
**THE EVIDENCE-BASED DESIGN LITERATURE REVIEW
AND ITS POTENTIAL IMPLICATIONS FOR CAPITAL BUDGETING OF
HEALTHCARE FACILITIES**

by

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TABLE OF CONTENTS

EXECUTIVE SUMMARY	4
WHY YOU SHOULD ASSESS EBD CLAIMS.....	4
RELATING QUALITY OF EVIDENCE TO MAGNITUDE OF RISK	5
WHOLE LIFE COSTS AND PATIENT OUTCOMES.....	9
THE EVIDENCE-BASED DESIGN LITERATURE REVIEW AND ITS POTENTIAL IMPLICATIONS FOR CAPITAL BUDGETING OF HEALTHCARE FACILITIES.....	11
ABSTRACT	11
1.0 INTRODUCTION	12
2.0 EVIDENCE BASED DESIGN: AN OVERVIEW	13
2.1 <i>Definition of Evidence-Based Design</i>	13
2.2 <i>Key milestones in EBD</i>	13
2.3 <i>From research into law</i>	15
3.0 EVIDENCE-BASED MEDICINE (EBM).....	18
3.1 <i>The need for reviews</i>	18
3.2 <i>Conducting a systematic review</i>	21
3.3 <i>Challenges of reviews</i>	22
3.4 <i>The diamond of literature reviews: the meta-analysis</i>	22
3.5 <i>Cochrane Collaboration</i>	23
4.0 EVIDENCE-BASED DESIGN REVIEWS	25
4.1 <i>Methodology</i>	25
4.2 <i>Classification of EBD reviews</i>	26
4.3 <i>Selecting an appropriate type of review</i>	27
5.0 IMPLEMENTATION.....	28
5.1 <i>EBD and life cycle costing</i>	28
5.2 <i>Must better healthcare facilities cost more?</i>	29
6.0 CONCLUSIONS AND RECOMMENDATIONS	30
BIBLIOGRAPHY	33

LIST OF FIGURES

FIGURE 1. INFLUENCE/COST DIAGRAM (PAULSON 1976)	5
FIGURE 2. THE CONCERNS OF EVIDENCE-BASED DESIGN (EBD) INTERSECT THOSE OF EVIDENCE-BASED MEDICINE (EBM)	6
FIGURE 3. SPECTRUM OF EBD EVIDENCE AND RELATED RISK.	7
FIGURE 4. SPECTRUM OF EBD LITERATURE REVIEWS.....	9
FIGURE 5. THE ITERATIVE EBD STANDARDIZATION PROCESS. THE SPIRAL INDICATES THAT THE PROCESS IS ITERATIVE AND PROGRESSIVE.....	16
FIGURE 6. STAGES OF EBD DEVELOPMENT.....	17
FIGURE 7. RESULTS OF THE META-ANALYSIS DONE BY ANTMAN ET AL., (1992) INDICATES THAT THE PROPHYLACTIC LIDOCAINE SERVED NO MORTALITY BENEFIT IN CASES OF MYOCARDIAL INFARCTION (LEFT). THIS WAS NOT THE RESULT THAT HAD BEEN SUGGESTED BY THE TRADITIONAL REVIEW (RIGHT).....	19
FIGURE 8. A META-ANALYSIS BY ANTMAN (1992) AND ADAPTED BY MULROW (1994) DEMONSTRATES THE ADVANTAGES INHERENT IN POOLING CUMULATIVE RESULTS FROM HOMOGENEOUS RANDOMIZED CONTROLLED TRIALS.	20
FIGURE 9. COCHRANE COLLABORATION LOGO (COCHRANE COLLABORATION 2007).	23
FIGURE 10. SPECTRUM OF EBD REVIEWS.....	26
FIGURE 11. RANGE OF EXPECTED RESULTS FOR REDUCTION OF HOSPITAL-ACQUIRED INFECTIONS ASSOCIATED WITH HAND WASHING AT 95% CONFIDENCE INTERVAL (RABIE AND CURTIS, 2006).	27

LIST OF TABLES

TABLE 1. EXAMPLES OF TRADITIONAL AND SYSTEMATIC REVIEWS	9
---------------------------------------------------------------	---

EXECUTIVE SUMMARY

If your role is to make decisions about the design of healthcare facilities, these pages have been written for you.

The topic of discussion is *evidence-based design* (EBD)—a movement that looks to rigorous evidence, such as that obtained from controlled experimentation, to improve outcomes for both patients and healthcare providers. Unlike more medicinal forms of healthcare interventions, EBD seeks to enhance outcomes by designing into facilities features shown to improve patient safety, accelerate cure rates, improve staff productivity, reduce energy consumption, and produce other such benefits. Examples of design features with positive outcomes for patients include a patient's view through windows, sunlight, sound (including both noise and music), and air quality.

You may have already heard about EBD from fellow board members, architects, community members, and even patients. Some of the recommendations being made—such as enhancing healing by including family-friendly living spaces in a patient's room—may seem to make intuitive sense. Despite likely benefits, however, you are probably also concerned that additional construction may require added expense. In today's building climate, you may be worried about escalating labor and material costs. Construction costs probably need to be defended before a board. You may need to demonstrate a corresponding increase in annual revenue or periodic cost savings resulting from the added investment. Furthermore, you may have heard mixed messages about EBD; although much may be accurate, some may also include enthusiastic hype.

This guide is designed to help put EBD into the larger context of Evidence-Based Medicine and to help you assess the validity of EBD claims.

Why you should assess EBD claims

If you have been involved in hospital design for some time, you are likely aware of the need to follow codes required by law. Codes are often drawn from industry standards of practice, such as the American Institute of Architects' *Guidelines for Design and Construction of Healthcare Facilities* (2006), which are the products of consensus among industry practitioners. Although this method may have seemed perfectly acceptable in the past, many advocates of EBD argue that design standards have too often been based on anecdotal evidence, rather than on more rigorous evidence, such as that obtained from randomized controlled trials.

Another complication is that both standards (and codes) and medical facilities take considerable time to develop. This means that decision-makers may not be aware of helpful design recommendations until critical decisions have already been made—or even until after the new facility has already been built. Additionally, by the time the new facility opens, any design improvements will likely be considerably more costly than they might have been had the enhancements been introduced during planning stages. An oft-cited relationship between influence and cost suggests that level of influence per dollar spent is highest during the earliest stages of a project and declines as the planning, design and construction of a project progress toward maturity (Paulson 1976). This means it is preferable, cost wise, to introduce design improvements during the earliest stages of project planning (**Figure 1**).

The combination of these two factors—the length of time it takes for new standards to be approved and the length of time it takes for a new hospital to be created and delivered—challenges the decision-maker to try to identify winning design features long before they have been formally adopted into standards and codes.

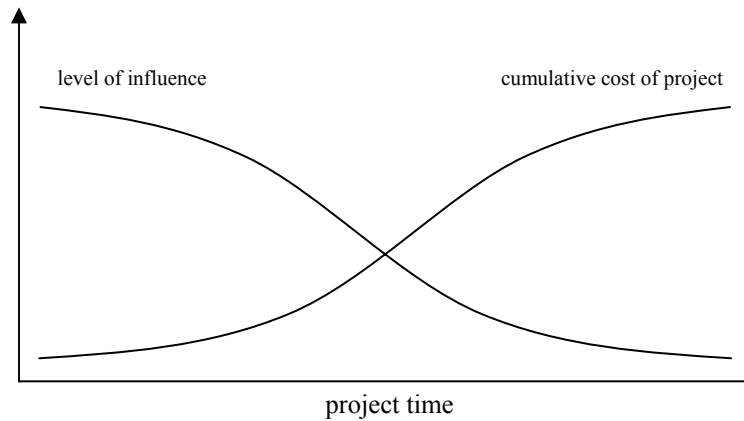


Figure 1. Influence/Cost Diagram (Paulson 1976)¹

Relating quality of evidence to magnitude of risk

Because, as facility decision-maker, one of your roles is to provide the infrastructure for medical practice, you may also be aware of a movement referred to as Evidence-Based Medicine (EBM). A precursor to EBD, EBM (**Figure 2**) urges medical decision-makers to base healthcare decisions, whenever possible, on statistically sound evidence obtained from less biased sources, such as randomized controlled trials. Randomized controlled trials follow rigorous experimental guidelines that include subjecting randomly selected participants to an experimental procedure in which one variable has been modified. Results are then compared against a control population not subjected to the modification. For example, when testing to see whether music has the ability to reduce stress in patients during a clinical procedure, patients might be randomly assigned to an experimental (music) group or control (no music) group. Taking precautions to randomize helps eliminate experimental bias, as well as the possibility of accidentally introducing confounding elements into the measurement. It is the decision to rely on statistically significant results obtained from rigorous evidence, such as randomized controlled trials, wherever possible—instead of anecdotal evidence²—that characterizes the EBM movement.

¹ This graph is a simplified version of Boyd Paulson’s diagram representing the inverse relationship between level of influence and cumulative project cost over time.

² non-scientific observations or studies, which do not provide proof but may assist research efforts (Webster’s New Millennium Dictionary of English, found at <http://dictionary.reference.com/browse/anecdotal%20evidence>, viewed on July 1, 2007)

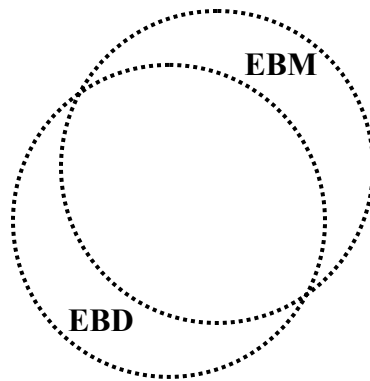


Figure 2. The concerns of evidence-Based Design (EBD) intersect those of Evidence-Based Medicine (EBM).

