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Essays on Evidence-Based Design as Related to Buildings and Occupant Health

John Christopher Haddox
West Virginia University

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Essays on Evidence-Based Design as Related to Buildings and Occupant Health

John Christopher Haddox

**Dissertation submitted to the
Davis Collect of Agriculture, Natural Resources and Design
at West Virginia University**

in partial fulfillment of the requirements for the degree of

**Doctor of Philosophy
in
Human and Community Development**

**Barbara S. McFall, Ph.D., Chair
Dennis K. Smith, PhD.
Ronald E. Dulaney, M. Arch.
Bill Reger-Nash, Ed.D.
Clement E. Solomon, Ph.D.**

Division of Resource Management

Morgantown, WV

2013

KEYWORDS: Green Buildings, Occupant Health, Evidence-Based Design, Systematic Review, Meta-Analysis, Health Care Facilities

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ABSTRACT

Essays on Evidence-Based Design as Related to Buildings and Occupant Health

John Christopher Haddox

This dissertation is comprised of three essays that explore the connections between buildings and their impacts on outcomes associated with occupant health. The essays are:

1. The Effect of Certified Green Office Buildings on Occupant Health: A Systematic Review and Meta-Analysis
2. Understanding Evidence-Based Design Through a Review of the Literature
3. Future Directions for Evidence-Based Design in Health Care Facilities

Essay one, entitled The Effect of Certified Green Office Buildings on Occupant Health: A Systematic Review and Meta-Analysis, explores the connections between certified green office buildings and their impacts on occupant health via the application of a systematic review and meta-analysis. An extensive literature search was conducted to locate any studies that examined the health of occupants in conventional buildings versus the health of the same populations after a move into a certified green building. The literature review followed the Cochrane Collaboration protocol for conducting systematic reviews. The results of a meta-analysis of the two studies uncovered by the systematic review show a positive relationship between certified green office buildings and improved occupant health (SMD 1.09), yet there was insufficient power (CI -0.88, 3.05).

Essay two, entitled Understanding Evidence-Based Design Through a Review of the Literature, relates the current understanding of the concept of Evidence-Based Design (EBD), as specifically related to health care facilities, through the vehicle of an annotated bibliography of the relevant literature. EBD lacks a universally agreed upon definition, but one of the stronger definitions from the architecture discipline states that evidence-based design is a process for the conscientious, explicit, and judicious use of current best evidence from research and practice in making critical decisions, together with an informed client, about the design of each individual and unique project. The outcomes of primary concern with health care facilities tend to fall into three categories—patient/family outcomes, staff outcomes and fiscal outcomes.

The thirty-one annotated articles reveal that the concept of EBD is quite complex, especially as it relates to the gathering and assessment of data and how such data is used to inform the building project. The bulk of the complexity lies with the word ‘evidence.’ The current literature suggests disparity among researchers and practitioners over the collection, assessment and incorporation of evidence related to the collection, analysis and incorporation of evidence into building projects that seek to have a positive impact on the three main outcome categories of interest in healthcare facilities—patient outcomes, staff outcomes and fiscal outcomes.

Essay three, entitled Future Directions for Evidence-Based Design in Health Care Facilities, anticipates the future of evidence-based design as related to the design and construction of health care facilities. Reimbursement policies are driving health care to include more community based and customer services oriented delivery models. Pay based on performance—quality and efficiency of health care delivered—as well as customer satisfaction are taking on new importance and will drive designers of health care facilities to develop ever new methodologies for gathering and assessing evidence.

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I would first like to thank my committee chair, Dr. Barbara McFall, for approaching me five years ago with an offer to develop a program on sustainable design in her academic unit at West Virginia University. The call was for “an odd bird to create an odd program.” How she could tell from a brief newspaper article about me that such a challenge would resonate with my temperament and abilities I will never fully understand. Little did I know at the time that five years hence I would be completing doctoral work that tied together years of interesting, but seemingly disconnected professional and academic work.

While Dr. McFall provided the initial nudge for this adventure, it took the consultation and encouragement from many others to move me to a state of action. My Division colleague, Ron Dulaney, perhaps more than anyone else on a daily basis, listened to me as I thought out loud about the prospect of tackling this undertaking. He encouraged me to move forward, exposed me to other view points on the topics at hand and challenged me to think more critically about both the research and the application of this work. Dr. Bill-Reger Nash, a long-time acquaintance turned close friend and mentor was perhaps my biggest fan. I met with Bill on several occasions to discuss and, frankly, fret over the prospect of taking on a doctoral program given my particular circumstances in life. Bill was ever positive and practical, helping me to think through things in a stepwise fashion, keep the project manageable in scope and, in his own subtle way, making sure I was always looking ahead and moving toward the finish line. On many occasions Dr. Clement Solomon and I discussed the importance of the sustainability work for which we had a shared passion. I recall a specific conversation with Clement about how things happen in the world of academia that helped seal my decision to move forward with the dissertation. While Dr. Denny Smith was extremely encouraging of the initiative, kindly offering, and subsequently providing, critical advice on how to navigate the course from start to finish.

Though my committee consisted of the above name individuals, my five years as a Visiting Assistant Profess at West Virginia University have brought me into contact with countless individuals who each have had some level of influence on this journey. All of my Division colleagues have been supportive and helpful in their own ways. My co-instructors, whom I also count as friends and mentors, provided inspiration just by doing what they do and including me in the mix. To the students who look to me for guidance and inspiration, I hope that this endeavor has equipped me to deliver as expected.

Finally, to my most critical supporters and encouragers—my family—blood and otherwise. You know who you are! I owe each of you a great debt of gratitude. Thank you! I love you each and all.

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Chapter 1: ESSAY 1-The Effect of Certified Green Office Buildings on Occupant Health: A Systematic Review and Meta-Analysis

Abstract

The purpose of this systematic review and meta-analysis was to determine if occupants of certified green office buildings enjoy any measurable health benefits over occupants of conventionally constructed office buildings of the same purpose. My literature base was that body of work relating to the greening of the built environment—those buildings that are designed, built and operated with deliberate attention given to the social, environmental and economic attributes associated with them. Through an extensive and systematic review of the said literature, I attempted to locate studies of any type that generated data reflecting the health aspects of occupants in buildings that were certified green versus health of occupants in conventional buildings of the same utility, ultimately arriving at two studies that met my inclusion criteria. Meta-analysis of the data from the two studies indicated a positive, yet non-statistically significant relationship between green building certification and improved occupant health (SMD 1.09, CI -0.88, 3.05). The search process revealed that while post-occupancy evaluations of buildings have existed for decades, there is only a small body of work focused on the study of certified green buildings in terms of occupant health. This study has several limitations, including the small number of studies relevant to the topic and the high degree of variability in the studies found. The implications for policy and practice are meaningful as the number of buildings seeking green certification is growing worldwide and improved occupant health is one of the many cited reasons for seeking the certification.

Keywords: Green buildings, systematic review, meta-analysis, occupant health

Introduction

Humans can be greatly impacted by the characteristics of the buildings in which they spend their time (Heerwagen, 2000). Over the past decade there has emerged a renewed and collective interest in the process of designing and constructing buildings that focus on efficient use of natural resources, buildings that are cost effective to maintain and operate over the long haul and that create healthy and productive environments for the building occupants. The buildings that emerge from this process are commonly referred to as green buildings (Eaton 2006). By 2015, an estimated 40-48% of new nonresidential construction by value will be green, equating to a \$120-145 billion opportunity (MCGraw Hill, 2010). One of the challenges to the green building industry has been to develop standards for defining and measuring performance of green buildings. In 2000, the US Green Building Council, a non-profit organization comprised of a wide representation of building-related professionals and stakeholders, responded to this challenge by releasing the Leadership in Energy and Environmental Design (LEED) rating system for new construction. The rating system was designed to be a roadmap for the design, construction and operations of new commercial building projects (Smith 2009). While LEED has grown into multiple rating systems that cover a range of building types and even neighborhood level design, a common feature of all rating systems is the five core categories under which the multitude of approaches to achieving a green building fall. These categories are Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR) and Indoor Environmental Quality (IEQ).

Americans spend on average 90% of their time in an indoor environment (EPA 2008). As the level of indoor pollutants can be as high as ten times that of the outdoor air (Williams 2010), the IEQ construct is of primary importance for this paper. The IEQ construct consists of

four impact areas—indoor air quality (IAQ), acoustic quality, thermal comfort and lighting comfort—and is largely focused on creating a healthy and satisfying physical environment for the occupant (Fisk 2002). While the IEQ construct in LEED offers protocols for keeping harmful pollutants out of occupied building spaces, it does not require the actual measurement or monitoring of IAQ (USGBC). Despite a general lag in the construction industry the green building movement is very strong, , and is anticipated to double in the United States over the next four years, going from a level of \$71 billion in green construction starts in 2010 to \$135 billion in green construction starts in 2015 (McGraw Hill, 2011).

Of primary interest to this researcher is the underlying assumption that certified green buildings take a more comprehensive approach to improving IEQ over conventional design and construction, thus creating healthier spaces for employees (Katz, 2003). This systematic review and meta-analysis asks the question “Is there a clear and measurable relationship between green building certification and improved occupant health when compared to the health of occupants in conventional buildings?”

Methods

Eligibility Criteria

My initial a priori plan was to look for randomized control trials for impacts of green buildings on college age (18-24 yr) subjects. Finding no studies to fit my criteria, I made post hoc changes to my search and expanded my criteria to minimize restrictions on the characteristics of studies I would ultimately include in my review. Under the new criteria the study must have been reported in peer reviewed journals in the English language; must have looked at some measure of occupant health for adult occupants in office buildings that had

achieved some level of third-party green certification (using LEED as my benchmark for what certification means) and compared that to a measure of occupant health for occupants in conventional buildings; and must have included or made available quantitative data from which conclusions were drawn. I did not pre-define what the measure of health would be. My time period for the search was 2000 – current, but as certified green rating systems were not in existence until 2000 and there was a lag period before any buildings received certification, I expected any available studies to be very recent. Heterogeneity was assessed with the Chi² value.

Study Selection

Table 1

Study Selection Parameters

PICOS Term	Parameter for this study
Population	Adult occupants of green office buildings
Intervention	Certified green building
Comparison	Conventional building
Outcome	Improved occupant health
Study Design	Any study design that reports quantitative findings of health outcome comparisons

Information sources. Studies were located through and an extensive search of the electronic databases MedLine, Web of Science, ProQuest. In addition to these electronic databases, I searched the Cochrane Collaborative for existing systematic review on the topic and contacted the Cochrane Public Health Group to determine if there were any relevant studies as this group lists the built environment as one of its study areas. I also searched Google and Google Scholar for studies or popular articles that may have referenced scientific studies. I examined all references listed in the studies I located via my database searches and also reviewed the research and publications sections of the University of California at Berkeley, the Carnegie

Mellon University, Michigan State University and the Center for Health Design, all of which operate research units focused on the built environment. I made multiple attempts to contact the author of a large, recent literature review on evidence based design, but to no avail. For one of my two included studies, the Singh, 2010 study, I needed variance data in order to calculate a standardized mean effect size and contacted three of the four of the authors on the study. My last search was conducted on November 4, 2011.

Search strategy. As my search limitations were very few, I conducted multiple searches with a variety of search terms, beginning more narrow and broadening the terms as I progressed. The characteristics of my searches appear in Table 2 below.

Table 2

Electronic Search Strategy Employed For This Review

Primary Search string	“green build*” AND health
Publication type	Scholarly Journals Peer Reviewed
Date Range	01/01/2001 – 11/04/2011
Language	English
Databases searched	PubMed, MedLine (EBSCO), ProQuest, Web of Science, GreenFile (EBSCO), Google, Google Scholar,
Additional sources I contacted by telephone, e-mail or by searching their publications sites to discover additional studies	University of California at Berkeley Center for the Built Environment; Carnegie Mellon University Center for Building Performance and Diagnostics; Michigan State University Construction Industry Research and Education Center; Clemson University School of Architecture; Center for Health Design; US Environmental Protection Agency; McGraw Hill Construction; Texas A & M School of Architecture

Data collection and coding. Data was collected by a single researcher using a pre-established coding book developed by the researcher. The code book was set up to code data on six levels:

- a. The first level coded for general study information (title, author, year, publication type/name, language).
- b. The second level of coding dealt with PICOS information from the study (population, intervention, comparison, outcome, study design).

- c. The third level of coding dealt with statistical information reported in the studies (N, n, means, standard deviations, variance, risk ratios, odds ratios).
- d. The fourth level of coding dealt with potential bias present in the study as defined by the Cochrane Risk of Bias tool
- e. The fifth level of coding dealt with quality of reporting on observational studies as defined by the STROBE statement.
- f. The sixth level of coding dealt with additional information that may have been present in each study, but its usefulness was not readily apparent beforehand.

Risk of bias considerations. Both of my included studies were observational studies involving the survey results from populations of office workers working in green certified buildings and conventional buildings. I considered each in the light of two common tools used to evaluate studies—the Cochrane Risk of Bias tool and the STROBE Statement for observational studies.

The Cochrane Risk of Bias tool is used to evaluate studies on six areas of potential bias: 1. sequence generation; 2. allocation concealment; 3. blinding of participants and personnel, blinding of outcome assessors; 4. incomplete outcome data; 5. selective outcome reporting; and 6. other sources of bias. Each bias area is evaluated and given a judgment of “high risk of bias”, “low risk of bias” or “unclear risk of bias.” The tool is subjective, but it does give reviewers something by which to rate potential for bias and provides a protocol by which different reviewers can discuss their assessments with other reviewers of the same studies. While the Cochrane Risk of Bias tool is better suited for randomized control trials where items such as randomization, allocation concealment and blinding are of utmost importance to ensure a rigorous study, I felt the tool had relevance with regards to missing outcome data, selective outcome reporting and other potential sources of bias.

The STROBE statement, developed by an international, collaborative initiative of epidemiologists, methodologists, statisticians, researchers and journal editors involved in the conduct and dissemination of observational studies, is a tool used by reviewers to evaluate each reporting section of a study. STROBE stands for **STrengthening the Reporting of OBservational studies in Epidemiology**) and is a more fitting tool by which to evaluate the level of reporting of my included studies. I compared each study to the STROBEs twenty-two criteria.

In addition to coding for information present in the included studies, I contacted the authors of the Singh study to request missing variance data on the two populations being followed.

