Evidence-based design for healthcare buildings in England and Wales

by

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Certificate of originality

This is to certify that I am responsible for the work submitted in this thesis, that the original work is my own except as specified in acknowledgments or in footnotes, and that neither the thesis nor the original work contained therein has been submitted to this or any other institution for a degree.

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Abstract

A substantial amount of credible evidence shows that properly designed healthcare built environments can positively impact upon the health outcomes of the building users. This offers an opportunity to improve the quality of healthcare through appropriately designed healthcare built environments. Evidence-based design (EBD) emerged within healthcare building design practice to enhance the process of designing with credible evidence. This research explored improvement opportunities for EBD in the UK which would subsequently improve the quality of healthcare through built environment interventions. Specifically, three key research gaps were addressed during this research. Firstly, this research explored current practices of evidence use during healthcare designing and opportunities to increase the direct use of research-based evidence and alternative ways of conveying research-based evidence into the design process through other source of generic evidence for design. Secondly, this research explored how evidence could be effectively expressed within healthcare design standards, guidance and tools (SGaTs) in the forms of performance and prescriptive specifications. Finally, considering the unique nature of built environment design, this research explored how project unique contextual circumstances impact EBD processes and how practitioners reflect on these circumstances. These challenges were then transformed into six objectives.

Following a comprehensive literature review, this research was divided into four phases. First, a model of the sources and flows of evidence (SaFE) was developed to represent evidence for EBD within generic evidence for design. The initial conceptual model was developed through desk study, based on the literature review, self-experience and the experience. This model was then verified with the comments from five un-structured interviews conducted with lecturers and senior lecturers of the School of Civil and Building Engineering. Finally, the model was validated using 12 semi-structured interviews conducted with design practitioners from the industry. In addition to the validating the sources and flows of evidence these interviews revealed rationales behind design practitioners use of evidence from four types of evidence sources. These results revealed improvement opportunities to increase the intake of research-based evidence use during healthcare built environments designing. The main data collection method for this research was case studies. Eight exemplar design elements within three case studies were investigated to explore details of evidence use practices; practices of using performance and prescriptive specifications; and impact of project unique contextual circumstances for EBD process and how design practitioners reflect on these circumstances.

Results of this research revealed that EBD needs to be supported by both externally published research evidence and through internally generated evidence. It was also identified that EBD could be significantly facilitated through research- evidence informed other generic design evidence sources. Healthcare design SGaTs provides a promising prospect to facilitate EBD. Performance specification driven healthcare design SGaTs supplemented by prescriptive specifications to define design outputs and design inputs could improve effective use of evidence-informed SGaTs. These results were incorporated into a framework to guide development of healthcare design SGaTs. Finally, by exploring how projects' unique contextual circumstances impact EBD processes and how practitioners reflect on these circumstances, this research identified the need for procedural guidance for designers to guide evidence acquisition, evidence application and new evidence generation.

Keywords

Evidence-based design; prescriptive and performance specifications; healthcare; standards, guidance and tools; construction

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Abbreviations

BE – Built Environment

EBD – Evidence-Based Design

DH – Department of Health

EfD – Evidence for Design

SGaTs – Standards, Guidance and Tools

EBM – Evidence-Based Medicine

ASPECT – A Staff and Patient Environment Calibration Toolkit

AEDET – Achieving Excellence Design Evaluation Toolkit

BREEAM - Building Research Establishment Environmental Assessment Method

PAM - Premises Assurance Model

PFI - Private Finance Initiative

HBNs – Health Building Notes

HTMs – Health Technical Memoranda

NIBS - National Institute of Building Sciences, US

CABE - Commission for Architecture and the Built Environment

CHD – Center for Health Design

NHS – National Health Service

WHE – Welsh Health Estates

NICE - The National Institute for Health and Care Excellence

QIPP - The Quality, Innovation, Productivity and Prevention

CQC - Care Quality Commission

NPSA - National Patient Safety Agency

Glossary of terms used in the thesis

***Evidence-based design**:* The maximum use of evidence (gleaned through research conducted according to the standards of rigour appropriate for that given research approach) and critical application of such evidence during the healthcare built environment designing to improve health outcomes of the users of such buildings

Evidence for design: The available body of facts or information indicating whether a design proposition is true or valid.