Evidence-based design can be viewed as both a subset and extension of EBM. In EBD, medical treatment is reconceived to include the therapeutic impact of the designed environment. However, facility design can have other positive outcomes as well. Patient waiting time may be reduced. Staff productivity may be increased by reducing time spent ‘hunting and gathering,’ for example. Facilities can be made more flexible, thereby improving service and reducing future alteration costs.

To quote Dave Chambers, Chief Architect for Sutter Health, “The hospital is a machine, the design of which facilitates or impedes the use for which it is intended.” Understanding the scope of EBD to extend beyond the ‘patient-in-the-bed’³ is critically important for several reasons: (1) Ever fewer patients who enter a healthcare facility, even a hospital, wind up in a bed, (2) the potential impact on business outcomes is enormous, and (3) the increasing cost of healthcare is a national emergency.

Quantitative, statistically sound analyses should be conducted wherever possible, but randomized controlled trials appear to be most feasible for testing claims linking design features of a facility with therapeutic outcomes. Impacts on whole life costs and business outcomes typically require different methods.

It is important to acknowledge that claims based on less rigorous evidence are not *necessarily* wrong. More often, it is a question of the ability to accurately forecast investment outcomes. However, because there may be unknown confounding factors and biases influencing the results, the decision to implement decisions based on evidence that is less rigorous than that obtained from randomized controlled trials tends to carry a higher *risk*, and quantitative forecasts must allow for greater ranges of possible outcomes. The supporting documentation section in this report demonstrates in greater detail some of the potential negative consequences of relying, unquestioningly, on results obtained by less rigorous means and failing to incorporate the probabilistic nature of the evidence into expectations of outcomes.

³ personal communication

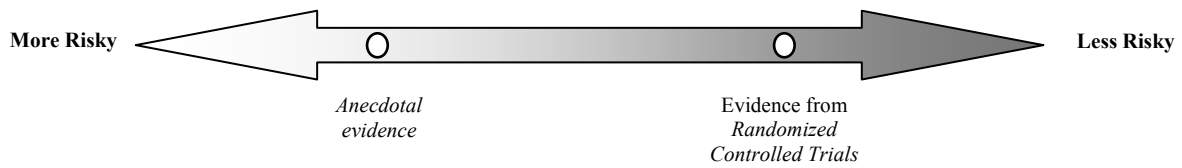


Figure 3. Spectrum of EBD evidence and related risk.

Every decision made carries some risk. The greater the uncertainty the greater the risk. This is also true for decisions informed by movements such as EBD. While some evidence supporting EBD decisions comes from rigorous experimentation, much does not—at least not yet. However, those who are trying to financially quantify benefits suggested by EBD interventions need to be aware that recommendations supported by less rigorous evidence carry a great risk and greater variability of expected results. It is important, therefore, for a decision-maker to be able to assess the quality of evidence being presented (**Figure 3**).

To develop your ability to evaluate claims about the beneficial impact of design options, it is helpful to understand how design knowledge develops. Evidence supporting a body of knowledge is often compiled by researchers into literature reviews. These reports draw together a range of related writings by specialists working within a field. Traditionally, medical literature reviews are commissioned by journal editors who request a recognized expert to write one. This is the way most literature reviews have been written and is the way many continue to be constructed today. However, research indicates that when the results of a number of literature reviews by different authors are compared on the same topic, correlation is quite low. Consequently, recommendations made in traditional reviews should be viewed critically and considered to be somewhat risky. Conversely, the more that evidence is supported by rigorous experimentation, such as

Literature reviews tend to fall into one of two general categories:

(a) *a traditional review* is often written by a recognized expert in a field, who pulls together information on a topic from numerous research studies. The review report neither discloses an underlying system for identification of papers selected to review, nor presents criteria used for assessment of research quality.

(b) *a systematic review* is generally considered more rigorous than a traditional review and may be qualitative (scored review) or quantitative (meta-analysis). A scored review reveals the methodology used for identification of research papers and the screening criteria used for inclusion and exclusion of studies. A defining feature is that it assigns grades or “scores” to research studies, according to incorporation of quality control features, such as randomization and inclusion of an experimental control. Scored reviews may examine multiple causal relationships between features of the designed environment and desired outcomes. The meta-analysis, considered the “gold standard” of reviews, shares many of the screening techniques of the scored review, but also quantitatively combines results of randomized controlled trials, and uses them to determine a statistically significant combined result. Although not flawless, the meta-analysis is currently considered the most reliable type of literature review produced.

randomized controlled trials, the lower the risk and the more confident one can be about future results. Therefore, it is important to assess the quality of a literature review when making a decision about acceptability of risk.

In EBD, researchers have already started moving beyond traditional literature reviews and have been compiling evidence using techniques required for systematic reviews. Unlike a traditional review, a systematic review is recognizable because reviewed articles are generally listed in a table and “graded” according to the reviewers’ evaluation of the underlying research. Reviewers may use an academic grading system (i.e. A through F) to rate the individual articles or another system of the reviewers’ choice.

The meta-analysis is the most quantitative—and rigorous—of the review typologies. Meta-analyses examine a single causal relationship between a feature of the designed environment and desired outcomes, and combine results from homogeneous randomized controlled trials. By combining results from a number of trials, the reviewer is able to achieve a higher level of confidence about the cause-effect relationship being examined. Compiling a solid meta-analysis requires the agreement of researchers worldwide on a common template for reporting results, so those results can be combined and analyzed. For Evidence-Based Medicine, this cooperation is being achieved through the efforts of non-profit collaborative research organizations such as the Cochrane Collaboration and the Agency for Healthcare Research and Quality’s Evidence-Based Practice Centers Program. However, unlike with EBM, in EBD, an umbrella organization dedicated to preparation of meta-analyses does not yet exist. For this reason, and because randomized controlled trials are still relatively rare on EBD-related topics, it is currently unusual to find meta-analyses published on EBD-related topics.

However, scored reviews—another type of systematic review--*are* being undertaken in EBD. Although they are not considered to be as thorough as meta-analyses, scored reviews are more rigorous than traditional reviews, and therefore carry less risk for the decision-maker who chooses to implement their findings (**Figure 4**).

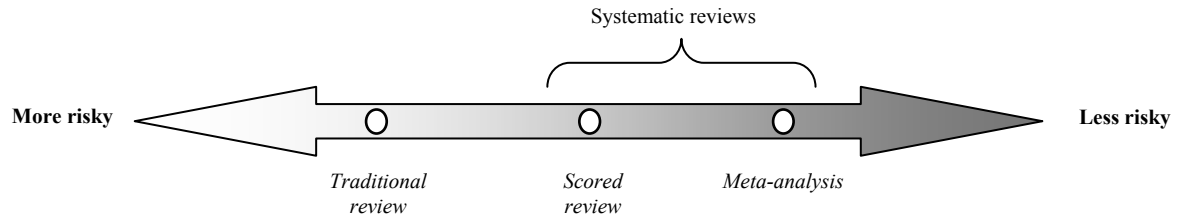


Figure 4. Spectrum of EBD literature reviews

Examples of traditional reviews and systematic reviews—including both scored reviews and meta-analyses—are listed in **Table 1**.

Table 1. Examples of traditional and systematic reviews

Traditional Reviews	
	Devlin, A. S. and A. B. Arneill (2003). "Healthcare environments and patient outcomes: a review of the literature." <u>Environment and Behavior</u> 35 (5): 665-694.
Systematic Reviews	
<i>a) Scored reviews</i>	Rubin, H. R., A. J. Owens, et al. (1998). Status Report (1998): An Investigation to Determine Whether the Built Environment Affects Patient's Medical Outcomes, The Center for Health Design. Ulrich, R., C. Zimring, et al. (2004). The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity. Center for Health Design.
<i>b) Meta-analyses</i>	Rabie, T. and V. Curtis (2006). "Handwashing and risk of respiratory infections: a quantitative systematic review." <u>Tropical Medicine and International Health</u> 11 (3): 258-267.

Whole life costs and patient outcomes

Once you have examined the papers listed in Table 1, you should feel more comfortable categorizing the risk level associated with EBD literature reviews when you see them. You can use literature reviews to determine how confident you can be about the return on investment you will receive should you decide to implement an EBD-influenced recommendation. For example, knowing that hospital-acquired infections are transmitted between patients via the hands of hospital staff, you

might be considering increasing the number of sinks or alcohol dispensers available to caregivers, to encourage an increase in hand washing. However, because construction funds are tight and you need to make decisions between various alternatives, you would like to know *how much* adding sinks increases hand washing and *how much* those increases in hand washing will reduce hospital-acquired infections. You reason that, once you know these amounts, you can calculate that facility's financial savings—and even a potential payback period--based on how much it usually costs your health care facility to treat hospital-acquired infections each year, plus perhaps an estimate of the benefits of improved reputation and image of the facility.

