and theory concerning environment and healthcare outcomes…Future research should be carefully designed and

controlled so that the independent role of specific environmental changes or interventions can be better understood. “

Since the publication of Ulrich’s literature review, seven high priority EBD topic areas have been identified by the Center for Health Design to guide researchers and designers toward interventions that can effectively impact patient and staff well-being. The seven topic areas are shown in Figure 1 and described in detail in the next chapter of this thesis.

The EBD topic areas fit into the healing environments concepts as shown in table 4 below.



As shown in figure 3, the EBD topic areas fit within the overall healing environments framework. Therefore, it can be argued that the Evidence-Design Concepts are an integral part of

creating a healing environment, but need to be combined with other organizational factors to accomplish the task.

As the graph demonstrates, the elimination of environmental stressors contributes to every critical EBD topic area. The effect of stress on patients and staff can be one of the most detrimental environmental variables in inhibiting healing and causing discomfort. Evans (1999) reviewed the measurement of environmental stressors that potentially impact health outcomes, including noise, crowding, and other architectural elements. Many researchers believe that it is an individual's appraisal or perceptions of the event rather than the event itself are predictive of the deleterious effects of stress on health and wellness. (Joseph 2007) Thus, regardless of whether or not an individual is in a stressful environment, if he or she perceives it to be stressful, the individual will experience the mental and physical effects of the perceived stress.

The body's reactions to continued levels of high stress may result in fatigue, nausea, memory loss, illness, or other problems. (McCullough 2010) In a healthcare environment, these are exactly the effects we are trying to combat in the first place. If the physical environment is actually contributing to the creation of the effects, we have done a disservice as designers to both hospital patients and hospital staff. Of course, it is impossible to mitigate entirely the effects of stress on hospitalized patients, as the situation itself is unfamiliar and stress-inducing. However, we can use environmental variables that will help mitigate these effects rather than intensify them. Stress levels of healthcare providers are also very important to consider. The intense and ever-changing healthcare setting, with its exceptionally high performance standards and demands on employees, often forces dedicated workers to be in a high level of stress for many hours a day. (Alimoglu and Donmez 2005) Senses impact the individual's perception of the

environment and aid in recovery when a stressful event occurs. (McCullough 2010) Design is a powerful tool for reducing the stress that impacts the senses of both patients and staff.

Chapter 6

EBD priority topics defined

A literature review was conducted to examine each of the EBD priority topics set forth by the Center for Health Design. Below are the results for each category, including environmental suggestions that designers can incorporate into practice.

Healthcare-associated Infections

The healthcare environment is a reservoir for micro-organisms that have the potential for infecting patients. (EBD Guide 3) If the impact of healthcare-associated infection is to be reduced it is important that infection prevention and control requirements are designed in at the planning stages of healthcare facilities, including new builds or renovation projects (Department of Health 2008). The environmental variables impacting healthcare-associated infections can be grouped according to the major routes of infection transmission–air, inanimate surfaces, water, and the hands of staff members (The Center for Health Design 2008).

Environmental variables impacting air hygiene can be classified into two categories—air flow design and air disinfection. Significant air flow design variables include patient room occupancy (single room versus open unit), location of ventilation grilles, ventilation rate, air flow, air pressure difference between adjacent spaces, and environmental factors impacting natural ventilation (Beggs, Kerr, Noakes, Hathway, & Sleigh, 2008; Jiang et al., 2003; Menzies, Fanning, Yuan, & Fitzgerald, 2000). Environmental strategies for air disinfection include high-efficiency particulate air (HEPA) filters, mobile air-treatment units, ventilation system maintenance, and control of construction work (McDevitt, Milton, Rudnick, & First, 2008).

Medical Errors

Research has found that the design of the physical environment can impact two groups of medical errors—medication errors and surgical errors. Environmental variables impacting medication errors include lighting fixtures, measures to reduce distractions and interruptions, acoustic design, use of acuity-adaptable rooms, and infrastructures for barcode-assisted dispensing and computerized physician order entry systems. (The Center for Health Design 2008) A recent study documented the relationship of medication errors to lighting levels. They found that as lighting intensity approaches 1,500 lux the incidence of medication errors dramatically decreases. (Buchanan 1991) Poor lighting and the lack of daylight are also linked to depression, increased need for pain medication, medication errors, and order entry errors. (Benedetti 2001)

Factors impacting surgical errors include environmental distractions, lighting, and noise. A simulated experiment showed that surgeons tended to make more errors while performing surgical tasks when exposed to auditory distractions such as popular songs and social conversation irrelevant to the surgical tasks (Pluyter, Buzink, Rutkowski, & Jakimowicz, 2010). Another experiment suggested that reducing the operating room's background noise level might help reduce surgical errors (Moorthy, Munz, Dosis, Bann, & Darzi, 2003).

Patient Falls

Environmental factors impacting patient falls can be grouped into two categories– environmental hazards that directly impact patients and factors that impact staff's ability to

monitor patients and provide assistance. Fall-related environmental hazards include physical restraints such as bedrails, hard flooring and sub-flooring, noise, shared bathrooms, limited opening area for bathroom doors, and other factors. (The Center for Health Design 2008) Capezuti et. al. (1998) reported that the removal of physical restraints such as vests, restraints, and belts resulted in lower rates of falls and fall-related injuries. Healey (1994) found that patients who fell on vinyl flooring received more injuries than patients who fell on carpets. Simpson et. al. (2004) found that the rate of fall-related hip fractures was lower for falls on a wooden sub-floor than for falls on a concrete sub-floor.

