

A CONCEPTUAL FRAMEWORK FOR EVIDENCE-BASED DESIGN AND CHOOSING BY ADVANTAGES SYNERGY

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ABSTRACT

Evidence-Based Design (EBD) has been identified as a worthy design approach towards achieving suitable design of healthcare facilities by linking healthcare design decisions to empirical evidence regarding potential impact on recovery rate and effectiveness of care. Choosing By Advantages (CBA), on the other hand, is a decision-making system identified as collaborative, transparent and reliant on the importance of the advantages of alternatives.

This study therefore sought to explore the synergies that exist between EBD and CBA. Insights on the synergistic interaction between EBD and CBA were obtained from literature review in line with abductive reasoning in qualitative research. Multiple dimensions of synergy have been found to exist between the EBD process and the CBA process. This involves an interaction among various elements across the respective processes in EBD and CBA. CBA could therefore be explored as a functional decision-making system for operationalizing EBD and vice versa.

KEYWORDS

Evidence-based design, Choosing By Advantages, healthcare design, decision-making, synergy.

INTRODUCTION

Evidence-Based Design (EBD) has been identified as a means of achieving suitable design of hospital environments to ensure better clinical outcomes, enhance safety, and reduce patient and staff stress (Hamilton, 2003). Generally, EBD involves a formulation of design strategies based on careful decision-making to maximise healthcare project outcomes and value (Cambra-Rufino et al., 2021; Bingham et al., 2020). Particularly, EBD theory indicates a significant relationship between the built environment and health related outcomes (Brambilla et al., 2019).

However, implementing EBD in healthcare involves decisions that are complex, and could be associated with trade-offs among multiple and often contending objectives. Therefore, employing structured and explicit approaches to decisions involving multiple criteria can enhance the quality of decision-making in EBD (Marsh et al., 2016) and enhance value delivery in healthcare projects. A set of approaches known as multi-criteria decision making (MCDM) methods, are useful for this purpose. Particularly, the choosing by advantages decision (CBA)

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system is a MCDM method that is generally seen as aligned to the lean construction tenets of transparency and collaboration (Arroyo et al., 2013).

There have been previous studies on the possible integration of lean construction and EBD. For instance, Zhang et al. (2016) tried to establish how the value generation dimension of lean construction interacts with the decision-making dimension of EBD. Rybkowski (2017) studied the possibility of integrating EBD and lean, concluding that EBD and lean can be integrated based on their shared insistence on the cultures of respect. Despite these previous studies on integrating EBD and lean construction, there has hardly been any discussion specifically on the synergies between the CBA decision-making system and EBD.

This paper therefore aims at undertaking an extended literature review involving in-depth analysis and synthesis of the steps in the EBD and CBA processes, and eventually proposing a framework of interactions between CBA and EBD. This will then lead to outlining various synergistic elements and dimensions of possible EBD-CBA integration as the preliminary outcome of a larger research effort targeted at drawing and expanding on those interactions. The increasing application of CBA as a structured approach to decision-making in the Architecture, Engineering and Construction (AEC) sector (Arroyo et al., 2018), and the call for an objective, rational and functional approach to decision-making in EBD (Hamilton, 2012) particularly make research on the synergies between CBA and EBD significant.

The framework is expected to create a synergy for value generation by blending EBD's strength in generating research-driven design solutions with CBA's approach of ranking advantages; this will offer an opportunity for healthcare design teams to optimise user satisfaction and patient outcomes while reducing waste. Additionally, the potential synergy is expected to enable systematisation of decision-making by providing a step-by-step method that departs from simply collecting evidence (as in EBD), to evaluating alternatives based on evidence of potential benefits of those alternatives.

LITERATURE REVIEW

EVIDENCE-BASED DESIGN

The complexity of healthcare building design has led to a growing interest in EBD especially since Ulrich's 1984 work on the impact of views of nature on patient outcomes (Zhang et al., 2016). EBD is the act of exploring, evaluating, and incorporating the most effective approaches in healthcare facility design and construction. It involves designing healthcare buildings to create environments that are therapeutic, enabling of family involvement, supportive of efficient staff performance, and restorative for stressed workers (Hamilton, 2003). EBD therefore uses a scientific approach to link design attributes to healing outcomes (Bingham et al., 2020).