Summary measures and synthesis of results. I used the Standardized Mean Difference as my summary measure to compare the results from the two included studies. From the means, standard deviations and *n* values available from each study, the Cochrane Review Manager 5.0 software (REVMAN) calculated the SMD using a Random Effects model and a 95% confidence interval.

I set my main outcome measure to be Improved Occupant Health. The construct for the outcome measure in Huang's study was his calculated Health Score (HS). As the Singh study did not have a Health Score metric, I had to decide on a construct which would represent occupant health and which I could compare to Huang's Health Score. In the study data supplied by Singh, I found numbers for absenteeism related to eighteen different health conditions. I made the decision to use these values to represent an overall measure for occupant health and ran my primary overall results meta-analysis using this data.

I contacted the authors about the missing data and they quickly shared the survey instrument as well as the missing data I requested.

Both the Cochrane Risk of Bias tool and the STROBE Statement appear as appendices to this paper. While I noted the concerns I found with each study, I did not use those concerns to inform the statistical analysis performed in REVMAN.

Results

My search strategy yielded sixty eight references that appeared to focus on green buildings and health. Removal of duplicates yielded forty eight references. Application of my study inclusion criteria eliminated all but two references and these are the two that I've included in my meta-analysis. They are referred to as Huang 2010 and Singh 2010. Characteristics of included and excluded studies appear in Table 3.

Table 3

Characteristics of Included and Excluded Studies

# of records found through database search	68	
# of records found through other sources	0	
# of records remaining after removal of duplicates	48	
# of records screened	48	
Excluded Studies		Reasons for Exclusion
# of records excluded	46	Not empirical study n = 19 Different intervention n = 7 Different outcome n = 9 Different population n = 11
Included Studies		Names of Included Studies
# of studies included in meta-analysis	2	Huang, 2010 Singh, 2010

Risk of Bias Results of Included Studies

As the Huang 2010 study represents a dissertation, my assumption is that there was more interest in presenting all findings rather than reporting positive findings that might lead to favorable publishing opportunities. Another factor coloring my assumption on this is that the

Huang study did not use the LEED certification as its certified benchmark, and thus may have been under less pressure to report favorable findings associated with this rating. The Huang study clearly stated four different hypotheses and outcomes and employed extensive regression analysis to determine the impacts of several variables, including the primary variable of “certified green building” on occupant health. I was unable to identify if the doctoral candidate was in anyway involved with the Taiwanese Architecture Building Center, the originator of the green building standard used in the Huang study, so there may exist the potential for some conflicts of interest that were not reported. When viewed through the Cochrane Risk of Bias tool, I found little concern over potential sources of bias. The Huang 2010 study held up generally well to all items on the STROBE statement. What was missing for me was access to the survey instruments used to gather data. The author supplied names of the instruments but then went on to say that each had been modified. However, the modified versions were not immediately available. One of the surveys HUANG used to assess the six outcomes was the Berkeley Post-Occupancy Evaluation (POE). The POE is a commonly used tool to assess occupant satisfaction with indoor environmental quality (CBE, 2011). Also, Huang does not make mention of funding sources or potential conflicts of interest.

The Singh 2010 study is a published observational study and being subject to page length restrictions, does not report on methods and statistical analysis in nearly as much detail as the Huang dissertation. As for applicable Cochrane Risk of Bias items, the Singh study holds up fairly well, reporting on all outcomes identified in the methods section of the study. The study does not hold up well to the STROBE statement and I attribute this mainly to the page limits of the journal in which it appears. The authors mention the software used to perform the statistical

analysis, yet the one table in which results are reported is lacking in data, namely the mean and variance data

Detailed Characteristics of Included Studies

Huang 2010: The Huang study was an observational study that involved survey instruments given to two populations that worked for the same governmental agency. One population worked in a conventional office building and the other worked in a building certified green by the Taiwan Architecture and Building Center. Huang administered two survey instruments. The first was a standard post-occupancy evaluation survey developed by the Berkeley Center for the Built Environment and modified by Huizenga, Laeser and Arens. The modifications by Huizenga are focused on occupational health as the Berkeley survey is focused on occupant satisfaction with the physical work environment. I searched the Berkeley site for a copy of the survey to no avail. I also tried contacting the center for a copy of the survey, also to no avail. I did read a presentation given by the authors on the survey and found no mention of the occupational health aspect mentioned by Huang.

The second survey instrument used was the Chinese version of the University of Massachusetts Job Content Questionnaire (C-JCL). The JCL is used to assess various aspects of job stress and satisfaction and has questions related to occupant health. Huang reports that the Health Score statistic represents a weighted sum of health symptoms scores from the survey instruments. Table 4 represents the statistical data extracted from the Huang study

Table 4

Data Used From the Huang Study

Outcome	Mean		SD		n	
	Con	Green	Con	Green	Con	Green
Health Score (HS)* *higher is better	43.981	51.896	4.53	3.1	161	211

Singh 2010: The Singh study employed pre-move/post-move occupant surveys with two populations. Each population represented office workers who worked in conventional buildings and subsequently moved into new, green buildings as certified by the US Green Building Councils LEED rating system. The survey instruments used in the Singh study were created by the Michigan State University Sustainable Built Environment Research Team. Both the pre-move and post-move instruments consisted of a battery of questions on a number of topics. Of concern to this study were the questions related to absenteeism and work hours impacted by asthma, allergies, depression and stress over a four week period. The instruments also collected data related to fourteen other health conditions but that data was not part of this study nor were those data sets provided to me. Table 5 represents the variance data extracted from the raw data supplied to me by Singh.

Table 5

Data Extracted From the Raw Survey Data Gathered By Singh

Outcome	Mean		SD		n	
	Con	Green	Con	Green	Con	Green
(Conventional/Green)						
Work hrs/mo gained all health conditions	148.6	148.9	4.25	2.68	109	109
Work hrs/mo gained asthma & allergies	141.3	146.6	19.08	6.88	46	46
Work hrs/mo gained depression & stress	135	142.5	24.75	16.77	51	51
Work hrs/mo in productivity gain all health conditions	146	147.43	5.88	4.07	107	107

Note. Data for this table was extracted from raw survey data supplied by Singh upon request.

The Forest Plot Explained

The results of the meta-analysis as performed by the Cochrane Collaboration REVMAN5 software are displayed in a Forest Plot. The Forest Plot contains much information, but once understood it allows for a quick visual interpretation of the relative strength of an intervention in various studies concerned with the same question. The Standardized Mean Difference (the small green square) along with the confidence interval (the black horizontal line in the square), is plotted for each study. The larger black diamond figure represents both the common effect size and the confidence interval for all studies in the meta-analysis. Forest Plots are a widely accepted way of reporting meta-analysis data in biomedical research and prove very useful for this study as well.

Figure 1. Forest Plot representing the results of the primary meta-analysis of my study.

As seen in Table 5, the Singh study also produced three other outcome measures that could be used as a construct for occupant health. The following three Forest Plots, figures 2-4,

represent the effect of the Huang data when pooled with the three other outcomes from the Singh study.

Figure 2. Forest Plot using the Huang Health Score pooled with the Singh outcome of hours/month not impacted by asthma/allergies.

Figure 3. Forest Plot using the Huang Health Score pooled with the Singh outcome of hours/month not impacted by depression/stress.

Figure 4. Forest Plot of the Huang data pooled with the Singh outcome of increased occupant productivity in hours/month.

Discussion

Summary of evidence

The findings from this meta-analysis indicate that certified green buildings have no statistically significant impact on improved occupant health. Looking first at individual study analyses, we can see from Figure 1 that the SMD of the Huang study is 2.09 (1.83, 2.34), indicating a statistically significant effect for certified green buildings on occupant health. Taken in the context of Cohen's scale for effect size, the 2.08 SMD is considered a large effect. The SMD of the Singh study outcome looking at work hours/month free of complications from a variety of health issues is .08 (-0.18, .35), indicating that certified green buildings have a positive effect on improved occupant health. Taken in the context of Cohen's scale for effect size, this effect would also be considered small. In addition, the effect is not statistically significant as the CI crosses the line of no difference, or zero for this continuous data.

The data from the two studies, when pooled together, suggest a large positive effect for certified green buildings and improved occupant health, yet that effect is not statistically significant as the CI crosses zero (pooled SMD of 1.09 (-0.88, 2.34).

The heterogeneity for the pooled results was quite large as evidenced by a Chi^2 of 113.9 and I^2 of 99%. Each study was weighted by the software at 50% in the meta-analysis.

The remaining Forest Plots all provide effect sizes greater than the SMD of 1.09 for what I construed as the most inclusive measure of health, yet each of these SMD's is not statistically significant as the CI for each crosses zero.

The Forest Plot pooling the Huang Health Score with the Singh work hours/month not impacted by asthma/allergies (Figure 2) gives us the strongest effect size with a SMD of 1.24 (-.045, 2.92), indicating that asthma and allergies may contribute to occupant health more than the other sixteen health conditions included in the survey.

The Forest Plot pooling the Huang Health Score with the Singh work hours/month not impacted by depression/stress (Figure 3) gives us an effect size nearly equal to that of the asthma/allergies comparison with an SMD of 1.23 (0.047, 2.93), indicating that depression and stress may contribute to occupant health as much as asthma and allergies and more than the other health conditions included in the survey.

The Forest Plot pooling the Huang Health Score with the Singh work hours/month gained in productivity related to all included health variables gives a SMD of 1.19 (-.058, 2.95). While productivity is not a direct measure of occupant health, there is a body of literature on the relationships between occupant health and productivity (Bearg 2009).

Significance to Stakeholders

As pointed out earlier in this review, there is a strong interest on the part of building project owners to develop their projects to a recognized green certification standard. While the traditional bottom line for project developers has been the fiscal bottom line and will continue to be, there is an increasing awareness of the impact a healthy employee base can have on that fiscal bottom line. One of the top cited reasons for building to a green standard is to provide a workplace that is conducive to a healthier and more productive employee base (Mille, 2009). Katz has shown that up to 77% of the increase in net present value/square foot in green buildings as compared to conventional buildings can be associated with a healthier and more productive workforce (Katz, 2003). The information from this meta-analysis, therefore, would be of interest to a variety of stakeholders involved in the development of building projects.

Nearly every sector of the building industry is being touched by and embracing green design and construction principles. As of this writing, the LEED rating system is an integral part of the building process in federal projects as well as in forty-five states, representing state and local governments, institutions of higher learning and public school districts. Additionally, since its initial offering of a green rating system for commercial buildings in 2000, the US Green Building Council now offers specific rating systems for a variety of project types (see Table 6). Given the huge planned investments in green development, it is safe to say that the results of meta-analyses focused on the health benefits of green buildings is of critical importance to numerous stakeholders.

Table 6

LEED rating systems for various building types as of 2011

LEED for New Construction	LEED for Healthcare
LEED for Commercial Interiors	LEED for Existing Buildings: Operations &
LEED for Homes	LEED for Schools
LEED for Core and Shell	LEED for Neighborhood Development

Limitations of this study

There are several limitations of this systematic review and meta-analysis. Table 7 highlights the limitations.

Table 7

Limitations of this systematic review and meta-analysis

Number of studies	<ul style="list-style-type: none"> • Only two studies met the inclusion criteria, even though the criteria were rather broad
Study design	<ul style="list-style-type: none"> • Included studies were observational studies of very different populations • Survey instruments used were different between the two studies • The Singh study conducted pre-move surveys post-move, so recall is in question • Neither study included much useful demographic information, but written descriptions in the Huang study indicated the green and conventional populations were very different • There is no record of how the green and conventional buildings compare in physical attributes • There is no record of what efforts were taken to improve IEQ in the green building nor how actual levels of IEQ varied among the green and conventional buildings • Timing of the surveys could have impacted the responses as some of the health conditions in question are affected by seasonal changes • The two studies used different constructs for measuring occupant health

Conclusions

This systematic review and meta-analyses, while of limited usefulness in terms of its statistical results, is of importance if for no other reason than it highlights the lack of standardized data needed to conduct meta-analyses on the topic. What research does exist is observational and has been collected using survey instruments that have been modified from study to study. Additionally, as buildings are not some type of magical environment where the non-work related issues of a person's life somehow don't come into play during their workday, it is extremely difficult to account for the plethora of variables that could be impacting respondents' answers to a survey.

There is a need for large, longitudinal studies that look at green buildings versus conventional buildings in a pre/post type study design by measuring occupant health and productivity as reported by occupants but that also attempt to mesh that with actual indoor environmental quality while controlling for other variables such as physical location of the buildings in question. It is not farfetched to think that occupants of a decent conventional building in a great setting might report higher health and IEQ satisfaction than similar occupants of a green building that may have just as good of actual IEQ but where the building is in a less than ideal setting. The list of such comparisons is endless. Thus the need for measurements of actual IEQ gains in green buildings over conventional buildings.

At this point in time, a more useful meta-analysis would be to compare studies that have used the same survey instrument on similar populations in similar buildings in similar settings. Do those studies exist? I am doubtful. I suggest that a large study within a specific company or agency, where there may be some degree of homogeneity of the population and variables, could provide useful information. One area where this might be more feasible is in school systems as

there are some common metrics—standardized performance scores—that could be used to benchmark some level of effect size.

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Chapter 2: ESSAY 2-Understanding Evidence-Based Design Through a Review of the Literature

Abstract

The purpose of this paper is to provide the reader with a current understanding of evidence-based design (EBD), as it relates to the design, construction and operation of health care facilities. A thorough review of the relevant literature was conducted with thirty-one key articles forming the basis for this paper. While any building project has a wide range of potential outcomes of interest, the literature reveals that evidence-based design for health care facilities primarily focuses on patient, staff and fiscal outcomes. The literature, limited in terms of breadth of sources and authors, reveals that evidence-based design is a concept that is still evolving, one lacking a singular definition and trying to find its way in the gray area that exists between the worlds of hard science and design.

Keywords: evidence-based design (EBD), patient outcomes, staff outcomes, fiscal outcomes

Introduction

In May 2013, I attended the 2013 annual conference of the Environmental Design Research Association, one of the associations at the forefront of the evidence-based design (EBD) discussion. While there I took advantage of several opportunities to engage with both researchers and practitioners involved in EBD to inform my nascent understanding of the state of the concept.

Multiple presentations and discussions, both facilitated and informal, confirmed my conclusions drawn from my review of the literature—the EBD concept seems simple on the surface—but there is a great deal of disagreement on the strength, validity and usefulness of the concept. EBD is best thought of as a continuum with one terminus being a position of “yes, there is solid evidence of what works and what doesn’t,” and the other terminus being “no, the evidence needed to make confident decisions is not yet available and our ideas about what works and what doesn’t is anecdotal.”

