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The Use of Evidence Based Design In the Construction of New Hospitals

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Since the 1960s, researchers have been exploring how the design of the built environment effects the health and well-being of occupants and users. By the 1980s, further research began to focus particularly on health care facilities and how design could influence patient healing and medical staff performance. Evidence based design (EBD) is the process of basing decisions about the built environment on credible research to achieve the best possible outcomes. The desired outcomes of healthcare design include improvements in the areas of patient healing, patient experience and comfort, medical staff performance, and medical staff job satisfaction. Extensive research has been done in the field of EBD; however, the question remains whether or not the findings are being put into practice as new healthcare facilities are designed and built. The purpose of this paper is to compare the design of recently constructed healthcare buildings with fundamental EBD principles to determine whether or not the latest research and knowledge is being utilized by the healthcare design community in practice. Based on the five hospitals studied in this paper, evidence suggests that EBD principles are in fact being put to practical use in the industry.

Key Words: Evidence Based Design, healthcare construction, hospital construction, healthcare design and construction, hospital design and construction

Introduction

At last count (at the time of this writing), there were 5,627 American Hospital Association (AHA) registered hospitals in the U.S. containing a total of 902,202 staffed beds (AHA, 2016). That number is actually down from 1975, the earliest year for which data is available, when there were 7,156 hospitals in the U.S. (HHS, 2017). The number of hospitals steadily declined in a mostly linear fashion between 1975 and 2000, and has since remained relatively flat (HHS, 2017). The reduction in U.S. hospitals is best explained by the improvement of medical technology and care, which has resulted in shorter patient stays in hospitals. In addition, more health procedures are offered as out-patient services, further reducing the demand on hospital space for longer stays. One specific way of improving the design and construction of medical facilities is through evidence based design (EBD). EBD is the process of basing decisions about the built environment on credible research to achieve the best possible outcomes (Hamilton and Watkins, 2009). The desired outcomes of healthcare design include improvements in the areas of patient healing, patient experience and comfort, medical staff performance, and medical staff job satisfaction.

In conjunction with improvements in medicine and care, the design of healthcare facilities has likewise improved tremendously over the past 50 years. Beginning in the 1960s, the first studies analyzing the link between building design and user health and well-being were conducted by the Environmental Design Research Association (EDRA). The purpose of the EDRA is to advance and disseminate research, teaching, and practice toward improving an understanding of the relationships among people, their built environments, and natural eco-systems (EDRA, 2017). In the 1980s, an increasing body of research began to focus specifically on the healthcare built environment. By 2006, a systematic review of existing research related to health care environments and their effects on users was completed (Dijkstra et al., 2006). In that review, over 500 potentially relevant studies on the subject were identified through eight different databases. In the end, 30 studies were found to meet inclusion criteria. Studies were included if they concerned interventions involving health effects of environmental stimuli in healthcare settings on patients, and were based on controlled clinical trials published in peer-reviewed journals. Both clinical and psychological outcome measures were also included. Ulrich et al. (2008) performed a similar review on EBD literature at this time.

In 2012, another similar review was conducted by Huisman et al. (2012). In this study 798 papers were found on the subject of Evidence Based Design (EBD). This study focused on papers published in English between 1984 and 2011, and 186 initial articles were narrowed down to 65 papers which met the criteria of academic rigor as described in the systematic review procedures of the study (Huisman et al., 2012). The body of knowledge supporting EBD principles, as evidenced by the two above-referenced systematic reviews, is substantial enough to merit industry adoption and standardization. Both Dijkstra and Huisman made such recommendations within their papers. The question remains whether or not those recommendations are being put to use by the design community for health care facilities. The intent of this paper is to determine just that, whether or not newly constructed hospitals are implementing the design elements that have been scientifically proven to improve healing and comfort for patients, and improve performance and satisfaction for staff. Bentley et al. (2013) have indicated that it is important the research be used to inform teaching in management related programs. Therefore, one of the purposes of this paper is provide context for EBD curriculum in construction management related courses on healthcare facility construction.

Methodology

Determining whether EBD principles are being put into practice by the industry requires three general tasks; first, identify recognized EBD principles; second, obtain the construction documents for new hospitals and medical care facilities that have been designed and built since the validation of the EBD standards identified in task 1; and finally, search the construction documents to determine whether or not the recognized EBD standards were specified for construction, compile and organize the results.