EBD is also closely associated with continuous quality improvements, such that the anticipated outcomes of the care environment, relative to user requirements, are closely related to the best research, knowledge, and experience available in the field (Elf et al., 2017). Thus, the fundamental purpose of EBD is to use prevailing evidence to inform decisions when designing new healthcare facilities (Stichler, 2013). The evidence that drives EBD could come from various sources such as literature, design standards and guidelines, and case studies (Kpamma et al., 2023). Stichler (2016) in distinguishing research-informed design from EBD indicates that research-informed design is restricted to using published research studies to guide decision-making, while EBD uses multiple sources of evidence such as vendor's opinion, advice from experts in healthcare design or healthcare practitioners, one's personal experience, best practice examples from site visits or published case studies, as well as various forms of qualitative and quantitative studies.

In operationalizing EBD, decision-making plays a central role. The EBD framework fundamentally encourages hinging important decisions in healthcare design on credible evidence (Zadeh et al., 2015; Hamilton, 2003). It has further been observed that, designing successful healthcare facilities requires a balance of knowledge exchange, experimentation, and mutual learning by all stakeholders, while concurrently defining and agreeing on the project objectives (Elf et al., 2015); and managing this situation successfully requires a systematic method to gathering information for effective decision-making (Chen & Sanoff, 1988).

According to Feldbauer et al. (2008), an effective EBD decision-making process requires analysis and critical thinking, as well as a systems approach to applying research findings. Hamilton (2012) recommends the application of rational and functional criteria, in an objective fashion, on a category of EBD decisions described as important, demanding, and of high impact. However, there is no research that articulates the organizational decision-making process and criteria used by healthcare administrators when considering the use of EBD concepts on projects (Shoemaker et al., 2010).

THE CBA DECISION SYSTEM

Multi-criteria decision making (MCDM) methods are employed to assist individuals or project teams to select the best alternative based on multiple factors. Conventionally, MCDM methods rely on the weighted sum method (e.g., Weighting, Rating and Calculating) or adopt linear trade-offs among decision criteria (Petkov et al., 2007; Huang et al., 2015). These methods have been applied to various types of design decisions in the architecture, engineering and construction (AEC) sector.

CBA is a collaborative MCDM method that was developed by Suhr (1999) with the aim of achieving consensus among stakeholders on the preferred alternative when the choice among the alternatives involves several factors. This method is based exclusively on the comparative advantages of alternatives and does not include disadvantages, which is common in other decision-making methods (Arroyo et al., 2018).

Unlike other MCDM methods, CBA is a multi-criteria decision analysis that characteristically relies on comparing the advantages of alternatives in decision-making (Suhr 1999). In the process, advantages of alternatives are assessed by assigning importance to the advantages using numerical weights. The preferred choice eventually becomes the alternative with the highest total Importance of Advantages (IoA) (Arroyo et al., 2022).

CBA is a comprehensive system for selecting the best alternative through a comparison process which creates transparency and collaborative environments for decision-making (Arroyo et al., 2013). Also, CBA is seen as being the best MCDM method, compared to the Analytical Hierarchy Process (AHP) method, Weighting Rating Calculating (WRC) and Best Value Selection (BVS) (Schöttle et al., 2015; Arroyo et al., 2013).

CBA is noted to create a transparent and collaborative atmosphere for auditable decisions in building design and construction (Schöttle et al., 2019), and has generally attracted increasing attention in the construction industry in recent years which has largely been motivated by growing demand for collaborative project organizations and transparent decision-making processes (Arroyo et al., 2019). Diverse studies have revealed that CBA leads to creative conversations, less discontent during decision-making, trust in the decision outcome, and traceable justification for decisions (Kpamma et al. 2017; Schöttle and Arroyo 2017; Arroyo and Long 2018, Schöttle et al. 2019). However, studies on the synergistic relationship between CBA and EBD are rare.

METHOD

The study fundamentally sought to identify the various dimensions of synergetic interactions between CBA and EBD through an extended literature review that offers a more in-depth analysis and synthesis of the CBA and EBD processes. A novel conceptual EBD - CBA interaction framework was therefore synthesized by reviewing literature on EBD and CBA in line with Tezel et al. (2022), and Webster & Watson (2002). Synthesis of the interactive connections emerged from examining and analysing the various process steps associated with EBD and CBA to mainly establish how EBD could influence CBA and vice versa.