The very word 'evidence' is equated with undisputed truth. Evidence-based design, then, would seem to imply a design process that is based on undisputed truth. As the exploration of the topic bears out, however, the word 'evidence' means different things to different disciplines. In order to accurately present both the opportunities and challenges inherent in EBD, I have chosen to frame the concept first with a consideration the disciplines humans created to categorize, study and influence the world around them; second through a view of evidence and the transformation of data to evidence; and third through a review of an analog to evidence-based design, that being evidence-based medicine.

Science, Humanities and Design

Nigel Cross believes that the well-established, defined and accepted disciplines of science and humanities don't adequately address the human-made world and that a fully separate but complementary discipline of design can be successfully argued (Cross, 1990). Figure 5 positions the three disciplines according to their main domains of inquiry, primary methods and primary values. A simple example is helpful to illustrate the interplay of these three disciplines, their domains of inquiry, methods and values. Humans are makers. We take natural materials, such as wood and stone, and make things with them such as furniture and homes. The act of creation and the created objects themselves are reflections of the human experience. After making, we analyze and remake—striving to make better. This act of making better is sometimes, but not always, driven or informed by hard scientific observations or data. Rather, we just try one thing, then another, until it seems we are “there,” with “there” being some level of satisfaction with the object, its utility and how it makes us feel. Thus the mix of science, humanities and design coming together to inform the way we as humans craft the environment around us.

The critical message from this example and Figure 5, and the message that will be analyzed in more detail throughout this paper, is that the mixing or cross pollination of these three disciplines, though necessary when addressing the built environment, is anything but a clear, straightforward exercise.

Science, Humanities, Design: The Three Cultures			
	Science	Humanities	Design
Domain of inquiry	The natural world ("what is")	The human experience ("who we are")	The institutions, practices, and artifacts of the human-made world ("how things ought to be")
Primary methods	Experimentation	Analogy	Modeling
	Pattern recognition	Metaphor	Pattern formation
	Analysis	Interpretation	Synthesis
	Classification	Valuation	Conjecture
	Deduction	Induction	Abduction
Primary values	Objectivity	Subjectivity	Practicality
	Rationality	Imagination	Creativity
	Neutrality	Commitment	Empathy
	Concern for "truth"	Concern for "justice"	Concern for "appropriate fit"

Adapted from: Cross, N. 1982. Designing ways of knowing.
Cross, N. 1990. The nature and nurture of design ability.
Banathy, B. 1996. Designing social systems in a changing world.

Figure 5. Representation of the work of Cross and Banathy by Howard David Silverman.
Retrieved from <http://www.solvingforpattern.org/2013/08/20/design-as-performative-sensemaking/>.
Reprinted with permission.

Positioning EBD Within Five Worldviews in Environmental Design Research

While Cross was not dealing explicitly with the concept of EBD, his position of the design culture beside the science and humanities disciplines nicely set the stage for the discussion that has been taken up by architects Keith Diaz Moore and Lyn Geboy. They position EBD with five worldviews of design-oriented knowledge and arrive at a table (Table 8) that nicely illustrates the aforementioned challenges of evidence and methodologies inherent to the concept of EBD (Diaz Moore & Geboy, 2010). The current practice of EBD lies, in some minds, firmly within the realm of traditional science as far as data-collection is concerned. Yet, traditional science is mainly concerned with discrete and existent problems, while design professionals generally live and work in the world that seeks holistic solutions to projectional problems. Muddying the waters even more is Hamilton's definition of EBD that allows for 'best

available evidence,’ citing a belief in technical-rationality—an approach that is open to data that is relational in nature (as opposed to sciences’ causal data).

Table 8

Five Worldviews in Environmental Design Research

	Traditional Science	Technical-Rationality	Pragmatism	Interpretivism	Intuitionism
The nature of knowledge is...	Objective	Applied, objective	Constructed	Subjective (at times constructed)	received
The nature of the problem is...	Discrete, reducible, existent	Discrete, reducible, projectional	Systemic, existent or projectional	Holistic, existent, perspectival	Holistic, singular, perspective, projectional
The purpose of knowledge is...	Explanation (ideally causal)	Instrumentality	Utility	Perspective	Insight
The habit of mind is...	Analytic	Procedural	Practical	Synthesis	Creative
The form of knowledge is...	Statistics	Protocols	Patterns, case-studies	Narrative, stories	Patterns
Truth is...	Causal laws are the ideal, data produced through approved methodologies	Causal adjustment	Operational	Persuasive rhetoric	Correspondence
Good evidence is...	Internally and externally valid, reliable, objective data	Valid, reliable, objective data that when applied achieves its ends	That which is efficacious	A persuasive, trustworthy (perhaps inspiring) narrative	That which inspires

Note. Adapted from “The question of evidence: current worldviews in environmental design research and practice” by K. Diaz Moore and L. Geboy, 2010, *Arq.* 14 (2), 105-114.

The Concept of Evidence

When considered in terms of the normal scientific method, evidence is that which supports an accepted paradigm (Kuhn, 1962). The word “that” in the previous sentence is more complicated than might seem possible. Is “that” raw data? Information? Knowledge? Wisdom? An attempt to understand those words in terms of a linear process has come to be known as the Data, Information, Knowledge, Wisdom (DIKW) model (Ackoff, 1989). The

terms of the DIKW model can be considered in the following fashion: Data can be considered symbols; Information is that data that has been processed to be useful; Knowledge is the application of the data and information; and Wisdom represents and evaluated understanding (Bellinger, 2008). Figure 6 illustrates the relationship of the DIKW progression to the more holistic notions of connectedness and understanding.

Figure 6. The progression of data to wisdom (adapted from Bellinger, 2008)

While not speaking in terms of evidence, information technology expert, Robert Dilenschneider, addresses the notion of information overload (too much useless data/information vying for our attention) and the necessity of manipulating that data and information into useful knowledge (Dilenschneider, 2001). Where then, exactly, does evidence lie? As designers are searching for that which helps them design buildings and processes that have positive influence on a given set of outcomes, evidence must reside on the knowledge/wisdom end of DIKW continuum. Only when a given piece of data has been integrated into a design process in a way that is likely to produce an intended result, and that result measured and verified, can we consider ourselves in possession of and working with evidence.

A hypothetical example will illustrate the point. Access to natural lighting within buildings is thought to be beneficial to humans working in those buildings. We can easily

measure the amount of natural light entering a workspace...that is data. We can develop test settings to control for other variables and try to see how human reactions/performance vary with varying levels of natural light...that exercise can provide information. We can then apply those patterns we have recognized to a real life building scenario and compare our findings with our controlled findings...that is knowledge. We can then try to reconcile differences in our expected and realized findings, trying to factor in the countless other variables that occur in the live setting (that we are unable to fully reproduce in the controlled setting) and perhaps arrive at the determination that our original assumptions about the benefits of natural are not as important to the outcome at hand as are other variables...this is wisdom and understanding.

Before moving to the relationship between EBM and EBD, it is necessary to discuss the design process as understood by those who identify themselves as designers. For the purposes of this paper, designers are considered to be those who design the physical environment and systems in which health care services are delivered. The design process can be viewed as being systematic (linear and orderly) or systemic (iterative) (Banathy, 1996). An iterative process best portrays the activities that lead to the building of a healthcare space. User-experience (UX) designer, Anders Ramsay, states that “until you have actually built what you are designing, you are not going to be able to fully understand it.” (Ramsay, 2013). Anyone who has built something from plans they have made (plans made on some sort of evidence that the thing will perform as desired) has stood back and said something akin to, “next time, I’ll change this or that aspect.” Looking back at the aforementioned DIKW framework, perhaps the plans were based on poor data, information, and knowledge or reflected no wisdom. Perhaps all of that was great but the anticipated outcomes/expectations for the thing had changed.

The systematic design process assumes that each incremental finding will lead you to the desired result. Kuhn (1962) does not buy into that notion as explained in his *Structure of Scientific Revolutions*. There he argues that we move in certain directions according to an accepted paradigm, looking for evidence to support that paradigm, only retreating from that paradigm when we have uncovered enough anomalies to suggest that our paradigm is faulty and we have crafted and accepted a new paradigm to replace the old. In other words, we ultimately have to disregard the incremental findings in favor of a whole new direction for our inquiry. Turning again to Banathy, he echoes support of this notion with what he calls leap out design. The ‘leaping out’ is his way of transcending the old system (Kuhn’s accepted paradigm) for a new system (Kuhn’s new replacement paradigm).

A Precursor to Evidence-Based Design: Evidence-Based Medicine

Before turning to a definition of EBD, it is helpful to think for a few moments on another evidence-based notion—that being the practice of Evidence-Based Medicine (EBM). EBM enjoys a widely accepted definition as put forth by Sackett in 1996, “*Evidence-based medicine is the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients.*” The practice of medicine, to many, falls within the realm of hard science—defined by and concerned with the parameters shown in Crosses first column. The question of just what constitutes evidence is a critical one. Considering “evidence”—the term implies some level of proof of relationship or causality. The word evidence poses problems for those involved in EBD as there are different levels and rigor of evidence. It can be thought of as hard, strong, soft, weak, empirical, anecdotal, testimonial, statistical, and analogical.

Returning to the medical analogy for a moment, the quality of evidence is often presented graphically by a pyramid (see Sackett DL, Straus SE, Richardson WS, et al. *Evidence-based medicine: how to practice and teach EBM*. 2nd ed. Edinburgh: Churchill Livingstone, 2000.) At the base of the pyramid lives what might be a great quantity of evidence of limited rigor. As one progresses toward the apex of the pyramid, the rigor of evidence increases. In the medical world, randomized controlled trials (RCTs), about midway up the pyramid, are considered the gold standard for generating rigorous evidence. Progressing past this point involves critical analysis of primary studies by secondary researchers and reviewers.

Panda (2006) points out, however, that the practice of medicine involves both science and art, with the art component being creativity on the part of the practitioner. That art component, reflected in Sackett's 'judicious use' wording, can be thought of as being related to the 'design' component in EBD.

It is useful to think about EBD within the context of this medical evidence pyramid model. Rarely, if ever, does the designer of the built environment enjoy an experimental setting that would yield evidence that would reside at the upper levels of the evidence pyramid. To the contrary, the design of something as complex as a healthcare facility involves a multitude of variables such that it is unlikely a researcher can fully understand the impacts of a single design variable (compare this to a RCT where the only variable is a medicine dosage). Of course, RCTs suffer from some degree of variability as well, but good experimental design coupled with multiple studies of similar design on large populations yields data that can be thought of as rigorous and that can be generalized to other populations. Again referencing Crosses figure, the value of design is concerned with the appropriate fit for a particular situation, not a hard and fast truth that holds up to any situation.

Making the Jump from EBM to EBD

For the sake of this paper, it is helpful to think of EBM as concerning that which is done by the healthcare provider to the patient. EBD can be thought of as concerning the physical setting in which the healthcare is being delivered. Long before the either phrase, EBM or EBD, was coined, the Greeks were studying the effects of the physical environment on people's health and using those conclusions to inform new design of physical healthcare facilities (Dickerman, 2008). Florence Nightingale instituted design changes in field hospitals based on her observations of what appeared to be working/not working in terms of patient outcomes (Zborowsky, 2010). Environmental psychologists have investigated the impacts of the physical environment on attitudes, beliefs and perceptions. Architects, landscape architects and interior designers claim sensitivity to the impact of their designs on humans at many levels.

A ground breaking study in 1984 by Ulrich is often pointed to as the genesis of the EBD movement. Ulrich used medical records to illustrate a relationship between the physical nature of a surgical recovery room and recovery times. Notably, Ulrich found that patients who had a view of nature had a shorter recovery, asked for less pain medication and were noted to have less complaints recorded in their nursing charts (Ulrich, 1984).

Since that study, designers have been seeking to gather evidence through the identification and measurement of metrics related to the built environment and to put that data to work in the design of more effective spaces. As with any concept that many are striving to embrace, it is helpful to have a standard—getting everyone to read off the same song sheet, if you will.

Unlike EBM, EBD does not yet enjoy a universally agreed upon definition. A variety of assumed meanings of EBD have emerged that generally reflect the notion that the design, construction and operations of the built environment should be informed by evidence as to what works in terms of achieving desired outcomes associated with the building project. The Center for Health Design, an organization at the forefront of the EBD movement, proposes that EBD be defined as “***Evidence-based design is the process of basing decisions about the built environment on credible research to achieve the best possible outcomes***” (Healthcare Design, 2008). Architect and leading EBD proponent, Kirk Hamilton, puts forth this oft cited definition of EBD, “*Evidence-based design is a process for the conscientious, explicit, and judicious use of current best evidence from research and practice in making critical decisions, together with an informed client, about the design of each individual and unique project.*” (Hamilton & Watkins, 2009). One quickly sees that Hamilton’s EBD definition closely mirrors Sackett’s EBM definition.

An example of how the rigor of data is considered by researchers and the impacts of cultural and societal experiences on how data is reviewed can be illustrated by looking at two studies on physical environment and healthcare facilities. In the first, American environmental psychologist and EBD pioneer, Roger Ulrich of Texas A&M University, reviewed the literature and found over 600 studies that purported to provide rigorous data to support design decisions of healthcare facilities (Ulrich, 2008). Just three years prior, in 2005, a group of researchers from The Netherlands, reviewed the literature for physical environment stimuli that positively impact health outcomes in healthcare facilities and found that of the 500 studies initially screened, only 30 studies met their standards for rigor (Dijkstra, 2006). Interestingly, 19 of the 30 studies identified by Dijkstra in 2005 were NOT included in Ulrich’s 2008 review.

Digging a little deeper into the review methods of each researcher reveals some clues as to why the difference in results. Ulrich calls his research ‘A Review of the Research Literature on Evidence-Based Healthcare Design.’ His methodology indicates a thorough attempt to locate applicable studies through the use of thirty-two search terms related to patient and staff outcomes, physical environmental factors and other healthcare-related issues. A variety of databases, detailed in the paper, were searched and any article that contained or alluded to the physical environment of healthcare buildings in its title or abstract was reviewed. Ulrich also scanned the bibliographies of identified studies for additional works of relevance. A second stage of review filtered out articles that were not empirically based or did not examine the influence of environmental characteristics on patient, family or staff outcomes. This second stage also included an evaluation of the quality of each study and the nature of the source in which it appeared (peer reviewed journal was favored).