Referring again to Table 1, you see that the Devlin and Arneill (2003) article—a traditional review—presents a broad spectrum of EBD findings by various researchers. If you read no further than the Devlin article, you have some assurance their assertions are correct. However, because the Devlin article is a traditional review, there is also some risk of inaccuracy from publication bias. There is some risk that the proposed causal relationships between design features and desired outcomes does not exist at all, but greater risk that any quantification of those relationships is inaccurate. To reduce your risk, you can look to either of the two scored reviews by Rubin et al. (1998) and Ulrich et al. (2004). For example, the Ulrich et al. team identified research papers that support the benefits of hand washing behavior on reducing hospital-acquired infections, and gave these papers “grades.” Noting that this information has been through a somewhat rigorous grading (screening) process and has therefore reduced your risk, you could take action to increase hand washing behavior among your staff and be more confident about the likely result. However, it is not until you look to the meta-analysis correlating hand washing and reduction of hospital-acquired infections that you can start to quantify benefits more precisely. For example, according to the meta-analysis by Rabie and Curtis (2006), hand washing reduces respiratory infections by an average of 16%, under certain circumstances. With this value, you can start to quantify potential annual savings and even a likely payback period associated with increased hand washing behavior.

It is important to mention here that even a meta-analysis carries some risk. For example, it is very unlikely that experimentation conducted by different researchers scattered in various parts of the world will be perfectly homogeneous. This suggests that combining results in a cumulative fashion may be somewhat misleading. Also, decision-makers need to understand that Rabie and Curtis suggest that hand washing reduces hospital-acquired infections by an average of 16%, under certain circumstances, that do not even involve hospital environments. Also, some trials revealed higher impact, and some lower. Furthermore, even if meta-analyses are eventually prepared to more appropriately reflect reduction of hospital-acquired infections in a hospital environment, it is important to note that increasing the number of sinks and/or alcohol dispensers alone will do nothing to reduce hospital-acquired infections if staff members do not use them. The decision-makers will need to ensure the sinks are positioned in locations that are convenient for the staff member to regularly access as well as continually support an organizational culture of hand washing. Nevertheless, assuming you are able to ensure implementation, an appropriately selected meta-analysis gives you some sense of the magnitude of the benefit to be expected by the particular EBD intervention.

EBD offers great potential benefits, but the prudent decision maker needs to be able to evaluate claims based on the underlying evidence. As with any insight that is just beginning to develop, anecdotal evidence and qualitative research are necessary first steps in the generation of new knowledge. Qualitative observations lead to hypotheses which eventually guide preparation of more rigorous experimentation, such as randomized controlled trials. The intention of this report is help place EBD literature review development into a wider context. This report is a contribution to the education of healthcare facility decision makers regarding Evidence-Based Design.

THE EVIDENCE-BASED DESIGN LITERATURE REVIEW AND ITS POTENTIAL IMPLICATIONS FOR CAPITAL BUDGETING OF HEALTHCARE FACILITIES

Abstract

Health facility managers need to look beyond laws and standards of practice in budgeting and designing healthcare facilities.

The development of knowledge regarding the relationship between facility design and healthcare outcomes is moving ever faster, and that acceleration is much needed given the long lag time between planning and use of healthcare facilities. Hospitals generally take years before they are available for use, while standards of healthcare design practice are established through a conservative, slow process.

This study categorizes published literature reviews to help decision-makers evaluate Evidence-Based Design (EBD) recommendations, even before they are adopted into standards or codified into laws. Existing EBD literature reviews are found to be both qualitative and quantitative in character and to consist of traditional reviews, scored reviews and meta-analyses. Once greater numbers of meta-analyses related to EBD appear, EBD will be better incorporated into capital budgeting.

Because of its potential for better healthcare facilities, with benefits for both the providers and recipients of care, we call for a broader understanding of EBD's scope, a sharpened definition of the EBD research frontier, an increase in methodological rigor, and coordination of research funding.

1.0 Introduction

Possession of almost clairvoyant discernment is needed by those who must plan in today's healthcare industry. Because hospitals generally take years to plan, fund, design, and construct, a miscalculation of future user requirements may endanger the very survival of a healthcare organization.

This brief report investigates the emerging field of *evidence-based design* (EBD)—a movement that assigns higher credibility to evidence from experimentation, in order to improve the quality of care patients receive and the financial outcomes for the organization. Unlike more invasive forms of medical intervention, EBD seeks to enhance therapeutic outcomes through designed features of the built environment in which healthcare is provided.

While many assertions of EBD proponents (e.g., assertions about noise pollution, length of stay, positive distractions, family interactions, medication errors, patient falls and hospital-acquired infections) make intuitive sense, claims about cost vs. benefit are sometimes questioned. Not all design interventions will necessarily offer the same magnitude of beneficial impact. It is therefore important that independent, disinterested third parties offer an evaluation of the claims being made. Because they are held accountable to standards of academic honesty and peer-review rigor, academic researchers are serving a significant role as evaluators in the EBD movement. They are doing this primarily as reviewers of clinical research literature.

This paper presents a brief review of EBD reviews and, drawing from developments in Evidence-Based Medicine, offers suggestions about how the EBD review might be reshaped to better serve the medical facility decision-maker's needs. For example, decision-makers want to know: If I invest in single patient rooms and implementation reduces the annual cost associated with treating hospital-acquired infections, what might be the Net Present Value (NPV) or Internal Rate of Return (IRR) for the investment? What is a likely payback period? An analysis of existing EBD literature reviews shows that while a traditional review might provide rough direction to answering these types of questions, systematic reviews offer the possibility of greater precision.

In addition to surveying and making recommendations regarding future EBD review development, this report has been prepared to help medical facility decision-makers recognize the level of rigor on which claims for individual EBD interventions have been made. Even with the codification of design recommendations into standards and laws, it is necessary for a medical facility decision-maker to develop a level of personal judgment about design claims. The reason is that medical facilities can take up to a decade to plan, fund, design and construct. By the time a design recommendation has been enshrined into standards or law, the EBD suggestion may be too difficult or costly to implement. It is therefore prudent for the decision-maker to be able to validate claims long before they are codified, as well as to evaluate claims that have been incorporated into standards of practice.

This report is intended not only for the primary decision-maker, but for anyone who wants to sharpen her or his ability to evaluate claims about the design of a healthcare facility--including designers and community members whose role is to advise the ultimate decision-makers.

The remainder of this report is divided into an overview of Evidence-Based Design and the challenges faced by those budgeting and planning healthcare facilities, a review of Evidence-Based Medicine as a possible model for the further development of Evidence-Based Design, a critical examination of Evidence-Based Design literature reviews, a concluding section with recommendations, and finally a glossary and references.

2.0 Evidence based design: An Overview

2.1 Definition of Evidence-Based Design

Evidence-based design “...refers to a process for creating healthcare buildings, informed by the best available evidence, with the goal of improving outcomes and of continuing to monitor the success of design for subsequent decision-making” (Ulrich, Zimring et al. 2004). Precise meaning of the term is in flux, as is apparent by progressive changes made to its definition in the communally-updated Wikipedia. The internet definition is interesting because the history of its creation is transparent to users and reflects some of the struggles inherent in the birth of a new concept. The web-based encyclopedia’s version alludes to a capital implication as well: “A natural parallel and analog to evidence-based medicine, it is currently being used in the healthcare industry to help convince decision-makers to invest the time and money to build better buildings—and realize strategic business advantages as a result” (Wikipedia 2007).

The methodology of developing design guidelines based on evidence is not limited to healthcare facilities, however that is the domain in which Evidence-Based Design (EBD) has been developed, largely in response to Evidence-Based Medicine (EBM), which builds on the medical culture’s appreciation for measurement data.

2.2 Key milestones in EBD

The EBD movement is in a state of flux. This makes it difficult to develop an understanding of the driving forces and players behind its development. Into what context are those changes being ushered? Who are the principal drivers behind the movement? How good is the evidence for their recommendations?

Prior to the formal EBD movement, a number of historical figures noted correlations between human health and the environments in which we live. For example, Asclepiades of Bithynia (ca. 50 B.C.) observed that sick individuals left in the dark are haunted by visions of their own mind, whereas those placed in bright light where their senses are available to them are better able to maintain a psychologically healthy balance (Gumpert 1794; Rubin, Owens et al. 1998). Modern nursing pioneer, Florence Nightingale (1820-1910), famously observed that patients who had access to fresh air, direct sunlight and views of bright flowers through a window recovered more quickly than those who spent their days looking at a dead wall, and even oriented their bodies and faces toward windows, just as plants orient themselves toward the sun (Nightingale 1860). Speculating that the impact of environmental surroundings on therapeutic outcomes are measurable, hospital architect E. Todd Wheeler predicted that a doctor will one day write a prescription for the environment as readily as he does for medicine (Wheeler 1971).

It is into this context of accumulated observations that Roger Ulrich set into motion the Evidence-Based Design movement in 1984, by publishing his now renowned *Science* article, “View Through a Window May Influence Recovery from Surgery.” Ulrich examined recovery records of cholecystectomy patients in a suburban Pennsylvania hospital between 1972-1981. He observed different outcomes for patients assigned to rooms with a window view of trees versus those whose window faced a brick wall. These differences were measurable and included a shorter postoperative hospital stay, a reduced intake of potent analgesics and the issuance of fewer negative evaluative comments on nurses’ notes (Ulrich 1984). Ulrich’s paper was groundbreaking because it was one of

the first recognized attempts to quantify the impact of environmental factors on therapeutic outcomes in a hospital environment.

Since that time, the number of investigations into the impact of the environment on healthcare have been continually expanding. Although there now appears to be a general agreement about the phrase “evidence-based design,” terms referencing this concept have not always been consistent. Descriptive phrasing has varied to include evidence-based practice, scholarly practice, and practice-based research (Guerin and Dohr 2006). As mentioned previously, one advantage of the term evidence-based design is that it appears a natural and logical complement to the parallel movement of evidence-based medicine—a concept founded on similar research principles.