The literature was mainly drawn from peer-reviewed journal publications and peer-reviewed conference proceedings. Particularly, literature on the CBA process was largely obtained from Suhr (1999) and articles in the International Group for Lean Construction (IGLC) conference proceedings (available at iglc.net/papers). Literature on the EBD process was mostly obtained from various articles in the Health Environment Research and Design (HERD) Journal, and complemented with articles from other journals. The HERD journal is identified as the premier journal on connecting the relationship and science between the built and natural environments, and health outcomes. The key concepts were the processes and steps involved in EBD and CBA application. Consequently, Units of analysis, emerging from the literature review, included the process interactions in EBD and CBA application.

In developing the framework, insights obtained from the literature review were used in line with abductive reasoning in qualitative research whereby conceptualizations are developed iteratively between theory and data. Data in this case refers to the existing research content (Bell et al. 2019). Through abduction, critical reflections and insights were progressively developed cyclically (Bell et al. 2019) by closely observing elements of the CBA and EBD process. Furthermore, the conceptual framework elements were evaluated based on the anticipated benefits and reverse impact of an interaction theme that can inform future EBD - CBA synergic applications.

CONCEPTUALISATION OF INTERACTION FRAMEWORK

The framework of interactions between EBD and CBA (Fig. 1) combines EBD process elements (Fig. 2) and CBA process elements (Fig. 3) into a scheme of interacting elements (Fig. 1 and Table 1). Fig. 1 shows the two-way (from EBD to CBA and vice versa) synergy framework dimensions.

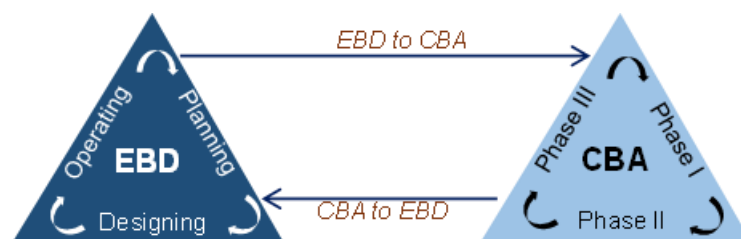


Figure 1: EBD and CBA synergy analysis framework

EBD PROCESS ELEMENTS

The EBD process triad schema in Figure 2 is inspired and synthesised from Fay et al. (2016) and Stichler (2013). It contains three broad elements: planning, designing and operating (Fay et al., 2016).

Planning (P)

This is the pre-design phase during when clinical questions are asked and the EBD goals and objectives are defined in line with organisational vision. Project goals are therefore articulated

in line with the desired outcomes. This phase of EBD also involves exploring sources of evidence that align with the goals and objectives. The possible sources of evidence include literature, design standards and guidelines, and case studies (Kpamma et al., 2023; Stichler, 2013).

Designing (D)

This is the second phase of the EBD process. This phase involves critical interpretation of the relevant evidence to determine if the evidence is credible enough to be applied in design. It is important to understand the rigor, relevance, validity and generalizability of the evidence. In this phase the relevant evidence is also translated into guidelines to direct aesthetic, functional and compositional design decisions. Preliminary design concepts will begin to emerge based on these guidelines (Fay et al., 2016).

Operating (O)

This is the third phase and involves ensuring that all design specifications are executed as indicated in design documents in compliance with evidence. Upon completion of construction, the project team need to verify that the commissioned building complies with EBD specifications. This phase also involves conducting a study through post-occupancy evaluation (POE) to measure the performance of the constructed facility. Outcomes of the POE then form the basis for adopting new design features as standards for application in future projects. POE findings need to be disseminated for adoption by the larger design community (Fay et al., 2016; Stichler, 2013).