Dijkstra’s review followed the Cochrane Collaboration protocol for a Systematic Review. The Systematic Review attempts to identify, appraise and synthesize all the empirical evidence that meets pre-specified eligibility criteria to answer a given research question. The methodology provides a very specific framework by which to conduct the literature review that strives for reliable and repeatable results. With the Cochrane protocol, the search process, including all search terms and databases, is explicitly spelled out as is the rationale for including or excluding studies from the review. The results of the review are detailed in both narrative and graphical format. The SR is often, not always, followed by a meta-analysis of the studies. Dijkstra chose to not perform a meta-analysis as the studies discovered by the Systematic Review were deemed too disparate for meaningful statistical comparison.

While it is reasonable to assume there was overlap in the interests of both researchers (as indicated by a degree of overlap within the search terms used by both), it would be going too far to say the search goals were identical. This author is not commenting on the quality of either authors review, but rather attempting to make the argument that there are different ways to conduct a literature reviews and the search for evidence on similar topics can lead researchers to very different conclusions.

Realizing the challenges with the term ‘evidence’, both Sackett and Hamilton modify the term ‘evidence’ with ‘current best’ in their respective definitions of EBM and EBD.

Patient Centered Outcomes: The Unspoken Raison d'être for both EBM and EBD

The underpinning legs for both EBM and EBD is better outcomes. Sackett's EBD definition is concerned with the ‘care for individual patients’ and Hamilton's EBM definition, though not explicitly stated, is concerned with desired outcomes in a positive manner. EBM outcomes can often times have ordinal value—decrease in blood pressure, decreased pulse rate, reduced size of a cancerous growth, increased blood oxygen saturation levels, etc.. Controlled scientific experimentation on large and varied populations has provided data that in many cases allows medical practitioners to take actions that will yield predictable results—positive outcomes that are definable and measurable.

While a building project can have multiple desired outcomes, for the purposes of this paper outcomes are understood to be primarily related to patients, patient's family, and the health care facility staff. Additional outcomes addressed in this review, though not as heavily as the aforementioned ones, include business operations. In other words, it is assumed that the EBD decisions implemented in built healthcare facility have positive impacts on the health and well-

being of patients, patient's family and the health delivery staff as well as the financial picture of the healthcare facility. Unlike the outcomes in EBM, the desired outcomes in EBD are less easily tied to some very controlled experimental setting where the only variable is one isolated design decision. Unlike EBM outcomes, the metrics are not ordinal. Perhaps a patient feels better or is less anxious. While these "feeling" states can be assigned ordinal values, the fuzzy logic behind that activity poses challenges to the researcher (Durmisevic, & Ciftcioglu, 2010). For example, the placement of a piece of painting in a patient's room may have some impact on the patient, but it is difficult to determine the true reason for the change. Is it the subject, the color, the frame, the artist?

The Study and Promotion of Evidence-Based Design

In attempting to understand the driving forces behind the adoption of a concept, it is helpful to identify the individuals and entities behind the concept. One doesn't have to spend much time reviewing the literature to recognize that the bulk of the work on EBD appears in relatively few places. While not exhaustive, the following list highlights those entities producing the bulk of the research on EBD.

a. Center for Healthcare Design

The Center for Health Design (CHD) is perhaps the leading group concerned with the study and advancement of evidence-based design. Comprised of both academics and practitioners, the CHD holds conferences, conducts programs/continuing education on EBD and offers a third-party EBD credentialing exam called the Evidence-Based Design Accreditation and Certification (EDAC) for those involved in EBD projects and research. The CHD Pebble Project is attempting to identify built environment designs and solutions that measurably

improve patient and worker safety, clinical outcomes, environmental performance and operating efficiency. Projects can enroll to become Pebbles that will create a ripple effect in the healthcare community by increasing the body of knowledge on EBD.

b. Texas A & M University

The Center for Health Systems & Design (CHSD) is a collaboration of two colleges at Texas A & M University—the College of Architecture and the College of Medicine. The stated goal of the CHSD is “to promote research, innovation and communication in an interdisciplinary program that focuses on health facility planning and design.” Among the faculty of the CHSD are two of the leading EBD proponents, Architect Kirk Hamilton and Environmental Psychologist Roger Ulrich. The CHSD offers programs on healthcare design at the undergraduate, graduate and doctoral levels.

c. Georgia Tech University

The School of Architecture at Georgia Tech offers programs on healthcare design at the master’s and doctoral levels with a Ph.D. in Evidence Based Design. Professor Craig Zimring researches and writes extensively on EBD and is a collaborator with Roger Ulrich on some of the leading papers defining the status and direction of EBD.

d. Health Environments Research & Design Journal (HERD)

As its name implies, the HERD Journal publishes peer-reviewed articles related to the design of the healthcare environment. The Journals’ Topics of Interest list includes patient outcomes, human factors, evidence-based healthcare design, post-occupancy evaluation, translating evidence into practice and other similarly couched expressions. The Journal is co-

edited by architect Kirk Hamilton and Nursing Scientist, Jaynelle Stichler. The editorial board includes Roger Ulrich.

e. Environmental Design Research Association (EDRA)

Founded in 1968, EDRA is an international, interdisciplinary organization comprised of design professionals, social scientists, educators and facility managers that is focused on the advancement and dissemination of environmental design research in order to better understand and improve the inter-relationships of people with their built environments. EDRA has eighteen knowledge networks design to provide a formal networking structure for its members. EDRA has held well attended annual conferences since its inception, with each featuring a multitude of peer-reviewed papers/presentations on cutting edge research and practices related to the built environment. The 2013 conference, EDRA 44, featured over 318 peer-reviewed sessions on Health + Healing Spaces.

Methods

Annotated bibliography of the literature

The following annotated bibliography, presented in chronological order, consists of thirty-one key articles that when considered collectively provide the reader an understanding of the current state of thinking around evidence-based design.

Ulrich, R. (1984). View through a window may influence recovery from surgery. *Science (New York, N.Y.)*, 224 (4647), 420-421.

Roger Ulrich (Professor of Health Facilities Design and Architecture at Texas A&M University, and Professor of EBD at Chalmers University in Gothenburn, Sweden) reports on his study that suggests that surgical recovery time may be impacted by the physical environment of the recovery room.

Ulrich examined medical records of 23 patients recovering from cholecystectomies and observed that patients who had a view of nature experienced shorter recovery time, asked for fewer pain medications and elicited fewer negative comments in nurses notes than did patients whose recovery rooms looked out into the brick wall of the building. The study sample was small.

This study from 1984 is oft-cited as the sentinel study that proved medical outcomes could be impacted by the physical environment in which healthcare was being delivered. Rarely does an academic article focused on the impact of the physical healthcare environment on health and well-being not reference this study.

Jonas, W., & Chez, R. (2004). Toward optimal healing environments in health care... Toward Optimal Healing Environments in Health Care: Second American Samuelli Symposium, January 22-24, 2004. *Journal Of Alternative & Complementary Medicine*, 10S-1-s-6.

Jonas and Chez (both physicians associated with the Samuelli Institute) focus this work on the roles of both physical environment and the recipients of healthcare in determining appropriate outcome measures to be addressed in the creation of holistic healthcare environments—termed Optimal Healing Environments (OHE) by the authors.

This paper reports on the dialogue on OHE's at the 2nd American Samuelli Institute symposium in January, 2004. A model With full recognition of the importance of the physical nature of healing environments, the process of creating an OHE looks to the individuals—healers, healees, significant others and/or the community entity as equally, if not more, important to the design, creation and implementation of the OHE. The authors outline seven components of an OHE that together address the social, psychological, spiritual, physical and behavioral aspects of health care. A graphical representation of the components of OHE is presented and discussed.

While the author's ideas of what components are critical to creating environments that promote health and healing are in-step with a general theme identified by many other writers on the topic, the Samuelli approach is decidedly more informed by the notion of compassion and service as opposed to a straight numbers driven, evidence-based approach.

Schweitzer, M., Gilpin, L., & Frampton, S. (2004). Healing spaces: elements of environmental design that make an impact on health... Toward Optimal Healing Environments in Health Care: Second American Samueli Symposium, January 22-24, 2004. *Journal Of Alternative & Complementary Medicine*, 10S-71-s-83.

Marc Schweitzer (architect with The Design Partnership) and Laura Gilpin and Susan Frampton (both with Planetree) layout a brief history of the study of the effects of physical spaces on human health and well-being.

Beginning with examples from ancient Greece, the authors examine how the physical space influences human behavior, actions and interactions. In what appears to me to be a backward order, they next evaluate the existing research, ultimately concluding that there is a paucity of what would be considered rigorous research on the impacts of physical space on healing and well-being. The article concludes with a survey of healing environment design models, both ancient and modern, that cultures have employed in order to promote healing and well-being.

This article is well-cited with 112 citations from studies that have assessed some component of the physical environment and its impact on healing and well-being. I find it to be a good overview article as it nicely lays out a framework by which to understand the current thought behind healing design. The 112 citations are useful and give the reader a feel for the broad range of disciplines involved in the research.

Hendrich, A., & Lee, N. (2005). Intra-unit patient transports: time, motion, and cost impact on hospital efficiency. *Nursing Economic\$, 23 (4), 157-164.*

Ann Hendrich (VP, Clinical Excellence Operations, Ascension Health, St. Louis, MO) and Nelson Lee (Lead Engineer, Rapid Modeling Corporation, Cincinnati OH) analyzed the intra-unit patient transport process from the perspective of time, personnel involved and cost of a transport.

They point out that intra-unit patient transports pose risks for patients—increased falls, less accurate medical monitoring during the transport, increased stress to both patient and family. Additionally, transports utilize already scarce hospital resources in terms of staff involved in the transport as well as the financial implications associated with payer directed health care decisions (multiple beds being encouraged by traditional payer systems). The study highlighted a cost of \$31.72/transport and documented the “waste time” associated with patient transports (also considered “non-value added time”). The reasons for patient transports—technologic capability of the room headwall, clinical skill of the caregiver and the nursing hours per patient per day (NHPPPD)—can be impacted by a redesign of the transport process itself and by a redesign of the facility to provide acuity-adaptable rooms that would alleviate the need to move patients as their acuity level changes.

While this study does not use the EBD terminology, it clearly fits with the notion of securing hard numbers to reflect opportunities for improvement of both systems and facilities through design and introduces the notion of acuity-adaptable rooms as a design feature based on such evidence. The study is helpful in that it adds weight to the position

that nursing staff are excellent resources for identifying opportunities for improvement and are key players in the advancement of such improvements.

Dijkstra, K., Pieterse, M., & Pruyn, A. (2006). Physical environmental stimuli that turn healthcare facilities into healing environments through psychologically mediated effects: systematic review. *Journal Of Advanced Nursing*, 56(2), 166-181.

doi:<http://dx.doi.org/10.1111/j.1365-2648.2006.03990.x>

Karin Dijkstra, Marcel Pieterse and Ad Pruyn (all Faculty of Behavioural Sciences at the University of Twente, Enschede, The Netherlands) report on the findings of their systematic review of the literature to determine the effects of physical environmental stimuli in healthcare settings on the health and well-being of patients.

The authors followed the Cochrane Collaboration method, initially identifying 4,075 papers that were then subjected to the inclusion criteria. The authors ultimately excluded all but 30 studies—these 30 studies reflecting some level of experimental control in their design. The authors sought data on seventeen environmental stimuli within three relevant dimensions of the physical healthcare environment —ambient, architectural and interior design features. The findings indicate that manipulation of the physical healthcare environment can indeed have an impact on patient’s well-being, but that conclusive evidence is limited or lacking with regard to the impacts associated with manipulation of specific environmental stimuli.

This study reviewed the existing literature through a much more stringent filter than Ulrich, et al., in their 2008 review of the literature that identified over 600 studies they

say support EBD. The conclusion reached by Dijkstra suggests that support for EBD is inversely proportional to the rigor of the examined studies.

Stichler, J. (2007). Evidence-based health facility design. Using EBD to improve outcomes. *Journal Of Nursing Administration*, 37(1), 1-4.

Jaynelle Stichler, DNSC, RN, discusses three levels of outcomes that can be impacted by health-care facility design decisions: patient, provider/health-care work and organizational performance.

Stichler advocates for health-care facilities as healing environments, building on Nightingale's observations, and cites Ulrich's work as positive examples of using evidence to effectively inform design. Stichler's unique take on the topic of EBD revolves around the role of the Nurse Executive and their unique perspectives inform the process and facility design teams.

Stichler explains her position clearly and is effective in highlighting the important role the nursing staff can play in the EBD strategy.

van de Glind, I., de Roode, S., & Goossensen, A. (2007). Do patients in hospitals benefit from single rooms? A literature review. *Health Policy*, 84(2/3), 153-161. doi:10.1016/j.healthpol.2007.06.002

Irene van de Glind, de Roode and Goossensen (all with the Institute of Health Policy & Management and Erasmus, MC, The Netherlands) conduct a literature review on the benefits of single patient rooms for patients.

They recognize the four categories of patient outcomes impacted by the physical environment as laid out by Ulrich et al. in their 2004 study and go on to identify six (6) more specific outcome measures: privacy and dignity of patients; noise and quality of sleep; patient satisfaction with care; hospital infection rates of MRSA; patient safety (fall accidents and medication errors) and patient recovery rates, complications and length of stay. The search strategy was well documented and the results were thoroughly assessed for rigor of the research. The authors found few rigorous studies on the defined outcome measures.

The article echoes other articles that have pointed out the healthcare policymaker's need for a larger body of rigorous research and solid evidence on the impacts of physical environment, in this case single patient rooms, on patient outcomes.

Dickerman, K., Barach, P., & Pentecost, R. (2008). We shape our buildings, then they kill us: why health-care buildings contribute to the error pandemic. *World Hospitals And Health Services: The Official Journal Of The International Hospital Federation*, 44(2), 15-21.

Ken Dickerman (National Resource Architect at Leo A Daly), Paul Barach (MD, PhD with Utrecht University, The Netherlands) and Ray Pentecost (Director of Healthcare Architecture, Clark Nexsen Architecture & Engineering) use the evolution of health care philosophies and hospital design, beginning with the Greeks and progressing up through the modern health-care system, to illustrate how changes in design approaches have led to, and will continue to lead to, improved patient outcomes.

