AN INVESTIGATION OF PERFORMANCE GAPS IN THE DESIGN OF UK HEALTHCARE FACILITIES

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The 'design performance gap', a situation in which design fails to meet user expectations, has been increasingly discussed in recent decades. This research concerns the design of healthcare facilities and ways of improving it, through the comparison of designers' performance and the satisfaction level of users. A literature review is first presented of existing work on the assessment of design performance, performance gaps and ways of closing them, with a particular focus on the key issues in the design of healthcare facilities. The data collection involved two questionnaire surveys and fourteen interviews. The surveys encompassed Likert scale and open-ended questions that were assigned to designers to explore their awareness and response to important problems encountered in the design of healthcare facilities. This was followed up by in-depth interviews with selected designers. The second survey questioned the satisfaction of healthcare users about aspects of the design of their healthcare environment. Two situations emerged: (1) where designers are aware of the issues, think they are addressing them, and users are satisfied; and (2) where designers are aware of the issues and believe they are addressing them, but users are nevertheless dissatisfied. The conclusion is that designers have insufficient information on certain user requirements. Better user information is paramount for better design decision-making and for the quality of healthcare facility design. A conceptual framework and matrices were developed that could raise awareness of this and help in improving design decision-making through improved Post-Occupancy Evaluation.

Keywords: healthcare facilities, performance gaps, post-occupancy evaluation

INTRODUCTION

The apparent inability of buildings (either because of their design, or because of the way they were constructed) to meet the needs of their users has been noted by numerous critics. As well as the more obvious failings, such as defects (Josephson and Hammarlund 1999, Forcada *et al.,* 2016, Kraus *et al.,* 2017), there are performance miscalculations and misconceived designs that are simply not fit for purpose (Somboonwit and Sahachaisaeree 2012, Driza and Park 2013, Smith 2016, Van den Brom *et al.,* 2018). This is made worse by the disconnect between designers and users in terms of meaningful feedback (Kujala 2003, Steen *et al.,* 2007, Jensen 2011, Andrade *et al.,* 2012, Caixeta *et al.,* 2013). In this study the focus is on the design of healthcare facilities. Like all buildings, healthcare facilities should be well

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designed, be constructed with no defects and provide a healthy and suitable environment for their users. In the case of healthcare buildings (HCBs), these users include patients, medical staff, and administrators. HCBs are particularly complex because of the variety of activities involved in their design, construction, and use. Architects and other designers have an important role in ensuring that what they design is adequate for care delivery (Caixeta and Fabricio 2013). HCBs may include general hospitals, specialised hospitals, and clinics, in addition to other facilities. People who receive healthcare may be inpatients and outpatients. Their needs and those of other users such as clinicians, nurses, and ancillary staff, including those responsible for the running and upkeep of the building (e.g. facilities or asset managers) may be affected negatively if the building is not well designed. For simplicity, this group is referred-to here as 'user-stakeholders'. The challenges faced include environmental comfort, sound insulation, and other aspects of space design (Bartley *et al.,* 2010) all of which designers need to recognise. This is, in theory, achieved by post-occupancy evaluation (POE), which helps the design team produce better designs (Nemeth and Cook 2007) by 'feed-back' that improves designs and avoids the repetition of mistakes (De Jager 2007). The research reported here leaves aside the aspect of defective construction (albeit an important issue) and focuses on the suitability of building design. For the purpose of this study, design is architectural design of the layout spaces and components that create a coherent, aesthetic and functional structure. To address the problem of design suitability and the satisfaction of healthcare users, it is well established that feedback from post-occupancy evaluations (POE) can offer significant benefits to design decision-making (Preiser, 2001; Preiser *et al.,* 2015; Hadjri and Crozier, 2009). If designers are able to take advantage of the post-occupancy evaluation (POE) and access feedback of the needs of user-stakeholders, these will be more likely to be met (Foulds *et al.,* 2013, Johnston *et al.,* 2016, Hay *et al.,* 2018). The research aim is to investigate on the performance gaps in the design of UK healthcare facilities through a literature review and a mixed-method approach that leads to develop a conceptual framework for the design of healthcare facilities based on users' needs. The concept is informed by the post-occupancy assessment of experienced users and builds upon the current awareness of healthcare facilities designers. The research focuses on the design of HCFs in the UK, specifically on the design of hospital inpatient wards. The research uses responses from healthcare designers and healthcare users (which includes staff and healthcare allied professionals). Although they may be relevant, it does not include the views of patients.

