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EVIDENCE-BASED DESIGN IN HEALTHCARE: A LEAN PERSPECTIVE WITH AN EMPHASIS ON VALUE GENERATION

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ABSTRACT

Evidence-based design (EBD) has been discussed in the literature, including its potential benefits and its limitations for its isolated and fragmented knowledge application. This study is an attempt to integrate the currently fragmented EBD findings to guide decisions for better designing, building and adapting hospitals through Lean thinking with an emphasis on value generation. An EBD review and assessment was carried out to update the current developments in the field. The paper discusses the importance of applying EBD in an integrated way. This is achieved through the development of a conceptual holistic framework based on three data strands inspired through Lean thinking, namely: Building performance, life-cycle cost and user value related evidence. This is an initial attempt and the paper concludes by identifying the limitations and potential future studies.

KEYWORDS

evidence-based design, healthcare, Lean, value,

INTRODUCTION

Healthcare building design presents a complex architectural challenge. Interest in EBD has been growing extensively since Ulrich's 1984 publication addressing the effect of views of nature on patients (Marcus and Barnes, 1999, Ulrich et al. 2008), and proper design decisions at initial stage will not only maximise the occupants' health benefit (Huisman et al. 2012), but also improve the service delivery (Grazier, 1999) and reduce life-cycle costs (Harris and Fitzgerald, 2015).

The idea of lean principles is to make the production process more efficient by reducing any sort of waste in the process, which has become also important for general management, and other disciplines like product development and construction. In healthcare, Lean has been targeted at problems that undermine the delivery of effective healthcare services. The

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concept of lean design has been also studied with a specific focus on the design of healthcare facilities for better value generation (Tzortzopoulos et al., 2005).

There is a clear link between the concept of EBD and that of value generation from a lean design perspective. However, our understanding of EBD and its application is still limited as there is scarce research in the area. This study is an attempt to integrate the currently fragmented EBD findings to guide decisions for better healthcare design through Lean thinking. In brief, the following questions are explored:

- How to fuse diverse information from different sources to generate actionable design information?
- How to ensure applicability of the results (use of information by designers)?

In order to answer these research questions, the paper is structured as follows: It begins by presenting an EBD review and assessing the current state of development of the field. Following, issues on the area of EBD are discussed. The paper goes on to present a conceptual framework based on the literature review and concludes by identifying limitations and potential future studies in this area.

THE CONCEPT OF EVIDENCE-BASED DESIGN

What is the concept of EBD? how it has been tackled by research? and how it may fit into the design process? These will be presented using examples drawn from diverse studies.

The earliest known meaning for the word evidence date from the 1300's and refers to 'appearance from which inferences may be drawn'. Other meanings from later periods also exist and refer to 'proof, distinction, clearness, ground for belief, obviousness' (Harper, 2011). Kelly (2008) pointed out that 'evidence' is directly related to knowledge reliability, which depends on the rigour of evidence gathering and authenticity of the relationship between evidence and phenomena.

This argument has been expanded further in the healthcare disciplines in many ways (Gray, 1997). The initial attempt to use the evidence as a supporting approach in decision making happened in the field of medicine, with a focus on identifying the best treatment alternative for patients based on individual clinical expertise with the best available external clinical evidence from systematic research (Sackett et al., 1996), which became known as evidence-based medicine (EBM). So far this concept has been used in other areas including the care of an individual (Lu et al, 2014), an organization (American Dental Association, 2013) or at the policy level (Boden and Epstein 2006). The success of this approach led, in the 1980's, to the start of discussions related to the adaptation to the field of design, giving origin to evidence-based design. Inspired by EBM, a few definitions of EBD have been proposed:

- Design solutions for healthcare buildings to create environments that are therapeutic, supportive of family involvement, efficient for staff performance, and restorative for workers under stress (Hamilton, 2003).
- 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 and Watkins, 2009, derived from Sackett et al. (1996))

- It is a process involving the reorganisation of thinking, the in-depth investigation and gathering of research, the development of scientific questions and hypotheses and, ultimately, the testing of creative and innovative design solutions (Cama, 2009).