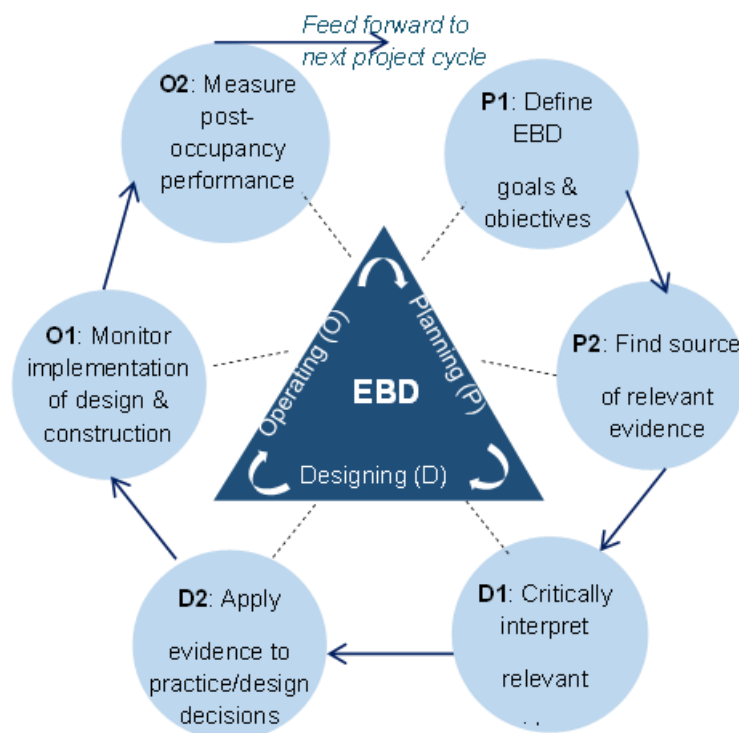


Figure 2: Elements of EBD application process

CBA PROCESS ELEMENTS

The scheme in Figure 3 is based on (Suhr, 1999). Accordingly, the CBA process involves three phases: Phase I, Phase II and Phase III.

Phase I

This is where the purpose of the decision is defined (Suhr, 1999). The team will begin to identify relevant factors as containers of other types of decision data based on the purpose. The defined purpose will also guide the formulation of criteria as the decision rules or guidelines. The ‘must have’ and ‘want to have’ rules are indicated here.

Phase II

This involves formulating and exploring design alternatives guided by the defined purpose and criteria (Suhr, 1999). Attributes of the alternatives relevant to the factors and criteria are also determined in this phase. In generating the alternatives, the factors and criteria act as controls in exploring unlimited possible alternatives.