LITERATURE REVIEW

Joseph and Rashid (2007) argued that failure to follow the design principles could impact adversely on the design, hence patient safety. Although the principles of good HCF design have been rigorously laid out in Health Building Notes' (HBNs), research has shown design problems. Phiri (2014) discussed a set of design principles that should be considered in the brief of the design including daylight, air quality, acoustic and noise, thermal comfort, artificial lighting, and fall prevention. Other design principles such as infection control, scalability, adaptability, flexibility of the space, medication errors, isolation of rooms and beds, privacy and dignity and colour used in space have been highlighted (Reiling 2006, Clancy 2008, Phiri 2014). HCFs are complex buildings that include complex mechanical and electrical systems (Fiset 2005). For example, hospitals demand high rates of air changes to control infection, and this is one of the notable issues to be addressed by their designers. Infection

control has governed the design of wards since the 1930s, where designers started to design smaller bed bays to increase patients' privacy and mitigate infection (Hughes 2000). According to Hughes (2000) the default (Nightingale) ward design - a simple configuration of layout that included open ward with 30 beds - was based upon medical orientations (limitation of infection through high-ceilinged wards cross-ventilated by windows) and social orientations (interactions between patients in same ward). However, such designs lacked privacy and were noisy. In the design of hospitals, flexibility and adaptability of the space is a major issue. Fiset (2005) explained that hospital design needs to suit different medical practices, emerging technologies and new developments. For this, the design must respond to the need for adaptability (i.e. "the possibility of using the same space for multiple functions") and flexibility ("the ability to change internally and to grow externally, and to replace parts that have become obsolete"). Designers need to follow a set of guidance and references to design HCFs, and this to ensure the optimal delivery of projects and their ability to meet the users' requirements. Douglas and Douglas (2005) discussed design indicators for healthcare facilities and divided them in external and internal indicators. These include wayfinding, internal signage, lighting, ambience and control noise levels and acoustics, temperature control and ventilation. In addition to access to and from transitional spaces, entrances, reception, social spaces, ward environment, views and natural outlook, washrooms/hygiene facilities, personal space and ownership, privacy and dignity, nurses station/staff contact, safety and security, homely facilities, accommodation for relatives, catering facilities, leisure and recreational facilities, shops and personal services and telephone, television and Internet. Besides the external indicators that are accessibility and transport, integrated public transport, parking facilities for staff and parking facilities for patients/visitors. Others include on-site traffic and pedestrian movements, wayfinding for directional aids based on named roads and buildings, landscaping and green areas with access from internal areas, noise reduction services, safety and security in and around hospital grounds.

Design 'performance gaps'

De Wilde (2014) exposed several performance gaps that included indoor air quality, thermal comfort, acoustic performance, daylighting levels, and other criteria related to quantifiable aspects of the building. Van den Brom *et al.,* (2018) have argued that the discrepancy between the calculated and actual energy in the building, is called the "energy-performance gap", i.e., the difference between the actual and theoretical levels of energy consumption (Van den Brom *et al.,* 2018). In addition to the performance gap, which can occur between the design expected to be realised and the building performance due to construction mistakes, failure in the design, management or unclear use of building (Loftness *et al.,* 2009). Less tangible issues have been highlighted by other authors. For example, Devlin and Arneill (2003) drew attention to three problems: patients' involvement with their healthcare (i.e. the role of patient control); the ambient environment (light, sound); and the emergence of specialized building types. Furthermore, Joseph and Rashid (2007) discovered that design issues such as air quality, lighting, and room design impact the health and well-being of patients in terms of nosocomial infections, patient falls and medical errors. Van de Glind *et al.,* (2007) discussed the benefits of single patient rooms by investigating an extensive literature review and using six outcome measures that are privacy and dignity of patients, noise and quality of sleep, patient satisfaction with care, hospital infection rates of MRSA, patient safety: fall accidents, medication errors and patient recovery rates, complications and length of stay. This was supported by Alfonsi *et al.,*

(2014) who regarded "the most significant reduction of nosocomial infection is due to the introduction of single rooms instead of multiple bedrooms". Other research work by Alalouch and Aspinall (2007) has raised the issue of privacy in hospital multi bedrooms by emphasising that the design of multi bedrooms affects this aspect but it can still be positive in terms of choosing lower integration and control values. Thus, although the use of single rooms reduces the infection rate, noise and medication errors, as well as increasing the privacy aspect it remains controversial (Ugboma *et al.,* 2011).