The authors cite specific examples of how health care delivery has evolved over the ages, beginning with the Greek patient focused hospitals, progressing through the specialized Roman hospitals, through the Charity Care of the Middle Ages up through the advent of a more scientifically based model for health care delivery. They, like others, point out the observations of Florence Nightingale and the changes in design brought about by her observations. They go on to critique the modern linear approach to design and construction practiced by architects and constructors. The authors point out that today's hospital and healthcare challenges cannot not be met with a personal approach, but instead require a systems approach and use evidence to show that hospital accidents are often caused by systems failures, not individual failures. They further point out that health-care systems are complex and tightly coupled, illustrating the high degree of interdependence of the related parts. The authors use Reason's model of layers of defenses as the best way to combat health-care challenges and accidents, which are latent in the system.

The authors are basically making the case for moving toward an integrated design approach and away from the traditional linear approach and use a few well cited and pertinent articles from the literature to support their case

Edelstein, E. (2008). Searching for evidence. *Health Environments Research and Design Journal*, 1 (4), 95-110.

Eve Edelstein (a highly respected researcher in the field of neuro-architecture at the University of Arizona College of Architecture, Planning and Landscape Architecture)

discusses the results of her research into information source usage by EBDers and points out the challenges of tapping the expansive and ever growing stores of knowledge.

She points out that design professionals tend to search deeply in a few select information databases, but forego utilizing the available breadth of information sources. Additionally, she notes the desire of the researchers for comprehensive peer-reviewed research that is available through a single point of entry—a system that is not yet available. Edelstein goes on to discuss how profession-specific ontologies stymie effective searching of the literature across disciplines. Furthering her findings, she suggests that search and analysis strategies should focus on the user's command of the subject matter rather than their skill with a particular database.

Edelstein effectively outlines the challenges to effective literature searches and describes developing tools that will aid all researchers with this increasing complex task. Only when such tools are available, she posits, will designers be able to fully incorporate the best available research into their design scenarios.

Joseph, A., & Hamilton, D. (2008). The Pebble Projects: coordinated evidence-based case studies. *Building Research & Information*, 36 (2), 129-145. doi:10.1080/09613210701652344

Kirk Hamilton (Professor of Architecture at Texas A&M) and Anjali Joseph (Director of Research at the Center for Health Design, discuss the Pebble Project and its goal of bolstering the knowledge base in support of EBD for healthcare facilities.

Hamilton and Joseph detail the genesis of the Pebble Project, the belief that physical environment impacts the quality of health care, and discuss its relevance to the field of

EBD. They describe a research framework based on the desire to positively impact four main outcome areas identified by Ulrich—staff, patient safety, patient/family stress and well-being and overall clinical outcomes. The Pebble Project is described as attempting to bring a level of rigor to the “testing” of different design approaches aimed at the aforementioned outcome areas. The development, a priori, of a set of hypotheses and planned follow up is key to this approach. The authors describe three broad categories of research activity—analysis and interpretation of existing data, documentation studies and original data collection—illustrating in table format 10 examples of Pebble participants that are engaged in studies within these categories.

Joseph and Hamilton nicely present the Pebble Project and its successes, but also point out that for the Project to be more effective, the development of standard metrics and analysis tools by which data gathered from EBD projects can be evaluated and disseminated must be forthcoming.

Sadler, B., DuBose, J., & Zimring, C. (2008). The business case for building better hospitals through EBD. *Health Environments Research and Design Journal*, 1(3), 22-39.

Blair Sadler (Past President and CEO of Rady Children’s Hospital in San Diego), Jennifer Dubose (a research associate in the College of Architecture at the Georgia Institute of Technology) and Craig Zimring (Professor of Architecture at the Georgia Institute of Technology) discuss the challenges to today’s healthcare landscape and build a business case for incorporating EBD innovations into health care facilities.

They point out that the emergence of hospital “watchdog” organizations that are focused on reducing the incidence of patient harm, as well as the aging healthcare infrastructure in the United States, is driving healthcare facilities to rethink their approaches to design and construction. Changing reimbursement scenarios, such as pay for performance standards, as well as public reporting of patient satisfaction ratings mean that the healthcare consumer will be more informed and, in theory, will choose a higher rated facility over one that has lower patient satisfaction and safety ratings. In addition to assisting with positive patient outcomes, the physical environment is shown to be a factor in cost avoidance associated with such things as patient falls, nosocomial infections, and medical errors by staff as well as staff injuries and non-value added time associated with lifting and patient transports between rooms. They do touch on the intersection of green building and EBD, mentioning the oft cited Kats cost/benefit study. The authors utilize several case studies to illustrate their points and merge into a discussion of the type of executive leadership required to develop a culture and process for transformation within a healthcare organization, outlining a 10 step plan for creating a business case for an evidence-based facility. A return on investment framework is presented as a means for evaluating the financial feasibility of incorporating EBD strategies.

Sadler, as a former healthcare CEO who has first-hand experience with positive EBD situations, and his colleagues stand firmly planted in the camp that subscribes to the notion that there is adequate rigorous data to support many of the EBD claims being made in the literature.

Ulrich, R.S., & Zimring, C. & Zhu, X., & DuBose, J., & Seo, H., & Choi, Y., & Quan, X., & Joseph, A. (2008). A Review of the Research Literature on Evidence-Based Healthcare Design. *Health Environments Research & Design Journal*, 1 (3), 61-125.

This article builds on an earlier literature review (2004) by the same authors and is held up as one of the most complete reviews of the literature on evidence-based healthcare design.

The authors' goal was to identify the current body of literature on evidence-based design and to categorize the findings into three general categories of outcomes: patient safety, other patient outcomes and staff outcomes. While the review is not as rigorous or reproducible as a Systematic Review (as defined by the Cochrane Collaboration), the search strategy is included as well as some commentary on the types of studies sought/included in the review. In an attempt to bring significant findings to light, the authors conclude the paper with a Conclusions and Design Recommendations section whereby findings are summarized as to their implications to the design process.

As with other studies by Ulrich, this paper is cited quite often by other researchers in the field. While no review of the literature will uncover every relevant study, this review is valuable reading and provides an informed entry into the realm of evidence-based design.

Zborowsky, T., & Kreitzer, M. (2009). People, Place, and Process: The Role of Place in Creating Optimal Healing Environments. *Creative Nursing*, 15 (4), 186-190.

Zborowsky (Director of Healthcare Education & Research at architectural firm Ellerbe Becket, Inc.) and Kreitzer (Director of the Center for Spirituality and Healing and a

Professor in the University of Minnesota School of Nursing) continue the holistic theme of healthcare environments presented by Jonas and Chez in their writing on the Samueli Institute model of Optimal Healing Environments (OHE).

Using the Optimal Healing Environment (OHE) language, the authors illustrate the concept with a three sphere Venn diagram graphic that is immediately recognizable by sustainability scholars. In their model, the Optimal Healing Environment occurs where the considerations for People, Place and Process intersect. A simple case study is used to illustrate how these components interact to create an OHE.

While the concepts presented in this article have been addressed by many others, the authors do take a small step toward bridging the gap between the two well-used and equally fuzzy terms of evidence-based design and sustainable design by using the phraseology of systems thinking to describe the thought process behind creating optimal healing environments. Systems thinking is also used by researchers who understand the interaction of all parts of a whole and the necessity to fully understand each part in order to generate useful data, or evidence, on which to base the design and delivery of healthcare environments.

Diaz Moore, K., & Geboy, L. (2010). The question of evidence: current worldviews in environmental design research and practice. *Arq*, 14 (2), 105-114.

Keith Diaz Moore (Professor of Architecture at the University of Kansas) and Lyn Geboy (researcher with Cygnet Innovations Group) review five worldview approaches to

knowledge generation in the design field and place the emerging field of EBD within that context, ultimately answering the question of what constitutes evidence in the design discipline.

Moore and Geboy begin their discussion by reviewing the genesis of EBD and its ties to environmental psychology and evidence-based medicine. They present current definitions of EBD and point out the contradictory nature of the notion that evidence is traditionally believed to emerge from traditional scientific methods in studies of existent problems, while the act of design is an intuitive process than deals with projected problems. At the core of this paper is the development of a visual representation of the five worldview approaches to knowledge generation and the range and nature of the problems such knowledge is intended to address. According to this model traditional science and design are diametrically opposed—existing in diagonally situated quadrants. With regard to Ulrich and Hamilton, two of the leading proponents of EBD, their views and definitions of EBD are somewhat challenged by the model. In this model, Ulrich’s definition of EBD would have it living more in line with traditional science whereas Hamilton’s assertion that EBD must use the “best available information from credible research” places EBD in a more technical/rational quadrant.

This paper goes adds nicely to the notion that the word “evidence” in EBD poses many challenges. To their thinking, evidence generated in artificial “unreal world” settings may be only marginally useful, if useful at all, in “real world” settings where the effects of the environment cannot be denied. Their call for a stronger approach to EBD can be found by embracing and thoroughly examining the diversity of the current environmental

design enterprise and eschewing the traditional view of evidence. This paper provides a much more thorough, if heavily theoretical, study of the challenges and shortcomings associated with trying to place EBD squarely within the realm of traditional science than do other papers cited.

Durmisevic, S., & Ciftcioglu, Ö. (2010). Knowledge Modeling Tool for EBD. *Health Environments Research & Design Journal*, 3 (3), 101-123.

Sanja Durmisevic and Ozer Citicioglu (both Faculty of Architecture at Delft University of Technology in The Netherlands) explain a model for managing the explosion of information available on EBD.

They point out that what information exists to support EBD decisions is often times lacking in rigor and currently exists in isolation. They suggest that the Architectural, Engineering and Construction (AEC) industry is a slow learning industry and that for it to benefit from EBD require cross-disciplinary collaboration and the sharing of expert knowledge across a larger framework. The model they put forth is built on the idea of "fuzzy logic," requiring first the identification of current knowledge from the literature, then a scoring and weighting of that knowledge according to a pre-defined hierarchy based on Maslow's hierarchy. The resulting framework is a feed-forward knowledge model that can help designers predict the effects of different design decisions on a particular outcome—in this this case, faster patient recovery. The model is intriguing and they use a hypothetical example to illustrate how it could be used in practice.

The authors clearly explain the model and point out both benefits and shortcomings. As with any model, the value lies in inputting sound and accurate information.

Ulrich, R. S., Berry, L. L., Xiaobo, Q., & Parish, J. (2010). A Conceptual Framework for the Domain of EBD. *Health Environments Research & Design Journal*, 4 (1), 95-114.

Roger Ulrich (Professor of Health Facilities Design and Architecture at Texas A&M University, and Professor of EBD at Chalmers University in Gothenburg, Sweden) et. al., provide a conceptual framework with which to further the body of knowledge around EBD.

The authors lay out a current snapshot of the field of EBD, using several matrices to illustrate where is strong, moderate or weak evidence to support nine categories of design variables judged by the authors to best represent the structure of EBD (as determined by their earlier in-depth review of the literature on EBD in 2008). They point out that while there have been gains in the amount and quality of EBD research in recent years, the matrices reveal major gaps in the knowledge.

Ulrich and his colleagues are perhaps the driving force behind the EBD movement and this paper clearly explains the current state of EBD from their collective perspective. From the newcomer's perspective, this paper provides a foothold into the trend for future research.

Carr, V. L., Sangiorgi, D., Büscher, M., Junginger, S., & Cooper, R. (2011). Integrating EBD and Experience-Based Approaches in Healthcare Service Design. *Health Environments Research & Design Journal*, 4 (4), 12-33.

Valerie Carr (Senior Research Associate, Imagination, Lancaster University), Daniela Sangiorgi (Lecturer, Imagination, Lancaster University), Monika Büscher (Director of CeMoRe, Mobilities Lab, Lancaster University) and Rachel Cooper (Co-Director of Imagination, Lancaster University) explore the links between evidence-based medicine, design and management and and experience based medicine, design and management.

The authors lay out a case for including the end user in a co-design type of relationship as a way to avoid devaluing what they see as an overuse of the phraseology 'evidence based.' In their thinking, evidence-based is often a polemic that relies on biased or poorly understood information, or "evidence." By incorporating the experiential component of the end-user, the designer can ensure that the lived experience of the service or building is the best evidence for the effectiveness of the process.

The article illustrates weaknesses with the current thinking around EBD and provides a framework by which to lend credibility to the process and effectiveness to the end product.

Kwan, M. A. (2011). Acuity-Adaptable Nursing Care: Exploring Its Place in Designing the Future Patient Room. *Health Environments Research & Design Journal*, 5(1), 77-93.

Melissa Kwan (MPH, San Diego State University's Graduate School of Public Health) seeks to corroborate the proposed benefits of acuity-adaptable care delivery as outlined by Ann Hendrich.

She endorses the idea that healthcare spaces need to be flexible in the amount and types of care they are capable of supporting, but uses the available literature to suggest that acuity-adaptable rooms, when subjected to a thorough cost/benefit analysis, may not be as suitable a solution as believed by some, especially Ann Hendrich, one of the main proponents of acuity-adaptable rooms. Kwan uses several cases of healthcare facilities backing away from the move to acuity-adaptable rooms after experiencing unexpected downsides related to nursing staff, physician staff, the added expense of fitting out a room to be acuity-adaptable as well as policies governing the reimbursement for services provided when acuity-adaptable rooms are utilized.

Kwan's main argument is that acuity-adaptable rooms appear to have certain benefits, but the downsides have not been adequately explored through standardized pilot programs in practice and, therefore, the literature is also lacking. Administrators cannot be expected to make informed decisions of such financial magnitude in the absence of empirical data.

Huisman, E. M., Morales, E. E., van Hoof, J. J., & Kort, H. M. (2012). Healing environment: A review of the impact of physical environmental factors on users. *Building & Environment*, 5870-80. doi:10.1016/j.buildenv.2012.06.016

Huisman and van Hoof (Research Centre for Innovations in Health Care University of Applied Sciences Utrecht, Netherlands), Morales (*Researcher & Adjunct Professor Centre interdisciplinaire de recherche en réadaptation et intégration social, Université Laval, Quebec, Canada*) and Kort (*Eindhoven University of Technology, Department of the Built Environment, The Netherlands*) examine the literature on evidence-based studies of health care facility design and associated impacts on patient/family and staff outcomes.

Making use of the Cochrane Methodology for Systematic Reviews, the authors initially identified 798 papers that met their inclusion criteria. Further review and evaluation based on their Ulrich and Rutten inspired framework for ordering and structuring the evidence regarding healing environments left 65 articles remaining, with 86% of these addressing patient/family outcomes and 14% staff outcomes. They found some evidence to support the notion of the physical environment being able to positively impact patient/family and staff healing and well-being. It is noted, however, that due to a lack of a consistent methodology with which to measure benefits and the difficulty of assessing qualitative data found in many studies, there is a lack of consideration of the impact of physical environment on outcomes from a holistic perspective. In their conclusions, the authors drill down to the shortage of studies on staff outcomes.

