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Evidence Based Design and healthcare: an unconventional approach to hospital design

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Abstract

Evidence Based Design (EBD) is a scientific analysis methodology that emphasises the use of data acquired in order to influence the design process in hospitals. It measures the physical and psychological effects of the built environment on its users. EBD uses formularization of hypothesis, testing/analyzing and outcome gathering as a framework.
The design practice, in general, has always been based on a combination of legal, technical/ functional/ and aesthetical knowledge. This generalization has been shifted to another level after the implementation of EBD. In the last 30 years many case studies were collected which demonstrate the built environment's impact on users. EBD methodology can be applied to any type of building, but it is particularly used to analyze the efficiency of healthcare facilities.
The Goal of this paper is to demonstrate various applications of EBD principles in healthcare buildings through case studies concerning:
- reduction of infections
- reduction of stress on medical staff
- improved patient healing
In addition to the analysis of case studies, we will also focus on official EBD researches developed by healthcare designers and professionals as "alternative solutions". These alternative "ad hoc" solutions are developed in order to answer EBD research results. The solutions that are developed from the results can answer the real needs of each hospital and improve best technological practice to reduce infection, stress and improve patient comfort. Abroad the EBD research results are studied and used by many contemporary hospital architects to develop new solutions to meet the specific requirements of any hospital project they are currently designing. This procedure demonstrates that for each outcome and key finding, there is always at least one alternative solution and, therefore, the achievement of a new hypothesis, case studies to test/measure and outcome to gather occurs. This repetitive attitude leads to a "virtuous circle" where the development of new samples produces a double- positive effect in both EBD research (in terms of new case studies to analyze) and in EBD lessons for implementation in various hospitals.
Through this paper the authors state that the combined effort is needed by EBD practitioners, healthcare architects and hospital managers for the improvement and diffusion of EBD in healthcare, especially in Italy where this methodology is not widely used.

Introduction

Evidence Based Design (EBD) is a scientific analysis methodology based on the assumption that the built environment can produce significant physical and psychological effects on its users (1-5). These effects might be either positive or negative: a careful study of case studies (collected through EBD practice) is an essential tool to

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support designers in their architectural and technological choices (6, 7).

The first studies on the connection between the built environment and its health effects were conducted during the 1960s by organizations like EDRA - Environmental Design Research Association - and similar ones. During 1980s these researches focused specifically on healthcare buildings' environment. The leading researcher on the subject was Prof. Roger Ulrich, who gave a great support through a wide number of studies and controlled experiments. Finally, in 1993, The Centre for Health Design (CHD) was founded in California by "a small cadre of pioneering healthcare and design professionals committed in advancing a single idea – that the design could be used to improve patient healing in healthcare environments". CHD includes excellent professionals and EBD's experts, like its Director Emeritus (since 2010) Prof. Kirk Hamilton (8).

In 2004, the CHD established the official definition of Evidence Based Design, as "the deliberate attempt to base building decisions on the best available research evidence with the goal of improving outcomes and of continuing to monitor the success or failure for subsequent decisions" (9).

The introduction of EBD definitely represents a revolution in the field of healthcare architectural design, by proving a good environment which can significantly improve the rate of healing and reduce the hospitals' errors.

The international analysis of various EBD case studies developed by this research, demonstrates that this scientific method is particularly useful for issues concerning reduction of medical errors (including nosocomial infections), reduction of stress (and injuries) on medical staff, and improvement on patients' healing. The knowledge of EBD outcomes should be a "mandatory step" for any designer involved in a healthcare building design. Overall, EBD should become the base of guidelines for the development of any healthcare project in the National Health System. Nevertheless, this topic has not been extensively used in healthcare design all over the world. In the US, where it was established, EBD is now quite popular and diffused into the process by a large number of healthcare designers. In Italy, is it still used rarely and not required by hospital administrators and organizations.

This research is aimed to underline how EBD is used throughout the international healthcare design practice. For this reason we have researched studies that developed with EBD criteria by official EBD researchers, whose goals were:

- Reduction of infections
- Reduction of stress and injuries on medical staff
- Improvement on patients' healing.

There are also some "alternative solutions" produced by healthcare firms, committed to meet the EBD standards for each hospital. This demonstrates that for each EBD assumption there might be several and logical design answers, each of them representing both a unique solution for a particular hospital and a new case study to be analyzed with EBD methods in order to increase the field of research.