Becker et al., (2003) evaluated environmental hazards contributing to patient falls and implemented a fall-prevention program that included modifications to lighting, chair and bed height, floor surfaces, room clutter, and grab bars. The program also included staff training, patient education, physical exercise, and protection. The patient fall rate decreased after the program's implementation. However, environmental interventions could not always be distinguished from other interventions, making it difficult to quantify the contributions of the environmental interventions.

The measurement of falls and fall-related injuries has been highly dependent on incidence/accident reporting systems used by individual healthcare facilities. Different facilities use different systems, and self-reporting by staff is often biased. This lack of a universally accepted measurement system threatens the validity of research. (Stichler 2010)

Patient Satisfaction

Environmental variables impacting patient satisfaction can be classified into two main groups – factors related to patients' physical comfort and factors related to aesthetic qualities of the physical environment.

Variables influencing patients' physical comfort include noise reduction measures, room occupancy, acuity-adaptable rooms, unit layout, and amenities. Single-bed patient rooms scored higher than double-bed and multi-bed rooms in terms of patient satisfaction with admissions, hospital environment, information, overall quality of care, and other aspects of healthcare services (Harris, Shepley, & White, 2006). A comparison of double-bed rooms and multi-bed rooms showed that patients staying in double rooms were more satisfied than patients in multi-bed rooms (Soufi et al., 2010).

Within the group of environmental factors related to aesthetic qualities of the physical environment, attractiveness of the physical environment is an important predictor of patients' overall satisfaction with healthcare service. Higher attractiveness rating scores were associated with higher overall satisfaction in both outpatient and inpatient settings (Becker & Douglass, 2008; Swan, Richardson, & Hutton, 2003).

Specific factors in this group include positive audio distractions such as music; positive visual distractions such as nature views and artwork; lighting; furniture; and finish materials. Patients were more satisfied with a waiting room environment incorporating healing features such as wooden chairs, nature photography, and indoor plants than with a traditional waiting room featuring elements such as plastic-covered chairs and small dried flower arrangements (Leather, Beale and Sullivan 2003).

Patient Waiting

Research has examined the possible connection between physical environment attractiveness and a patient's perceived waiting time but has not yet found a significant direct relationship. (Quan, et al. 2011) Environmental attractiveness has been associated with more favorable perceptions of the quality of care, a higher percentage of anxiety reduction, and higher ratings of staff interactions (Becker & Douglass, 2008; Pruyn & Smidts, 1998). Positive distractions such as visual-audio stimuli presented on a plasma TV, nature photographs on canvas, window films with garden scenes, and cloud patterns attracted patients' attention during waiting time, significantly reduced patients' restless behavior and "people watching", and helped calm children (Nanda, 2010; Pati & Nanda, 2011). A correlation exists between the key outcomes of actual patient waiting time and perceived waiting time, although patients tend to overestimate short waiting times and underestimate long waiting times (Becker & Douglass, 2008).

A patient's cognitive perception plays a significant role in the relationships between patient waiting and patient satisfaction (Pruyn & Smidts, 1998). In a study by Pruyn & Smidts, actual patient waiting time was measured by direct observation or using existing medical records. Perceived waiting time was measured by patients' responses to questionnaire surveys. Typically, patient waiting behaviors were directly observed to determine the percentage or number of behaviors in different categories, including continuous behaviors (reading) and discrete behaviors (getting out of chair) as well as distraction activities, non-distraction activities, and restless/anxious behaviors. There was a positive correlation between the amount of discrete behaviors observed and a patient's perceived wait time being higher than the actual wait time.

Staff Efficiency

Research has identified staff efficiency outcomes that can be influenced by the physical environment. These outcomes include staff travel time and distance, team communication, circadian misalignment, nurse response time to patient calls, medication processing time, and surgeon/anesthesiologist performance. (Zborowsky and Kreitzer 2009)

Several studies found that nurses working in radial units walked less and spent more time with patients than nurses working in rectangular units (Shepley & Davies, 2003). One study found that nurses in units with decentralized nursing stations spent more time on all types of communication activities except communication with other nurses for patient information and spent more time on patient care activities in patient rooms (Gurascio-Howard & Malloch, 2007). Another study found that nurses in decentralized units had fewer verbal interactions with other nurses (Dutta, 2008). Patient room layout is an important factor impacting staff efficiency. Nurses in a NICU spent less time traveling after moving from an old unit with six rooms to a new unit with an open floor plan (Shepley, 2002)

Staff efficiency outcomes were measured using a variety of methods. Staff travel was measured by direct observation, work sampling studies (nurses using PDAs to record their locations and activities), pedometers worn by nurses, and indoor position systems that tracked RFID badges worn by staff. Methods to measure team communication included observation, audio recording, interview, and questionnaire.

Staff Satisfaction

Multiple environmental variables have been found to impact healthcare staff's job satisfaction. Nurses' self-reported daily exposure to daylight correlated positively with job

satisfaction (Alimoglu & Donmez, 2005). Staff working in single-patient rooms reported higher satisfaction with the physical environment, higher job satisfaction, and lower work stress than staff working in open bays (Harris, Shepley, & White, 2006; Shepley, Harris, & White, 2008).

Noise is a major source of stress and annoyance and has a negative impact on staff (Morrison, Haas, Shaffner, Garrett, & Fackler, 2003). Applebaum and colleagues (2010) reported that noise was positively correlated with stress, stress negatively related to job satisfaction, and job satisfaction negatively correlated with turnover intent.