Step 1: Identification of Recognized Evidence Based Design Principles

The EBD factors chosen for inclusion in this analysis were taken from the findings of Huisman et al. (2012), due to the criteria and academic rigor utilized by the study during the performance of the systematic review. The findings of Dijkstra were considered, but the list provided by Huisman is more recent. In addition, after further analysis, Huisman's list was found to be more comprehensive. The information gathered was organized into five categories of desired outcomes: (1) the reduction of errors, (2) increasing safety and security, (3) enhancing control, (4) privacy, and (5) comfort. Each of the five categories include design elements that, according to the body of knowledge, are proven to produce the desired impact. This paper accepts the validity of the recommendations made and does not attempt to explain the science or evidence behind the recommendations. For explanations behind the recommendations, reference Huisman et al. (2012). The Huisman study identified research supporting results and commendations for both hospital patients and staff. Inasmuch as the body of research is overwhelmingly focused toward patient outcomes (rather than staff outcomes), the purpose of this paper is to analyze outcomes and recommendations which specifically cater to the patient population. The subset of Huisman's list dealing with patient outcomes, as well as the corresponding EBD recommendations, are shown in Table 1.

Table 1: EBD desired outcome and recommendations

Desired Outcome	*EBD Recommendations*
Reduction of Errors by Hospital Staff	**Identical Rooms**
	Lighting
Increase Safety and Security (Reduce falls, infection; improve hygiene, cleanliness, accessibility)	No Slippery Floors
	Appropriate Door Openings (no curtains)
	Safety Rails and Accessories
	Correct Toilet and Furniture Height
	Single-bed Rooms
	Easy-to-clean Surfaces
	Automated Sinks / Sink in Patient Room
	Smooth Edges in Rooms
Enhancing Patient Control of the Environment (Room features which allow patients to personally make adjustments to various environmental elements)	Bed Position
	Air Conditioning / Heating
	Lights (including dimmers)
	Sound (music and television)

	Natural Light
Privacy	**Single-bed Rooms**
	Waiting Rooms
Patient Comfort	**Single-bed Rooms**
	Materials without Glare
	Windows with a View / Daylight View
	Wayfinding

From this list, the items in bold were determined to be variables which would most likely need to be included during the initial design phase of a new health care facility. If not included prior to construction these recommendations would be difficult or costly to implement after construction. The other recommendations either don't appear in construction documents or could be added after construction for no more expense than during construction. These recommendations have more to do with furniture, fixtures, and equipment which are commonly installed post-construction. The items listed above in bold are the variables which were analyzed in this research.

Step 2: Obtain Construction Documents

In order to perform a proper analysis of whether or not EBD findings are fully implemented in practice, a review of construction documents for new health care facilities is required. Construction documents for five new ground-up medical facilities were obtained from the archives of a general contracting firm. This firm is among the top ten largest healthcare contractors in the U.S. as ranked by Modern Healthcare. It is also ranked in the 2016 ENR top 100 list of general contractors.

Inasmuch as the articles used in the Huisman paper were published between 1984 and 2011, the construction documents obtained for the purposes of this paper were limited to those designed in 2011 and later. (Huisman, 2012). Of the data selected for inclusion for this paper, each project was designed for a different health care organization, by different design firms, and built in different states. Diversity of healthcare organization, design firm, and project location is important in order to ensure that the results are not influenced by any one of those factors in particular. The five facilities chosen for review include:

Hospital 1: New Women's Center located in California and designed in 2011
Hospital 2: New Medical Center located in Idaho and designed in 2015
Hospital 3: New Cancer Center located in Utah and designed in 2015
Hospital 4: New Medical Center located in Hawaii and designed in 2014
Hospital 5: New Medical Center located in Florida and designed in 2015

Step 3: Search Construction Documents for EBD Recommendations Identified in Step 1

Most of the EBD recommendations selected for analysis are related in some way to the patient rooms of the facilities. The first action taken with each set of construction drawings was a thorough floor plan review to quantify patient rooms or bed locations and organize by type. Once room counts and bed location counts were established, the following EBD recommendation were evaluated. After all of the documents were analyzed for the identified EBD recommendations, the results were tabulated into charts and conclusions were drawn.

Identical Rooms. Each patient room was compared to others designed for the same purpose and grouped into three categories: Identical Room, Mirrored Room, or Non-Identical Room. Identical rooms are exactly alike in every way. All aspects of the mirrored rooms are exactly identical in dimension and layout, the only exception being that the layout is mirrored with the adjacent room. Non-Identical rooms vary in size or layout, usually for ADA accommodations. See Figure 1.