After publication of the Ulrich paper, the architecturally-trained designer, Wayne Ruga, co-founded the Center for Health Design (CHD) in 1986. The center, a not-for-profit research and advocacy organization with a mission to transform healthcare outcomes through the creative use of EBD, now operates under the direction of interior designer and president, Debra Levin, and serves as a central meeting point for research and publication of research on evidence-based design. Importantly, many of the key US-based people in the field, including the pioneering Ulrich, sit on its fourteen-member board of directors and help steer the organization’s progress (Center for Health Design 2007).

Seeking to establish a scientific foundation for the emerging field of EBD, in the mid-90’s, the Center for Health Design enlisted a team of medical researchers led by Haya Rubin, MD, PhD. The group’s task was to undertake the first systematic review of clinical literature on the effect of facilities and furnishings on patient outcomes.⁴ Review types are discussed in detail in Section 4.2, but briefly: a systematic review is more rigorous type of literature review than that which had been done previously. In preparation of the paper, *Status Report (1998): An Investigation to determine whether the Built Environment affects Patients’ Medical Outcomes* (Rubin, Owens et al. 1998), the team identified 78,761 potentially EBD-related articles and subjected them to rigorous scrutiny. Of these, 84 articles were deemed acceptable for inclusion in their study and 88 percent of these suggested that some environmental intervention could be correlated with at least one healthcare parameter. The team proposed a model to suggest several factors impact a patient’s clinical outcome, including features of the physical environment. Whereas medical research tends to focus on collecting information on treatment provided, a patient’s personal characteristics, and type of illness contracted, the researchers noted that reliable information pertaining to impact of the physical environment on patient recovery was severely lacking. The report classified primary research that had been already conducted and called for more highly controlled experimentation on the topic.

After Rubin et al., additional overviews on EBD appeared, including a comprehensive traditional review by Devlin and Arneill (2003). However, the next landmark systematic review was undertaken by Roger Ulrich and Craig Zimring in 2004 (Ulrich, Zimring et al. 2004). In their report: *The Role of the Physical Environment in the Hospital of the 21st Century: a Once-in-a-Lifetime Opportunity*, the team discovered over 600 studies they considered sufficiently rigorous to be regarded as evidence of a link between environmental cues and patient outcomes in healthcare environments. The purpose of their review was to address the high rate of medical errors and hospital-acquired infections reported in the Institute of Medicine’s *Crossing the Quality Chasm* report (Institute of Medicine 2001). After screening the studies for rigor, the team categorized the various studies and looked for evidence to support potential recommendations. In their conclusion, the authors called for the following six actions:

⁴ A systematic review is one that reveals its criteria for including/excluding studies and its criteria for evaluation of studies.

- Provide single patient rooms in almost all situations and widely adopt acuity-adaptable rooms.
- Implement acoustic design strategies to dampen noise levels
- Offer views of nature and positive distractions to patients
- Develop clear wayfinding systems
- Improve ventilation through the use of filters and other means
- Design wards to reduce staff walking fatigue

Of note is that most of these recommendations are designed to improve therapeutic outcomes by reducing hospital-acquired infections and patient and staff stress. Recently, Craig Zimring has assembled a team to extend the results of the 2004 literature review, which will be published by The Center for Health Design in association with the Georgia Tech Research Corporation, with funding from the Robert Wood Johnson Foundation.

Additional information about specific recommendations related to healing environments is readily available from a number of excellent, downloadable for free or available-for-purchase publications on the Center for Health Design and Planetree websites (www.centerforhealthdesign.org and <http://www.planetree.org>), and also from the American Institute of Architects.

2.3 From research into law

Naturally, making decisions based on evidence is not new. Many standards, such as the AIA's *Guidelines for Design & Construction of Healthcare Facilities*, are formed by consensus (Blumgart 2007; Joseph 2007). That consensus is established, for the most part, on the experience and judgment of those serving on the standards committee who evaluate recommendations presented to them (Blumgart 2007). Anecdotal and qualitative evidence has thus far constituted the backbone of standards generation. While these represent, in fact, categories of evidence, advocates of the EBD movement are working toward replacing anecdotal and qualitative evidence with that which is more quantitative and generalizable, such as evidence derived from rigorous, randomized controlled trials. (Joseph 2007).

Figure 5 illustrates a simplified cycle of transformation from research hypotheses and experimentation into legislated standards. In general, researchers test hypotheses by conducting controlled experiments. Other researchers then collect and compare similar studies by preparing literature reviews. Interested advocacy groups, composed of industry practitioners as well as researchers, help transform collected research observations from journal articles into industry norms via standard-making bodies. Once recommendations enter standards such as the AIA *Guidelines for Design & Construction of Healthcare Facilities* (The Facility Guidelines Institute, The American Institute of Architects Academy of Architecture for Health et al. 2006), they are picked up by US state legislative bodies, where components are accepted and then, section by section, enshrined into state law. The process is represented as a spiral because standards creation is progressive; recommendations are developed and refined over time.

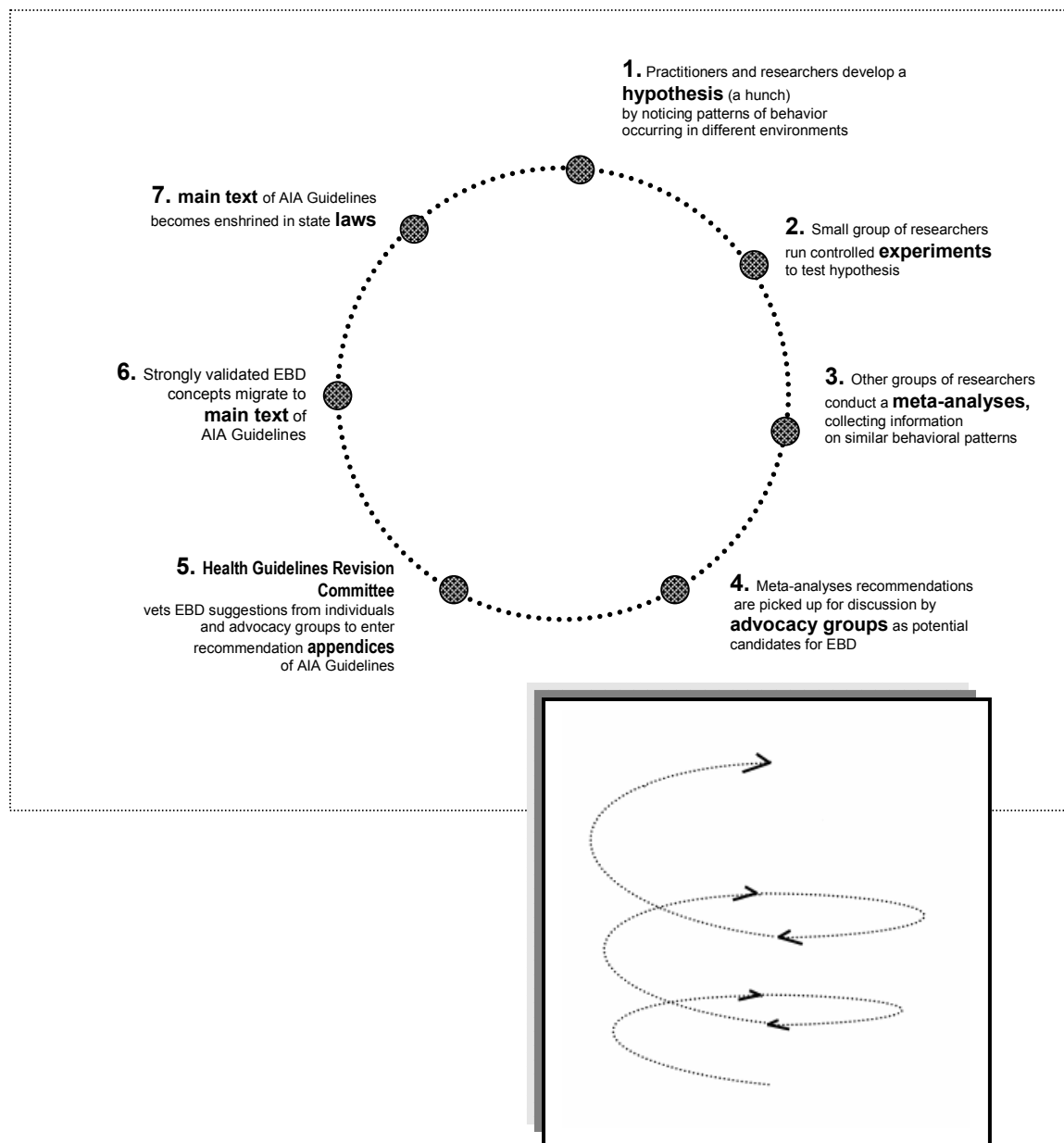


Figure 5. The iterative EBD standardization process. The spiral indicates that the process is iterative and progressive.

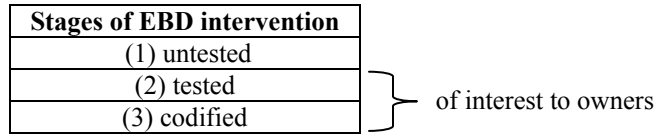


Figure 6. Stages of EBD Development

Another way to group EBD development is into three phases: (1) an idea that has not yet been subjected to sufficiently rigorous testing, (2) claims that are tested and verified for the causal relationship between features of the designed environment and desired outcomes, and (3) claims that have been codified into laws (**Figure 6**).