Several studies examined the relationship between staff's perception of physical environment and job satisfaction. Cannon and others (2008) found significant relationships between some staff-perceived environment qualities, such as facility cleanliness and availability of phones, with overall job satisfaction. A survey study by Djukic and colleagues (2010) revealed a group of nurses who negatively perceived their physical work environment, and that the nurses' perception of the work environment positively related to their job satisfaction.

The vast majority of outcomes were measured using questionnaire scales, some of which are well-developed and validated: Job Satisfaction Scale, Nurses' Intent to Stay Questionnaire, Rehabilitation Job Satisfaction Inventory, PedQL Staff Satisfaction Coworker Module, Maslach Burnout Inventory, and Work Related Starin Inventory. (The Center for Health Design 2008)

These priority topics are just the beginning of developing design standards and guidelines to promote the health and well-being of building occupants. Designers can use these interventions with assurance that they are scientifically sound, but should continue to investigate new interventions and priority topics as the body of evidence-based design research continues to grow.

**For a list of other design variables found in the author's research as well as interventions that may have an impact on user health and well-being, see Appendix F.*

Chapter 7

The Future of Design Research

Wayfinding, perception and cognition, cognitive mapping, imaging, and designing are among the many ways people relate to their environment. (Sternberg 2010) It is known that the way one perceives and relates to his environment will impact his experience within that environment. What is now emerging is a field of research that can provide clarity for designers and researchers into why and how people perceive and relate to environments differently. This field is neuroscience. In response to new discoveries about the brain and environment, The Academy of Neuroscience for Architecture was founded to promote and advance knowledge that links neuroscience research to a growing understanding of human responses to the built environment. (Academy of Neurscience for Architecture 2010)

Emerging neuroscience research shows that environment-related activities are reflected both in our brains and in the way our minds manage environmental input and knowledge. (Academy of Neurscience for Architecture 2010) The practice of designing the environments in which we live, work, and play has previously been carried out with little knowledge of these processes. Acknowledging this in his seminal book Neuronal Man (1986), neuro-pharmacololgist Jean Pierre Changeux poses a dramatic and challenging research and design question:

"Do the forms of architecture we enclose ourselves in, and the working conditions we endure…favor a balanced development and functioning of our brains? It is very doubtful (p.283).

If we want to work toward architecture that will favor "a balanced development and functioning of our brains", researchers must now embrace emerging neuroscience tools in addition to our evidence-based design model. Our minds and our brains are among the few truly renewable resources we have. If designed environments are to support this resource, we must better understand the brain. (Zeisel 2006) Thus, the better designers and researchers understand how the brain and mind work, the better they can create design environments that support our brain functions.

Evidence-based Design and Neuroscience

If researchers can understand how people's brains and minds develop and function in different situations, and how they have evolved over time to respond to physical environments, then environments can be designed to contribute to people's quality of life, creativity, and survival. (Sternberg 2010)

In traditional environment-behavior studies, the physical environment is considered the context for and object of actions such as perception, memory, cognitive mapping, and use. (Zeisel 2006) Neuroscience research tells us, however, that while environment is a contextual object for minds to relate to, it also plays a role in basic mental functions, such as learning, memory, orientation, and perception. (Academy of Neurscience for Architecture 2010) Only by including neuroscience in evidence-based design studies can we understand the interaction between environmental stimuli and behavioral responses in ways that inform and improve design.

What this means for designers is that "the brain controls our behaviors and genes control the blueprint for the design and structure of the brain, but that the environment can modulate the

function of genes and, ultimately, the structure of our brain. Changes in the environment change the brain, and therefore they change our behavior. Architectural design changes our brain and our behavior". – Fred Gage (AIA, 2003)

Research also shows that enhanced environments can foster brain development. For example, studies show that animals brought up in toy-filled surroundings have more branches on their neurons and more connections than isolated animals. (Society for Neuroscience 2009) In one recent study, scientists found that enriched environments resulted in more neurons in a brain area involved in memory. (Society for Neuroscience 2008) The implications of these studies are not yet completely understood by the design community at large, but the impact that environment has on brain functioning, and thus overall well-being, is slowly developing a solid research base.

The evidence-based design framework and the emerging neuroscience concepts discussed in this research are complimentary in nature. Our understanding of brain capabilities reinforces and explains studies of users' needs, behavior, attitude, and opinion. (Academy of Neurscience for Architecture 2010) By using the evidence-based design process, we understand how environments can meet essential user needs. By using the neuroscience paradigm, we can actually produce designs that reflect how our brains produce experiences of environmental functions. These designs ultimately support brain development and functioning while meeting user needs, and may cause us to change how we interpret these needs. Applying the evidence-based design process supports current design standards, but gong further and applying neuroscience concepts to our design supports environments created to support and encourage healthy brain functioning.

Although evidence-based design practitioners have successfully demonstrated that EBD methods like those described in this research contribute usefully to design, researchers and designers employing these methods have to justify their role in the design process by appealing to clients on a social and humanitarian basis. (Eberhard, 2005) However, by practicing evidence-based design in combination with neuroscience principles, professionals can more precisely and more persuasively identify the improvements in functioning that a brain-responsive environment provides. (Eberhard, 2005) If we want to understand *how* people behave, evidence-based design is sufficient and very helpful. If we want to understand *why* people behave in certain ways when they interact with their environment, the additional of neuroscience research is required. To assist in discovering why people react in certain ways to their environments, Eberhard identified three environment and neuroscience concepts: personalization, territory, and way-finding. These concepts are clues for studying the joining of evidence-based design and neuroscience approaches. Each has also been found to contribute to patient and staff satisfaction in studies of various hospital environments. (Goertz, et al. 2008)