Appropriate Door Openings (no curtains). Each room type was checked and designated as either having a door or a curtain as the primary means of entry and privacy.

Single-bed Rooms. Each patient bed in the floor plans was identified as single-bed or not.

Windows with a View / Daylight View. Each patient room was checked for a window. In the case that the floor plans weren't clear, the exterior elevations were referenced to make the determination.

Safety Rails and Accessories. Each restroom within a patient room was checked for safety rails and accessories. When patient rooms did not feature restrooms, the nearest restroom to the patient room was similarly checked. See Figure 2.

Automated Sinks / Sink in Patient Room. Each patient room was checked for a handwashing sink. Plumbing drawings were checked to determine whether automated faucets were specified. Three of the five sets of construction documents did not contain the information necessary to confirm the faucet type. See Figure 3.

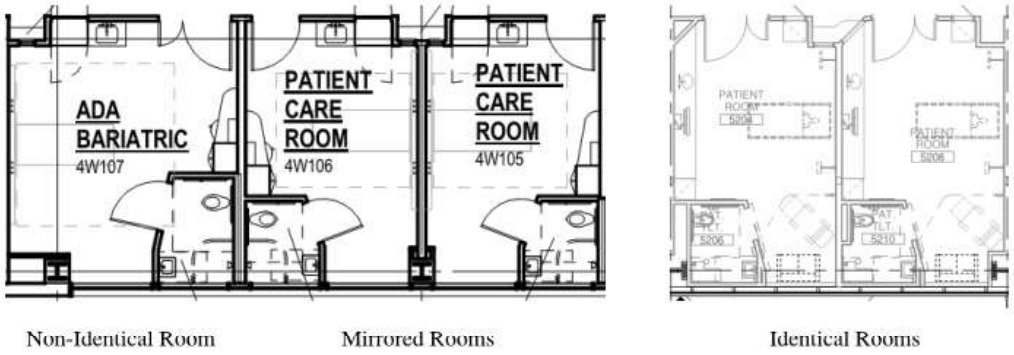

Figure 1: Examples of each of the three room types.

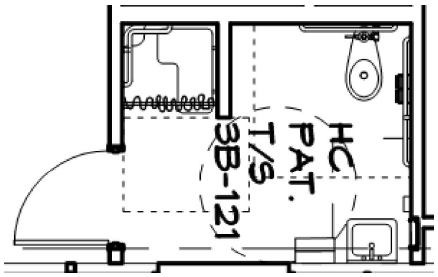

Figure 2: Example of patient restroom featuring safety rails and accessories in the restroom.

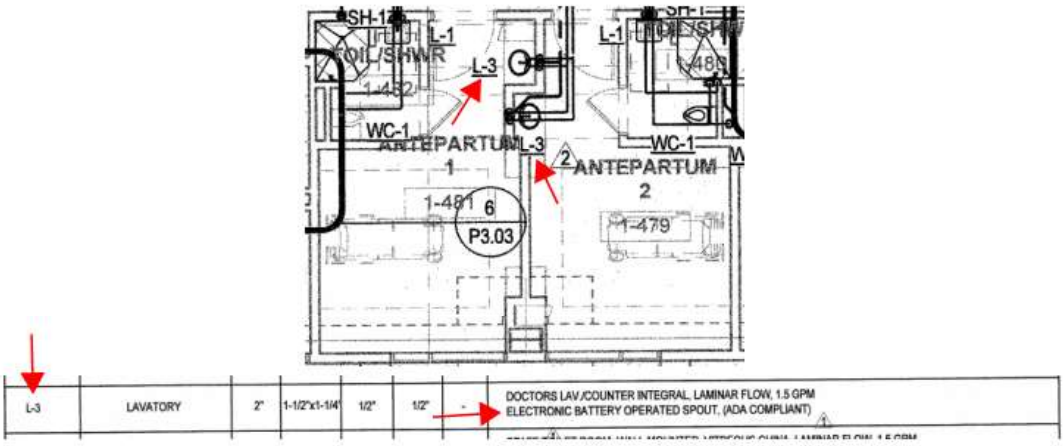

Figure 3: Example of mirrored patient room with sinks (L-3) specified with automated faucet

Results

Hospital 1: This new women's center included 36 total patient beds: 31 patient rooms and a 5 bed NICU (newborn intensive care unit) area with bassinets separated by curtains. The inclusion of the NICU beds may seem to skew the data since the needs for these patients are unique and thus some of the EBD principles may not have the same application. Aside from the NICU area, this hospital had 100% compliance with the EBD recommendations in the areas of appropriate door openings, safety rails and accessories, single-bed rooms, and windows with a view. This hospital design seems to have met the spirit of the identical room recommendation with 9 exactly identical labor/delivery rooms and NICU stations with the remaining standard rooms being mirrored. The non-identical rooms in this hospital were as similar in layout as was possible while still meeting ADA clearances. See Figure 4.