***Evidence for EBD**:* Evidence which indicates whether a design proposition (for improving health outcomes through the design) is true or valid and is gleaned according to the standards of research rigour generated by practitioners in the industry or researches within research institutions.

***Prescriptive specifications**:* The specifications which set down the characteristics of a product in terms of its size, shape, materials and other dimensions

***Performance specifications**:* The specifications which set down the characteristic functions a product has to perform.

***Design element**:* An essential or characteristic part of a design

Sub-design elements: An essential or characteristic part of a design element

Element story: A sequential account of events (timing and type of evidence used) in the development of sub-design elements.

Process steps: 15 activities of the design process described in the table 6-8.

Design steps: Design practitioners' actions of a series taken in order to achieve a particular design solution.

Design activities: Similar to process steps above.

Sources of evidence: A place, person, or thing from which evidence originates or can be obtained.

Types of sources of evidence: The four types of evidence sources categorised in the chapter five which have common characteristics.

- **Type A sources.** Evidence captured by the project team non-shared (Organisational specific evidence);
- **Type B sources.** Evidence of best practices from the industry shared by other organisations (Shared evidence from the industry);
- **Type C sources.** Published research evidence ; and
- **Type D sources.** Standards, guidance and tools.

The SaFE model: The model presented in the chapter five which demonstrates the sources and flows of design evidence.

De facto standards: A custom, convention, product, or system that has achieved a dominant position by repeated use during designing.

Guided solutions (GS): Design solutions which are chosen from published standards and guidance

Selected solutions (SS): Design solutions which were chosen from previous experience or from de facto standards but not from published standards and guidance .

Problem definition based on guided specification (GP): Problem definition based on the specifications which are set based on the published SGaTs.

Problem definition based devised specification (DP): Problem definition based on the specifications which are devised based on evidence other than SGaTs.

No pre-determined approach to problem definition (-): Instance which any pre-determined performance criteria were not apparent before proceeding to designing

Designerly ways: *Designers' preferred ways of engaging in the design activities*

CHAPTER 1. INTRODUCTION

1.1 INTRODUCTION

This Chapter presents an introduction to the research and to the thesis and is structured in six sections. The Chapter begins by providing the background and the context to this research ultimately aiming to improve quality of healthcare. This section establishes the importance of the quality of healthcare; taking a broader view and discussing contemporary efforts on improving quality and establishes the role of built environments (BE) in improving the quality of healthcare. The next section introduces evidence-based design (EBD) as a means of improving the quality of healthcare through built environments, and discusses how EBD performs this. The fourth section presents the origin and the development of the thesis concept and states the knowledge gaps focused within this research. The fifth section states aims and objectives of the research and the sixth section provides an overview of research methods used. The final section provides a guide to the structure of this thesis.

1.2 RESEARCH BACKGROUND

The ultimate aim of this research is to support improving the quality of healthcare built environments. An enormous amount of research has been conducted on quality management bringing advancements to various sectors including construction. With the rapid development of science and technology, as the society progresses, the concept of quality, scope and techniques of quality management have undergone tremendous changes (Yu and Wang, 2009). Traditionally, this started with a focus on quality inspection, quality management underwent stages of Quality control and Quality Assurance and now entered into the era of Total Quality

Management to achieve quality improvement through a management approach (Dahlgaard et al., 2005). The awareness of the state of art philosophy of quality management benefited this research. Importance of quality for healthcare and existing initiatives to improve quality within healthcare sector was identified as a background for this research. However, the main focus of the research was to contribute to the knowledge of EBD, as a means of achieving quality of healthcare.