Personalized environments that express who we are to the outside world represent our memories and feelings about ourselves. (Bastea 2004) Triggering memories of our past through personalized environments can help to reinforce a sense of who we are. We can call environmental cues that have these effects environmental personalization memory cues. (Academy of Neurscience for Architecture 2010) For those with healthy brains, small environmental cues such as seeing a picture of a loved one can achieve this memory stimulation. However, environmental personalization memory cues grow in importance for people whose brains are not functioning as well, such as people living with Alzheimer's disease. (Society for Neuroscience 2008) Continual environmental reminders of their history and who they are can

help them to overcome these feelings. One theory on why this happens is that personalized environments stimulate brain regions that this group of people cannot stimulate themselves. The same process takes place as we all age and becomes more important as our brains generate fewer memories of who we are that provide us with a sense of self. (Bastea 2004) In the early years of environment-behavior studies, there was speculation about such truths, but researchers did not have sophisticated ways to test them. Newer neuroscience technologies provide researchers the opportunity to achieve much greater understanding.

Recognizing different types of territory, a skill closely related to place recognition, is an environment/ neuroscience concept essential to the survival of all species. The simplest cue to distinguishing one territory from another is when one moves from a familiar place to an unfamiliar one. (Sternberg 2010)

Linking place and territory, *wayfinding* describes the mental and physical activities associated with finding the way to food and potential mates, avoiding predators, and getting home to safety. (Zeisel 2006) Cognitive science has already uncovered cue recognition information that designers can apply in this area and the healthcare field has begun to take advantage of this. For example, physical cues located below eye level are more readily processed and attended to than those located above it. (Gazzaniga 1998) Thus, wayfinding cues that designers place in our lower field of vision are likely to be most effective.

In addition to personalization, territory, and wayfinding, further scientific understanding of environmental cues will help designers more effectively plan environments to meet user's cognitive needs. As the field continues to blossom, researchers should be aware of future neuroscience concepts and approaches that may change current standards of design.

DOMAINS OF STUDY				
Design	Neurosciences			Environment-Behavior
Variables in each domain				
Physical environment elements	Neuroscientific dimensions	Physiological factors	Behavioral outcomes	Performance outcomes
MEASUREMENT TECHNIQUES AT TARGETED TO SPECIFIC DOMAINS				
Measures describing the characteristics of environment such as plans and dimensions	Neuroscientific methods to measure this dimension such as PET, MRI, and ERP evoked potentials	Indicators of physiological reactions such as cortisol saliva tests and blood pressure readings	Behavioral observation and other measurements such as systematic observation, photography, and self-report	Paper and pencil test, performances, portfolios, expert judgement

Source: Sternberg, Esther M. *Healing Spaces: The Science of Place and Well-being.* Harvard University Press, 2010.

Conclusion

Becoming well-versed in the practice of evidence-based design and research can be a challenging and time-consuming endeavor for design professionals. However, the benefits of EBD far outweigh the potential challenges. Research has confirmed that elements of the built environment do in fact have an impact on occupant healing, behavior, and overall well-being. This is an exciting discovery for the field of interior design, but also places a new responsibility on design professionals. Not only do designers have the responsibility of creating beautiful and functional spaces, they must now consider how these spaces are affecting occupants on a psychological and physiological level. Designers should document their processes and record the outcomes of design interventions in order to contribute to the growing body of EBD literature. As we continue to discover more about how the environment affects the brain, and in turn,

affects behavior and health, it is the responsibility of the design community as a whole to establish frameworks and standards to ensure that designers are responding to this phenomenon.

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Appendix A

RESEARCH RESOURCE LIST

Contract Magazine

http://www.contractmagazine.com/contract/index.jsp

Environment & Behavior

http://eab.sagepub.co

Facility Care

www.facilitycare.com

Healthcare Construction & Operations

www.hconews.com

Healthcare Design Magazine

www.healthcaredesignmagazine.com

Health Facilities Management

http://www.hfmmagazine.com/hfmmagazine_app/index.jsp

HERD Journal

www.herdjournal.com

Hospitals & Health Networks

www.hhnmag.org

Interiors & Sources

www.interiordesign.net

Journal of Architectural and Planning Research

http://www.lockescience.com

Physician Executive

www.acpe.org

Academy of Neuroscience

www.anfarch.org

Avery Index

www.columbia.edu/cu/lweb/indiv/avery

Cochrane Collaboration

www.cochrane.org

Ebsco

http://www.ebscohost.com

GoogleScholar

http://scholar.google.com

Informe Design

http://www.informedesign.umn.edu

IRB's and Ethics

http://www.hhs.gov/ohrp/

Literature Reviews

http://www.deakin.edu.au/library/findout/research/litrev.php

National Transportation Library

http://ntl.bts.gov/

National Nurses Association Survey

http://www.nationalnurses.org/surveyintro.html

OAIster

http://www.oaister.org/

Open Archives Initiative

http://www.openarchives.org

PubMed

http://www.ncbi.nlm.nih.gov/sites/entrez/

PsychINFO

www.apa.org/psychinfo

The Center for Health Design

www.healthdesign.org

Webfeat (federated search technology)

http://www.webfeat.org/index.htm

American Academy of Healthcare Interior Designers

http://www.aahid.org

American Association of Interior Designers

www.asid.org

American Association of Nurse Executives

http://www.aone.org/

American College of Healthcare Architects

http://www.healtharchitects.org

American Institute of Architects/Academy on Architecture for Health

www.aia.org/aah

Global Health & Safety Initiative

www.globalhealthsafety.org

The Center for Health Design

http://www.healthdesign.org/resources/weblinks/

International Association of Interior Designers

http://www.iida.org

Joint Commission

http://www.jointcommission.org

RIPPLE

www.ripple.healthdesign.org

Appendix B

Conducting a Content Validity Test

1. After the survey is written, select five to fifteen experts in the field of study who will agree to participate in the content validity analysis. (designers, architects, physicians, researchers, etc.)
2. Create a new questionnaire with a likert scale and comment box next to every original question. Ask the experts you have selected to rate on a scale of 1-5 how strongly they agree or disagree that each original item should be included on the survey.
3. Assign each question a number for coding if it doesn't already exist. (example, Q1, Q2, Q3, etc.)