	Room/Bed Count	Identical Rooms	Mirrored Rooms	Non-Identical Rooms	Door	Curtain	Rails/Accessories	Single-Bed Rooms	Automated Sinks	Window/Daylight
Labor/Delivery	11	9	0	2	11	0	11	11	11	11
Ante Partum	4	0	4	0	4	0	4	4	4	4
Post Partum	16	0	14	2	16	0	16	16	16	16
NICU Isolette	5	5	0	0	0	5	N/A	0	5	3
Total	**36**	**39%**	**50%**	**11%**	**86%**	**14%**	**100%**	**86%**	**100%**	**94%**

Figure 4: Hospital 1 (new women's center – California) results.

Hospital 2: This new medical center features out-patient rooms without windows or bathrooms on the first level. The level 2 operating rooms likewise do not feature windows or bathrooms. The in-patient rooms found on levels 3 and 4 rate perfectly for each of the EBD recommendations with the minor exception of identical rooms. As was the case for Hospital 1, the non-identical rooms were designed to be as identical as practical while still meeting the additional design requirements for ADA compliance. See Figure 5.

	Room/Bed Count	Identical Rooms	Mirrored Rooms	Non-Identical Rooms	Door	Curtain	Rails/Accessories	Single-Bed Rooms	Sink in Room *	Window/Daylight
Level 1 - ED	**28**	**0%**	**86%**	**14%**	**100%**	**0%**	**100%**	**100%**	**100%**	**0%**
Major Exam	2	0	2	0	2	0	2	2	2	0
Exam	20	0	17	3	20	0	20	20	20	0
Fast Track	6	0	5	1	6	0	6	6	6	0
Level 2 - OR	**6**	**100%**	**0%**	**0%**	**100%**	**0%**	**N/A**	**100%**	**0%**	**0%**
Operating Room	6	6	0	0	6	0	N/A	6	0	0
Level 4 - Patient Care	**36**	**0%**	**83%**	**17%**	**100%**	**0%**	**100%**	**100%**	**100%**	**100%**
Patient Care	18	0	15	3	18	0	18	18	18	18
ICU	18	0	15	3	18	0	18	18	18	18
Level 5 - Patient Care	**36**	**0%**	**83%**	**17%**	**100%**	**0%**	**100%**	**100%**	**100%**	**100%**
Patient Care	36	0	30	6	36	0	36	36	36	36
Total	**106**	**6%**	**79%**	**15%**	**100%**	**0%**	**100%**	**100%**	**94%**	**68%**

*Automated Sink data not available

Figure 5: Hospital 2 (new medical center – Idaho) results.

Hospital 3: This new cancer center features one room type. The only misleading data point here is in the Automated Sinks column. Each of the 12 exam rooms feature a sink just inside the entry door; however, only six of the rooms were specified to have an automated faucet. It was unclear from the construction documents why some rooms

included the automated feature while others did not. Each of the other EBD recommendations were met with 100% compliance. See Figure 6.

	Room/Bed Count	Identical Rooms	Mirrored Rooms	Non-identical Rooms	Door	Curtain	Rails/Accessories	Single-Bed Rooms	Automated Sinks	Window/Daylight
Exam Room	12	0	10	2	12	0	12	12	6	12
Total	**12**	**0%**	**83%**	**17%**	**100%**	**0%**	**100%**	**100%**	**50%**	**100%**

Figure 6: Hospital 3 (new cancer center – Utah) results.

Hospital 4: This new medical center seems to align with the EBD recommendations more than the data may indicate. The various room types on level three are not designed for extended patient stays and therefore were not provided with windows. Aside from that, each of the other criteria were met at very high percentages. On the level four NICU ward similar results were observed. Newborns are provided with private rooms behind a door. A window in the room allows natural light flowing from the corridors to enter. Each NICU room has ample space to allow extended private parental and family visits. The perimeter of the floor features several respite seating areas for visitors that feature floor-to-ceiling windows with island and metropolitan views. The level five patient care rooms meet all of the EBD recommendations 100% across the board. See Figure 7.

