# USING THE "FIVE WHYS" AS A DECISION-MAKING FRAMEWORK FOR EVIDENCE-BASED DESIGN

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## ABSTRACT

Evidence-Based Design (EBD), the judicious and conscientious use of current best evidence to make design decisions for unique projects, is being applied to the design of healthcare facilities with increasing frequency. Because of both the need to replace and expand aging buildings and a retiring baby boom generation, construction of healthcare facilities is currently on the rise in the US. Advocates of EBD argue that its rigorous application will reduce incidence of medical error and improve rates of patient recovery. However, while some promises made by EBD can be scientifically substantiated, design of facilities may not be the only appropriate solution to the problems EBD advocates cite; healthcare facility designers are pressing for EBD adoption, even when a less costly, non-capital program response might be equally effective. This paper suggests that while the error-proofing logic of EBD makes sense, a structured framework for the "Five Whys" should be rigorously implemented by design decision-makers, to ensure that multiple options are considered before final solutions are adopted.

## KEY WORDS

evidence-based design, lean construction, five whys

## INTRODUCTION

At the time of this writing, there is a convergence between a need to construct new health care facilities in the US on a large scale, and a striving by architects and designers to improve the quality of health care facility design using Evidence-Based Design (EBD) (Postrel 2008; Ulrich et al. 2004).

Despite growing interest in EBD and its potential to improve healthcare quality, a number of owners and designers have expressed frustration over the difficulty of communicating EBD recommendations to their budgeting and design staff. Sorting through research articles can be unwieldy and time consuming. Furthermore, many owners and designers have little background in research methodology and are ill-equipped to make judgments about the validity of published experimental results.

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To address these concerns, members of the EBD research community are developing tools to systematize findings and to render recommended EBD interventions easier to comprehend and implement (Geboy 2007; Guerin and Dohr 2007). Although these early attempts are reasonable, some of these tools appear to fixate on design solutions to problems that may not actually require an architectural response (e.g., potted plants might offer some of the same health benefits as healing gardens). Other tools, such as those that take the form of printed books and checklists, codify the current state of EBD knowledge, freezing it at a potentially premature stage—a concept that undermines the nature of continual EBD development. Several websites are being created to offer helpful search functions, but the results they present can be overwhelming to those who, time pressed and unwilling to sort through details, would benefit from an unbiased framework around which to organize their decision-making strategy. No tool, to our knowledge, is yet being developed to integrate national quality indicators with EBD decision-making. And none, yet, appears to consider the financial concerns of the capital budgeting decision-maker.

To assist the practitioner, an appropriate tool needs at least to be able to (1) classify the certainty of EBD knowledge claims, (2) quantify the probable impact of the EBD intervention and (3) offer alternatives without imposing solution bias.

## Birth of EBD

In her 1860 book, *Notes on Nursing: What It Is and What It Is Not*, nursing pioneer Florence Nightingale observed: "Almost all patients lie with their faces turned to the light," she writes, "exactly as plants always make their way towards the light" (Nightingale 1860). Although Nightingale's observations were astute, they had not resulted from a controlled scientific experiment relating recovery rates to light, and so were considered anecdotal by the scientific community.

However, in a 1984 publication in *Science*, researcher Roger Ulrich reported that patients subjected to an identical surgical procedure recovered three-quarters of a day more quickly if their window faced foliage rather than a brick wall. Because Ulrich's research methodology was deemed scientifically rigorous (he minimized confounding variables by matching patient records according to sex, age, smoking status, obesity and year of surgery) (Ulrich 1984), it was possible to determine that the difference between the experimental and control population was statistically significant. Ulrich's paper led to the birth of the Evidence-Based Design movement. Since then, hospital owners, architects and engineers have begun to rely on evidence when making design decisions.

According to D. Kirk Hamilton, Evidence-Based Design (EBD) is "the conscientious and judicious use of current best evidence, and its critical interpretation, to make significant design decisions for each unique project. These design decisions should be based on sound hypotheses related to measurable outcomes" (Hamilton 2006). Examples of health benefits associated with EBD decisions include reduced length of stay thanks to views of foliage and sunlight (Walch et al. 2005), reduced patient falls thanks to rubberized flooring, reduced hospital-acquired infections thanks to single patient rooms, reduced drug costs thanks to patient stress reduction from quieter rooms, reduced nursing turnover thanks to a less stressful work environment, increased market share, and increased philanthropy thanks to a more patient-oriented spaces (Joseph 2006a; 2006b). Although EBD can be applied to other building types as well, the current focus on healthcare facility design is likely due to two realities: a) data is easier to collect in the healthcare arena, and b) the financial stakes linked to occupant health are especially high.