Quality of healthcare provided to people is a major concern for a wide range of stakeholders in healthcare, such as governments, policymakers, patients/consumers, providers and tax payers (Guo, 2008). Healthcare organizations, professional associations, public and private payers, accrediting bodies and consumer groups make significant investments to improve quality of healthcare (Torres and Guo 2004 cited in Guo 2008). International and local literature, such as scholarly publications and government publications, reveal opportunities and the importance of improving the quality of the health service over many aspects (Darzy report, 2007; Institute of Medicine, 2001; Powell et al., 2009). The World Health Organisation in several of their major reports has highlighted opportunities and the importance of improving the quality of health service to all people, in all settings. The World Health Report 2000 (WHO, 2000) emphasised that money spent on health, in many countries is inadequate to achieve systems' full performance potential. The World Health Report 2002 (WHO, 2002) identified a number of critical risks to human health and how much of that could be avoided in the next couple of decades. The World Health Report 2013 (WHO, 2013) identified the importance of increasing international and national investment and support in research aimed specifically at improving coverage of health services. All these reports revealed poor performance of health services in the developing countries over developed countries. The European Observatory on Health Systems and Policies (Eurohealth, 2013) highlighted prevailing crises of health systems in Europe and called for middle and long term changes to build resilient and innovative health systems in the Europe. The US Institute of Medicine emphasised the importance of improving the quality of healthcare and provided a new strategy in their report '*Crossing the quality chasm – A new health system for 21st century*' (IoM, 2001). This strategy intends to reinvent the healthcare system by increasing the system's ability to translate knowledge into practice, and to apply new technology safely and appropriately. The strategy set aims to improve health service in six areas: *safe, effective, patient-centred, timely, efficient, equitable*.

In the UK, several national level initiatives were commenced to address the issues related to quality of healthcare. In 2010, the Department of Health published a white paper: '*Equity and*

excellence: Liberating the NHS', in which they proposed several changes to place patients at the heart of the system; to shift focus to clinical outcomes; and to empower health professionals. The changes proposed in the white paper are now being implemented. For example, the NHS Outcomes Framework was established to set out the outcome specifications of the health service and it provides corresponding indicators that could be used to measure performance of individual healthcare providers in relation to each targeted outcome (DH, 2012). Following the white paper the government passed 'The Health and Social Care Act 2012', aiming to safeguard the future of NHS. The act brought legislative changes to six policy areas: *clinically led commissioning; provider regulation to support innovative services; greater voice for patients; new focus for public health; greater accountability locally and nationally; and streamlined arms-length bodies*. In addition, few independent organisations are established to improve the quality of the health service.

- Since 1999, The National Institute for Health and Clinical Excellence (NICE) (formerly known as the National Institute for Clinical Excellence) provides national guidance and advice to improve health and social care (NICE, 2013).
- The CQC (Care Quality Commission), established in 2010, inspects the services of individual providers to ensure hospitals, care homes, dental and GP surgeries, and all other care services in England provide people with safe, effective, compassionate and high-quality care (CQC, 2013).
- The National Patient Safety Agency (NSPA), established in 2001, aims to identify and reduce risks to patients receiving NHS care and leads on national initiatives to improve patient safety (NSPA, 2013).

Despite these efforts, performance data shows that the health service in the UK has further opportunities to improve (NPSA, 2010a; Darzy, 2007; CQC, 2013). The recently published public inquiry into the Mid Staffordshire NHS Foundation Trust revealed serious failings of care provided within the trust, primarily caused by a serious failure on the part of a provider Trust Board (Francis, 2013). According to the statistics from NPSA, 612,414 patient safety incidents have been reported for the data collection period between October 2011 and March 2012 (NPSA, 2012). This is an increase of 2.3% from the previous period of data collection (April 2011 to September 2011). The results show a similar trend of increase over the last decade. The most common type of incidents reported was patient accidents (slips, trips and falls) which accounts for 26% of all reported incidents, whilst another nearly 5% of incidents related to built environments (NPSA, 2012). In their March 2013 inspection results, CQC (Care Quality

Commission) identified that 82% of the inspected care facilities met all the essential standards of quality and safety, whilst 18% of the locations failed to meet at least one of the standards (CQC, 2013). Further previous reports highlighted issues relating to poor staff and patient satisfaction and longer patient waiting times (CABE, 2008; Darzy, 2007). Examining these results, it is becoming increasingly difficult to ignore investing on research aiming to improve quality of care.