According to Fischl (2006) this approach aims to provide scientific evidence to fill the designer's knowledge gap about humans' social and behavioural attitudes towards the surrounding environment. In this respect, the researcher/designer works as an interpreter investigating and describing human behaviour, wants and needs, which implies in changing the traditional practice of architecture once designers are increasingly required to have considerable knowledge beyond their own field (Hamilton and Watkins, 2009).

CURRENT RESEARCH ON EVIDENCE-BASED DESIGN

There are quite a few literature reviews on EBD published in recent years. Some focus on collecting the evidence in healing environment that can make a difference to the patients' health conditions (Salonen et al. 2013, Huisman et al. 2012). Broadly speaking, studies have been focusing on the therapeutic effects of design from three main perspectives: physiological proof, psychological studies and design theory (Codinhoto et al., 2009). These reviews were very informative in terms of updating the state-of-art evidence including both quantitative and qualitative studies.

As the assessment of evidence heavily rely on its reliability (Kelly, 2008), randomized controlled trial (RCT) were considered rigorous studies with credible data and commonly viewed as providing the highest level of evidence (Evans 2003). The findings from RCT has important implications for those developing practice guidelines and recommendations mainly because the processes used during the conduct of a RCT minimize the risk of confounding factors influencing the results (e.g. Walch et al., 2005). Recently there is a debate that the RCT is not an appropriate methodology in research on long-term healthcare settings, in part because of "*the virtual impossibility of randomly assigning individuals to different environmental / treatment interventions and controlling cross-site variations*." (Calkins 2009, pp146). However, there is an increasing evidence of how environmental cues link to physiological functions in the human body and therefore therapeutic outcomes (Sternberg, 2009).

The studies carried out without random assignments are called quasi-experiments, which follows same RCT methods. A common form is comparative studies with a discussion that the difference of group baseline was compared and then adjusted in data analyses. The research normally collected data from two different built environments and analysed them using same measuring tool, e.g. predefined activity task, comfort / satisfaction level and energy cost annually etc. (e.g. Beauchemin and Hays, 1996). Another typical example is a comparison between before-and-after scenarios. Two sets of data were collected from same group of occupants before and after moving into a new building, a refurbished environment, or any facility replacement (e.g. Tyson et al., 2002). Comparative studies can produce a rich source of information and give a certain confidence to embark on the new design strategy intervention. However, it is difficult to extend the results and findings to other building cases due to its small sampling size. Only when obtaining more evidence in a similar way can actually identify and eliminate alternative explanations.

Post-occupancy evaluation (POE) is a typical quantitative study type without seeking causation but evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time (Preiser et al., 1988, Sherman et al., 2003). Nowadays, POE is one of the most popular way in terms of collecting evidence from varied functional building types, office, schools and hospitals. Unfortunately, these works are mainly supported within academic institutions and tend to be specific to research purposes rather than being routinely applied to mainstream building design practice, e.g. feeding it forward to new projects.

Besides the quantitate studies discussed above, qualitative studies, e.g. interviews, focus group, workshop, site observation, etc. are some common methods especially to those studies that interest in problem solving, innovation (new study area), complex opinions, beliefs and attitudes (e.g. Rowlands and Noble, 2008). The qualitative studies are very project (case) focused and do not provide a strong evidence base for practice. However, it provides potential design interventions and opportunities for future studies that require additional investigation and evaluation (Evans 2003).

This section summarized the current research in EBD. What is shown is that evidence collected for healthcare buildings come from multi-dimensional perspectives and through varying methods, depending on the study interests and targets. Though research and studies made an effort to contributing the richness of the data, yet there are questions regarding the evidence integration for the most effective design solutions and actionable advice for future healthcare building projects. Therefore, a holistic approach is needed.