The Goal of this paper is to demonstrate further "alternative solutions" that are proposed. The more EBD researches are made, the more this discipline is diffused in hospital projects. Therefore, the continuous development of EBD design solutions will generate a "virtuous circle" that the goal is to improve healthcare conditions and efficiency through environmental design based on scientific methodologies.

Materials and method

EBD is mainly used to analyze the effects of healthcare buildings on patients and medical staff. This paper will focus on particularly EBD research that analyzes:

- reduction of infections
- reduction of stress and injuries on medical staff
- improving on patients' healing.

The research methodology has been divided into three subsequent sections:

The first phase was an extensive analysis through EBD literature to find out which researches have produced significant outputs for each of these fields.

The second phase included an assessment of these researches and choice of the most representative and comparative outcomes in the case studies. The most important ones have been briefly described along with the effects produced and where they have been applied.

The third phase included a search for an "alternative solution" that have been introduced in minor cases and which could be considered as a valuable substitution. They have been spontaneously developed by healthcare designers, to get new applications from EBD lessons. Many of them are currently under measurement to prove their efficacy in healthcare improvement

Results

Reduction of infections

Infection literature addresses three transmission routes of nosocomial infections: air, water and contact. Airborne and waterborne pathogens are transmitted mainly by hydraulic and ventilation systems and, therefore, EBD knowledge for these vehicles, is addressed mainly for engineering studies. Contact-transmitted infections can be controlled and reduced also through environmental design by both influencing staff's behavior (*direct contact*) and by reducing the rate of pathogens on hospital's surfaces (*indirect contact*) (10). Studies have demonstrated that hand-washing compliance is often insufficient (rarely reaching 45-50%) (11).

EBD assumption: increasing the ratio of hand-washing sinks per bed and providing accessible, alcohol-based hand-rub dispensers at the bedside, hand-washing compliance increases.

There are many examples of design challenges where this principle has been introduced. One of the most representative case studies is the project for the new Intensive Care Unit of St. Joseph's Medical Center (Bryan, Texas) follows as : different location of sinks and gel dispensers closer to staff work paths, improved the hand-washing compliance by 28% (12). This outcome demonstrates that hand-hygiene (and the subsequent infections' reduction) is strictly linked with the existence and the accessibility of hand-washing sinks. An alternative solution might be represented by increasing the number of gel dispensers along with sensing devices which detects the level of alcoholic gel on the skin's surface. If the rate is not sufficient, the device sends an infrared signal to the personnel's badge to record the washing event. If the medical personnel enter a 7-foot zone near a patient monitor without washing their hands, the badge will vibrate as a reminder. The first prototype, called "Hy-Green", was tested by Dr. Cook, chief of the Section of Infectious Diseases, Immunology and International Medicine at the University of Illinois, Medical Centre of Chicago, US.: "All the data we have so far are very good", said Dr. Cook, "There are very few people below 90% compliance (whereas before installation it was 67%). They know they are now being watched, and they get reminded if they forget. When this thing buzzes, they get conditioned to wash them" (13).

Another important EBD assumption to reduce the contact-spread infection is regarding the single bedroom. In this case, the EBD hypothesis is: the most significant reduction of nosocomial infection is due to the introduction of single rooms instead of multiple bedrooms.

As demonstrated by Bronson Methodist Hospital (Kalamazoo, Michigan, US), after the extension of single bedrooms in low acuity units and the proper hand-washing facility locations, the rate of infection has been reduced by 45% in those units and by 11% in the entire hospital (12).

Alternative solutions: single bedrooms provide a great advantage, but switching from a multi- bedroom system to a single-bedroom ones is not affordable.

An alternative solution presented by Nightingale Associates is:

- Cruciform ward (for example, those created in Princess Elizabeth Hospital, Guernsey, UK): 58 sqm, 4 beds disposed in order to maximize the space between patients' heads;
- Bed Pod (for example, those used during the renovation of King's College Hospital, London, UK) which provides a sort of private space for each patient in multiple rooms.

Alternative solutions for both outcomes are still under process.

Reduction of stress on medical staff

According to the statistical studies that were conducted in the US, hospital workers experience injuries due to work difficulties and unsafe work environment. The immediate consequence is the increasing of absenteeism or restricted job duties (an average of 3.3 days/year away from work per 100 full-time workers) and a general discontent. The subsequent one is a decreasing in quality care (76% of nurses state that unsafe working conditions interfere with effectiveness of healthcare team- American Nurses Association, 2002) and, thus, increasing the hazards for patients.