The quality of the health service is measured based on the ultimate service received by the users of the system. Yet, the final outlook of quality received by end-users is a collective effort of sub-systems of the whole system of healthcare comprising people, organizations, technologies, processes and environments. Previous literature has reviewed the total burden of diseases that can be attributed to environments related factors associated with the behavioural, social, natural and physical environments. For instance, drawing from literature and over 100 expert interviews, WHO (2006) states that an estimated 24% of the global disease burden and 23% of all deaths are attributed to environments related factors. Drawing from previous literature reviews, OECD (2001) states that the share of environments related human health loss is as high as 5% for high-income OECD countries, 8% for middle-income OECD countries and 13% for non-OECD countries. These results are less comparable since they have considered different scopes for countries, diseases and injuries and environments related factors within their researches. However, these figures raised the importance of improving our environments in order to improve health performances. These two studies cover a vast array of aspects related to environments such as impacts from air pollution, problems resulting from noise, unsafe drinking-water and poor sanitation and hygiene to inadequate pedestrian and cycling infrastructures. Built environments play a major role within environments. It is being increasingly recognised that healthcare built environments, as part of a healthcare system, can significantly influence the ultimate service quality of the system. Several systematic reviews of published literature (for instance, Henriksen et al., 2007; Phiri, 2006; Codinhoto et al., 2009; Ulrich et al., 2004 & 2008) revealed how properly designed built environments can improve psychological, behavioural, physiological and mechanical outcomes of patients and other users of buildings. A detailed review of this evidence is presented in Chapter 3 of the thesis. The NHS estate is valued at almost £40bn, in 2011-12, making it the single largest property holder in the public sector (NHS Estates & Facilities Policy Division, 2013) and is estimated to spend around 4.4 billion pounds as capital expenditure for the coming years until 2015, for new developments and a considerable amount for refurbishment projects (Department of Health, 2010). Therefore, quality improvements that could be gained during these investments by utilising existing knowledge cannot be ignored. In order to respond to this opportunity of improvement, several new

approaches emerged in the design and construction of healthcare built-environments. Some of them include participatory design, patient-centred design, Evidence-based design (EBD), experience-based design, and adaptable healthcare design. Based on an interest from within the research project which funded this research explored EBD as a way of improving healthcare built environments by utilising existing knowledge (see Section 1.4).

1.3 EVIDENCE-BASED DESIGN

The term EBD is generally understood to mean application of evidence during the designing of built environments to improve health outcomes of the building users. Traditionally, in the past, the focus of many hospital designs was efficiency, cost and clinical functionality (Gesler, 2004) and designing was based on a common set of sources of evidence. Designers today need to deal with increasingly complex issues and challenges. Consequently, normative design practices based on formal education, personal and colleagues' experience, common sense intuitions and personal interpretations is no longer sufficient when making critical design decisions (Martin and Guerin, 2007; Chong et al., 2010; Lawson, 2004; Hamilton, 2003). By incorporating the focus of health outcomes into the process of designing, and by basing design decisions on evidence, EBD intends to add value to the health service. EBD emerged in healthcare built environment design practice nearly three decades ago. The approach is backed by a substantial amount of evidence on how properly designed built infrastructure can improve health outcomes. Specifically, researchers have generated evidence of BE design strategies that could improve patient safety, patient outcomes, staff performance and staff and patient satisfaction (Phiri, 2006; Codinhoto et al., 2009; Ulrich et al., 2008). Therefore, BE designed based on this evidence can improve the quality of healthcare. However, it is worth mentioning at this juncture that there is a debate among scholars concerning what constitutes evidence for EBD. A detailed discussion regarding the definition of EBD is presented in Chapter 3. In addition to the health outcomes of patient and other users, EBD has a potential to increase operational efficiency (Berry et al., 2004) and support innovation within healthcare built environments (Lawson, 2005; Suttell, 2007). EBD gained attention at conferences and in research journals and books as a topic of interest which shows the popularity of the approach (Moore and Geboy, 2010). Due to this recognition, practicing EBD is recognised as a competitive advantage within the healthcare built environment designing market for those who practise (Stankos and Schwarz, 2007; McCullough, 2009; Stichler, 2014). EBD initially started within the healthcare sector and now recognised as good design practice for the design of other places, such as offices and learning environments (Hamilton and Watkins, 2009). All these emphasises the great potential of EBD as the future of designing healthcare BE.