METHOD

Literature review is used with an emphasize on two aspects which responds to the research questions that set out in the 'Introduction':

(1) *Maximize value (Optimise the healing environment)*: There is an illustration of EBD refined by Lima (2014) called the three-legged stool which was from Spring (2007) originally (Figure 1) captured the essence of an individual's holistic experience of design decision-making process. Her work becomes a starting point for this study and literature review were carried out to establish the links between design decision-making (EBD means) and value generation (Lean output). (2) *Development of a theoretical framework:* Recently, some researchers have explored the potential solutions to create a manageable framework that integrate varied design features together. For example, Durmisevic and Ciftcioglu (2010) developed a framework through a fuzzy neural tree structure that combine the EBD for more efficient use. Rybkowski and Ballard (2008) use the 'five whys' as a decision-making framework for EBD to ensure that multiple options are considered before final solutions are adopted. Inspired by their work, the conceptualization of three Lean strands becomes the base for the literature review to develop the framework specifically fit into healthcare building design for value generation.

CHALLENGES FOR AN INTEGRATED APPROACH

Lean is associated with the elimination of waste (Womack and Jones 1996) and value generation (Hines et al, 2004). Today, the emphasis on 'value' and how it can be generated and maximised, is growing rapidly. The value generation process was argued through many

viewpoints. One of the essential issues regarding value is how to define and measure it (Koskela, 2000). According to Zeithaml (1988), perceived value is the consumer's overall assessment of the utility of a product based on perceptions of what is received and what is given. To provide benefits, a product or service must be able to perform certain tasks or functions, solve identified problems, or provide specific pleasures (Monroe (2012). Haque and James-Moore (2004) also argued that engineers need to move from a production focus in which the primary aim is waste reduction to one of identifying and enhancing value. Clearly, there appears to be a significant opportunity to benefit from the adoption of Lean in EBD for healthcare design, as the key concepts are similar: it tries to identify the effective and efficient design solutions for value generation. Inspired by previous works (Spring 2007, Lima 2014), Figure 1 maps a link between lean and EBD.

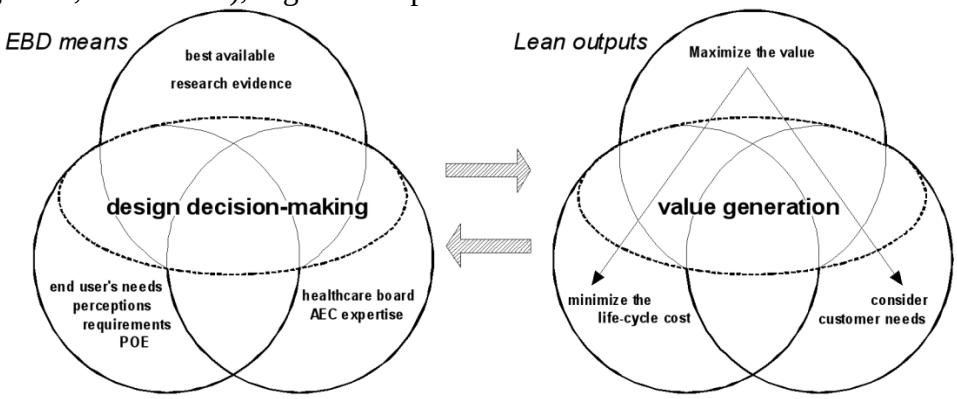

Figure 1: Links between Lean and Evidence-based

MAXIMIZE VALUE (OPTIMISE THE HEALING ENVIRONMENT)

Baines et al. (2006) carried out a systematic review and stated that an understanding and definition of value is key to success when applying the Lean. Gautam and Singh (2008) in their lean product development study argued that when existing product design is modified to improve its perceived value, it is important to identify and pursue those changes (decisions), which give maximum improvement in the perceived value. Healthcare buildings are purpose-built for a specific functioning usage: healing. Crucially, it supports not only the functional but also emotional needs of all healthcare facility users (patients, staff, visitors). In this context, value can be tangible (such as staff absenteeism, medical errors, falls, budget plan, service cost, energy consumption etc.) or intangible (such as comfort, satisfaction, quality of sleep and working efficiency etc.). Patients, staff, visitors are particularly affected by the intangible aspects of the building.