This paper is helpful to the study of EBD as it lends credence to the notion that while there may be numerous studies of the impact of the physical environment on health care

outcomes, it is difficult to draw hard conclusions from many of those studies due to the lack of a controlled study design.

Jha, A. K., Joynt, K. E., Orav, E., & Epstein, A. M. (2012). The Long-Term Effect of Premier Pay for Performance on Patient Outcomes. *New England Journal Of Medicine*, 366(17), 1606-1615. doi:10.1056/NEJMsa1112351

Jha, Joynt and Epstein(all with the Department of Health Policy and Management, Harvard School of Public Health) and Orav (Division of General Medicine at Brigham and Women's Hospital) found no difference in the 30 day mortality rate in hospitals participating in the Premier Hospitals HQID program, a pay for performance reimbursement program, and non-Premier facilities.

While this article does not deal directly with EBD, it is relevant as it comes from the medical literature and somewhat counters the argument made by Sadler that pay for performance will ultimately steer healthcare facilities to incorporate EBD principles if they want to maintain market share, therefore fiscal viability. The authors acknowledge that Premier is but one model of pay for performance and that the results of their study may not be generalized to other programs.

As the case for evidence-based is continually evolving, it will be important to monitor a myriad of potential outcomes—patient, family, staff, financial—with an eye toward gathering hard evidence to support future design decisions. Pay for performance programs will likely provide hard numbers on the patient outcome front, these numbers

also being useful to identify latent problems or opportunities that may exist within a healthcare system that is performing particularly well or not meeting the bar.

Pati, D. (2011). Generating Evidence from Day-to-Day Activities: Methodological Issues-Part 1. *Health Environments Research & Design Journal*, 5 (1), 120-124.

Pati, D. (2012). Generating Evidence from Day-To-Day Activities: Methodological Issues-Part 2. *Health Environments Research & Design Journal*, 5 (2), 117-121.

Debajyoti Pati (Professor of Design at Texas Tech University) defines concepts of evidence and examines the potential for generating useful evidence from activities that are regularly conducted by design teams, explaining how that evidence can be used to inform future decision making.

The term “evidence” generally implies data generated through rigorous experimental studies. Pati points out that while this level of evidence is highly desirable, certain non-research activities can incorporate elements of scientific research and are capable of generating quality evidence. Six such activities are: Visioning, Programming/Needs Assessment, Room Mock Ups, Facility Performance Evaluation, Quality Improvement Projects and Pilot Projects for Transition Planning/Culture Change. Pati indicates both the potential methods of data collection and the types of data, qualitative/quantitative, associated with each activity. Pati argues that with forethought, the opportunity exists to extract data from these activities that is both reliable and valid, and as such worthy of being considered valuable evidence, as opposed to anecdotal—a process referred to by Pati as data quality enhancement. Pati’s focus is on enhancing the quality of data and he

highlights the importance of standardization as it relates to entities—that which we wish to measure. Standardization is crucial in terms of definitions, measurement techniques/instruments and documentation of process used to collect data.

Pati spells out in simple terms what should be intuitive—that hard data generated through experiments is not the only information that can/should be considered useful data. He attempts to shed light on ways to strike a balance by transforming information generated in regular on-going activities from an “anecdotal” level to a useful “evidence” level. His argument is in the same vein as that made by Keith Diaz Moore and Lyn Geboy and Edlestein, though Edlestein focuses more on the effective cataloging and searching of the vast amounts of data that have been generated—a topic Pati mentions but leaves for others to address.

Tam, D. A. (2012). The Role of the C-Suite in the Incorporation of EBD in Healthcare Construction. *Health Environments Research & Design Journal*, 5 (), 3-6.

David Tam (Chief Administrative Officer of Pomerado Hospital in Poway, CA) explains the role of the C-Suite—the Corporate officers (CEO, CFO, COO, CNE)—in the design and building of healthcare facilities that incorporate innovative evidence-based features.

He discuss how shrinking operating margins and reductions in financial capital necessitates the C-suite to embrace facility design elements that have been proven to improve patient outcomes, staff outcomes and facility operating efficiencies. Tam gives examples of levels of understanding each member of the C-suite must exhibit for the EBD features and decisions. Tam's editorial is straightforward, leaving no doubt in the

reader's mind that he fully subscribes to the idea that evidence gleaned from disciplined research protocols should inform the allocation of limited capital dollars.

Tam's editorial is straightforward, leaving no doubt in the reader's mind that he fully subscribes to the idea that evidence gleaned from disciplined research protocols should inform the allocation of limited capital dollars on health-care facility projects.

Conclusion

The concept Evidence-Based Design is both more complex and more controversial than one might assume. Taken at face value, EBD represents the practice of design—typically within the realm of architecture of health care facilities—that is founded upon evidence of what works in terms of improving a range of both human and financial outcomes. The humans of concern in EBD are generally considered to be the patients receiving health care in the designed facility, the family of those patients and the staff of the facility. The outcomes are focused on improvements to the health and well-being of those populations. Among the range of outcomes is focused on patients and their family members is decreased healing times, decreased stress, decreased length of hospital stay, increased patient satisfaction and increased family satisfaction. Regarding the facility staff outcomes include decreased human errors (medication and procedural), decreased staff complaints/burnout/turnover, and decreased staff injury (from lifting/moving patients). Financial outcomes include decreased operating costs and increased returns on investment (though some EBD approaches such as acuity-adaptable and same handed rooms result in a premium in the capital expenditures for the facility).

Few would disagree that EBD seems like a good idea, but there remains disagreement on what constitutes evidence and how to best evaluate the effectiveness of design decisions based on the evidence. To the bench scientist, evidence means hard, reproducible data that supports a generally accepted paradigm. To a systems thinker, data is merely the building blocks to knowledge and wisdom—data needs to be manipulated into information that is useful enough to build knowledge and wisdom. To the design practitioner, evidence means whatever pieces of information may help build a case for a particular design decision. Those pieces of information may derive from rigorous studies and experimentation or may merely be anecdotal—based on the designers understanding of what did or didn't work on the last project.

The literature is ripe with journal articles that both support and question the emerging field. Some health care facilities and educational institutions, schools of architecture most notably, have embraced EBD and are leading the charge in advancing the principles. Others subscribers are questioning their own decisions to move forward with what they now suspect was not enough evidence to support their decisions.

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Chapter 3: ESSAY 3-Future Directions for Evidence-Based Design in Health Care Facilities

Abstract

This paper discusses and anticipates the role of Evidence-Based Design (EBD) in the design, construction and operations of health care facilities, especially the role of data and evaluation of the implementation in the coming years. As are other design approaches, evidence-based design is an iterative process, but one that is linked to the desire for ever increasing amounts of data, both qualitative and quantitative, and evaluation instruments that can guide the design process. Though the mega-hospital complex will remain, the health care delivery landscape is morphing into a more customer service/retail oriented industry with customers having many more choices for satisfying their health care needs. Federal health care policy is resulting in the development of Accountable Care Organizations that hope to benefit financially from delivering more effective health care in a more efficient manner. This changing landscape will drive the demand for facilities and delivery systems that can demonstrate improved quality and efficiency and that can link those improvements directly to the design of the facility.

Keywords: evidence-base design, data, facility performance evaluations, post-occupancy evaluations, health care delivery

Introduction

A discussion of the future of evidence-based design is best prefaced with an exploration of the current status of concept. This is accomplished through a series of sub-topics within the health care enterprise, these being:

1. The Genesis of Evidence-Based Design (EBD)
2. The Development and Current Status of the Dominant Building Rating Systems Geared Toward Advancing the Concepts and Principles of EBD in healthcare facilities
3. The Center for Health Design (CHD): Design Research, Education and Advocacy
4. The Anticipated Growth and Changing Face of Healthcare Facility Construction
5. Current Tools for Evaluating Effectiveness of Building Performance: Post-Occupancy Evaluations: (POEs) and Facility Performance Evaluations (FPEs)
6. Expanding the Scope of Evidence-Based Design: Connecting the Dots Between Facility Performance and Fiscal Performance
7. EBD in the Changing Face of Health Care Delivery—Challenges and Recommendations for Improvement

The Genesis of Evidence-Based Design (EBD)

The story of Evidence-Based Design from its genesis through its current status has been outlined in detail in a previous paper by the author (Haddox, 2013a). To briefly review, leading EBD advocates, architects Kirk Hamilton and David Watkins, define evidence-based design as, “A process for the conscientious, explicit and judicious use of current best evidence from research and practice in making critical decisions, together with an informed client, about the design of each individual and unique project.” As it relates to healthcare facilities, evidence-based design seeks to enable the best set of positive outcomes as related to patients and health care staff, while doing so in the most cost effective manner. The reader might ask, “Have not health care facilities always been designed this way?” The answer to that would be an emphatic,

“perhaps.” Perhaps, and most likely, those goals were present in the design and implementation, but the underlying information on which the design was based probably lacked the level of rigor being sought today. At the heart of the EBD discussion is the question of evidence. The evidence continuum is quite broad. This I demonstrated by evoking the positions of several writers on the topic—Ackoff (Data, Information, Knowledge, Wisdom model); Banathy (iterative design process); Cross (design as a stand-alone discipline); Dilenschneider (information overload); Edelstein (profession specific ontologies and the data search process); Kuhn (scientific revolutions); Pati (evidence generation from daily activities); Sadler (pay for performance as a driver of evidence); Tam (evidence and the allocation of capital dollars)—to name a few.

It is critical to consider the two main disciplines involved in evidence-based design projects involving healthcare facilities—healthcare and design. These two disciplines often have very different tolerances for what constitutes evidence and given a problem, will likely approach a solution from very different perspectives. At one extreme is the bench scientist engaged in basic research in the healthcare field. In that setting, evidence is data that derives from controlled experiments that are repeatable and predictable. To the bench scientist, only such raw, hard data can be manipulated into meaningful information that can ultimately inform an approach to solving a known problem. The design professional also enjoys such hard data, but in the absence of such, is comfortable making decisions based on what has worked in the past or what appears to be working on another project. The level of experience of the design professional comes into play through what may be referred to tacit knowledge (Schön, 1983). Schön describes tacit knowledge as the ability to think on one's feet, tapping past experiences in real time in a way that defies a succinct written or verbal explanation of what is occurring in the

practioners' thought processes. Some may categorize it as moving forward with what we *know* is going to work (hard data) versus moving forward with what we *think* is going to work (tacit knowledge). In a perfect world we would know. The definition of EBD (and, for that matter, EBM—evidence based medicine) reflects the reality of a non-perfect world by calling for ‘*best available* evidence.’ Thus, we find ourselves in 2013 with a great desire to build better healthcare facilities and with some general head nodding that we need some type of evidence to guide our decisions.

The Development and Current Status of the Dominant Building Rating Systems Geared Toward Advancing the Concepts and Principles of EBD in Health Care Facilities

Green building rating systems purport to define and measure the parameters that make for a green building. The problem is that there is no one generally agreed upon definition of what makes for a green building. This point is illustrated by a study conducted by the Pacific Northwest National Laboratory (PNNL). During the course of an exercise aimed to identify those green building rating programs deemed suitable for GSA building projects, researchers at the lab identified an initial pool of thirty-four (34) systems that were being used in some form or fashion to evaluate the built environment from a whole systems perspective. Another eighty-two systems existed that looked as some aspect or component of green buildings. Many of these systems were spinoffs or modifications of other systems. Of the initial thirty-four systems, five passed through all the lab’s filters: the Building Research Establishment’s Environmental Assessment Method (BREEAM); the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE); GBTool; the Green Building Initiative’s Green Globes Program (Green Globes); and the U.S. Green Building Council’s Leadership in Energy and Environmental Design (LEED) (Fowler, 2006).

While the initial focus of green building rating systems was commercial building space, namely office space, the programs gradually expanded to include single family homes and other residential construction. Later to the game were specialty buildings such as schools and health care facilities, namely hospitals. For the latter, six entities have created the five programs that currently occupy center stage: the Building Research Establishment's Environmental Assessment Method (BREEAM); Green Building Initiative (GBI); Healthcare Without Harm (H2E); Center for Maximum Potential Building Systems (CMPBS); the U.S. Green Building Council (USGBC); and The Green Building Council of Australia (GBCA).

Each of the six listed entities has created documentation spelling out the parameters that must be met in order to design, build, operate and maintain a green hospital. While each entity makes its own claims as to its position in the heap, it is safe to say that BREEAM and CMPBS enjoy some level of matriarchal status with BREEAM tracing its origins back to the early 1900's and CMPBS to the mid-1970's. It is important to note that all of these programs are somewhat incestuous as each has had some bearing on the conceptualization and/or evolution of the others—a fact reflected in the point categories associated with each program.

The five rating systems at work in the green healthcare movement today, along with some of their key characteristics, are:

Green Guide for Healthcare (GGHC). Created as a joint venture between H2E and CMPBS. This system bills itself as the progenitor of green rating systems specifically targeted to hospitals. In form, and to a great degree content, it is modeled after the USGBC's LEED New Construction rating system. It was designed to assist hospital facilities designers and planners grappling to apply the existing LEED NC standards to their hospital projects. Like LEED, it

assigns points for attaining certain benchmarks in several categorical areas: Sustainable Sites; Water Efficiency; Energy & Atmosphere; Materials & Resources; Environmental Quality and Innovation & Design Process. Unlike LEED, however, the attainment of points does not result in a particular certification level, but rather gives the building designers/operations & maintenance staff a system for benchmarking and analyzing building performance over time. As there is no third-party oversight as it relates to the attainment of points, the GGHC represents a self-certifying type of system. In theory, facilities that have been designed to the GGHC standards should be well on the way toward the third-party LEED certification as described below.

Green Globes Continuous Improvement for Existing Buildings Healthcare (CIEB Healthcare). The Green Globes programs come from the Green Building Initiative and are descended from the aforementioned BREEAM program. The initial program was geared toward the assessment of existing buildings—Green Globes for Existing Buildings. Later versions addressed the design and construction of new buildings—Green Globes for New Buildings. The complexities of greening the hospital facility are now addressed with the Green Globes CEBI Healthcare. As with other Green Globes systems, CEBI awards points in various categorical areas similar to, but not identical to, those found in the GGHC program: Energy; Water; Resources; Emissions, Effluents and Pollution Reduction; and Indoor Environment. Green Globes does include a level of third-party verification and awards those projects that obtain key point thresholds with a rating of one to four globes.