The dilemma for healthcare facility decision makers is that the codification process takes time. For those whose business is to finance, design or construct facilities that may not become operational until nearly a decade later, waiting for that codification to take place may result in missed opportunities and the construction of an already outdated facility. While the first stage of EBD knowledge development--that of the untested--usually belongs to the realm of the researcher, decision-makers, such as owners, must be able to predict EBD intervention outcomes as early as the “tested” stage in order to remain competitive. Because both codifying EBD concepts and developing facilities can take years to realize, decision-makers need to become conversant not only with that which has been codified, but also with that which has been tested but not yet codified.

The balance of this report is intended to help guide the decision-maker in evaluating evidence that currently resides in the “tested” category, but that is not yet mandated by law.

3.0 Evidence-Based Medicine (EBM)

Because the EBD movement is rooted in many of the same values as that of Evidence-Based Medicine (EBM), the following sections will explore the development of EBM literature reviews, for the purpose of determining how the EBD movement might benefit from EBM lessons learned.

3.1 The need for reviews

The well-designed research experiment resides at the heart of the EBM movement. However, it is unreasonable to expect practitioners and policy-makers to unearth, read and digest the vast number of primary research articles published each year. In 1987 alone, it was reported that two million articles were published in 20,000 journals (Ad Hoc Working Group for Critical Appraisal of the Medical Literature 1987).

Literature reviews help bridge the gap and solve this dilemma. Once results are reported in peer-reviewed journals and industry publications, the reviewer is able to draw together an accumulated understanding from research results on a similar topic.

Historically, “authoritative reviews” were conducted by invitation only. Editors engaged recognized experts to survey the literature of a field. On the surface, this assumption seems reasonable. However, in reality, the correlation between reviews by multiple experts has been poor ($r=0.19-0.54$) (Oxman and Guyatt 1993). In the rest of this report, this type of authoritative review will be referred to as the *traditional review*.

Systematic reviews, on the other hand, evolved as a reaction against traditional reviews, which tend to be ad hoc compilations of past research reflecting the bias of the individual reviewers. Mulrow (1994) cites an exemplary case (Antman, Lau et al. 1992) where traditional literature review recommendations lagged far behind the current state of research on a medication, prophylactic lidocaine, administered to patients with acute myocardial infarction. In 1990, data collected from 15 randomized trials and subjected to statistical meta-analysis demonstrated no mortality benefit associated with prophylactic lidocaine for acute myocardial infarction. However traditional reviews continued to recommend the administration of prophylactic lidocaine, despite statistical evidence to the contrary (**Figure 7**). By contrast, a cumulative meta-analysis of 33 trials indicates that streptokinase is effective in treating cases of acute myocardial infarction. Mulrow argues that 1971 was the year streptokinase’s effects were determined to be statistically significant—20 years before it was approved by the US Food and Drug Administration and its use generally adopted (**Figure 8**). Because of this misjudgment in the traditional review literature, more effective treatments to reduce myocardial infarction mortality, such as streptokinase, were not recommended as often as they might have been.

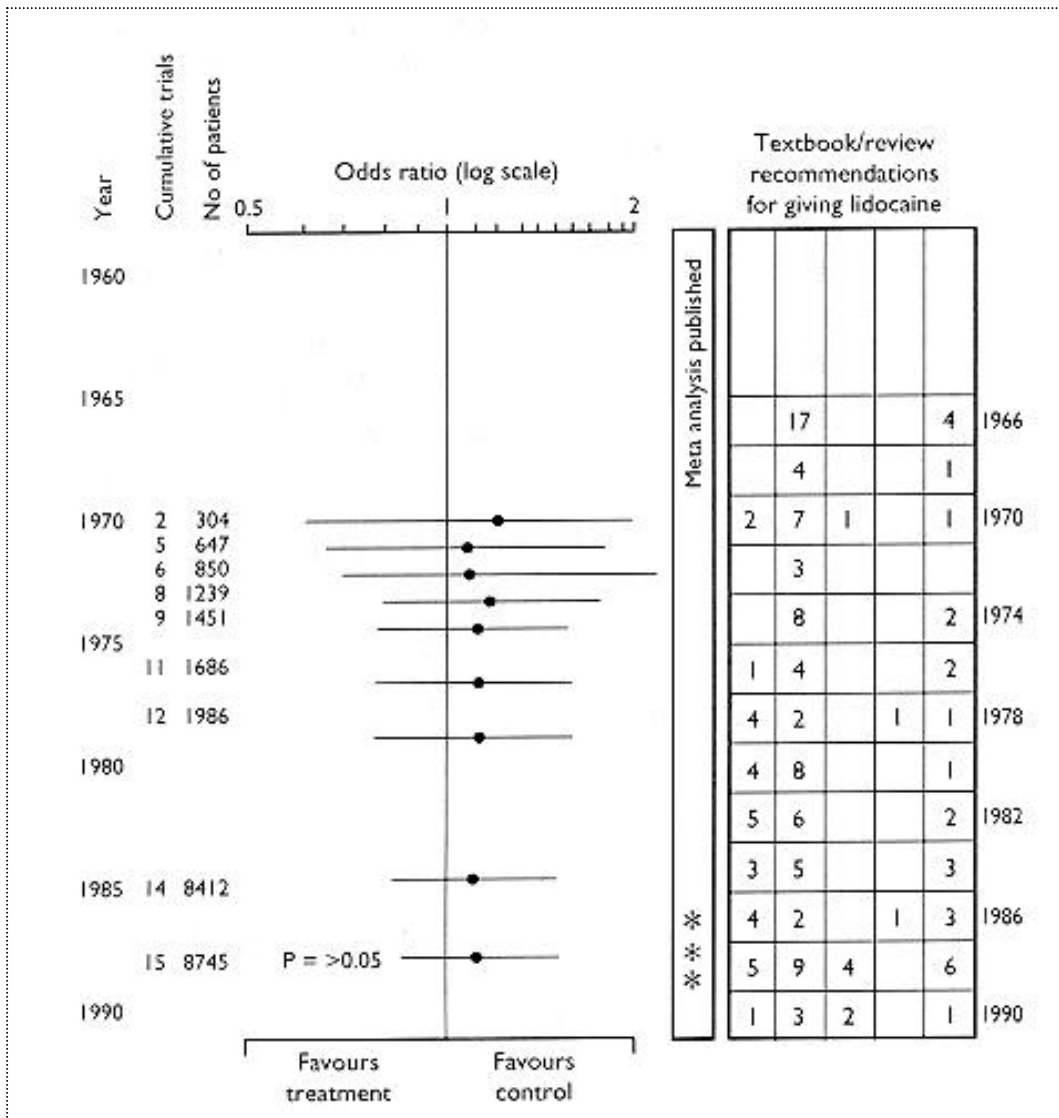


Figure 7. Results of the meta-analysis done by Antman et al., (1992) indicates that the prophylactic lidocaine served no mortality benefit in cases of myocardial infarction (left). This was not the result that had been suggested by the traditional review (right).

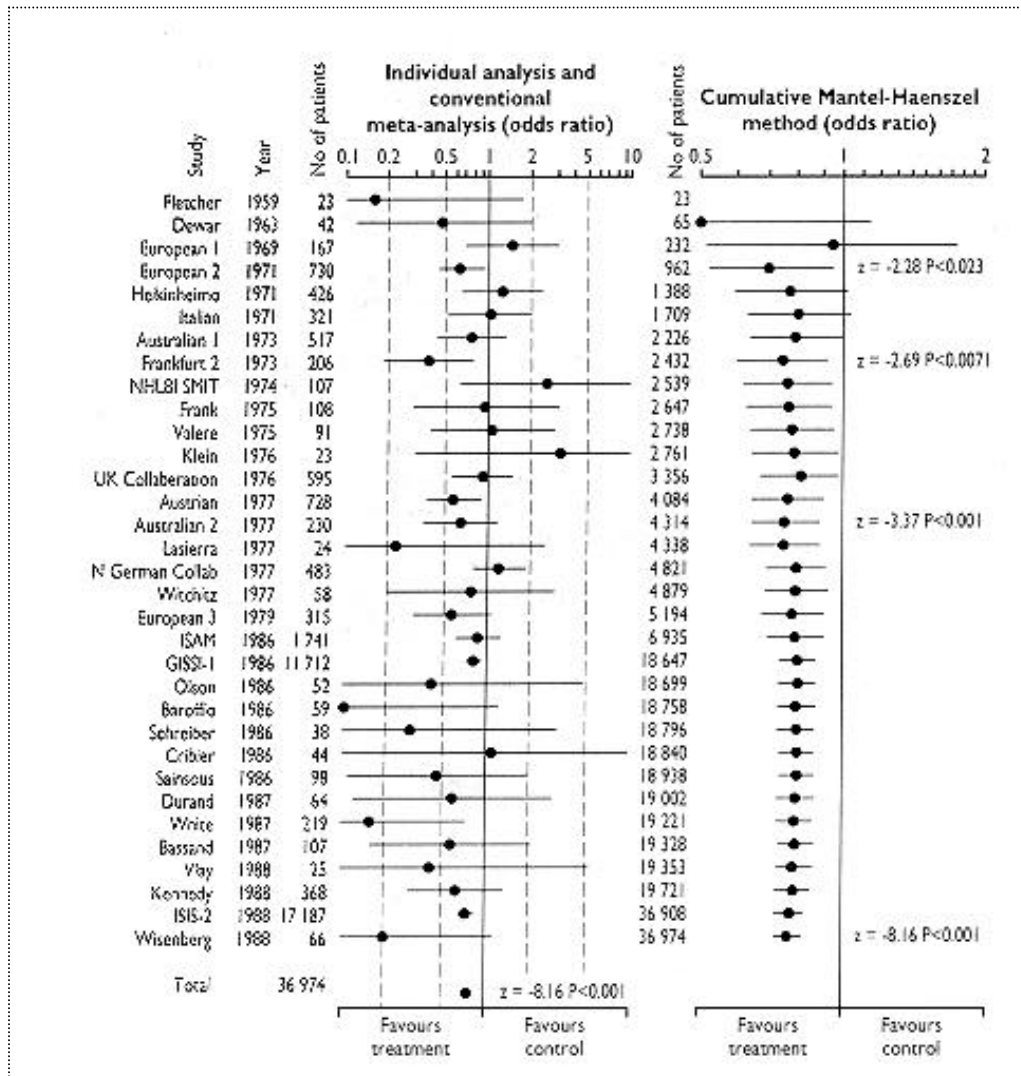


Figure 8. A meta-analysis by Antman (1992) and adapted by Mulrow (1994) demonstrates the advantages inherent in pooling cumulative results from homogeneous randomized controlled trials.