Most studies tended to follow a similar perspective, developing one specific evidence to address specific health outcomes. EBD needs to endeavour to combine all individual design features that lead to positive impact to optimize the healing environment, and designers could use these evidence to make decisions based on the best information available. However, the evidence fragmentation makes it difficult for implementation in practice because the value is unpredictable due to the different level of credibility. Therefore, the implementation of EBD confronts a big challenge due to lack of the integrated evidence. Lean is a holistic approach, which can be interpreted as 'emphasizing

the importance of the whole and the interdependence of its parts.' In this case, two central arguments were explored in terms of the evidence integrating.

Minimize the life-cycle cost (guide the investment decision)

Minimizing the life-cycle cost is one of central arguments when it comes to maximizing the value generation. Life-cycle costs, in AEC industry often refers to the initial cost with future-based costs like running, operation, maintenance and replacement etc. (Bennett, 2003). Despite the benefits of EBD, there are economic barriers to implementing EBD in healthcare projects. Central to the business case is the need to balance one-time construction costs against ongoing operating savings and revenue enhancements (Sadler et al. 2008). According to several sources 70-90 % of the total life cycle costs become defined already in the design phase and once the design is completed, the potential to reduce the cost in later stages is rather small (Bescherer, 2005). However, the implementation of lean in design has been slow, exactly at the stages where decisions have a major influence on the level of value realised in the project (Emmitt et al. 2004).

Nowadays, healthcare worldwide is facing severe funding constraints and increased pressures on the quality of healthcare delivery, which means the updated knowledge that could guide investment decisions during the initial phases of healthcare projects becomes more crucial. Blair et al. (2011) proposed an updated hypothetical Fable Hospital 2.0. The cost premium for 16 separate EBD interventions, e.g. single patient rooms, sound absorbing ceiling tiles and larger windows etc. was estimated to be 7.2% on a $350 million hospital build. As described by the authors, the payback for the Fable 2.0 investment should occur within three years—a reasonable return by any business standard.

Consider the customer's need (focus on user-centred design of the healthcare)

A critical point in lean thinking is to consider the customer' needs, enhancing the value to them by adding product or service features and/or removing wasteful activities. Mikulina (1998) states that each of the participants on the new product introduction process should work only when and on what is needed, or in other words 'in demand by customer'. Paralleled with customer-driven idea, user-centred design also emphasised that the integration of knowledge of users work practice, preferences etc. into the design process is crucial to a successful design outcome (Norman and Draper 1986).

To build a user-centred environment is particularly crucial for healthcare facilities, where occupants are likely to experience a psychologically difficult situation. Recent developments in healthcare design have highlighted the importance of 'humanizing' healthcare contexts by focusing on a set of design attributes, which should be provided in order to satisfy fundamental users' needs (Evans and McCoy, 1998), e.g. privacy and social interaction; perceptual consistency; control over space. In a situation of increased sensitivity, to create a relaxing environment, pictures on the wall, soft background music and beautiful view outside have potential to reduce anxiety and depression of the patients and staff (Ulrich et al. 2008).

From the discussion above, it was found that Lean thinking has the potential in integrating the EBD knowledge particularly in enhancing the building performance, lowering the life-cycle cost and the patient-centred benefits.

DEVELOPING A HOLISTIC FRAMEWORK

Though compelling arguments were made on the importance of EBD, few well-constructed empirical studies have been carried out to explore the complexity and interactions of the healing environment as a whole. Within this challenging context, one potential research focus is to take an integrated approach to identify the impacts of the built environment on health outcomes. Lean concepts provide a conceptual basis for this.