4. After you have received at least 5 responses, you can begin coding the scale responses and compiling the comments and wording suggestions into a spreadsheet.
5. Each value on the likert scale is assigned a number (1-5). For each question, record the number of responses corresponding to each value. (see table below) The numbers may be different from those used on the survey to guide the respondents. Make sure that strongly agree has the highest value when coding (5) and strongly disagree has the lowest value (1). This survey was divided into several sections but it is not necessary to always do so for coding purposes.

General Building Section

	SA-5	A-4	N-3	D-2	SD-1
Q1	6				
Q2	5		1		
Q3	6				
Q4	5		1		

There were 6 total respondents and 4 questions in the general building section.

METHOD 1 – if the responses are generally good and you do not need to know each question's individual content validity index for reporting.

For each question, multiple the number of responses for each scale item (Strongly agree to strongly disagree) by the value assigned to that item.

Example for General Building section:
Q1. 6 x5 = **30**
Q2. (5x5) + (1x3)= **28**
Q3. 6x5 = **30**
Q4. (5x5) + (1x3)= **28**

We then add all of these values.
30 + 28 + 30 + 28 = **116**

You then calculate the highest score that could have possibly been given (if all response had been strongly agree). So, 4x6= 24 and 24x5=**120**

Next, divide the sum of the actual responses (116) by the total possible score (120) -
116/120 = .97

.97 is the content validity index (CVI) for this section.

To calculate the overall content validity index, add each section's CVI and divide by the number of sections.

If the survey was not divided into sections, you will do one long calculation as shown above.

If a particular question received poor ratings, you will want to look at it individually to see if it should remain in the survey.

Example: (6 responses)

	SA-5	A-4	N-3	D-2	SD-1
Q1	1			4	1

1x5 = 5
4x2 = 8
1x1= 1

5 + 8 + 1 = **14**

Total possible score = (6x5) **30**

14/30 = **.47**
This question has a CVI of .47 and would be thrown out.

Typically, questions with a CVI over .75 are considered valid. Those with a CVI less than .75 should be removed from the survey questionnaire.
A high CVI is useful when reporting results to further ensure to readers that the tools used in the research study were valid.

METHOD 2 – if you want to know each question's individual score and the overall CVI.

You can calculate the entire CVI from individual question scores as shown below:

General						Sum	CVI

Building							
	SA	A	N	D	SD		
Q1	6					30	1
Q2	5		1			28	0.934
Q3	6					30	1
Q4	5		1			28	0.934

Add the Content Validity Indices for each question and divide by the number of questions.

1 + .934 + 1 + .934 = 3.868

3.868/4 = .967 = .97

Again, we get .97 for the content validity index of this section.

- **Sometimes a respondent will miss a question or simply not respond to a question. In this case, the CVI is calculated the same way as shown EXCEPT for the overall possible score. This takes into account the fact that there is a response missing. For example, if there were 5 responses to a specific question but 6 total surveys returned, the "possible" score for this question becomes 25 instead of 30. This way, the missing response doesn't negatively impact the question's CVI.**

Appendix D

Adapted from Quan, et al. 2011

A

Acoustic Ceiling Tile

Environmental Variable – Patient Satisfaction

Definition

Ceiling tiles that absorb sound reflected off hard surfaces and can be used in a grid or directly glued to a solid ceiling deck. Typically porous, these products accept and trap sound/vibration and allow it to dissipate before leaving the products (ASI Pro Audio Acoustics, 2010).

Acuity-adaptable room

Environmental Variables - (Medical errors, Patient satisfaction, Staff satisfaction)

Definition

Rooms designed with sufficient space and provision for equipment, medical gases, and power to accommodate any level of patient acuity (Evans, Pati & Harvey, 2008). Single-room maternity care refers to maternity care rooms where families are admitted and stay throughout the intrapartum and postpartum periods. The rooms are spacious and include amenities for families. They differ from the traditional care model which requires patients to transfer between multiple rooms, depending upon their care status. (Janssen et al., 2001).

Air pressure difference between adjacent spaces

Environmental Variables - (positive/ negative pressure room) (HAIs)

Definition

Positive pressure room: a room supplied with enough air pressure to prevent air in corridors and adjacent areas from entering the room. Negative pressure room: a room where enough air has been evacuated to prevent air from flowing out of the room and into adjacent areas (Sehulster et al., 2004).

Alcohol-based hand rub

Environmental Variables - (HAIs)

Definition

A preparation containing alcohol that is designed to be applied to the hands for the purpose of reducing the number of viable microorganisms on the hands. (Boyce & Pittet, 2002).

Amenities

Environmental Variable - (Patient satisfaction, Patient waiting)

Definition

Features of health services that do not relate directly to clinical effectiveness but may enhance the client's satisfaction and willingness to return (Brown, Franco, Rafeh, & Hatzell, 1998).

Antimicrobial-finished textile product

Environmental Variable - (HAIs)

Definition

Textile products containing antimicrobial agents which show antibacterial activity against a wide range of microorganisms (Takai et al., 2002).