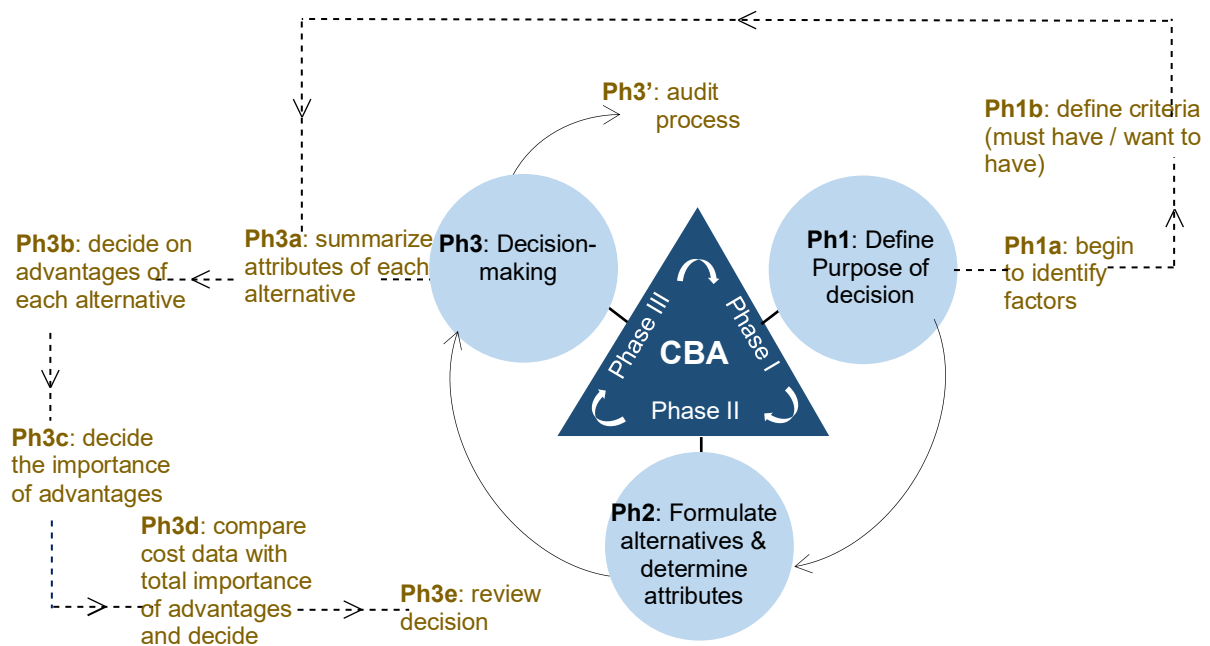


Figure 3: Elements of CBA application process

Phase III

The actual decision-making in the process is at this stage (Suhr 1999). The attributes of each alternative are summarised according to the defined factors in the first step of this phase. Next step in this phase involves deciding on the advantages of each alternative followed by deciding on the importance of the advantages. The final decision is reached by comparing cost data with total importance of advantages of each alternative. If costs of the alternatives are equal, the alternative with highest total importance of advantages is chosen.

THE SYNERGETIC INTERACTIONS

Table 1 shows details of the synergetic interaction between the process elements of EBD and those of CBA. These interactions, as presented, emerged from examining and analysing the various process steps associated with EBD and CBA to establish how EBD could influence

Table 1: Interaction between EBD and CBA

Evidence Based Design to Choosing by Advantages			
No.	Root	EBD process	CBA process
1.	Objectives at planning stage (P1) facilitates purpose definition and formulation of alternatives (Ph1)	P1	Ph1 (Ph1a and Ph1b); Ph2
2.	Sourcing evidence at EBD planning stage (P2) enables data on attributes (Ph2, Ph3a)	P2	Ph2, Ph3a
3.	Interpreting evidence (D1) guides summarization of attributes (Ph3a) and advantages (Ph3b)	D1	Ph3a, Ph3b
4.	Interpreting evidence (D1) and applying evidence (D2) guides Importance of advantages (Ph3c)	D1, D2	Ph3c
5.	Applying evidence to design (D2) activates design alternatives generation (Ph2)	D2	Ph2
6.	Measuring post-occupancy performance during operation (O1, O2) facilitates CBA audit (Ph3e)	O1, O2	Ph3e
Choosing By Advantages to Evidence Based Design			
No.	Root	CBA process	EBD process
1.	Defining decision purpose (Ph1) shapes and defines EBD objectives (P1)	Ph1	P1
2.	Defining decision purpose (Ph1), formulating alternatives and determining attributes (Ph2) guides evidence sourcing (P2)	Ph1, Ph2	P2
3.	Formulating alternatives (Ph2), and determining attributes in line with factors stimulates criticality in interpreting evidence (D1)	Ph1a, Ph1b, Ph2, Ph3a	D1
4.	Formulating alternatives (Ph2), determining attributes (Ph3a), deciding advantages (Ph3b), and determining importance of advantages (Ph3c) provide a framework for applying evidence to design decisions (D2)	Ph2, Ph3a, Ph3b, Ph3c	D2
5.	Reviewing decisions in CBA (Ph3e) provides a context to monitor design (O1) and measure post-occupancy performance (O2)	Ph3e	O1, O2

CBA and vice versa. ‘Root’, as indicated in Table 1, defines the basis upon which each step in EBD could enable respective steps in CBA, and how each step in CBA could also enable respective steps in EBD. The colour transition across the table relates to the interactions influenced by various steps across the respective phases in the EBD or CBA processes.

The study, for instance, revealed that the establishment of EBD goals at the planning stage of the EBD process (P1) has the potential of facilitating the ‘definition of purpose’ and the ‘formulation of alternatives’ steps in the CBA process (Ph1a, Ph1b & Ph2). This suggests that goals established at the commencement stage of EBD could provide a premise to define the decision purpose and generate alternatives in the application of CBA. Additionally, the step of ‘finding source of relevant evidence’, also at the planning stage of the EBD process (P2), could facilitate the identification of data to appropriately describe the attributes of alternatives in the CBA process (Ph2 & Ph3a). This will result in a situation where attributes of alternatives in the CBA process are defined using empirical data from reliable and credible sources. It then results in a situation of creating synergy to establish value by employing researched-driven data to validate value in design choices, and reduce reliance on

intuitive and biased decisions. Consequently, the synergy will reduce non-value adding interventions in healthcare designs.