	Room/Bed Count	Identical Rooms	Mirrored Rooms	Non-identical Rooms	Door	Curtain	Rails/Accessories	Single-Bed Rooms	Sink in Room*	Window/Daylight
Level 3	**19**	**0%**	**100%**	**0%**	**100%**	**0%**	**100%**	**100%**	**94%**	**11%**
Exam	7	0	7	0	7	0	7	7	7	0
ST	5	0	5	0	5	0	5	5	5	2
Hearing	2	0	2	0	2	0	2	2	2	0
OT	2	0	2	0	2	0	2	2	1	0
PT	3	0	3	0	3	0	3	3	N/A	0
Level 4 - NICU	**70**	**0%**	**100%**	**0%**	**100%**	**0%**	**100%**	**100%**	**100%**	**100%**
NICU	70	0	70	0	70	0	70	70	70	70**
Level 5 - Patient Care	**26**	**100%**	**0%**	**0%**	**100%**	**0%**	**100%**	**100%**	**100%**	**100%**
Patient Care	26	26	0	0	26	0	26	26	26	26
Total	**115**	**23%**	**77%**	**0%**	**100%**	**0%**	**100%**	**100%**	**99%**	**85%**

*Automated Sink data not available

**Corridors have extensive daylight, each NICU room has a window to the corridor

Figure 7: Hospital 4 (new medical center – Hawaii) results.

Hospital 5: Similar to hospitals 2 and 4, this new medical center features outpatient rooms on level 1 that do not feature windows or provide daylight. The PACU (post-anesthesia care unit) beds are in a large area separated by curtains and do not feature individual sinks, but the area is not intended for long-term stays. Aside from those variations all other EBD criteria is met. Levels two and three of this medical center comply with all EBD recommendations 100%. See Figure 8.

Overall Results: In all, the five new hospitals have a combined 364 patient beds which serve various purposes. 91% of all rooms were either identical or mirrored. The remaining 9% of rooms were designed as similarly as possible likely for the purpose of maintaining compliance with additional design requirements. A total of 96% of the rooms were private with a door. The 4% of rooms which utilized a curtain for privacy were NICU rooms and PACU rooms. 100% of the bathrooms either within patient rooms or within close proximity met the recommendation to have safety rails and accessories. Automated sinks and daylight views were found in 86% and 83% of rooms

respectively. Eliminating outpatient rooms from the data results would push those percentages even higher. The results suggest that daylight and views are a higher priority for in-patient rooms, and less so for rooms used for out-patient purposes. See Figure 9.

	Room/Bed Count	Identical Rooms	Mirrored Rooms	Non-Identical Rooms	Door	Curtain	Rails/Accessories	Single-Bed Rooms	Sink in Room *	Window/Daylight
Level 1	**31**	**58%**	**39%**	**3%**	**74%**	**26%**	**100%**	**100%**	**58%**	**0%**
Exam	10	9	0	1	10	0	10	10	10	0
PACU	9	9	0	0	1	8	9	9	0	0
Pre-Op	8	0	8	0	8	0	8	8	8	0
OR	4	0	4	0	4	0	4	4	0	0
Level 2	**34**	**0%**	**100%**	**0%**	**100%**	**0%**	**100%**	**100%**	**100%**	**100%**
Patient Room	24	0	24	0	24	0	24	24	24	24
ICU	10	0	10	0	10	0	10	10	10	10
Level 3	**30**	**0%**	**100%**	**0%**	**100%**	**0%**	**100%**	**100%**	**100%**	**100%**
Patient Room	24	0	24	0	24	0	24	24	24	24
Labor/Delivery	6	0	6	0	6	0	6	6	6	6
Total	**95**	**19%**	**80%**	**1%**	**92%**	**8%**	**100%**	**100%**	**86%**	**67%**

*Automated Sink data not available

Figure 8: Hospital 5 (new medical center – Florida) results.