Attractiveness, physical environment

Environmental Variables - (Patient satisfaction, Patient waiting, Staff satisfaction)

Definition

Aesthetic appeal of the physical environment, including the surrounding external environment, the architectural design, facility upkeep and cleanliness, and other physical elements (Becker & Douglass, 2008).

B

Barcode-assisted dispensing system

Environmental Variable - (Medical errors)

Definition

A medication dispensing system that uses barcodes to ensure that the correct medication, in its correct dose and formulation, is being dispensed (Poon et al.,
2006).

Bed alarms, medical vigilance system (bed sensors connected to a nurse call system)

Environmental Variable - (Patient falls)

Definition

A passive sensor array, including bed exit sensors, embedded into a coverlet around the patient bed's mattress and connected to the nurse call system (Spetz et al., 2007).

Bedrail and other physical restraints

Environmental Variable - (Patient falls)

Definition

Physical restraints: mechanical or manual devices used to limit a patient's physical mobility (Capezuti et al., 1998). Bedrail: a rail or board running along the side of a patient bed; often used to prevent easy egress from the bed (Hanger et al., 1999).

Bedside assortment picking (BAP) trolley

Environmental Variable - (Medical errors)

Definition

A new type of drug trolley with separate compartments for ward specific stock and patient-specific medicines. Equipped with a wireless laptop that connects to electronic medication administration records and guides the nurse to the correct location of a drug (Ros & de Vreeze-Wesselink, 2009).

C

Computerized physician order entry (CPOE)

Environmental Variable - (Medical errors)

Definition

Computer-based systems for automating the medication ordering process. A basic CPOE ensures standardized, legible, complete orders by accepting only those orders that are typed and in a standard and complete format (Kaushal & Bates, 2001).

Computerized (automatic) reminder of hand hygiene

Environmental Variable - (HAIs)

Definition

A computerized system providing prerecorded, audio/visual messages instructing healthcare personnel to wash their hands before exiting the room or within 10 seconds of exiting the room. The system monitors room entry/ exit and hand washing device usage (Swoboda et al., 2004).

Copper-silver ionization system

Environmental Variable - (HAIs)

Definition

A system that reduces Legionella colonization of a hospital water supply by introducing positively charged copper and silver ions into the water system (Modol et al., 2007).

D

Daylight

Environmental Variables - (Medical errors, Staff satisfaction)

Light originating from the sun that reaches Earth’s surface after reflecting off the sky's vault (Zunde & Bougdah, 2006).

Distraction

Environmental Variable - (Medical errors)

Definition

An external stimulus causing observable responses from healthcare workers without disrupting the ongoing, productive activity. Distractions (Flynn et al., 1999).

E

Emergency Department Layout

Environmental Variable – Patient waiting

Definition

Spatial configuration of the ED, including treatment rooms, work stations, and other components (Hall et al., 2008).

F

Falls – Multifaceted environmental intervention

Definition

Simultaneous modification of multiple aspects of the physical environment for the purpose of reducing patient falls and injuries (Becker et al., 2003; Brandis, 1999).

Hand hygiene devices, number of

Environmental Variable - (HAIs)

Definition

The number of staff – accessible hand washing sinks (Kaplan et al., 1986).

Head-mounted display

Environmental Variable - (Staff efficiency)

Definition

A scanning retinal display that uses a laser to project a monochromatic red image onto a transparent monocle which then reflects the image on the wearer's retina. The device keeps patients' vital signs within view of the anesthesiologist at all times, precluding the need to look at a patient monitor (Liu et al., 2009).

High-efficiency particulate air (HEPA) filter

Environmental Variable - (HAIs)

Definition

A high-efficiency air filter that removes at least 99.97% of airborne particles measuring 0.3 micrometers in diameter ((Sehulster et al., 2004). Can be portable or installed in an HVAC system.

HEPA filters, location of

Environmental Variable - (HAIs)

Definition

The location of HEPA filters in an HVAC system (Crimi, et al, 2006).

Illumination level (illuminance)

Environmental Variables - (Medical errors, Staff efficiency)

Definition

The intensity of luminous flux (Stein, 1997).

Information access

Definition

Patient access to information regarding ED process (time to see a doctor/consultant, blood draw) and medical and therapeutic plans (Tran et al,. 2002).

Interior finish material

Environmental Variables - (HAIs, Patient falls)

Definition

Material covering interior surfaces such as ceiling, floors, and walls (Calkins et al., 2011; Noskin et al., 2000).

Interruption

Environmental Variable - (Medical errors)

Definition

Cessation of productive activity before completing a prescription filling task, due to any externally imposed, observable, or audible reason. Interruptions can be caused by staff looking at people passing through the ambulatory care pharmacy and related to prescription-processing questions (Flynn et al., 1999). Situation in which a nurse ceased a medication preparation or administration task in order to attend to an external stimulus (Westbrook et al., 2010).

L

Laminar air flow (LAF)

Environmental Variable – HAIs

HEPA-filtered air blown into a room at a rate of 90 ± 10 feet/min in a unidirectional pattern with 100 ACH–400 ACH (Sehulster et al., 2004).

Light Fixture (luminaire)

Environmental Variable - Medical Errors

Definition

A complete lighting unit consisting of a light source (one or more lamps), and the parts designed to position the light source and connect it to the power supply. Parts for protecting the light source or ballast and for distributing the light may be included. (National Fire Protection Association, 2010)

M

Medication Distribution System

Environmental Variable - Staff Efficiency

Definition

A system for preparing and distributing medications for the treatment of patients in healthcare settings (Poley et al., 2004).