1.4 JUSTIFICATION OF THE RESEARCH

1.4.1 Origin

This research first reviewed literature published on the topic of EBD. Previous literature revealed that, despite the significant role of EBD, the actual practice of EBD is limited (CHD, 2010; Chen et al., 2010; Codinhoto et al., 2010; Stichler, 2014). Thus, there was a clear need to improve the practice of EBD and contemporary scholars continue researches to explore opportunities to improve EBD.

EBD is an approach to designing. EBD suggests a progressive practice to designing by emphasising the application of evidence. Many knowledge domains can form the basis for improvements in EBD. Literature revealed that EBD has extensions to several domains including design management, project management, design knowledge, implementation of innovation, and change management. Linkages between EBD and implementation of innovation, change management, design management and project management exist as secondary aspects to EBD. For instance, underpinnings of innovation implementation literature and change management literature were used to explore the ways of promoting and implementing design solutions emerged as a result of EBD (Joseph and Hamilton, 2008; Brown and Ecoff, 2011; Zimring et al., 2008). Underpinnings from project management and design management literature were used to explore improvements to post occupancy evaluations of design as a mean of generating new evidence by designers and as a mean of verifying evidence applied (Sailer et al., 2010; Dvlin and Arneill 2003; Hamilton Fall, 2010; Viets, 2009; Stichler, 2011).

Even though there were several routes and choices to explore EBD, this research was initiated based on an interest from within the research project which funded this research: Nurturing an Evidence-Based Learning Environment which supports the Innovative Design of Healthcare Facilities (EBLE). EBLE was a collaborative research project between Loughborough University and Sheffield University. The research project had following four objectives.

1. Evaluate and integrate the systematic and structured guidance and tools that drive/generate and demonstrate/report/evaluate good healthcare outcomes.
2. Investigate building quality and safety standards, and evaluate their relationship to existing and new methods of evidence and best practice based design.
3. Develop ways of continuously improving evidence-based design while facilitating innovative practices thus nurturing a Design Quality Learning Environment.

4. Develop an approach to the categorisation and integration of healthcare service, space and estate design.

EBLE contributed to existing knowledge and practices of EBD significantly in several ways. This includes updating the previously established evidence database of international research (by Michael Phiri, Brian Lawson and their team on behalf of Department of Health UK) to include up to date evidence on how built environment improve health outcomes of their users. This evidence database is now being considered to develop into a web enabled database. Furthermore, England's and Sweden's approaches to healthcare quality and safety assurance systems were explored to understand the interrelationship between centralised and decentralised organisational structures and quality and safety assurance systems (Phiri et al., 2011; Chen et al., 2011). Finally, based on workshops and case studies the application of standards, guidance and tools (SGaTs) during the designing of different healthcare facilities and building types were identified. The categorisation and integration of healthcare services, space and estate design was explored through workshops and by being integrated into a framework by researchers at the School of Civil and Building Engineering at Loughborough University.

This PhD research was primarily conceptualised around evidence and integrating evidence into standards, guidance and tools (SGaTs) to contribute towards the second and third objectives of EBLE. The author's experience of working with construction standards and guidance also encouraged and drove this focus. Despite its origin, based on EBLE, the significance of EBD as a promising practice for designing and research gaps within EBD drove the development of the thesis concept from start to finish.

1.4.2 Development of the thesis concept

1.4.2.1 Evidence-based design (EBD) and Evidence for Design (EfD)

Previous scholars have investigated the concept, principles and the process of EBD (for instance, Hamilton, 2003; Cama, 2009; Hamilton and Watkins, 2009; Moore and Geboy, 2010; McCullough, 2009). In EBD, evidence is placed at the core of the approach and scholars have often attempted to define 'evidence'. According to EBD literature, credibility frames evidence. According to the definition of evidence (for EBD) adopted in this thesis (see Chapter 3), evidence results through research or any evidence generation activity conducted in accordance with standards of research rigour (Moore and Geboy, 2010; Zimring and Bosch, 2008). However, before the emergence of the concept of EBD, design literature used the term 'evidence' more casually and no significant, scholarly effort of a definition for 'evidence' could be identified. The