The stages of ‘critically interpreting relevant evidence’ and ‘applying evidence to design’ (D1 & D2) in the designing phase of the EBD process has been found to have the tendency of influencing a number of steps in the CBA process such as ‘defining attributes’, ‘determining advantages’, ‘deciding on importance of advantages’ and ‘generating design alternatives’ (Ph3a, Ph3b, Ph3c & Ph2). This is expected to lead to a situation whereby the activities of ‘defining attributes’, ‘determining advantages’, and ‘deciding importance of advantages’ are grounded on credible and verifiable evidence. This is another instance of the synergistic interaction creating an enabling system for evidence-based evaluation of design alternatives, guided by research-informed beneficial difference among choices, in order to maximise clinical outcomes and patient satisfaction.

On the other hand, the ‘decision purpose’ step in the CBA process (Ph1) has been identified to have the potential of providing a guiding premise to define the EBD goals and objectives at the planning stage (P1). Furthermore, the act of ‘defining decision purpose’, ‘formulating alternatives’, and ‘determining attributes’ in the CBA process (Ph1, Ph2 & Ph3a) could potentially become a guiding framework to explore sources of relevant evidence in the EBD process (P2). Similarly, ‘generating alternatives’, and ‘determining relevant attributes’ in the CBA process (Ph1a, Ph1b, Ph2, Ph3a) could provide a premise to guide the intensity, depth and direction of interpreting relevant evidence in the EBD process (D1). It implies that the CBA-EBD synergy could provide a platform to manage the complexity of healthcare design which involves a diversity of stakeholder perspectives, large amount of quantitative and qualitative data, and several alternatives. The synergy is particularly able to achieve this by enabling participatory process through increased transparency, communication and trust among stakeholders.

The CBA process of ‘generating design alternatives’, ‘determining attributes of alternatives’, ‘deciding advantages’, and ‘determining the importance of advantages’ (Ph2, Ph3a, Ph3b, Ph3c) could also provide a guiding framework for ‘applying evidence to design decisions in the EBD process (D2). The activity of reviewing decisions in the CBA process (Ph3e) has also been found to be useful in providing a context to monitor the implementation of the design proposals and measure post-occupancy performance (O1 & O2). Due to the documentation of decision rationale particularly associated with CBA process, this dimension of synergic interaction creates an audit trail for review and accountability which is significant in context of the complexity and high specialty associated with healthcare projects.

Generally, the synergy between CBA and EBD creates a robust framework for decision-making in projects like healthcare projects which are complex and are associated with high stakes. One dimension of robustness of the framework draws on the CBA-EBD blend creating a system whereby design teams transition from arbitrary and intuitive scoring of design options to anchoring design choices on verifiable data that objectively establish the beneficial difference between design choices. Essentially, in the CBA-EBD synergetic interactive framework, EBD provides the facts to answer the question of “what?” in the design process, and CBA provides the decision-making structure to answer the question of “how?” in the design process.

DISCUSSION

In Table 1, multiple dimensions of synergy between the EBD process and the CBA process are shown. This involves an interaction among various elements across the respective processes in EBD and CBA. Largely, at the level of EBD to CBA, and CBA to EBD, the number of elements in the interaction is almost comparable.

However, whereas there are generally more elements in the CBA process potentially being influenced by a single element in the EBD process (as in EBD to CBA), there are more elements in the CBA process potentially influencing one element in the EBD process (as in CBA to EBD). In the case of EBD to CBA, the interaction occurs across the various phases of EBD (planning, designing and operating). Though here, it is the phase of designing in the EBD process that has most elements interacting with elements in the CBA process, the synergistic impact appears to be more intense from elements in the EBD planning and operating phases, compared to elements in the EBD designing phase. In the case of CBA to EB, the intensity of the impact of synergy varies among elements across the various phases of CBA. For instance, whereas the strength of the impact of Ph1 on P1 appear to be potentially strong, the impact of Ph1 on P2 appear to be potentially medium.

The several dimensions of interaction between EBD and CBA illustrates the key role of decision-making in the EBD process, and the significant role of evidence in the CBA process. This aligns with the observation by Zadeh et al. (2015) that the EBD framework essentially requires utilising credible evidence for important decision-making in healthcare design. Furthermore, the synergistic interaction between EBD and CBA presents CBA as a means of operationalising the observation by Feldbauer et al. (2008) that, effective EBD decision-making process requires critical thinking and a systems approach to applying research findings.