### Current Interest in EBD

Health care facility construction is on the rise, with some reports suggesting the start of the new millennium to be "the most significant expansion and replacement of US hospitals since the post-World War II building spree" (Carpenter and Hoppszallern 2006). According to a survey by HFM/H&HN/ASHE, the current boom is being driven by a number of factors, including the need to: repair and replace aging facilities (68%), increase operational efficiency and patient flow, especially given new forms of technologies (62%), respond to increased competition in the marketplace (51%), meet the needs of a specific population (48%), and increase market share (47%) (Babwin 2002; Carpenter 2004; Carpenter and Hoppszallern 2006).

Coincident with this boom is an urgent call to improve the quality of care provided in the US. According to two Institute of Medicine reports released within this decade, *To Err is Human* (2000) and *Crossing the Quality Chasm* (2001) the US health care system faces serious challenges. The reports reveal that between 44,000-98,000 Americans die each year due to preventable medical errors. These reports raise concerns about patient safety.

The sudden increase in healthcare facility construction makes improvement in their design all the more important. Especially at a time when construction costs are escalating (Moon 2005), hospital facility decision-makers need to prioritize allocating capital costs to the most critical items, such as those that will likely have the greatest impact on patient outcomes. Additionally, new Medicare reimbursement pay-for-performance policies are forcing hospitals to rethink ways to reduce incidence of hospital-acquired infections and medical errors (Associated Press 2008).

### Assessing Scientific Quality of EBD Research

Even as scientific methodology has progressed, not all experimental research results are equally valid. To address these concerns, academic researchers are attempting to offer an unbiased assessment of the claims. As with other bodies of medical knowledge, many reviews of EBD-related literature represent little more than ad hoc collected citations of experimentation in fields related to EBD. This way of approaching reviews of scientific literature has been challenged (Dickersin and Min 1993; Oxman and Guyatt 1993) because of poor consistency between expert ratings resulting from a number of factors, including lack of blinding of authorship and publication bias (Oxman and Guyatt 1993). The need to consolidate an unwieldy expansion of data, as well as to better assess the reliability of health impact claims, requires a more methodical and rigorous approach. This has resulted in the development of a systematic review methodology (Antman et al. 1992; Buendia-Rodriguez and Sanchez-Villamil 2006; Chalmers 1993; Counsell 1997; Meade and Richardson 1997; Mullen and Ramírez 2006; Mulrow et al. 1997).

In fact, systematic reviews are increasingly being compiled by those who advocate Evidence-Based Medicine (EBM), a movement which regards randomized controlled trials (RCT)[1] as its gold standard (Sandercock 1993). In some sense, EBD runs both parallel to and intersects with EBM. Both EBM and EBD regard evidence as supreme when making decisions. Since some EBD decisions, such as stress-reducing music or sunlight, can arguably lessen or displace the administration of some forms of medication, EBD shares much in common with EBM. However, EBD logic can be applied to business as well as medical decisions, and therefore needs to be considered a subject in its own right.

Collaborative not-for-profit organizations have emerged to produce systematic reviews within EBM. For example, the Cochrane Collaboration (Chalmers 1993) statistically combines homogeneous RCT results from research from around the world. However, randomized controlled trials in EBD-related topics are generally more difficult to develop than in EBM areas, perhaps because so many confounding variables in an environment need to be controlled. Preparation of randomized controlled trials is predicated on the ability to hold constant all variables between experimental and control groups but one—a trick that is not as simply done with environmental cues as with testing the effects of a pill versus a placebo.

Although preparation of meta-analyses may still be far off, a form of systematic review *has* started to emerge within Evidence-Based Design (Rubin et al. 1998; Ulrich et al. 2004). These reviews represent an early step toward the coveted gold standard of reviews, the meta-analysis. Migration toward meta-analyses is clearly desirable in order to quantify the outcomes resulting from EBD; however the number of randomized-controlled trials related to EBD concerns is not yet sufficient to be able to conduct meta-analyses. A report prepared for the Health Research and Education Trust (HRET) argues that EBD research would benefit greatly by working toward meta-analysis as an ultimate goal (Ballard and Rybkowski 2007).