Mobile air-treatment unit that uses nonthermal-plasma reactors

Environmental Variabel - (HAIs)

Definition

A portable device utilizing nonthermal-plasma reactors to destroy microorganisms and electro-statically capture particles and molecular residues for the purpose of reducing airborne bioburden in high-risk areas (Bergeron et al., 2007).

Music

Environmental Variable - (Staff efficiency)

Definition

The art of arranging sounds in time so as to produce a continuous, unified, and evocative composition, as through melody, harmony, rhythm, and timbre (The Free Dictionary).

N

Noise

Environmental Variables - (Medical errors, Patient falls, Patient satisfaction, Staff efficiency, Staff satisfaction)

Definition

Auditory stimulus, such as a change in loudness, bearing no informational relationship to the presence or completion of the task.

Sound: a change in loudness bearing some informational relationship with the task at hand (Flynn, et al, 1996). A sound that is loud, unpleasant, unexpected, or undesired (The Free Dictionary).

Nursing station, layout – decentralized, centralized

Environmental Variables - (Patient falls, Staff efficiency)

Spatial arrangement of nurse work stations in a nursing unit (Dutta, 2008; Gurascio-Howard & Malloch, 2007; Hendrich et al., 2004).

Nursing unit shape/layout

Environmental Variable - Staff efficiency

Definition

Spatial arrangement of patient care rooms and nursing stations in nursing units (Donahue, 2009; Shepley, &Davies, 2003: Trites et al., 1970).

P

Patient bathroom design

Environmental Variable - (Patient Falls)

Definition

Architectural and interior design of bathrooms containing bath and toilet facilities for patients (Calkins et al., 2011).

Patient room layout

Environmental Variables - (Patient falls, Staff efficiency)

Definition

Spatial arrangement of architectural elements and equipment in patient rooms (Calkins et al., 2011; Pati et al., 2010).

Patient room occupancy

Environmental Variables - (HAIs, Patient satisfaction, Staff efficiency, Staff satisfaction)

Definition

The number of patients per patient room—one (single room, private room), two (double room), four (multi-bed open bays) (Ben-Abraham et al., 2002; Nguyen Thi, Briancon, Empereur, & Guillemin, 2002; Shepley, Harris, & White, 2008).

Pharmacy equipment

Environmental Variable - (Staff efficiency)

Definition

Fixtures and equipment used in the pharmacy area for the purpose of preparing and distributing medications (Lin et al., 1988).

Physical configuration of drug stock shelves

Environmental Variable - (Staff efficiency)

Definition

Spatial arrangement of drug items including the amount of space between drug items on shelves (Flynn et al., 2002).

Physical proximity

Environmental Variable - (HAIs)

Definition

A risk factor of nosocomial infection. A patient is considered to be in physical proximity when he/she is a roommate or neighbor of a patient with an infectious disease, or when he/she stays in the room after the patient with the infectious disease has left (Change & Nelson, 2000).

Positive distractions

Environmental Variables - (Patient satisfaction, Patient waiting)

Definition

A set of environmental features or conditions that have been found by research to effectively reduce stress. These features or conditions include nature and certain types of music, companion animals, laughter or comedy, and certain types of art (Ulrich, 1991).

R

Rapid assessment clinic/pod/zone

Environmental Variable – Patient Waiting

Definition

An ED area for quick clinician assessment and procedures on patients whose disposal is readily apparent for whom required interventions can be quickly undertaken, and for problems that do not require prolonged assessment or decision-making. Generally adapted from existing ED space, it is a novel intervention for reducing ED waiting time (Ardagh et al., 2002; Bullard et al., 2011).

S

Subfloor

Environmental Variable - (Patient falls)

Definition

Rough floor serving as a base under a finished floor (Simpson et al., 2004)

Surface cleaning- cleaning, disinfection, sterilization

Environmental Variable - (HAIs)

Definition

Cleaning: removal of visible soil and organic contamination from a device or surface, using either the physical action of scrubbing with a surfactant or detergent and water, or an energy-based process such as ultrasonic cleaners with appropriate chemical agents; thorough cleaning is an important step before high-level disinfection and sterilization (Sehulster et al., 2004). .

Disinfection: compared to sterilization, a less than lethal process of microbial inactivation that eliminates virtually all recognized pathogenic microorganisms but may not eliminate all microbial forms (e.g., bacterial spores) (Sehulster et al., 2004).

Sterilization: use of physical or chemical procedure to destroy all microbial life, including large numbers of highly-resistant bacterial endospores (Sehulster et al., 2004).

U

Ultraviolet germicidal irradiation

Environmental Variable - (HAIs)

Definition

Use of ultraviolet radiation to kill or inactivate microorganisms (Sehulster et al., 2004).

Ventilation grilles, location

Environmental Variable - (HAIs)

Definition

Arrangement of ventilation grilles on ceilings and walls (Beggs et al., 2008).

Ventilation, natural

Environmental Variable - (HAIs)

Definition

Movement of outdoor air into a space through intentionally provided openings such as windows, doors, or non-powered ventilators) (Sehulster et al., 2004).

Ventilation rate

Environmental Variable - (HAIs)

Definition

The rate at which air enters and leaves a building, space, or room (EPA, n.d.).

Wireless technology

Environmental Variable - (Staff efficiency)

Definition

Technology enabling the transfer of information over a distance without the use of electrical conductors or wires (Guarascio- Howard, 2011; O'Connor et al., 2009).

Workroom layout

Environmental Variable - (Staff efficiency)

Definition

Spatial arrangement of equipment in a workroom (Lu & Hignett, 2009).

Appendix E

Example Focus Group Questions

In what ways does this facility help or hinder your job performance?