Furthermore there are some inefficiencies due to the time wasted walking: one study in particular assessed this rate at 28.9%, second only to the rate addressed to patient-care activities, which accounted 56.9% of nursing staff time (14).

There is obviously a link between the unit layout and the amount of time spent walking: the shape of wards, the relationship between patient's room and nursing stations/stores supplies are deeply influencing on nursing staff (15).

EBD assumption: decentralized nurse stations reduce staff's walking time and increase patient-care time, especially when supplies are also decentralized and located close to the nurse stations.

This research presents different case studies and different results as well. The Clarian Methodist Hospital in Indianapolis, for example, developed a novel demonstration project, the Cardiac Comprehensive Critical Care (2004). One of the considered aspects, focused on the effects of nurses' unit distribution. In this project nursing stations with computer access were decentralized and additional workspaces were provided outside each patient room as well as supplies stores. Through EBD observation, they noticed that efficient unit design helped in reducing nursing staff walking and the saved time was thus translated to patient-care activities (16).

A recent study (17) has demonstrated that, the lack of a central nurse station sometimes affects communication between the personnel and new trainees. Hybrid solutions (a central nurse station + some decentralized smaller ones) are currently under review to perform a better result in staff- work effectiveness. Furthermore, for what concern decentralized supplies, it is important to notice that it's always quite difficult to find room enough for a number of satellites disposals.

A valid alternative for this issue might be a sort of "daily supply storage" for each bedroom. A good example might be the solution invented by PineArq (Studium Albert De Pineda) for Galliera Hospital (Genova, Italy). It is a wall-drawer (included in the external wall of each bedroom) where every evening the sterile medical equipment (I.V.

drips, catheter, etc.) might be stored, ready to be used the following day. This design solution represents a valid support for hospital logistic, avoiding thus continuous trips to get equipment from a unique disposal. Furthermore, this example perfectly demonstrates how the knowledge of EBD studies might generate design solutions which can significantly improve the work and management of a hospital unit.

Improving on patients' healing

Strong evidences demonstrate the positive effects of distractions such as nature, art, music, companion animals in the improvement of patient healing (18). View of nature (real or simulated, for an exposure of 3-5 minutes at most) is assigned to reduce negative emotions such as fear, anger, and sadness (19, 20). The benefits are demonstrated by clinical studies as well. Contact with nature or nature's image reproductions produces quick drop in the stress levels and, subsequently, physiological changes in blood pressure, heart activity, muscle tension, and brain electrical activity occur(21). Those positive effects are valid for anyone but they particularly produced significant outcomes for hospital patients (22, 23).

EBD hypothesis: view of the nature (real or pictured) produces significant improvement on patients' healing, such as reduction in length of hospital stay and lowering the sensation of pain.

In 1984, Roger Ulrich conducted a study based on recovery records of gallbladder surgery patients who had a bedside with window view with either trees or a brick building wall with no nature (24). The outcome of the study showed that those with the nature view, compared to those who looked out at the wall, had shorter hospital stay and suffered less minor post-surgical complications (such as persistent headache or nausea). Therefore, patients with the view of trees needed fewer doses of strong narcotic pain relievers in comparison with those whose view was a brick building. The importance of natural light is historically established (25, 26) but thanks to the EBD research now we know the effects of vision on the environment (aspect often overlooked). Patients' satisfaction has confirmed these findings: the POE (Post-Occupancy Evaluation) questionnaire has demonstrated that bedridden patients assign especially high preference to having a hospital window view of nature (24).

If we consider the location and dimension of contemporary hospitals, (multi-floor buildings sites in urbanized areas) it's clear that a bedroom window would have difficulty in achieving the view of trees and nature. Although, simulated-nature view produces positive effects, a valid alternative can be represented by:

- green-integrated shading systems (for example: that one proposed by Philippe Samyn+ Partners in the Project for Hospital in Liege, Belgium)
- nature pictures on the bedroom's walls and on the ceiling, over the bed (for example: ZZ Architect, Hospital in Bangalore)
- H-Pod (prototype designed by Nightingale Associates + Tribal) with soothing effects, to be used during medical treatments (dialysis, etc.)