generic definition of evidence, according to the Oxford English Dictionary (2013), is, '*the available body of facts or information indicating whether a belief or proposition is true or valid'*. This definition contains nothing about the research based nature of evidence. In this context, evidence, as referred to in EBD, appears to be misunderstood or confused with generic evidence for design (EfD) by designers and scholars outside the domain of EBD. For instance, Kim (2001) found that more than 88% of designers defined site visits as research, followed by 82% who identified post occupancy evaluations as research. In 2010, based on a survey primarily responded to by US designers (78%), the Center for Health Design (CHD, 2010) reported a greater awareness of EBD among healthcare designers. However, this questionnaire survey failed to identify what designers mean by evidence and EBD. According the results of the survey, designers gather information about design strategies frequently from past projects and internet searches for projects and materials. Using the term 'methods of gathering information' this survey missed the opportunity to reveal whether the designers considered past projects, internet searches for projects and materials and other none research based information as evidence. This misunderstanding could lead to the miss-use of the term and to a situation whereby designers claim to be EBD practitioners without necessarily following the principles of EBD; as claimed by Hamilton and Watkins (2009). It was expected that clarifying the term 'evidence' as used in EBD and 'evidence' as used in EfD would help designers to progress with EBD and subsequently achieve the benefits of EBD. It would also help design researches to use the term appropriately.

EBD scholars often claim that the actual practice of EBD is limited (CHD, 2010; Chen et al., 2010; Codinhoto et al., 2010; Stichler, 2014). It was clear that this claim is based on the fact that there is a limited application of evidence published in peer reviewed academic journals or research databases. This finding corroborates the findings in design research which claimed that research produced at academic intuitions is underutilised by designers (Heylighne, 2000; Emmitt, 2007; Neuckermans and Fontein, 2002). It is true that, evidence base of EBD is primarily exists in peer reviewed academic journals and research databases. Yet, limited use of evidence from these sources does not necessarily mean that practice of EBD is limited in the UK. There are indirect means which convey research-based evidence into the process of designing. Generic EfD described above could contain research-based evidence to facilitate EBD indirectly. Specifically, in the UK, designers use an ensemble healthcare specific SGaTs produced by DH which indirectly convey research into the process of designing to a certain extent. So far, however, there was a little discussion about these alternative means of facilitating EBD or existence of EBD within

generic EfD. This formed one of the key research gaps for this research: *How is the concept of evidence-based design (EBD) applied in the practice and its linkages to evidence for design (EfD)?*

This research is different from other researches related to EBD investigating similar questions, since the research investigated the evidence (for EBD) use within the broader domain of EfD. It was expected that subsequent results may be useful for designers engaged in designing BE to identify a full array of paths they can use to access research-based evidence, and would help other researchers investigating EBD to postulate indirect approaches to EBD. Further, previous literature presented the reasons behind the limited application of research evidence and EBD. Yet, most of these researches have isolated EBD and evidence base of EBD in their exploration. In this thesis, it was supposed that investigating rationales of using and not using different sources of EfD (including research evidence) would provide better insights into limited use of research evidence compared to other EfD. It was expected that this result would help to improve utilisation of research evidence by incorporating features of well used sources of evidence.

1.4.2.2 Evidence generation

Previous scholars have identified several issues relating to evidence generation, evidence and evidence application. There is a large volume of published studies describing these issues and solutions for them. These are presented and discussed in detail in Chapter Three.

Previous scholars suggested difficulties associated with evidence generation due to lack of funding (Nelson et al., 2005; Joseph and Hamilton, 2008) and the complicated nature of researches that relates the built environments and health impact (Lawson, 2010; Codinhoto et al., 2010; Ulrich et al., 2010; Phiri, 2011). Research gaps that exist in this area are related to the generation of better evidence through integrating medical and design research and through improving post occupancy evaluations. A considerable amount of research was undertaken to improve post occupancy evaluation to support EBD and a series of generic construction management researches related to POE is being conducted. Exploration into integrating medical and design research to generate better evidence needed the support of medical researchers and medical practitioners which could have been a challenge within the limited resources available for this PhD. Therefore, this research did not explore issues related to evidence generation and as stated earlier, for the reasons stated in the section 1.4.1, this research was conceptualised around evidence, and evidence application. However, the findings from this thesis also provided some insights into issues relating to evidence generation.