One possible strategy of exploiting the synergistic relationship between CBA and EBD, especially at the micro-level of managing design process, is to apply the concept of reflective practice in design process (Dong et al., 2013) whereby decision-making frames in the design process are identified to define the context of design activity such as applying EBD with CBA. In this case the design activity is partitioned into various episodes of design activity involving application of EBD with CBA. This approach aligns with the model of grouping decisions in EBD into four categories by Hamilton (2012), leading to the description of a particular category of decisions as important, of high impact, and demanding. This category of decisions, according to Hamilton (2012), need to be made in an objective manner and on the basis of rational and functional criteria. Therefore, a typical application of EBD in healthcare design could involve dividing the design process into various episodes of CBA decision-making and relying on relevant and credible evidence to particularly define attributes, determine advantages and decide on importance of advantages.

Operationalizing the use of CBA in EBD based on the various dimensions of synergetic connections will involve a participatory design approach involving various stakeholders such as designers, estimators, health practitioners, researchers, regulators, facility managers and contractors. These stakeholders, among others, will play the crucial role of collectively defining project goals and objectives, providing credible and relevant evidence, defining decision criteria and providing feedback for review. It will therefore be useful to make use of the mutual insistence of CBA (as a lean decisions system) and EBD on the culture of respect (Rybkowski, 2017; Schöttle et al., 2019) to foster a collaborative and cooperative atmosphere among the stakeholders. Furthermore, the transparent and consensus building attribute of the CBA process (Arroyo et al., 2018) in conjunction with the reliance of the EBD process on objective data (Stichler, 2016) has the potential of engendering trust and collaboration among the stakeholders to enhance the EBD-CBA integration process.

Practical implications of the CBA-EBD synergy are in various dimensions. One dimension involves the identification of design alternatives which should be undertaken by using EBD principles to generate a set of workable design options in the form of set-based design. Another implication of the synergy is that definition of factors and criteria should be undertaken by establishing what matters (e.g. patient privacy, wayfinding) based on project objectives and research-driven data. Additionally, in determining attributes and evaluating advantages of

options, it implies that evidence should be gathered by using EBD to provide factual and hard data for each option (e.g., option 1 increases daylight factor by 1% more than option 2).

CONCLUSION

EBD has received increased interest as a suitable means of designing healthcare facilities based on evidence to ensure improved clinical outcomes; CBA is also increasingly being identified as a decision-making system that is collaborative, transparent, and relies on evidence. Since EBD fundamentally seeks to link healthcare design decisions to empirical evidence, this paper sought to explore a potential synergistic interaction between EBD and CBA.

Abductive reasoning on insights obtained from literature review resulted in a conceptual framework which depicts various dimensions of synergistic interaction among various EBD process elements and CBA process elements. Generally, the conceptual framework is expected to bridge the gap between research evidence and decision-making by creating an organised process that translates scientific research findings into actionable design choices of significant value. Practically, the framework should systematise decision-making in EBD beyond gathering evidence; enhance transparency and collaboration among stakeholders in healthcare design; create synergy for value generation and waste reduction in healthcare projects; ensure documentation of decision-rationale for future audit and accountability; and manage the complexity in healthcare design. Consequently, the conceptual framework transforms healthcare design process from being dominated by only opinions and cost considerations, to a process focused on value whereby the greatest beneficial difference, based on evidence, is delivered.

The study therefore contributes to theory on the specific dimensions of synergy between EBD and CBA. In terms of practice, the paper provides insight on how CBA could potentially become a functional and rational decision-making system for operationalising EBD. Although EBD is conventionally associated with healthcare design, the established synergy between EBD and CBA can be extended to benefit the design of other facilities beyond healthcare facilities. One limitation of this study is its reliance on highly targeted literature largely focusing on CBA and EBD process steps. Conceptualisation of the framework which is largely based on the authors' understanding and synthesis is another limitation of this study. Consequently, there's the need for empirical studies particularly in the form of case studies, and surveys to expand the interaction and empirically validate the interacting framework.

A key theoretical proposition that has emerged from this study is that the application of EBD can be improved by employing the CBA decision system in making key decisions during the EBD process. Further research is therefore recommended, particularly by using empirical data from case studies, to test this theoretical proposition and further explain the benefits and utility of the complementarity of CBA and EBD.

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