## EBD Collaborative Networks

The Center for Health Design (CHD) in Concord, California, has become a central driving force behind EBD research and promotion. In the 1990s the CHD engaged Johns Hopkins University to collect and evaluate the caliber of all pre-existing scientific literature that showed a link between patient wellbeing and the physical environment. The document, *Status Report (1998): An Investigation to Determine Whether the Built Environment Affects Patients' Medical Outcomes,* is one of the first attempts

[1] A randomized controlled trial (RCT) is a clinical study with two major characteristics: randomization and the presence of a control group (Leandro 2005). (Leandro, G. (2005). "Meta-analysis in Medical Research:The Handbook for the Understanding and Practice of Meta-Analysis." Blackwell Publishing.

to systematically review existing studies relating to EBD topics. Researchers found 84 studies produced since 1968 that met specified criteria, assessed their scientific merit, and classified them into four primary categories: (1) randomized control trial, (2) experimental, paired, (3) observational, paired, and (4) observational, unpaired, nonrandom assignment. The team proposed a conceptual "Environment-Outcome Interface" model, suggesting three ways that features of the physical environment might impact a patient's rate of recovery. According to the model (Figure 2), the environment may (1) support or hinder a caregiver's actions and medical interventions, (2) impair or strengthen a patient's health status and personal characteristics, or (3) protect a patient from or expose him or her to causes of illness (Rubin et al. 1998).

Five years following publication of the Rubin report, Ann Devlin and Allison Arneill from the Department of Psychology at Connecticut College examined three areas of research: patient involvement with health care (the role of patient control), the impact of the ambient environment (e.g., sounds, light, art), and specialized building types for defined populations (such as Alzheimer's patients) (Devlin and Arneill 2003).

One year later, a milestone literature review on EBD appeared. The review team was jointly led by now University of Texas A&M professor, Roger Ulrich, and Georgia Tech professor, Craig Zimring, both teaching and researching professors in departments of architecture. The review, entitled, *The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity*, identified 600 rigorous studies and assessed their scientific merit, evaluating them using an academic letter grade scale (Ulrich et al. 2004). After assessing the literature, the team called for facility design decision-makers to: (a) *Reduce staff stress, health, and safety* through environmental measures, such as improved ventilation, ergonomic design, better designed nursing stations, improved lighting, and floor plans that reduce the need for staff to walk great distances; (b) *Improve patient safety* by controlling hospital-acquired infections with HEPA filters and single-patient (rather than multi-patient) rooms and with sinks and/or alcohol-based hand-rub dispensers in each room for staff use between patients, reducing medical errors by installing improved lighting, and reducing patient falls by introducing wider bathroom doors; (c) *Reduce stress and improve outcomes* by eliminating noise, improving way-finding, introducing bright light, visions of nature, positive distractions, gardens, art, and comfortable areas for families and friends to offer social support, and enhancing communication between staff and patient; and (d) *Improve overall healthcare quality* (Ulrich et al. 2004).

However, despite growing enthusiasm, EBD is not without its critics. An article by researchers at the University of Twente in the Netherlands (Dijkstra et al. 2006) argues that of 500 potentially relevant EBD studies, only 30 pass highly rigorous scientific criteria. They suggest that conclusive evidence is so limited, it is premature to formulate evidence-based design guidelines for healthcare environments. David

Chambers, Director (Planning Architecture & Design) of Sutter Health criticizes the EBD movement for focusing on the patient in the bed, and recommends advocates should instead acknowledge the increasing role that ambulatory care is beginning to play (Chambers 2006).

Nevertheless, advocacy groups have been pushing EBD forward. A number of papers by Anjali Joseph (Joseph 2006a; 2006b; 2006c), Director of Research of the Center for Health Design, have served as a bridge between academic research and decision-makers who seek to implement its findings.

What can be discerned is that the caliber of literature takes many forms, and ranges from (a) anecdotal observations to (b) traditional reviews, to (c) systematic reviews and (d) meta-analyses (Figure 1). While anecdotal evidence is not necessarily incorrect (it often seeds more rigorous scientific research work later on) it does not follow strict research methodology, and therefore offers limited ability to generalize. Much EBD research is now being subjected to systematic reviews and like its cousin, Evidence-Based Medicine, will likely become more rigorous in coming years.