The table below shows a thematic representation of extant research and the research gaps to support the problem statement, objectives and knowledge gaps.

Table 1: The gaps of research in literature review

Key references	Ref 1 Phiri (2014)	Ref 2 (Rashid 2013)	Ref 3 Ulrich *et al.* (2008)	Ref 4 (Li and Zhang 2013)	Ref 5 (Hay *et al.,* 2018)	Ref 6 (Andrade *et al.,* 2012)
Research core	The design issues and design principles	Benefits of implementation of EBD in HCFs	Outcomes of EBD on patient's safety	Importance of knowledge in designing HCFs	Use of POE in their research	Users' perception from HC buildings
Knowledge Gaps	The update of guidance	Limitation of EBD	Shortage of evidence	Lack of sharing the knowledge	Lack of capture of lessons learnt	Lack of involvement of users

RESEARCH METHODOLOGY

The study employed a mixed method sequential design to achieve the research objectives. This began with an online survey of HCF architectural designers to identify key design issues in hospital wards. Although other designers (for example Building Services or Structural) are involved in healthcare facility design, it was their architectural design that best fitted the context (i.e. wards) and the overall responsibility for their performance. Of the 165 architectural practices contacted (based on the RIBA register of healthcare facility specialists) 29 responded in full. This phase was then followed with 14 semi-structured recorded interviews to identify the type of data and information that should be captured and used as a reference for future projects to help improving design decision making. The final phase was an online survey of healthcare practitioners (i.e. nurses, clinicians and allied healthcare professionals) identified through contacts in the healthcare environment in hospitals and academia. The objective was to compare their responses and their satisfaction with those of the architects. A total of 47 complete responses were received, 27 were currently working as healthcare professionals and 20 were experienced healthcare professionals but had moved into academia or the third sector. The quantitative data were thematically analysed to produce descriptive statistics using SPSS and the qualitative data, after transcription were subjected to content analysis using NVIVO.

RESULTS

From the survey of designers several key design issues were identified. These were: Avoidance or reduction of the spread of infections, medication errors, and falls; fire escape strategy; the balance between daylight and artificial light, between light and shade, and between the need for isolation and visual and acoustic privacy against the need for visibility of patients and space availability. Other related criteria were air quality, noise, scalability, furniture placement, and the use of colour in the design space. The follow-up interviews with designers added greater detail to the survey

responses and confirmed earlier findings from the literature. The work of Devlin and Arneill (2003) on design and its impact on the patient's healing was confirmed in the interviews with designers who mentioned that patients need a healing environment through a better design. Designers pointed out that the visual and acoustic privacy could be achieved through the design of single bedrooms that offer privacy, dignity and confidentiality for patients besides of preventing the spread of infection control. Sometimes, however, design was compromised by inappropriate use. Designers agreed that location of ward furniture was an issue in better patient safety but said this could depend on the moving of furniture by the staff around the room. Regarding the preference of Van de Glind *et al. (*2007), Alfonsi *et al.,* (2014) and other researchers for single rooms, they noted that single bedrooms can have an adverse effect on patient psychology. Additionally, open wards help in monitoring all patients at the same time rather than travelling from one room to another and most designers conceded that the design of wards requires a mixed use of single and multi-occupant rooms. The findings indicate that designers need an update of the design guidelines, besides some requirements and feedback while designing the ward or after the building is in use. These should be given by the users such as continual user engagement, cost issues, space required, brief establishment, design follow up, user choice in design. According to one of the designers who stated that "all of the issues are equally important, and a design has to balance all of these things within guidelines, costs, time to meet the demographic [sic] of the patient and staff groups".