These applications have also produced different results. It gave the possibility to evaluate the state of EBD hypothesis' diffusion as well as testing the effectiveness of EBD since they have been introduced. In fact the research identified which alternative solutions for the healthcare- design-industry has spontaneously produced an accomplishment with EBD requirements that meet the hospital's context and necessities. This method is used not only by designers as a diffused approach but also the "alternative solutions" presented above must be considered only as a starting point whose goal is to encourage the EBD practitioners to create a new healthcare-design-challenge.

Conclusions

EBD principles are essential for performance based healthcare design. At the same time, an EBD practitioner must be aware that EBD is a field which continue to develop. This paper demonstrates that each EBD hypothesis can produce a wide range of solutions. These solutions are specific for a particular context and situation. EBD is not a standardized repetition of tested examples, it must be considered as a "continuous process" that produces different "ad hoc" solutions. Many examples in this paper demonstrate that EBD is a field of research that is widely used in the real healthcare design practice. Furthermore, this paper demonstrates that EBD is a "research that can produce further research": for each different solution there will be new case studies to measure and outcomes to gather. It is important that each EBD practitioner can feel part of this process and use EBD assumptions/results as a useful tool to create further innovation and development. The collective commitment by healthcare designers can improve this research field further and integrate the EBD practice to a large number of hospitals.

Riassunto

Evidence Based Design e strutture sanitarie: uno strumento scientifico per la valutazione degli effetti sanitari del progetto ospedaliero

L'Evidence Based Design (EBD) è una metodologia di analisi scientifica che studia l'influenza fisica e psicologica dell'ambiente costruito sui propri fruitori. Tale procedimento prevede che gli effetti fisici e comportamentali indotti dall'ambiente siano individuati attraverso il metodo scientifico classico secondo la procedura sequenziale: "formulazione dell'ipotesi - sperimentazione - analisi e misurazione - raccolta dei risultati".

La valutazione e la comparazione degli studi condotti negli ultimi 30 anni ha permesso di costituire un corpus di informazioni di valenza scientifica che ha elevato l'architettura dal livello della "comune pratica del buon progettare" a quello di "elaborazione formale fondata su dimostrazioni scientificamente attendibili".

La ricerca di EBD si estende a qualsiasi ambito progettuale, ma viene utilizzata prevalentemente all'estero e nel campo ospedaliero, con l'obiettivo di individuare le caratteristiche progettuali in grado di migliorare il livello del benessere dei pazienti, oltre che la qualità delle prestazioni offerte dalla struttura e dallo staff medico/ infermieristico.

La ricerca oggetto del presente articolo ha quindi perseguito due finalità:

- Riunire ed analizzare tutte le analisi EBD significative, riguardanti ricerche condotte in ambito ospedaliero con lo scopo di ridurre il tasso delle infezioni nosocomiali/ abbassare il numero di incidenti e stress per lo staff medico/ migliorare la guarigione dei pazienti
- Individuare le soluzioni alternative proposte dagli studi e/o dai tecnici di settore in funzione degli esiti delle suddette ricerche di EBD in ambito ospedaliero,
- Evidenziare la scientificità e l'importanza dello strumento ai fini dell'efficienza ospedaliera.

Nel contesto sanitario nazionale lo strumento dell'EDB non è particolarmente diffuso, infatti tutti gli studi presi in considerazione sono prevalentemente esteri. Nel testo vengono citate le più significative ricerche effettuate per la riduzione delle infezioni nosocomiali/per il miglioramento delle condizioni dello staff medico- infermieristico e per la guarigione del paziente, presentando le scelte progettuali che hanno condotto la ricerca al risultato positivo. Oltre a queste, vengono presentate alcune possibili soluzioni alternative individuate successivamente da professionisti esterni all'ambito della pura ricerca, ma fortemente attivi nel settore della progettazione ospedaliera. Tali proposte alternative, tuttora in fase di valutazione, dimostrano che i risultati delle applicazioni dell'EBD vengono scientificamente presi in considerazione dai progettisti contemporanei per assecondare le esigenze contingenti. La ricerca evidenzia quindi l'efficacia dell'EBD per la definizione delle strategie più idonee al miglioramento progettuale delle strutture sanitarie e dimostra l'effettiva sinergia tra ricerca e ambiente progettuale-produttivo. L'EDB potrebbe quindi essere lo strumento che stimola ed incentiva la progettazione e la sperimentazione di nuove soluzioni per l'efficienza e la sostenibilità delle strutture sanitarie che tengano realmente conto delle esigenze nonché delle peculiarità tecniche ed economiche di ogni singolo ambito di intervento.

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