Mulrow (1994) cites a number of reasons why the scientific community should collaboratively focus on constructing systematic reviews. Her reasons include:

- Since quality of experiments and results vary, decision-makers need integrated knowledge to make prudent decisions. Once experimental results are integrated systematically, it is possible to make generalizations about a topic.

- A well-conducted review, although expensive, is less costly than many scientific experiments, and ensures that funds are not wasted by reproducing existing knowledge.
- Systematic reviews help to overcome the shortcomings of traditional reviews that can be haphazard and reflect the personal bias of the reviewer.

3.2 Conducting a systematic review

Systematic reviews share certain procedural traits. A number of authors recommend specific methodologies. For example, Mullen and Ramírez (2006) recommend a nine-step strategy for a proper systematic review:

1. Specify the study's aims
2. Set inclusion criteria for participants/evidence
3. Design the recruitment/search strategy
4. Screen potential participants/evidence against inclusion criteria
5. Decide on measures and design the data collection protocol
6. Select an appropriate metric to represent the magnitude of the findings and assess the likelihood that these findings could be the result of chance
7. Collect the data/code the primary studies
8. Analyze and display the data using appropriate methods, and
9. Draw conclusions based on the data and discuss alternate interpretations in view of the study's strengths and limitations.

(Mullen and Ramírez 2006)

It is helpful to discuss a few hallmarks of a systematic review in greater detail:

- Because there are so many articles with varying characteristics, Carl Counsell (1997) suggests that inclusion criteria be established with a properly formulated question. This question should comprise four specific parts. They include the type of: (a) *intervention*, (b) *outcome* anticipated, (c) *person* involved, and (d) *control* to which the exposure is being compared. In EBD research, an appropriate screening question might therefore be written as follows: Does (a) regular hand washing by caregivers (b) reduce incidence of hospital-acquired infection in (c) ICU patients compared to (d) situations where hand washing is not enforced? This type of question establishes criteria against which reviewers can decide whether or not an article qualifies for inclusion in a review.
- To guard against variability and personal bias during the review process, it is suggested that researchers enlist at least two independent screeners who develop explicit inclusion criteria, and evaluate articles based on the same criteria. They should compare results and achieve consensus. There is also a danger that reviewers may unknowingly express screening bias by recognizing an article's author. To mitigate this potential bias, researchers might consider coding authors' identities. Screeners should look for quality, quantity, consistency, and coherence of evidence when evaluating articles (Mullen and Ramírez 2006).
- Reviewers also need to guard against publication bias. A number of researchers warn against the tendency to restrict a search to articles published in peer review journals and only in the English

language (Dickersin and Min 1993; Mullen and Ramírez 2006). Also, there is a tendency for journals to publish only positive results. Much good work exists outside of these boundaries.

Reviewers should search article databases extensively and internationally, seeking out “fugitive literature.” One researcher suggests a literature search should include mining databases such as MEDLINE, EMBASE, BIOSIS, CINAHL, PsychLit, CancerLit, Dissertation Abstracts, and SIGLE (for unpublished literature). A thorough search should also include a manual page-by-page examination of important conferences and journals because many articles are not properly indexed (Counsell 1997). Sources of information may come from human and non-human research, as well as from prior literature reviews (Mulrow, Langhorne et al. 1997).

3.3 Challenges of reviews

Despite their advantages, systematic reviews have been adopted slowly by the scientific community in many areas of medical research. Some of the challenges involved with the preparation of a systematic review are:

- The time required to prepare a review is usually grossly underestimated. Because of this, many well-intentioned reviewers have neither the time nor the resources to prepare a high quality review (Chalmers 1993).
- The heterogeneity of data sources makes it difficult to combine evidence (Counsell 1997; Mulrow, Langhorne et al. 1997). Identifying, downloading and screening thousands of articles often requires time and resources far beyond that which is available. Therefore, a number of researchers have recommended standardizing the format of data reporting—including the abstract--so that methodologies and results can be more efficiently subjected to collective statistical analyses (Sandercock 1993; Mullen and Ramírez 2006). However, this type of experimental design and data reporting requires a level of collaboration that is not always easy in a culture that tends to value research independence.

In other words, just as not all experiments are equally meritorious, not all literature reviews are equally useful and reliable. The Evidence-Based Medicine movement derives its impetus from the methodological precision of the systematic review; the EBM movement would benefit by heeding lessons learned by EBM.

3.4 The diamond of literature reviews: the meta-analysis

A subcategory of systematic review is the “meta-analysis.” Although now generally a stabilized term, nomenclature for this type of review has varied from “meta-evaluation,” and “research synthesis,” to “integrative review” (Mullen and Ramírez 2006).

A meta-analysis can be defined as “the statistical combination of studies to produce a single estimate of the healthcare intervention being considered” (Buendia-Rodriguez and Sanchez-Villamil 2006). Because it represents the quantitative compilation of numerous primary studies, a meta-analysis has been called a “tower of statistical power” (Mulrow 1994). By combining results from various sources, one is able to determine statistical significance with greater accuracy, thus rendering the final result more meaningful.

Meta-analyses are done on the causal relationship between a single feature of the designed environment and desired outcomes. In the best of all worlds, there would be meta-analyses for all EBM and EBD causal relationships, and scored reviews could then evaluate the various studies done on specific relationships using quantitative methods. Where such quantitative methods cannot be applied, qualitative evaluation is the next best option and can also be included in scored reviews, with evaluation criteria made explicit.

3.5 Cochrane Collaboration

One of the most extensive efforts in meta-analysis formed as a response to Archie Cochrane's call to improve accuracy of collected information by systematizing the review process. Cochrane's book, *Effectiveness and Efficiency, Random Reflections on Health Services*, published in 1972, set forth straightforward principles, which included developing reviews from randomized controlled trials (RCTs). His principles resulted in the formation of the Cochrane Collaboration, an international not-for-profit organization, that sets a highly rigorous standard for meta-analyses (Cochrane Collaboration 2007). The meaning of the group's logo, the stylization of an actual, historic, meta-analysis of seven RCTs (**Figure 9**), is explained by Iain Chalmers: "Each horizontal line represents the results of one trial (the shorter the line, the more certain the result); and the diamond represents their combined results. The vertical line indicates the position around which the horizontal lines would cluster if the two treatments compared in the trials did not differ in their effects; and if the horizontal line touches the vertical line, it means that that particular trial found no clear difference between the treatments. The position of the diamond to the left of the vertical line indicates that the treatment studied in the trials is beneficial" (Chalmers 1993).



Figure 9. Cochrane Collaboration logo (Cochrane Collaboration 2007).

In the same publication, Iain Chalmers wrote about the then-forming Cochrane Collaboration. A lengthy quote is included here because it describes a potential collaborative model to which EBD researchers and reviewers might look should they seek ways to synergistically enhance collaboration. Bold-facing of words has been retained from Chalmer's original text:

“Although the Cochrane Collaboration is still at an early stage of its development, its basic structure and methods of working have been established. Each **reviewer** is a member of a **collaborative review group**, which consists of individuals sharing an interest in a particular topic (stroke, for example). Collaborative review groups have

often grown out of an ad hoc meeting of people who have recognized that they share an interest in preparing and maintaining systematic reviews of RCTs within a particular field. But review groups have also emerged in other ways. Members of the review group seek funding and other support for their activities from whichever specific sources they consider appropriate. Each of the collaborative review groups is coordinated by an **editorial team**. The editorial team is responsible for preparing an **edited module** of the reviews prepared by members of the review group for dissemination through the **Cochrane Database of Systematic Reviews...**

The pregnancy and childbirth collaborative review group, for example, comprises about 30 reviewers who, collectively, are currently responsible for maintaining between 500 and 600 systematic reviews of RCTs, and for dealing with between 200 and 300 new reports of trials every year. The group includes reviewers in Australia, Canada, Ireland, the Netherlands, South Africa, the United Kingdom, and Zimbabwe. The individual reviewers are responsible for obtaining the resources (of which their time is often the most important) which are needed to prepare and maintain the reviews that fall within their respective areas of expertise. The editorial team coordinating the group consists of four editors, an administrator and administrative secretary, and the work of the team is supported by a grant from the Department of Health for England. Together with members of the collaborative review group, the editorial team is responsible for preparing an edited **Pregnancy and childbirth Module** for incorporation in the **Cochrane Database of Systematic Reviews.**”

(Chalmers 1993)

In addition to the Cochrane Collaboration, other organizations dedicated to bringing together collaborators to prepare meta-analyses have emerged in the field of Evidence-Based Medicine. For example, the Evidence-Based Practice Centers program, developed under the wing of the Agency for Healthcare Research and Quality, has established centers at universities and other institutions such as Duke University, Johns Hopkins University, McMaster University, Oregon Health Sciences University, the University of California at San Francisco, Stanford University, Research Triangle, the RAND Corporation and Blue Cross and Blue Shield Association (Institute of Medicine 2001).