Building Research Establishment's Environmental Assessment Method (BREEAM). The BREEAM system, based in the UK, was established in 1990 and sought to inform the design of, and stimulate the demand for, sustainable buildings. BREEAM

was the first to attempt to provide a meaningful, measureable, verifiable label for sustainable buildings. As with other systems, BREEAM has created a program, BREEAM XB, to better address the design, construction and operations of healthcare facilities. BREEAM awards points in several categories: Management, Health & Wellbeing, Energy, Transport, Water, Materials, Waste, Land Use & Ecology, Pollution, and Innovation. While BREEAM for new construction is a third-party verification system that awards levels of recognition based on point thresholds, BREEAM XB is designed to be a self-assessment tool with an option for later third-party verification.

Leadership in Energy and Environmental Design (LEED) for Healthcare. The LEED family of rating systems originated with LEED for New Construction (LEED NC v1.0) in 1990 and has since grown to include specialty rating systems for a variety of situations, including the design, construction & operations of healthcare facilities. The basis for nearly all LEED systems is the current version of LEED NC, v3.0. Within LEED NC v3.0, points are awarded for attaining thresholds in the following categories: Sustainable Sites; Water Efficiency; Energy & Atmosphere; Materials & Resources; Indoor Environmental Quality; and Innovation in Design. The LEED Healthcare largely reflects the same criteria as LEED NC v3.0, but does include some additional human health related provisions dealing with the reduction of heavy metals in the indoor environment as well as creating preferred acoustical environments. Like all LEED systems, LEED Healthcare is a third-party verification system involving a rigorous process of information submittals to demonstrate compliance with program requirements.

Green Star Healthcare. Green Star is a product of the Green Building Council of Australia. Like many of the other rating systems, the Green Star Healthcare arose out of the

recognition that their program for typical commercial space (Green Star Office) did not adequately address some of the special needs for healthcare facilities. It is a third-party verification system that awards points based on several categories: Management; Indoor Environmental Quality; Energy; Transportation; Water; Materials; Land Use & Ecology; Emissions; and Innovation.

Comparison of rating systems

The above described programs have in common a genesis in programs originally designed for commercial/office building type of structures. As such, they all address basically the same set of core components, albeit they may address them under different categorical headings. For example, whereas LEED addresses transportation issues under its' Sustainable Sites category, the BREEAM system has a separate category entitled Transport. Where Green Globes has a credit category entitled Emissions, Effluents and Pollution category, the GGHC addresses some of those issues in two different categories: Energy & Atmosphere and Indoor Environmental Quality. Many more examples could be given.

“Healthcare” version versus “regular” version. What sets the “health care” versions apart from each system’s “regular” version differs among the programs (see Table 9). Each of the programs include, to varying degrees, provisions that generally focus on occupant well-being as impacted by improved indoor environmental quality, this construct being concerned with acoustic, thermal, ventilation and lighting quality.

Of the five programs, one of the largest, LEED marginally addresses its rationale for its Healthcare version, taking one paragraph of a 113 page reference manual to highlight how LEED

Healthcare was created in close collaboration with H2E and CMPBE. True, there are a few credits that focus on patient, staff and visitor health and well-being (above those included in LEED NC), but by and large the LEED Healthcare (and by association, the GGHC) is a mirror of LEED NC v3.0.

Green Globes for Healthcare (CIEB) also exhibits little difference from its non-hospital ancestor. A review of the program documentation reveals some focus on hazardous materials, such as lead, asbestos, mercury and radon that may exist in older hospital facilities. All other aspects of Green Globes for Healthcare (CEIB) remain identical to the guidelines for new construction.

With BREEAM, the healthcare version makes specific mention of the benefits to staff and patient's wellbeing associated with improved indoor environmental quality.

The Green Star Healthcare makes specific references to improved patient health outcomes and staff productivity. These issues are addressed in the Indoor Environment Quality and Materials credits related to lighting, ventilation reduced pollutant/contaminants in the indoor environment.

Table 9

The Primary Green Building Rating Systems Related to Health Care Facilities

Rating System	Stated Green Design Categories	Green Design Areas of Emphasis Specific to Health of Building Occupants
Leadership In Energy and Environmental Design (LEED) & LEED Healthcare Rating	<ul style="list-style-type: none"> • Sustainable Sites • Water Efficiency • Energy & Atmosphere • Materials & Resources • Indoor Environmental Quality • Innovation & Design 	<p>Obtain high indoor air quality levels by focusing on ventilation rates and pollutant avoidance (VOCs, heavy metals and particulates).</p> <p>Other indoor environmental quality factors include access to natural light and exterior views, thermal comfort/control and acoustic environment considerations</p> <p>Access to places of respite with connection to natural world</p>
Green Globes: Continual Improvement Existing Buildings Healthcare (CIEB)	<ul style="list-style-type: none"> • Energy • Water • Resources • Emissions, Effluents & Pollution Reduction • Indoor Environment • Environmental Management Systems 	<p>Obtain high indoor air quality levels by focusing on ventilation rates, pollutant avoidance (VOCs and particulates).</p> <p>Other indoor environmental quality factors access to natural light and exterior views, thermal control and comfort</p> <p>Special acoustical environment considerations</p>
BREEAM Healthcare	<ul style="list-style-type: none"> • Management • Health & Wellbeing • Energy • Transport • Water • Waste • Pollution • Land Use and Ecology • Materials • Innovation 	<p>Achieve health & wellbeing through approaches that focus on access to daylight, thermal comfort, acoustical environment, indoor air and water quality and lighting.</p>
Green Guide for Healthcare	<ul style="list-style-type: none"> • See entries for LEED Healthcare 	<p>-See entries for LEED Healthcare</p>
Green Star for Healthcare	<ul style="list-style-type: none"> • Management • Indoor Environment Quality • Energy • Transport • Water • Materials • Land Use and Ecology • Emissions 	<p>Obtain high indoor air quality levels by focusing on ventilation rates, pollutant avoidance;</p> <p>Other indoor environmental quality factors access to natural light and exterior views, thermal control and comfort</p> <p>Special acoustical environment considerations</p> <p>Special mold prevention considerations</p> <p>Inclusion of places of respite with natural connection</p>

The Center for Health Design (CHD): Design Research, Education and Advocacy

The Center for Health Design (CHD) is a non-profit organization dedicated to advancing transforming healthcare environments "or a healthier, safer world through design research, education and advocacy." While the CHD does not produce a building rating system, it is considered the leading organization in terms of educating the practitioner on best evidence-based design practices. The CHD acts as an information clearinghouse of sorts evidence-based design. Among several noteworthy projects are:

- The Fable Hospital—a 2004 case study of an imaginary hospital based on evidence-based design principles, complete with capital and operating cost estimates. The purpose of the Fable Hospital was to provide design practioners, as well as hospital administrators and boards of directors, with evidence that such a hospital could indeed be built at competitive costs and to demonstrate potential benefits in terms of patient, staff and fiscal outcomes.
- The Pebble Project—a collaborative of health care design and industry partners working together to identify design solutions that are measurably improving patient, staff, fiscal and environmental outcomes.
- The Ripple Database— a free, open source, searchable database of evidence-based design research and information.
- Clinic Design—an interactive web resource that provides process and recommendations to designers of community health centers and safety-net clinics.

- Evidence-Based Design Accreditation and Certification (EDAC) Exam—a third-party credentialing exam for practioners and researchers of evidence-based design. According to the Center's website, the stated goal of the EDAC certification exam is "to educate and test people on the process to identify research, hypothesize, implement, gather, evaluate and report their results."

The Anticipated Growth and Changing Face of Healthcare Facility Construction

In 2008, Evidence-Based Design enjoyed a boost in popularity and urgency thanks to a landmark white paper that commented on the aging U.S. healthcare infrastructure and the anticipated growth in health care construction over the next few years—\$70 billion per year by 2011 (Ulrich, 2008). The message was clear—the coming construction boom was to provide a unique opportunity to get things right—for the infrastructure to be developed during that period would remain in place for many years to come. Since 2008 a variety of construction industry forecasting entities have adjusted their projections to reflect a more moderate pace of healthcare facility construction in the coming years. FMI, a construction industry consulting firm and the source of Ulrich's construction forecast, shows in their 2nd quarter 2013 report that healthcare construction will top out around \$44 billion in 2013 and climb steadily to \$63 billion by 2017—very different than their earlier projections of \$70 billion annually by 2011 (Figure 7).

Figure 7. Line graph showing health care construction put in place by year. Adapted from Giggard 2013.

Health Facilities Management, a trade journal of the healthcare industry, reports that overall healthcare facility construction was flat or slightly down in 2012, a trend that is predicted to continue until 2014 (Carpenter, 2013). McGraw Hill construction industry data reveals a 41% decrease in healthcare facility construction square footage over the time period of 2008 – 2013 (Figure 8).

Figure 8. Bar and line graph showing health care construction in millions of square feet by year with percentage change from the previous year. Adapted from Gavin, 2013.

The aforementioned lowered forecasts and stalls in the healthcare facility construction industry are just that—lower forecasts and stalls. An aging U.S. population, coupled with healthcare policy mandates such as the Patient Protection and Affordable Care Act (PPACA), ensure the growth of the healthcare facility infrastructure. Some of the sluggishness in healthcare construction is a reflection of the ‘wait and see’ attitude of healthcare systems as they try to anticipate how to best invest their capital dollars to position themselves for the greatest return on investment. The new reimbursement models will influence the way in which facilities are designed, constructed and operated. According to the Health Facilities Management/American Society for Healthcare Engineering 2013 Construction survey, the PPACA is greatly influencing the way healthcare organizations are thinking about their capital projects. There is a trend away from stand-alone megaprojects and toward upgrades and additions that will help them meet the mandate of providing more customer centered, accessible,

affordable and effective health care. To accommodate the customer centered, accessible and affordable aspects, we will likely see a rise in community based walk-in health care facilities coupled with other services such as grocery stores, big-box retailers, recreation/health clubs and drug stores, as the growth in visitation to these types of clinics is already on the rise (Retail Health News, May 2013). We are also seeing, and will continue to see, the growth of Accountable Care Organizations (ACOs) hoping to share in the savings they help the Medicare program achieve (Muhlestein, 2011).

Will our new approaches to the design of healthcare systems and delivery of healthcare achieve the desired improvement in outcomes? ACOs hoping to benefit financially from improved delivery of healthcare will have to demonstrate that they have indeed had a positive impact on patient outcomes.

The healthcare industry is experiencing a resurgence in interest in Pay for Performance (P4P) programs as a way to improve health care access, reduce costs and increase positive patient outcomes. Although the jury is still out on whether or not P4P actually results in measureable improvements in health outcomes (Wheeler, 2007; Christensen, 2008; Emmert, 2012). In theory, P4P programs drive an increase in the quality of service in two ways—clearly defining the expectation of care and creating appropriate patient/physician assignments (matching). While it is beyond the scope of this paper to delve too deeply into the intricacies of Pay for Performance, Cromwell nicely discusses the challenges with outcome assessment (Cromwell, 2008) under such systems.

Current Tools for Evaluating Effectiveness of Building Performance: Post-Occupancy Evaluations (POEs) and Facility Performance Evaluations (FPEs)

Manning is credited with describing the modern concept of evaluating building performance (Manning, 1965). Two commonly used evaluation tools have emerged—the Post-Occupancy Evaluation (POE) and the Facility Performance Evaluation (FPE). Historically, the Post-Occupancy Evaluation has generally focused on data that is qualitative in nature (occupant perceptions), while the Facilities Performance Evaluation has focused on quantitative data (physical attributes and performance measures such as, but not limited to, energy and water efficiency, air quality measurements, temperature and humidity levels and costs of /maintenance). It is important to note two things about POEs and FPEs—a recognized standard does not exist and the delineation between the two tools is becoming fuzzy, resulting in the two terms often being used interchangeably (Zimring, 2010).

The current understanding of Post-Occupancy Evaluations built upon Manning's work and was first fleshed out by Preiser and Schramm (1988/2002). At its simplest, a POE is a series of questions aimed at identifying the perceptions of building occupants on any number of variables. One can easily imagine that the amount and level of detail of information gathered by a POE will vary greatly according to the design of the instrument. Various researchers have identified different levels of classification and specificity for their evaluations. A few of the more prominent positions follow. The Preiser/Schramm model sports three levels—Indicative, Investigative and Diagnostic—that address six phases the building delivery and life-cycle process. The level of detail and focus increases as one moves toward the Diagnostic POE. Vischer (2001) identifies four types of POE—Building behavior research, Information for pre-design, Strategic space planning and Capital asset management. As with Preiser/Schramm, Vischers' types address the building delivery process.

Berkeley Center for the Built Environment POE tool. With regards to specific POE tools, of particular interest is a suite of three evaluations created and managed by University of California Berkeley Green Center for the Built Environment (CBE). The Berkeley instruments are sophisticated web-based tools capable of providing designers and researchers with unprecedented levels of information, in terms of both volume and detail, related to occupants' perceptions of indoor environmental quality (IEQ), overall building performance and overall satisfaction with the building. There is a growing body of literature on green building performance, especially related to perceived occupant health and well-being, which references the data obtained through the Berkeley POEs. The Berkeley site alone harbors 118 academic publications, representing indoor environmental quality research from around the globe, with the bulk of those publications coming in the past five years (CBE, 2013).

While the Facility Performance Evaluation was generally used to assess the measureable physical attributes of a building space, it has come to be used as an umbrella term for an evaluation approach that includes a variety of evaluative processes, such as Program Review, Design Review, Construction Evaluation, Conceptual Research, Post-Construction Evaluation, Post-Occupancy Evaluation and Present/Future Need Evaluation with Market Analysis (Zimring, 2010).

The United States General Services Administration (GSA), recognizing that physical space data and occupant input/perception were both critical, took a combined approach in a performance study of 22 green buildings in the national portfolio. They used the aforementioned Berkeley suite of POEs to assess the perceived building performance and supplemented that with actual performance measures in the areas of energy, water, IEQ and maintenance costs. This combination of quantitative and qualitative data was compared to similar data from non-green

buildings and found to support their adoption of green building strategies as a cost-effective approach to building design, construction and operation (GSA, 2011).