1.4.2.3 Evidence base

A number of studies revealed issues of existing evidence base and evidence application. Issues related to evidence base were associated with incomplete nature of evidence base (Stankos and Schwarz, 2007; Becker and Parsons, 2007; Codinhoto et al., 2010); form and format of existing evidence (Martin and Guerin, 2007; Lawson, 2010; Chen et al., 2011); and difficulties in accessing evidence (Hamilton, 2007 & 2010; Edelstein, 2008; Martin and Guerin, 2007; Devlin and Arneill, 2003). Issues related to the comprehensiveness and completeness of evidence bases are expected to improve over time and more solutions are suggested and being investigated. But, issues related to form and format of evidence and difficulties in accessing evidence needed further attention.

With the intention of contributing towards EBLE's objectives and based on the author's experience and interest in this area, consideration was given to exploring opportunities to disseminate evidence into healthcare design SGaTs. The UK's healthcare sector is guided by a well-established set of SGaTs produced by DH. Previous scholars have suggested that these provide a promising prospect in conveying evidence into designing (Hignett and Lu, 2009; Lindhal et al., 2010; Glen et al., 1998; Tetreault and Passini 2003; Chen et al., 2011; Phiri et al., 2011; Codinhoto et al., 2010; Lawson, 2010). This opportunity has already been used previously to promote EBD. In 2004, Dr. Michael Phiri and his colleagues at Sheffield University in collaboration with DH Estates and Facilities (2008) introduced a design evaluation tool: ASPECT (A Staff and Patient Environment Calibration Toolkit). The tool was developed based on over 600 pieces of research evidence on how the built environments can impact health outcomes. Few recent studies have investigated applications of healthcare standards and guidance (Phiri and Chen, 2014) and issues related to healthcare design SGaTs (Hignett and Lu, 2008 & 2009; Lindhal et al., 2010) and how SGaTs should be made available to the designers in effective ways (Lindhal et al., 2010; Phiri et al., 2011). Researchers (EuHPN, 2011; Bishop, 2014) discussed the advantages and disadvantages of centralised and decentralised approaches to generate and disseminate SGaTs. Previous researches have highlighted the impact of the form of evidence on its subsequent use (Martin and Guerin, 2006 & 2007; Lawson, 2004; Demian and Fruchter, 2006 a, b and c; 2009; Evans, 2009). Whilst the importance of SGaTs within EBD is understood, there is little known about how evidence should be effectively expressed within SGaTs (Phiri and Chen, 2014). This thesis takes a further step and explored: '*how could evidence be effectively expressed into the healthcare design standards, guidance and tools*?'

SGaTs contents specifications in the form of performance and prescriptive specifications. Prescriptive specifications referred to the specifications which set down the characteristics of a product in terms of its size, shape, materials and other dimensions and performance specifications referred to the specifications which set down the characteristic functions a product has to perform. A too little attention has been paid to identify the composition of these two forms of specifications within healthcare design guidance and to explore how designers use these two forms of specifications. The importance of investigating this issue was also raised by the industry partners during the first steering group meeting of the EBLE project and by previous scholars (Phiri and Chen, 2014). Performance specifications promote innovation within design and innovation is encouraged by the government and researches to improve the performance of the construction sector. Several initiatives (e.g., CIB Task Groups TG 11 and TG 37, Performance Based Building Network) were established during the last two decades to explore and promote the use of performance specifications. The findings from these initiatives also suggested the importance of prescriptive specifications within a performance specifications based regulatory system. In contrast, prescriptive specifications promote standardisation in design through the use of previously tested reliable solutions. Particularly, in the healthcare sector, standardisation is also encouraged to increase safety. Furthermore, several researches have highlighted the ways in which design incorporates previously used design solutions and the existence of case based reasoning in design which is supported by prescriptive specifications. It is also recommended that use and appropriate balance between performance and prescriptive specifications should be determined relevant to the particular context (CIB Task Groups TG 11 and TG 37). Particularly, in a risk adverse sector such as healthcare, an appropriate balance of these two types of specification is important to achieve the right levels of innovation and standardisation. Therefore, taking a bottom-up approach this research investigated how designers use performance and prescriptive specifications within EBD. It is expected that these results would guide SGaTs developers to develop specifications in designers-friendly ways, and to identify the appropriate composition between performance and prescriptive specifications. Further, researchers could use these results to identify the effective forms of presenting their research findings.