The advantage of establishing organizations such as the Cochrane Collaboration and the Evidence-Based Practice Centers program is that they draw reviewers together into a community that maps and maintains knowledge about a specific area of study.

4.0 Evidence-Based Design Reviews

4.1 Methodology

The previous sections described types of reviews being developed by the EBM research community. Similar to those of EBM research, EBD literature reviews can be categorized. To determine the types of reviews currently being published by the EBD community, spot searches were conducted on the bibliographies of EBD-related articles, as well as on the databases, MEDLINE, PsycINFO, and Google Scholar.

The intent was to develop a snapshot understanding of the EBD field at this point in its history. To this end, the following individuals who are working near the center of the movement were interviewed:

Pamela Blumgart, Development Editor
Knowledge Resources, American Institute of Architects

David Chambers, Director
Planning Architecture & Design, Facility Planning & Development, Sutter Health

Robin Guenther, Principal
Guenther 5 Architects
Author, *Green guide for Healthcare*

Sandi Isaacson, Director (User Liaison and Research Translation)
Agency for Healthcare Research and Quality

Anjali Joseph, Director of Research
Center for Health Design

Debra Levin, President
Center for Health Design
(with research team members Laura Ellington, Carolyn Quist, and Amy Keller)

Andrew Mazurek, Director
Navigant Consulting

Peter Morris, Principal
Davis Langdon

John Reiling, former CEO
Synergy Health and St. Joseph's Community Hospital, West Bend, WI
President and CEO, *Safe by Design*

Blair Sadler, former CEO
Rady Children's Hospital, San Diego
Senior Fellow, *Institute for Healthcare Improvement*

Craig Zimring, Professor

4.2 Classification of EBD reviews

In order to better understand the developing nature of EBD literature reviews, selected EBD reviews were classified along a spectrum ranging from qualitative to quantitative review methodologies (Figure 10). The spectrum is intentionally roomy, allowing for the future insertion of review typologies that may be developed as the EBD field matures. The double-headed arrow signifies that these additional types of reviews may evolve at and beyond either end of the spectrum.

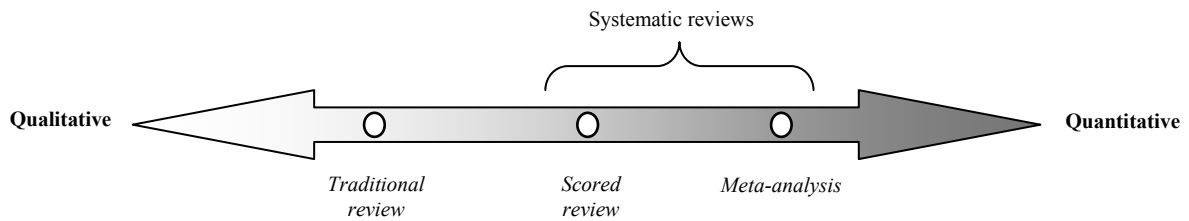


Figure 10. Spectrum of EBD reviews.

Because EBD is still a developing field with boundaries yet to be fully defined, it has been necessary for reviewers to create rough classifications of collected information. These categories of knowledge first emerged and continue to appear as traditional literature reviews, as described in section 3.1 (Devlin and Arneill 2003; Joseph 2006a; Joseph 2006b; Joseph 2006c; Joseph and Ulrich 2007).

As the field matures, systematic scored reviews have begun to appear with greater frequency. For example, Rubin et al. restricted their literature review to experimentation that fell within one of four primary areas: (1) Randomized controlled trial, (2) Experimental, paired, (3) Observational, paired, and (4) Observational, unpaired (Rubin, Owens et al. 1998). By comparison, Ulrich and Zimring assessed primary research on a typical academic scale, awarding grades that ranged from “A” to “D” (Ulrich, Zimring et al. 2004). Both review teams reported on recurring patterns of results within categories of EBD-related experimentation. Additionally, Dijkstra et al. argue that of over 500 EBD-related studies found, only 30 met the stringency of their one permissible category—the well-conducted controlled trial (Dijkstra, Pieterse et al. 2006).

As larger numbers of randomized controlled trials start to appear, highly rigorous meta-analyses on EBD topics will emerge. For example, Rabie and Curtis (2006) published a paper on the impact of hand washing on hospital-acquired infections. The review is structured as a meta-analysis. The abstract itself is cleanly organized into the categories of Objective, Methods, Results and Conclusions. The authors pool the results of seven homogenous studies to discover that, on average, hand washing lowers the risk of hospital-acquired infection by 16%. Although the authors specifically exclude studies conducted in hospitals and caution that the pooled studies are of poor quality and limited geographic scope, they also affirm that the “results show a coherent and significant pattern of impact of hand cleansing on (hospital-acquired) infection.” For the purpose of understanding how meta-analyses can help health care financial decision-maker’s make decisions, let us imagine the study had demonstrated that hand washing reduced hospital-acquired infections in hospitals by 16%, with a

95% confidence interval between 0.11 and 0.21. We could then suggest that decision-makers considering equipping sinks or alcohol dispensers in every patient room in a way that demonstrably encourages hand washing can reduce hospital-acquired infection rates by approximately 16% (Rabie and Curtis 2006). A reported confidence Interval (CI) of 95% means that we would be 95% confident that the actual level of hospital-acquired infection reduction lies between 11% and 21% (**Figure 11**).

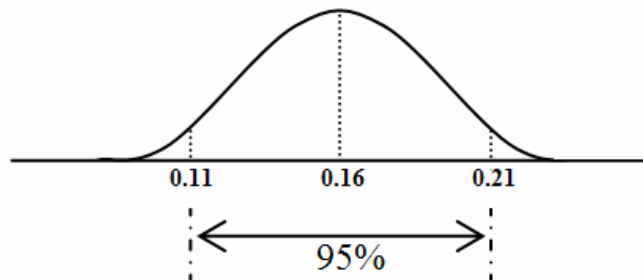


Figure 11. Range of expected results for reduction of hospital-acquired infections associated with hand washing at 95% confidence interval (Rabie and Curtis, 2006).

Once the quantification of information becomes available and reliable, the decision-maker is able to use the tools of capital budgeting. Quantification enables estimation of payback periods, Net Present Values (NPV) and Internal Rates of Return (IRR). For example, in the hand washing example, one could then multiply the outer bounds (11% and 21%) of hospital-acquired infection reduction by the average annual cost of treating hospital-acquired infections in one's own facility, to determine the likely range of financial savings expected.

4.3 Selecting an appropriate type of review

Researchers of EBD come from a variety of backgrounds, including the fields of medicine, environmental psychology, architecture, interior design, organizational behavior and marketing. Each field brings insights that enrich the EBD movement as a whole. But communicating across disciplinary lines also presents challenges.

It is important to note that although quantitative systematic reviews offer the measurable results that decision-makers want, the preparation and publication of both traditional reviews and qualitative forms of systematic literature reviews are still essential to the basic task of defining the boundaries of the EBD field. Different types of reviews serve important roles at each stage in a field's development. While compilation of randomized controlled trials into a meta-analysis—the gold standard for reviews—may be an ultimate goal, it is not always possible to conduct randomized controlled trials at every point in the process. For example, it is not possible to randomize participants with regard to smoking use, alcohol use, use of contraceptive methods or family history (Petitti 2000). Also, preparation of a randomized controlled trial must be guided by a hypothesis, or educated guess. Hypotheses are preceded by qualitative observations—and even anecdotal evidence. Because the field of EBD is still young, many observations are still qualitative. But the field is maturing, as is

evidenced by the publication of systematic (scored) reviews within the last ten years (Rubin, Owens et al. 1998; Ulrich, Zimring et al. 2004).

Nevertheless, just as has been the developmental path for EBM, we recommend that the EBD field strive toward preparation of meta-analyses, whenever possible. The reason is that meta-analyses can reduce the probability of bias and facilitate the quantification of results. These consequences then make it possible for decision-makers to include EBD interventions in their capital-budgeting processes.

5.0 Implementation

5.1 EBD and life cycle costing

One of the tacit motivators behind EBD research is an underlying assumption that a well-designed facility improves outcomes sufficiently to both enhance revenue streams and reduce operating costs throughout the life cycle of the facility. Though a plausible assumption, the already intensive capital requirements of healthcare facilities force choices between competing items on a wish list. The EBD movement must work toward answering key investment questions, such as: How great a health impact does the built environment actually have? If I only have X dollars, will it be better to construct private rooms or install sinks in every room? These questions concern both therapeutic impacts of the designed environment and business outcomes not mediated by therapeutic impacts; e.g., increased patient satisfaction from reduced waiting times; increases in nursing productivity from reduced travel time.

The repetitive nature of annual expenses and receipts over the life of a 20+ year facility makes the prospect of EBD enhancements attractive. Owners frequently weigh the returns from alternative investments. Additionally, possible increases in capital costs induce owners and financial stakeholders to request quantification of benefits that would enable estimation of potential payback periods.