Table 2: The comparison of responses of designers and healthcare users

Common issues	Recognition		Implementation	
	Evidence derived from Designers' surveys and Healthcare Surveys		Evidence derived from Designers' surveys (open-ended questions) + interviews and Healthcare Surveys (open-ended questions).	
	Designers	HC users	Designers	HC users
Privacy	24.1%	31.9% Disagree	Designers' survey and open-ended quest and interviews	Healthcare survey
Comments	Healthcare users agreed on the privacy and dignity of patients being maintained but disagreed that the patients have enough privacy in patient areas. Yet, designers in the open-ended questions section and the interviews argued that they are trying to do their best to keep the privacy of patients despite the difficulty to achieve it, while balancing the observation and monitoring of patients at the same time.			
Noise (e.g. by effective sound insulation of the space)	37.9%	48.9% disagree	Designers' survey and open-ended quest and interviews	Healthcare survey
Comments	Although designers said that they focus on the sound insulation in the design, HC users disagreed that it was sufficient.			
Sightline	Not ranked	40.4% disagree	Open-ended quest	Healthcare survey
Comments	Although, designers and healthcare users agreed on the raised issues, HC users felt this was not implemented in practice, and evidence for this is shown above.			

Comparison of the Responses of Designers and Healthcare Professionals

When compared to the responses of healthcare professionals, there was clear agreement on the importance of the key design issues, yet when it came to

implementation (i.e. whether the issues were being addressed) there was a marked difference of opinion in three important areas. These were privacy, sound insulation and noise reduction, and visibility and lines of sight.

A Conceptual Framework

From the findings of the study, a conceptual framework was produced that could be implemented on a live project in order to improve design capabilities and design decision-making. Its aim is to raise the level of awareness of HCF designers regarding the users' needs and their satisfaction. The conceptual framework (Figure 2) has been developed based upon the analysis of data collected from healthcare HC users and designers (via the surveys and interviews), on how these compare to the prevalent observations derived from the literature review, and from the suggestions offered by the experts during the process of validating the framework. The framework is unique amongst existing frameworks because of the type of data and the way it was collected. Additional features of the framework were extracted from the literature review such as "General Design Problems".

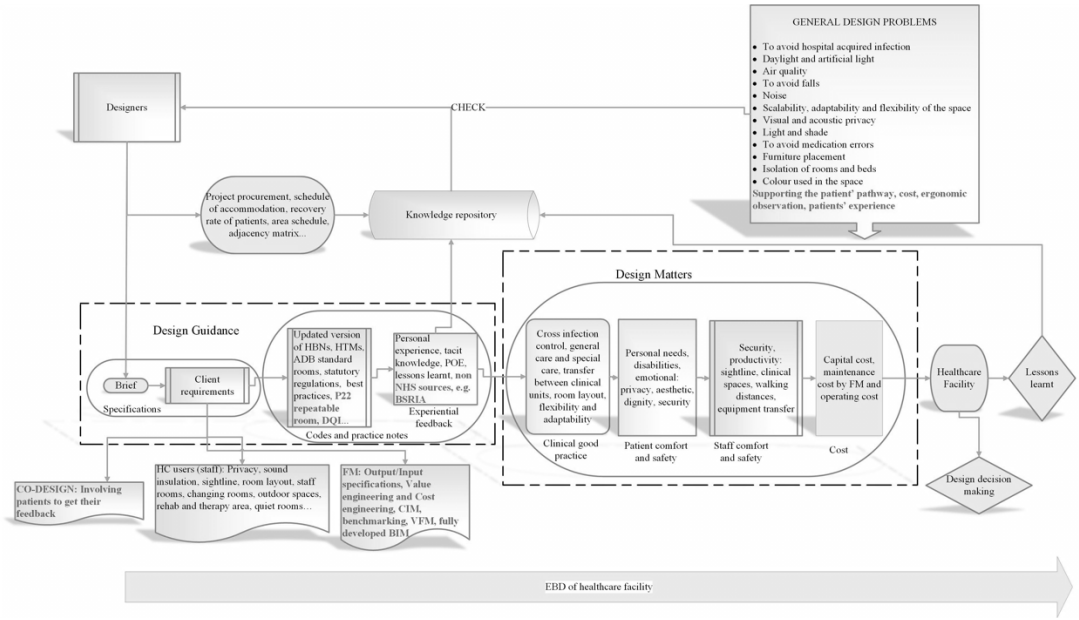

Figure 2: The conceptual framework

The conceptual framework consists of two parts; design matters and design guidance and includes designers and clients (i.e. healthcare users HC, facility managers FM, director of hospital or government). At the beginning of the process, designers meet with the clients during the brief to set their own needs. These include project procurement, schedule of accommodation, recovery rate of patients from previous healthcare settings, area schedule and adjacency matrix. During the brief meeting, clients also discuss their requirements that could be privacy, sound insulation, sightline, room layout and others. These two steps: brief and client requirements are called specifications, which is then followed by the use of designers for the codes and practice notes (i.e. health building notes 'HBNs', health technical memoranda 'HTMs', activity database 'ADB' standard) and others. When designers do not get the requirements and feedback that they need from the specification step or the design regulations, they compensate it with their experiential feedback that could involve personal experience, POE, lessons learnt and tacit knowledge. Some of these lessons learnt could be encapsulated within the knowledge repository of their system. The