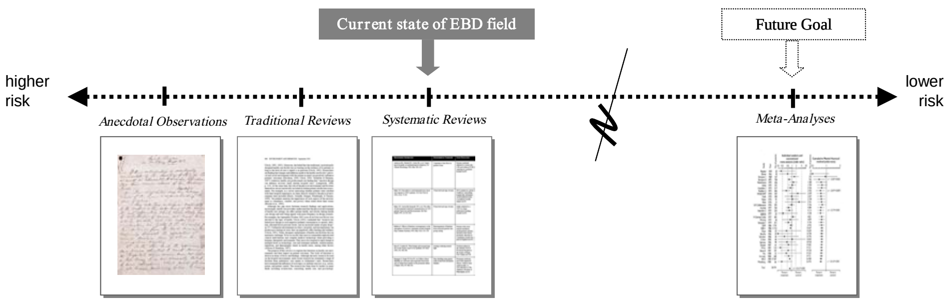


Figure 1: The four principle types of literature review offer varying degrees of certainty.

## METHODOLOGY FOR CREATION OF AN EBD DECISION TREE

While using EBD to enhance built-in quality is a sound concept in theory, there is always a concern that EBD may be applied inappropriately or indiscriminately. When individuals solve problems, proposed solutions may tend to be biased toward the perspective or skill set of the decision-maker. For example, architectural or interior designers are educated to seek physical design solutions to problems; engineers have been trained to apply physical laws, and hospital administers may opt to manipulate financial resources. Each of these approaches yields legitimate solution opportunities; however no one strategy may be optimal for the particular dilemma at hand. One way to avoid (even unintended) solution bias is to construct an EBD decision tree based on the Five Whys. The Five Whys is a problem solving technique that attempts to locate the root cause of a problem by asking "why?" at least five times in succession until reaching an actionable cause (Ohno 1988; Tsao et al. 2004; Wilson et al. 1993). Because it ensures that decision-makers seek solutions that address the root causes of the problems appropriate to the particularities of the individual facility, this paper proposes using the Five Whys as a framework for EBD decision-making.

It is important to note that the appropriate solution for a specific health care facility challenge may or may not require that the intervention be architectural in nature. For example, excessive incidence of nosocomial infections may be more a result of staff negligence than an inadequate provision of sinks for a facility. In other words, asking "why?" at least five times ensures that hospitals undertake systematic root cause analysis before investing in expensive capital solutions that may or may not offer appropriate responses to their specific problems.

Naturally, nodes on each tree are not mutually exclusive; patients may be acquiring hospital infections both from staff hands *and* unfiltered HVAC systems. Also, because potential solutions may simultaneously solve problems on multiple fins, relational tendons should connect nodes between fins.

The final link--the potential solutions proposed at the end of Five Whys--should be rated based on the literature review scale discussed previously. Grades of A (Anecdotal), T (Traditional), S (Systematic) and M (Meta-analysis) should be supplied for each potential solution, depending on the most rigorous state of currently available evidence. Also, a rating system that quantifies the impact of individual interventions could be applied as follows: (a) up to 30% reduction of symptoms, (b) up to 60% reduction of symptoms, (c) up to 100% reduction of symptoms, and (d) 100% reduction of symptoms. At this point, a facility owner can input the probable quantity of symptom reduction into a financial benefit:cost or internal rate of return analysis. Because the described framework offers a systematic way to examine certainty of existing evidence, owners have some basis to determine financial risk when considering the implementation of an EBD intervention. When capital funds are limited, it makes sense to prioritize funneling of resources into solutions that offer the highest magnitude and probability of demonstrated health benefit per unit cost.

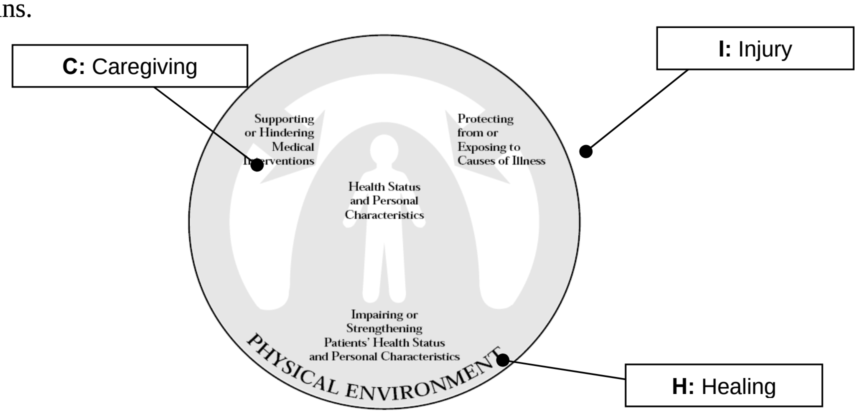


Figure 2: Categories applied to the Johns Hopkins *Environment-Outcome Interface Model*. Adapted from Figure 1, Rubin et al. (1998).