Although the need to quantify the impact of EBD interventions had long been acknowledged, one difficulty inherent in EBD research is that it relies on experimental observations that are not always randomized and controlled, or rigorously modelled. This is partly due to the nature of medical experimentation in which deprivation of healthful conditions may be considered unethical, and partly due to the reality of confounding factors within an environmental surround. This is perhaps why the oft-cited 1984 Ulrich study was so long in coming. The circumstances of the study—that all patients, both experimental and control, had been subjected to nearly identical surgical procedures and were placed in nearly identical rooms, save the view from their window—are difficult to come by. Nevertheless, since then, a number of indicators have been collected from Pebble Projects (a initiative of the Center for Health Design) and other collaborative healthcare institutions.

Thanks to the willingness of industry participants to share their collected before-and-after-EBD-interventions data, several researchers and hospital CEOs made a first attempt to quantify the costs and benefits associated with EBD adaptations in a paper entitled, “A Business Case for Better Buildings” (Berry, Parker et al. 2004). In this milestone report, the authors arrange elements of EBD into three primary categories, namely those interventions which contribute to (1) stress reduction, (2) safety, and (3) ecological health.⁵ They further classify stress reducing elements to include connection to nature,

⁵ Although the focus is largely on the ‘patient-in-the-bed,’ the report is nonetheless valuable for its attempt to quantify EBD benefits.

options and choices, social support, pleasant diversions and eliminations of environmental stressors, giving examples from each of these categories. At the heart of the Berry et al. piece is the Fable Hospital, a fictional facility that represents a composite of healthcare facilities with facets of EBD. Among its features, the hospital includes oversized rooms with dedicated space for families, acuity-adaptable rooms, double-door access, decentralized nursing stations, alcohol-rub hand hygiene dispensers in every room, HEPA filters in ventilation units to improve air quality, noise reducing measures, and art work displays and gardens. The article then itemizes incremental costs associated with each of these additions and compares them to the financial impact of the design decisions. At the time of the article's publication, the authors presented an itemized incremental cost of over \$12 million. However, based on data obtained from a number of hospitals, they estimate the additional cost could be offset by \$11.5 million in savings garnered from reductions in patient falls, patient transfers, hospital-acquired infections, drug costs, and nursing turnover, as well as increases in market share and philanthropy (Berry, Parker et al. 2004). In other words, they believe the increased incremental capital cost would be offset by significant annual savings, and would enjoy a payback period of just a little over one year.

The Berry et al. paper is admirable as an early attempt to quantify some of the costs and benefits associated with the implementation of EBD interventions. As meta-analyses related to EBD issues begin to emerge with greater frequency, one can expect increasing reliability associated with these predictions. However, it is important to emphasize that, even as predictive accuracy increases from the compilation of meta-analyses, any financial estimate must also be framed within the context of risk. The better the evidence, the lower the risk involved with taking action based on that evidence.

5.2 Must better healthcare facilities cost more?

In the study by Ulrich, Zimring et al. (2004), the authors write: "Many of the improvements suggested by EBD are only slightly more expensive than traditional solutions, if they are more expensive at all."

While this may, at first, seem to reflect wishful thinking, it is worth considering an analogous dilemma owners face when designing and constructing LEED-certified buildings. Estimators at Davis Langdon, an international cost management consulting firm, accumulated costing data per square foot from almost 600 building projects in nearly 19 states. They observed that the costing of LEED-certified buildings was scattered throughout and then subjected the data to statistical t-tests. They found no statistically significant difference between cost-per-square-foot of LEED-certified and non-LEED-certified buildings (Matthiessen and Morris 2004). Skeptics may wonder: How can this be? The authors, anticipating this response, wrote: "The projects that were the most successful in remaining within their original budgets were those which had clear goals established from the start, and which integrated the sustainable elements into the project at an early stage. Projects that viewed the elements as added scope, tended to experience the greater budget difficulties."

In another example, the authors of Natural Capitalism (Hawken, Lovins et al. 2000) speak to the importance of integrating design decision-making early in the decision-making process. Systems thinking enables stakeholders in the design and construction industry to work together to offset first costs with reductions elsewhere in the system. Those who wish to incorporate Evidence-Based Design into their healthcare facilities would do well to look to the precedent of integrated design delivery (Ballard 2007).

6.0 Conclusions and Recommendations

Those who are tasked with budgeting and planning healthcare facilities have the opportunity and responsibility of making weighty decisions. The Evidence-Based Design movement is producing design recommendations based on causal relationships between features of the designed healthcare environment (e.g., acuity adaptable hospital rooms, spatial layout) and desired outcomes (e.g., reduction in patient falls, lower staff requirements). The combination of long lead times for facility development and the slow adoption of design standards force decision makers to judge the evidence behind EBD recommendations that are not yet in the law, nor possibly even in design standards. The shortage of capital relative to demand makes it necessary to forecast the benefits of alternative investments even when the available evidence does not support precise forecasting. Alternatively, it leads decision makers to neglect difficult-to-quantify design options in capital budgeting for healthcare facilities.

The EBD research community employs various forms of literature review to consolidate and analyze the results of individual studies. Facility decision makers should be aware of these different forms of review and be able to ask informed questions regarding EBD recommendations. The EBD research community could help facility decision makers by revealing the evidence behind its recommendations, by using quantifiable testing methodologies whenever feasible, and by shaping the evidence resulting from tests and studies to facilitate comparison of alternative investments.

To this point in the development of EBD, quantitative studies have been relatively rare, but are expected to become more frequent, following the historical development of Evidence-Based Medicine. Such quantitative studies are necessary for more accurate estimates of the relative values of alternative investments, and so to enable capital budgeting for healthcare facilities that looks beyond capital cost to the impact of facility investments on running costs (staff requirements, productivity and retention; energy consumption, environmental sustainability, maintenance) and patient outcomes (waiting times, recovery times, satisfaction, safety).

Many characteristics of EBD overlap with and are influenced by Evidence-Based Medicine. Perhaps as a result, EBD has tended to focus on the patient-in-the-bed. Even when impacts on staff satisfaction and productivity are sought, they are typically conceived within the context of caring for such patients. Understanding the scope of EBD to extend beyond the ‘patient-in-the-bed’⁶ is critically important for several reasons: (1) ever fewer patients who enter a healthcare facility, even a hospital, wind up in a bed, (2) the potential impact on business outcomes is enormous, and (3) the increasing cost of healthcare is a national emergency.

EBD research offers great promise for better healthcare and better healthcare facilities. Faster development is much needed, and would benefit greatly from a shared understanding of the field’s frontier and agreement on methodological principles among researchers. An analog to EBM’s Cochrane Collaboration is much needed to facilitate more rigorous research methodologies and sharing of data. A collaborative research program could, in turn, provide a basis for coordinating, and perhaps increasing, research funding.

Below is a summary list of recommendations:

⁶ as expressed by Dave Chambers, Chief Architect of Sutter Health

1. That the scope of EBD be reconceived to extend beyond the patient-in-the-bed to all desired outcomes of facility design.
2. That EBD primary researchers employ quantitative methods of testing and evaluation where feasible.
3. That EBD primary researchers focused on therapeutic outcomes ally themselves with the EBM movement and organizations, embrace its methodological standards and follow its protocols. Alternatively, that an organization be formed to perform for EBD the functions that the Cochrane Collaboration or the Agency for Healthcare Research and Quality Evidence-Based Practice Centers Program performs for EBM.
4. That EBD academic reviewers employ systematic reviews, revealing inclusion and evaluation criteria.
5. That facility decision makers and their advisors prepare themselves to evaluate the evidence behind EBD claims.
6. That facility decision makers and their advisors collaborate with academic researchers to develop methods for capital budgeting of healthcare facilities that are sufficiently robust to accommodate EBD evidence ranging from the qualitative to the quantitative.
7. That facility decision makers and their advisors fully incorporate sound EBD recommendations into capital budgeting of healthcare facilities.
8. That EBD researchers and funding organizations develop a shared understanding of the research frontier, methodological requirements, and a strategy for creating new knowledge.
9. That an Evidence-Based Design research colloquium be initiated to develop and implement these recommendations.

Glossary

Evidence-based design: “Evidence-based healthcare designs are used to create environments that are therapeutic, supportive of family involvement, efficient for staff performance, and restorative for workers under stress. An evidence-based designer, together with an informed client, makes decisions based on the best information available from research and project evaluations. Critical thinking is required to develop an appropriate solution to the design problem; the pool of information will rarely offer a precise fit with a client’s unique situation. In the last analysis, though, an evidence-based healthcare design should result in demonstrated improvements in the organization’s clinical outcomes, economic performance, productivity, customer satisfaction, and cultural measures.” (Hamilton 2003)

Randomized controlled trials (RCT): “An experiment in which two or more interventions, possibly including a control intervention or no intervention, are compared by being randomly allocated to participants. In most trials one intervention is assigned to each individual but sometimes assignment is to defined groups of individuals (for example, in a household) or interventions are assigned within individuals (for example, in different orders or to different parts of the body).” (Cochrane Collaboration May 2005)

Experimental trial with paired data: “The same patients are assigned to different environmental conditions at different times, under the direction of the investigators. Each patient serves as his or her own control for comparisons.” (Rubin, Owens et al. 1998)

Observational study with paired data: “the same patients are observed under different environmental conditions in the course of routine care. The environmental conditions are not controlled by observers but are those that occur naturally.” (Rubin, Owens et al. 1998)

Observational study of different groups: “groups of patients are compared in different environments in the course of routine care. If performed in sequential time periods, perhaps before and after a design change or policy change, such studies are referred to as ‘natural history’ studies.” (Rubin, Owens et al. 1998)

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