	Room/Bed Count	Identical Rooms	Mirrored Rooms	Non-Identical Rooms	Door	Curtain	Rails/Accessories	Single-Bed Rooms	Sink in Room	Window/Daylight
Hospital 1	36	39%	50%	11%	86%	14%	100%	86%	100%	94%
Hospital 2	106	6%	79%	15%	100%	0%	100%	100%	94%	68%
Hospital 3	12	0%	83%	17%	100%	0%	100%	100%	50%	100%
Hospital 4	115	23%	77%	0%	100%	0%	100%	100%	99%	85%
Hospital 5	95	19%	80%	1%	92%	8%	100%	100%	86%	67%
Overall Avg. Percentage	**364**	**17%**	**74%**	**9%**	**96%**	**4%**	**100%**	**97%**	**86%**	**83%**

Figure 9: Overall results.

Conclusions

The purpose of this paper is to compare the design of recently constructed healthcare buildings with fundamental EBD principles to determine whether or not the latest research and knowledge is being utilized by the healthcare design community in practice. Judging from the results contained herein, it is overwhelmingly evident that the Evidence Based Design recommendations identified in the body of scientific research since 1984 is being put to use by the healthcare design industry. Since many of these types of projects are constructed using design-build and other innovative project delivery methods, this means that design and construction companies are appropriately incorporating current EBD recommendations.

While the above results are encouraging, due to the relatively small sampling of data analyzed in this paper it would be premature to draw definitive conclusions. However, this study has demonstrated that further research into this topic is warranted. Many opportunities exist to expand on this preliminary effort. Further research into the EBD recommendations made by Huisman which were not selected for analysis in this paper is necessary. In addition,

similar efforts could be made to analyze healthcare renovation projects designed since 2011. Further research should be conducted to determine if additional EBD criteria have emerged since the Huisman paper was published and new projects can be analyzed to determine whether or not the design industry has taken note. Studies of construction documents produced pre-2011, pre-2005, and pre-1984 may also shed light on when industry adoption of EBD principles took hold. Additional research can be conducted to understand why such high use of EBD principles were observed in this paper. Perhaps building codes or other regulatory agencies adopt EBD principles which in turn influence the design industry. It is possible that patient satisfaction has become a greater focus in the industry which is impacting the design and use of healthcare infrastructure.

It should further be noted that EBD principles may also be applicable to industries outside of healthcare and wellness. Further research into how the design of the built environment impacts the well-being of users and occupants in several other areas may prove to be valuable. If changes in design elements can improve healing and satisfaction in hospitals, surely similar outcomes can occur in other sectors of the built environment such as office, institutional, retail, education, government, religious, and residential. Finally, we note that academic institutions should seek to participate in more evidence based design research as a means of contributing to the design and construction practices associated with improving healthcare facilities. Further, courses dealing with healthcare facility construction can in turn provide context for appropriate industry changes based on EBD.

References

American Hospital Association (AHA) (2016). Fast Facts on US Hospitals. *American Hospital Association*, http://www.aha.org/research/rc/stat-studies/101207fastfacts2016.pdf

Alfonsi, E., S. Capolongo, and M. Buffoli. (2014). Evidence based design and healthcare: an unconventional approach to hospital design. *Ann Ig, 26* (2), 137-143.

Bentley, Y., Richardson, D, Duan, Y., Philpott, E., Ong, V., and Owen, D. (2013). Research-informed curriculum design for a master's level program in project management. *Journal of Management Education*, *37* (5), 651-682.

Dijkstra, K., Pieterse, M., and 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.

Environmental Design Research Association (EDRA) (2017). About – mission, value, history. *Environmental Design Research Association*, http://www.edra.org/page/missionvaluehistory

Hamilton, K. D., & Watkins, D. H. (2009). *Evidence-based design for multiple building types*. Hoboken, NJ: John Wiley and Sons.

Huisman, E. R. C. M., Morales, van Hoof, J., and Kort, H. S. M. (2012). Healing environment: a review of the impact of physical environmental factors on users. *Building and Environment* 58 (1), 70-80.

The Center for Health Design (CHD) (2017). About us. *The Center for Health Design*, https://www.healthdesign.org/about-us

Ulrich, R. S., Zimring, C., Zhu, X., DuBose, J., Seo, H. B., Choi, Y. S., Quan, X., and Joseph, A. (2008). A review of the research literature on evidence-based healthcare design. *Health Environments Research & Design*, *1* (3), 61-125.

US Department of Health and Human Services (HHS) (2017). Number of all hospitals in the U.S. from 1975 to 2014. *Statista*, https://www.statista.com/statistics/185843/number-of-all-hospitals-in-the-us-since-2001/