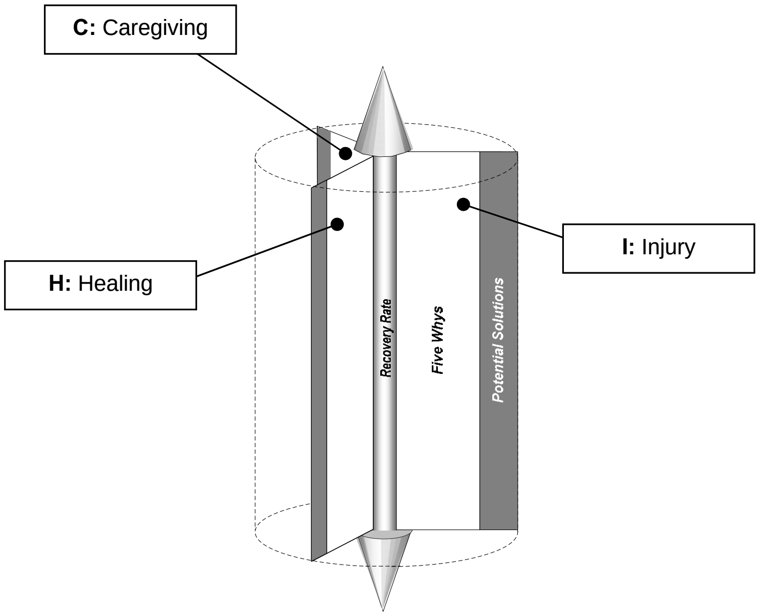


Figure 3: Three-dimensional extrusion from the Johns Hopkins Environment-Outcome Interface Model.

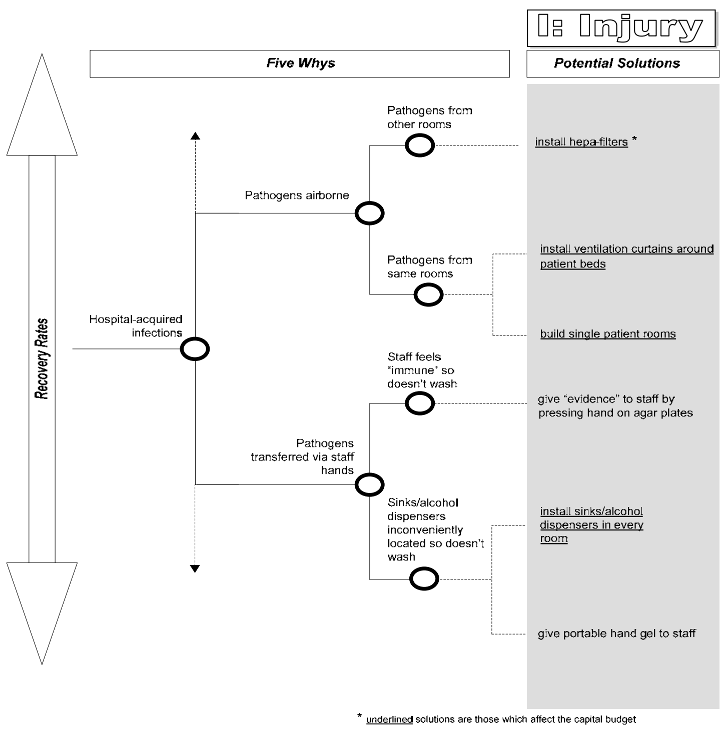


Figure 4: Root cause analysis using Five Whys and preliminary EBD literature review results.

## CONCLUSION

As with other industries, US healthcare providers are searching for solutions to solve multi-facetted problems. One advantage of EBD is that it has the potential to offer built-in quality and error-proofing for a healthcare organization. For example, creating single patient rooms simultaneously solves several problems: reduction of hospital-acquired infections, softening of stressors such as noise, and reduction of confidentiality breaches. Once a solution provides built-in quality, many of the problems it addresses are no longer a concern, resulting in long term annual savings and benefits to the healthcare organization (Berry et al. 2004; Grout 2007).

However, given the financial constraints that many health care facilities now face, it is important to evaluate EBD solutions within the context of the full range of strategic options available to decision-makers. EBD recommendations need to be evaluated with a level of neutrality and methodological rigor that is suited to academic pursuit. Root cause analysis using the Five Whys enables this.

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