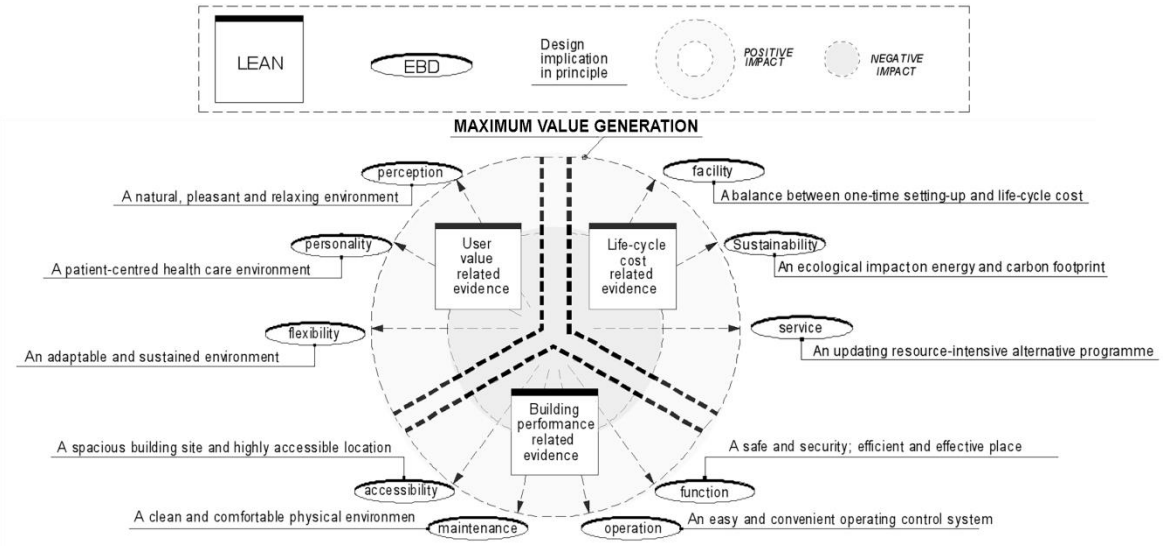

Figure 2: A conceptual framework for implementation of EBD integration and examples of evidence in each data strand

Figure 2 is an initial attempt to fuse diverse information from different sources to generate actionable design information. Based on available literature, some of which has been presented in this paper, it maps a holistic view of the EBD implementation through Lean in terms of value generation. Some design implications in principle in each strand are also given to ensure applicability of the results (use of information by designers). There are three data strands and each one represents one perspective of decision making that needs to be considered and integrated to determine the value generation to the customers. *Building performance related evidence* plays an essential role in providing a well-functioning healing space. *User valued related evidence* will optimize the healing environment from patients, staff and visitors' point view. And the *life-cycle cost related evidence* will guide the investment decision in order to ensure the the best available resources for value generation. It has to be mentioned that the EBD included in each Lean strands are not identified in an isolated way. For example, the maintenance focus on providing a clean and comfortable environment (building performance related evidence) which will directly affect the user perception (user value related evidence). Their positive/negative feedbacks may further become a solid evidence in updating the healthcare service (life-cycle cost related evidence). In this case, which Lean strands the evidence is located does not matter. What matters for this holistic approach is that these EBD characteristics are included in this framework to be taken into consideration.

LIMITATIONS AND CONCLUSION

The ultimate goal of EBD is to generate actionable advice that could be used as the basis for healthcare building design and improvement (including refurbishment). However, due to the fact that (i) the evidence is scattered and heterogeneous, (ii) the effect on end-users' health and wellbeing is at varied levels and perspectives, naturally, it raised a very popular question: what is the best design solution? Or what evidence can inform the designer to locate the main resources to the most effective design solutions? Though compelling arguments were made on the evidence and their impact, very few well-constructed empirical studies have been carried out to explore the complexity and interaction of the healing environment as a whole. The paper discussed the implementing EBD in healthcare building design at early stage through Lean thinking.

It has to be mentioned that this paper does not attempt to collect and review all EBD in healthcare; nor does it provide a final framework for the practical usage. The particular objective is to focus on the current EBD knowledge in an integrated way based on value generation. It presents the starting point of our research in this area with unavoidable limitations. For example, it is constrained by the lack of clear demarcation point between evidence and other factors influencing the value generation and maximization (e.g. wellbeing when compared to the effects of the physical environment.) By discussing and publishing, the research team aims to continually improve the integrated approach, being open to new ideas and constructive suggestions. This paper is part of this process, an exercise in critical reflection and appraisal. Hopefully, a future developed framework will provide the means by which better understanding and actionable knowledge can be generated for healthcare building design. And the integrated approach through Lean thinking will be a promsing area for healthcare buildings' research, highlighting the importance of the design challenge for policy makers, designers and users.

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