The increased sophistication of evaluation tools is addressing what Vischer identified as two challenges to using them—time and money. The growing interest in utilizing POEs to evaluate building performance is a promising trend. It appears the evaluation of buildings commonly referred to as ‘high performance buildings’ is driving this trend. The phrase ‘high performance building’ includes, but is not limited to, green buildings. It is not used to reflect any particular building rating system—such as those identified earlier in this paper—but rather it is a more general phrase used to identify any building specifically designed to ‘integrate and optimize all major high-performance building attributes, including energy efficiency, durability, life-cycle performance and occupant productivity’ (EPA 2005). That definition was expanded to include energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations’ (Energy Independence and Security Act of 2007).

Expanding the Scope of Evidence-Based Design: Connecting the Dots Between Facility Performance and Fiscal Performance

One of the stated outcome categories of EBD is fiscal. Whether a healthcare facility or not, sustainable fiscal success is a reflection of overall organizational success. While an in-depth exploration on the topic of organizational performance is not the focus of this paper, it is necessary to give cursory recognition to the concept that facility performance, however measured, is inextricably tied to overall organizational performance. Organizational performance has traditionally been addressed within the realm of the management experts, not the facilities designers. The last several years, however, have seen the lines between disciplines

blur as the triple bottom line concept of sustainability—people, planet and profit—has called for everyone to reexamine their discipline within the context of a more holistic approach to how we as a society approach all of our collective activities. In 2002, the General Services Administration launched the Workplace 20-20 research and development program. The program is a response to the recognition that workplace setting has an impact on organization success. The program looks at facility performance within the context of four categories: Financial, Business Process, Customer and Human Capital, as seen in Table 10. Here one can see the mixing of the types of information sought with the different evaluation tools and the all-encompassing nature of the sphere of concern.

Table 10

Facility Performance Evaluation Measures of Concern Within the Balanced Scorecard Approach

Financial Considerations Related To	Business Process Considerations Related to	Customer Centered Considerations Related to	Human Capital Considerations Related to
Operating/maintenance cost Cost of building related litigation Resale value of property Rentability of space	Process innovation Work process efficiency Product quality Time to market	Public image and reputation Customer satisfaction Community relationships	Quality of work life Personal productivity Psychological and social well being Cultural change

Note. From The Balanced Scorecard by Kaplan and Norton (table adapted from Zimring, 2010).

Another concept of note is that of The Resilient Workplace (Heerwagen, 2011). The concept reflects an understanding that the physical workplace has tremendous bearing on organizational health and success, embracing the design and development of spaces that represent “a system of interlinking components, none of which alone will generate resiliency...but in

combination...will create synergies and mutual reinforcements that will drive the co-evolution of behavior and place toward resiliency.” Heerwagen states that the creation of resilient workplaces will be driven by an evidence-based process.

EBD in the Changing Face of Health Care Delivery—Challenges and Recommendations for Improvement

As discussed previously, one of the great challenges to EBD is the notion of evidence. On what data should designers rely to inform their design decisions? The current approach with evaluation tools, even the most sophisticated ones such as the Berkeley tools, is to gather occupants’ perceptions about what is/is not working with regards to their physical spaces. A participant could be report on some level of satisfaction and/or comfort with a particular parameter—say thermal comfort or lighting levels. In addition, they could also report on their perceived productivity, health and wellness while in a given space. Recall that to the bench scientist, such data would not be considered rigorous data. Is there any guarantee that by acting on such data a designer can elicit identical responses from the same population? A different population? Of course not...the data is subjective and is dependent on unlimited combinations of variables that could be in play at any moment during the course of a day for a building occupant. This is not to say such information is without value, but rather it is different than something that can be measured consistently on a known scale—temperature, energy usage or illumination levels, for example.

The relationships between humans and their surrounding environments are complex. Attempts to intervene in these relationships for purposes of improving them requires, ideally, a formulation of the current state of the relationship as well as some indication of a desired future state. Both of these actions can prove difficult because of the complexity of the relationships.

Researchers have given the labels of 'ill-structured problem' (Simon, 1973) and 'wicked problem' (Rittel and Webber, 1973). Such 'ill' and 'wicked' problems are those problems that are inherently immune to solution via traditional systems approaches. They are multivariate and have circular aspect to them in that the formulation of the problem, so necessary for developing a solution, cannot be separated from the creation of a solution. Teasing out just one of the outcome areas related to evidence-based design and healthcare facilities—patient outcomes—one can quickly grasp the complexity and fuzziness of the problem. Patient outcomes are impacted by patient/staff interactions, patient/patient interactions, patient/family interactions, patient/facility interactions and patient/process interactions. Add to the mix that patients are humans and humans have willpower, patient outcomes are impacted by patient/self-interactions. Measurable data? Hardly. Data critical to the formulation of problems and solutions? Definitely.

What should we be collecting and measuring in terms of performance metrics for healthcare facilities? This is the top question for practitioners of EBD. The short answer, “any data we can collect—whether qualitative or quantitative.” Recall that EBD in healthcare concerns itself with positive outcomes related to patients and their families, the health care staff and fiscal operations. Fiscal operations are potentially impacted by every activity occurring in the healthcare facility. Looking back to the list of parameters identified under the green rating systems and the high-performance building definitions, it is easy to begin ranking these parameters in terms of ease of measurability. Energy usage, water usage, lighting density, ventilation rates, ambient temperature levels, avoidance of certain materials and chemicals—these are easily measured and/or verified by use of meters and checklists. Parameters such as safety, sustainability, security, productivity pose different challenges to measurement and verification. Consider now

the added parameters of improved patient and staff outcomes and the level of complexity involved in measurement and verification increases dramatically. Not only is the difficulty in measurement increased, the parties with an interest in the measured outcomes has expanded to include third party payors. These payors, insurance companies and the federal government, will reimburse, or not, for the effectiveness of a healthcare delivery system—a system whose enterprise consists of both built environment components and human services components. In this paradigm, perceived health outcomes seem hardly enough evidence alone to satisfy financiers of healthcare infrastructure projects, let alone the third-party payors. Perceived health outcomes will, however, have to be included in evidence mix.

What, then, to do? How to proceed? I am not suggesting that evaluations focused on occupant perception be tossed. Rather, I suggest they be supplemented with as much data as can be gathered. To be sure, some of this is happening. For example, a healthcare facility may find that in the new wing of the hospital that has decentralized nursing stations and same handed rooms, the nursing turnover rate is lower than in the old wing with a traditional stations and common headwall rooms (a layout that results in alternate rooms having flipped—backward—floor plans). In such a scenario, designers, administrators and researchers are tapping human resource and nursing administration records to verify the lower turnover rates. The costs savings associated with the reduction in nursing staff turnover could be determined and thus we have an example of an EBD approach that appears to have impacted two of the three main EBD outcome areas—healthcare staff and fiscal soundness.

What, if any, is the impact to patient outcomes—arguably the EBD outcome of greatest importance—of the room design/nursing station changes? A variety of information may be used to make some initial determinations: nursing chart notes on the patient, medical records that

track the patient's progression from admission to discharge; self-reports from the patient on the impact the room layout may have had on their healing (perhaps the nurses seemed better prepared, less stressed, had more quality time with the patient, etc.). What, ultimately, is the payor going to consider a positive impact? Did the patient get better more quickly—were they discharged earlier than the average patient with that condition. Once they left the facility, did they stay away, or was there an unexpected readmission for the same/related condition? The point again is that the patient perception of their healing is an important piece of evidence, but likely not sufficient on its own to fully satisfy the drivers of the healthcare system we have in place today—third-party payors.

At a recent conference of the Environmental Design and Research Association (EDRA), I attended several presentations on post-occupancy evaluations and the theme of each centered on how designers of buildings—architects, engineers and interior designers—could utilize those evaluations to allow building occupants to more easily and accurately recount their stories of their perceptions of building effectiveness. Much of this effort is geared toward preparing healthcare facilities to earn high consumer ratings, which when coupled with other indicators of positive performance around actual health outcomes, should assist healthcare facilities with their fiscal performance in the aforementioned healthcare delivery system changes to a customer service driven industry no different than other service sectors.

The question I did not hear being asked with nearly as much fervor was the one dealing with whether or not evidence-based design strategies are actually—measurably—improving patient outcomes and by whose measurements was that being determined. I posit that it will not be the designers alone making those determinations, but rather a conglomeration of entities working in

close coordination, with massive amounts of information being exchanged and analyzed before arriving at a collective opinion on the success or failure of certain approaches.

The previously mentioned Patient Protection and Affordable Care Act (PPACA) and the ensuing Accountable Care Organizations seem to be in the drivers' seat with respect to the creation of new systems that improve the quality and the cost-effectiveness of health care. How will this improved quality and cost-effectiveness be measured? It is projected that the thirty-three quality measure and performance standards mandated by the PPACA will allow third-party make those calls.

Does this mean that the Affordable Care Act a death knell to current evaluation tools and processes? Will it dictate the design of future healthcare facilities? Hardly, in my estimation. If the Affordable Care Act works as anticipated, it should help to identify patterns of positive and negative patient outcomes associated with health care delivery systems and facilities. Such patterns will become yet another piece of data that will have to be mined by design professionals to determine what is at play in a particular situation.

The future of evidence-based design will require an ever growing level of complexity and sophistication of its evaluation tools in terms of both content (information required) and the mechanics of conducting evaluations and gathering the desired information. From where will the data come and how will the cost associated with its genesis and evaluation be covered? Of course there will be the traditional sources already mentioned—occupant data (largely qualitative), physical space data and fiscal data (largely quantitative). I anticipate a third data source of growing importance that I will label “third-parties.” In this category are the entities that pay for healthcare expenditures, whether governmental or commercial, and their reviewers.

As previously discussed, evidence-based design as related to healthcare facilities is a design approach concerned with three distinct outcome categories: patients, staff and fiscal. The process is fed by data, both qualitative and quantitative, that presently derives largely from facility evaluations. Given the increasing complexity, scope and changing methods of healthcare delivery, the number of outcome categories of concern will increase, as will the sources and types of data on which design decisions will be made. A schematic of the basic repeating unit in the evidence-based design process is illustrated below in Figure 9. As indicated, the EBD process is both data driven and data generating—an iterative process that is constantly striving for improvement

Figure 9. The EBD process as a repeating link that is both data driven and data generating.

Collection of both the initial and new data in the link above poses challenges in terms of time, budget and methodology. Two common instruments of data collection, along with the types and representative examples of data collected, are shown in Table 11.

Table 11

Common Evaluation Instruments and the Types of Data Each Generates

Facility Performance Evaluation (FPE) (Generally Quantitative Data)	Post-Occupancy Evaluation (POE) (Generally Qualitative Data)
Facility operations data such as: <ul style="list-style-type: none"> • operations costs (energy, water, insurance) • maintenance costs 	Patient/Staff perceptions related to: <ul style="list-style-type: none"> • wellness • stress • productivity and job performance • thermal comfort • indoor air quality • quality of lighting, natural and artificial • acoustic environment • overall satisfaction with the physical space
Space Attributes data such as: <ul style="list-style-type: none"> • temperature • lighting levels • access to natural light • proximity to nursing stations • type of room layout • ambient noise levels 	

As indicated earlier, it is anticipated that both the sources and types of data that will ultimately populate this table will expand to include what I categorize as third-party data—data that either derives from, or is driven by, payors, regulators and policy makers—as well. A representation of third-party data is listed below in Table 12.

Table 12

Third-Party Data: Data That Will Be of Increasing Importance to the EBD Process

Third-Party Data (derived from or driven by payors, regulators and policy makers)
<ul style="list-style-type: none"> • measures of health • measures of wellness • measures of healing • measures of cure • measures of efficiency • measures of community health • measures of fiscal impact on community • measures of environmental impact

Currently, the outcomes of concern for healthcare projects tend to be considered within three separate, but interconnected outcome categories—patient, staff and fiscal. Figure 10 illustrates the current, as well as emerging, mix of outcomes expected to come into play with evidence-based design for healthcare facilities.

Figure 10. The outcomes of current and future concern for EBD related to health care facilities.

Conclusion

Evidence-Based Design (EBD) is the practice of incorporating the best available evidence into the design process for buildings so that the best combination of outcomes can be achieved. EBD as practiced within the design, construction and operations of healthcare facilities aims to impact three main outcome categories—patient, staff and fiscal. In the past, building performance outcomes and occupant/user outcomes were analyzed and studied in separate silos. The building performance group has sought and used relatively easily quantifiable data while those studying occupant based performance have relied on human reported data—data that is much more qualitative in nature. Thus, the question of what types of data can be considered a valid evidence is a point of debate among groups involved in the study and research of EBD.

The emergence of green building rating systems reflects a desire to identify and codify design and construction practices that will have a positive impact on a variety of outcome measures related to sustainability—social, environmental and economic. The leading rating systems have each further developed more specialized rating systems for a variety of building types, including healthcare facilities. In general, the specialization has led to increased attention on improved health of patients and occupants. To remain relevant, the rating systems must evolve to reflect current thinking and experience.

Healthcare facility construction is on the rise and is projected to be so for the next five years. As the delivery of health care morphs to a consumer service delivery model, the typology of health care facilities is also changing. It appears that health care reform, especially as it relates to third-party reimbursement, will put increasing weight on increased quality and cost-efficiency of health care delivery, prompting health care delivery systems, and those who design them, to be ever mindful of the need for useful data to both guide and evaluate facility design. Design firms hoping to employ their EBD expertise will necessarily have to provide proof positive of a causal relationship between their design decisions and improved outcomes. Every player in the healthcare delivery system will be clamoring for evidence.

The process of evaluating and assessing facility performance will become more holistic, reflecting the need for increased amounts and types of data. No longer will designers and facility managers be satisfied using internally generated data for evaluating their projects. There will be increased attention placed on data from without—third party information. These third parties will include payors and regulators. Additionally, as healthcare delivery models begin to broaden their scopes to include measures of community health, the larger community will be mined for data that can be used as evidence in the EBD process. Emerging outcomes of interest will

include environmental outcomes and community based outcomes (such as the impact of a health care facility on the health and well-being of the larger community, not just the patients of that particular facility).

As design practices focused on evidence-based design become more sophisticated in their research efforts, specifically their methodologies for gathering and assessing data, entities such as the Center for Health Design will continue to play an important role in making the findings evidence-based design research more accessible.

These factors should combine to act as a bolus of creativity, in terms of developing methods to address concrete issues as well as in methods of structuring the initial issue so that a response can then be crafted, injected into the arm of the design world, stimulating a wave of relevant evidence-based design responses to the increasingly complex design challenge inherent in the healthcare delivery enterprise.

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