design guidance is then followed by the design matters that consists of the design issues designers need to pay attention to and address properly. These include clinical good practice, patient and staff safety and cost. The design guidance and matters would help in achieving the healthcare facility project, which improves the design decision making and the lessons learnt. At the end of the design phase, designers need to check the general design problems such as (infection control, daylight, artificial light…etc.). The lessons learnt from the project will then be fed back to the knowledge repository that feeds back the designers before the brief of the next project.

Matrices for Pre-Design Requirements and Post-Design Evaluation

The research also contributed to the development of designers' requirements and healthcare users' needs in matrix format in terms of designing healthcare facilities in the UK. The matrices for Pre-Design Requirements and Post-Design Evaluation for any healthcare project in the design of inpatient ward.

The first matrix "Pre-design Requirements", consists of designers' requirements that have been identified in the interviews. These requirements were the missing data/information that designers would like to receive from the facility managers and clients. The second column is assigned to the facility managers and clients who will notify designers with the availability or unavailability of the requirements needed as illustrated in figure 3.

Designers Req / FM evaluation	Schedule of accommodatio	Recovery rate of patient	Area schedules	Adjacency matrix	Material choice	Material lifespan	Fire&management policy	Transports	Patients' Measures	Ground conditions	Project procurement
Availability	X			X	X				X		X
Unavailability		X	X				X			X	

Figure 3: Matrix of Pre-Design Requirements

The second matrix "Post-design Evaluation", consists of Healthcare users' requirements that have been identified. The second column is assigned to designers who will evaluate the tasks 'requirements' as achieved, unfinished or failed as illustrated in figure 4.

HC users Req / Designers' evaluation	Privacy	Sound insulation	Sightline	Room layout same handed	Room layout inboard	Staff rooms	Changing rooms	Outdoor spaces	Rehab & therapy area	Quiet rooms
Achieved	X			X	X		X			X
Unfinished		X	X					X		
Failed		X	X					X		

Figure 4: Matrix of Post-Design Evaluation

CONCLUSION

The empirical research in this study was conducted entirely in the UK. The study explored designers' awareness of the key challenges and problem areas that exist in the design of healthcare facilities. In general, their awareness accorded with the literature on these issues. The study also compared designers' evaluation of their performance with the satisfaction of healthcare users. There were many instances where users were satisfied, though this was not the case in certain areas. In general, it appeared that designers were somewhat complacent about their performance, the methods they use, particularly the adequacy of their experience and tacit knowledge. According to designers, facility managers do not get involved at the early stages of the design. This lack of feedback at an important stage represents unexploited

knowledge. Where FM feedback does exist, it can be conflicting at times and can change during the whole process. Designers would benefit from more systematic and explicit knowledge based upon post-occupancy feedback. Similar approaches could be taken with other respondents beyond those that were considered in this study such as FM, patients and visitors within other spaces in HCFs that could include clinical areas, outpatient or others. Evidence-based design is critical in the design of healthcare facilities (Alfonsi *et al.,* 2014), as it can reduce: the spread of infection in hospitals, stress and injuries on medical staff, and improve the healing of patients. To maximise the impact of evidence-based design and thus improve user-satisfaction, there is a need to capture lessons learnt from occupied projects. Such evaluations could be stored in a database or a knowledge base using digital (BIM-type) technologies. The conceptual framework presented in this study could form a basis for a knowledge-based repository that would inform new designs. The conceptualised framework would represent a basis for its live implementation in the future by incorporating the emerging technologies, such as BIM. Further works could also include developing enablers of real-time and rapid feedback (for example, electronic touch screen tablets) that are accessible by healthcare users to notify facility managers 'FM' with the problem area (that were identified in the designers' survey) in the ward and/or the patient room. The notification of the problem area would allow FM to fix the problem and send the lessons learnt to designers. The research can be extended to other countries based upon the design guidance and regulations implemented. Another factor to consider for further research would be cost, time that would ultimately mediate the performance of designers and the final outcome.

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