Tell us about the environment inside the facility (air quality, trash, clean-up, sun/shade, lighting, etc.)

How comfortable is this facility to be in?

Does the facility fully meet the needs of disabled patients and staff?

How safe do you feel in or around this facility?

How satisfied are you with the aesthetics/appearance of the facility?

Were you involved in the planning that went into this facility? How do you feel about it?

How well is this facility maintained and how easy is it to do?

Overall, how satisfied are you with the quality of this facility?

If you could change anything about the facility what would it be?

What were the three most important goals this building project needed to achieve? How successful is the building in supporting each of these goals?

How do you measure success (i.e., Press Ganey, patient volumes, patient satisfaction, and staff efficiency)?

Describe any unexpected outcomes you have observed in the building since occupancy.

Now that you have been in the building, is there anything you would do differently?

Do you find that the building functions (patient intake, treatment, admin and support, amenity, etc.) are appropriately organized to promote the desired level of efficiency and interaction?

Does the patient care space allow for the efficient delivery of care?

Are there any building attributes that either support or inhibit work processes and effectiveness?

Is there a higher level of staff efficiency and overall work performance attributed to the new building?

Are there any activities in your department that the building design impedes?

Discuss new diagnostic and treatment activities, work processes and technology that the building has been able to adapt to.

How adaptable has your environment been to changes in care delivery?

How well does the building support collaboration between interdisciplinary groups?

Appendix F

Built Environment Design Variables

Audio Environment

- Environmental Surface finishes: sound-absorbing vs. sound-reflecting (ceiling, walls, flooring)
- Equipment noise (alarms, paging, monitors, carts)
- Acoustic walls
- Music

Visual Environment

- Windows (natural light & nature views)
- Siting and orientation of building
- Art
- Visual Stimuli on Ceiling
- Gardens and plants
- Video games
- Internet access
- Television

Safety Enhancement

- Location of alcohol gel hand rub dispensers
- Location of hand washing sinks
- Air quality and ventilation
- Staff visual access to patients
- Easy-to-clean surfaces
- Optimized water systems
- Ceiling hoists for lifting patients
- Brighter task lighting levels in staff work areas
- Levels of interruptions and distractions in medication dispensing, other work areas
- Appropriately placed handrails and non-slippery floor coverings

Wayfinding

- Building entrance
- Signage
- Floor plan
- Information desk
- Consumer services (e.g. cafeteria)

Sustainability

- Building mass/shape

- Building materials
- HVAC system
- Energy efficient measures
- Waste management
- Water treatment system

Patient Room

- Single vs. mulit-bed room
- Private vs. shared toilets
- Hard wall partitions vs. curtains (e.g. in EDs, post anesthesia recovery)
- Acuity-adaptable single rooms
- Same handed rooms
- Convenient control of light, temperature
- Patient choice of art and decorations

Family Support Spaces

- Comfortable waiting rooms (movable seating, quiet, uncrowded)
- Convenient access to toilets
- Access to food
- Overnight bed in patient room
- Personal storage
- Computer/work space; Internet access
- Private meeting rooms
- Gardens
- Availability and Proximity of Parking

Staff Support Spaces

- Quality of workstation
- Centralized vs. decentralized nurse stations
- Nursing floor layout
- Proximity of supplies, storage
- Proximity of medications
- Quality of spaces for meetings, handoffs, other communication
- Quality and accessibility of break areas
- Availability and proximity of parking

Physician Support Spaces

- Availability and proximity of parking
- Proximity of offices
- Quality of break area
- Quality and location of workstation

- Quality of meeting spaces
- Acoustics of operating rooms (noise, distractions, music)
- Air quality of operation rooms
- Task lighting

Participant Outcomes

Patients

- Hospital acquired Infections
- Medical errors
- Falls requiring treatment
- Re-hospitalization rates
- Use of pain medications
- Length of stay
- Patient Transfers
- Social support/family presence
- Perceived pain
- Sleep quality
- Sense of privacy
- Stress/emotional distress
- Depression
- Confidentiality of patient information
- Quality of staff communication to patients
- Quality of patient communication to staff
- Perceived medical quality
- Perceived service quality
- Commitment to hospital
- Overall satisfaction

Families

- Quality of staff communication to family
- Perceived medical quality
- Perceived service quality
- Perceived respect for family role
- Time spent at facility
- Time spent with patient
- Commitment to hospital
- Overall satisfaction
- Stress/emotional duress

Physicians

- Rounding efficiency

- Role satisfaction
- Perceived control in job
- Perceived teamwork in unit
- Perceived fatigue
- Perceived job strain, demands
- Perceived medical quality
- Perceived service quality
- Commitment to hospital
- Stress/emotional duress
- Work performance
- Job-related injuries and illnesses

Nurses, other staff

- Job-related injuries and illnesses
- Absenteeism
- Time for direct patient care
- Time spent fetching, other non-care activities
- Job satisfaction
- Stress/emotional duress
- Perceived control in job
- Perceived workplace social support
- Perceived teamwork in unit
- Perceived fatigue
- Perceived job strain, demands
- Perceived medical quality
- Perceived patient safety
- Perceived services quality
- Commitment to hospital

Demographics

- Age
- Gender
- Ethnicity/Language
- SES
- Diagnosis/procedure

Control/Confounding Variables

- Culture for internal communication
- Culture for medical errors & safety
- Culture for patient & family-centered care

- Practice of evidence-based medicine
- Physician/staff competence
- Supervisor support
- Acuity mix
- Number of beds
- Occupancy rates
- Nurse/patient ratio
- For profit vs. not-for-profit