1.4.2.4 Application of EBD

Issues related to application of EBD are associated with lack of skills required to gather and apply evidence (Hamilton, 2010; Martin and Guerin, 2007; Devlin and Arneill, 2003); lack of resources required to gather and apply evidence (Martin and Guerin, 2006; Lawson, 2010; Hamilton, 2010; Sailer et al., 2009; Codinhoto et al., 2010); controversies between designers preferred ways of

practising (designerly ways) and Evidence-based design (Evans, 2009; Lawson, 2004); nature of built environment designing (Becker and Carthers, 2007; Kamara et al., 2003) and performance measurement and evidence sharing (Nelson et al., 2005; Codinhoto et al., 2008; Joseph and Hamilton, 2008; Stichler, 2011; Sailer et al., 2009).

Designers need procedural knowledge of EBD to reflect on these issues and EBD scholars often emphasise this as being critical during the application of evidence (Hamilton, 2003; Hamilton and Watkins, 2009; Moore and Geboy, 2010). Very little is known about how designers tackle these issues during the practice of designing. Literature on EBD processes (see Section 3.5) provides some insights into the procedural knowledge required for EBD. However, these models have paid too little attention to the actual project level activities involved in each stage of EBD. Most of the issues discussed above exist at project level and an in-depth investigation into project level practices is required to identify solutions. Therefore, it was expected that a detailed investigation into project level approaches to EBD could be beneficial. In order to fill this gap of knowledge, this research investigated: *impact of project-unique circumstance on EBD and how designers reflect on these issues during built environment designing?* It was expected that results would provide insights into the best practices of evidence acquisition and application. It was also expected that these results would be useful for the people engaged in the process of designing to improve their EBD processes by adopting best practices, and results may convince funders of infrastructure about the importance of allocating funds on EBD activities.

1.5 AIM AND OBJECTIVES

This research aims to explore opportunities to improve EBD within healthcare built environment designing and to develop a decision support framework to guide how evidence could be better expressed within design SGaTs to support EBD. Key research gaps identified within the literature reviews around research questions stated earlier in this Chapter were then transformed into the following objectives.

1. To establish a state of art literature review for evidence-based design for healthcare building and to identify conceptual linkages between evidence-based design, evidence for design and designerly ways of using evidence.
2. To explore the current practice of evidence use within designing for healthcare buildings in order to identify how the concept of EBD is being applied.
3. To identify opportunities to improve research-based evidence use during designing for healthcare buildings.

4. To explore how design team use performance and prescriptive specifications during designing for healthcare buildings.
5. To explore the project-unique circumstances that impact EBD processes and how designers reflect on these circumstances.
6. To develop a decision support framework to develop a decision support framework to guide how evidence could be better expressed within design SGaTs to support EBD.

1.6 RESEARCH DESIGN

A thorough literature review was undertaken to examine studies related to subjects of this research and research methodology. Based on these, this research was then structured into four phases.

Phase 1. Development of a conceptual model to represent the sources and flows of evidence for EBD within generic sources and flows of evidence for design (EfD) for the healthcare built environment designing.

Phase 2. Conduct an interview survey:

a. to validate the conceptual model by identifying the sources and flows of evidence for design (including research evidence) used by designers; and
b. to identify the rationale behind using and not using evidence from different evidence sources.

Phase 3. Conduct multiple case studies to investigate:

a. how designers use evidence for design from different sources;
b. how practices use performance and prescriptive specifications; and
c. how project-unique circumstances impact EBD processes and how designers reflect on these circumstances.

Phase 4. Develop a decision support framework to guide how evidence could be better expressed within design SGaTs to support EBD.

Figure 1.1 provides further details on how the four phased design is used to achieve the aims and objectives of this research.

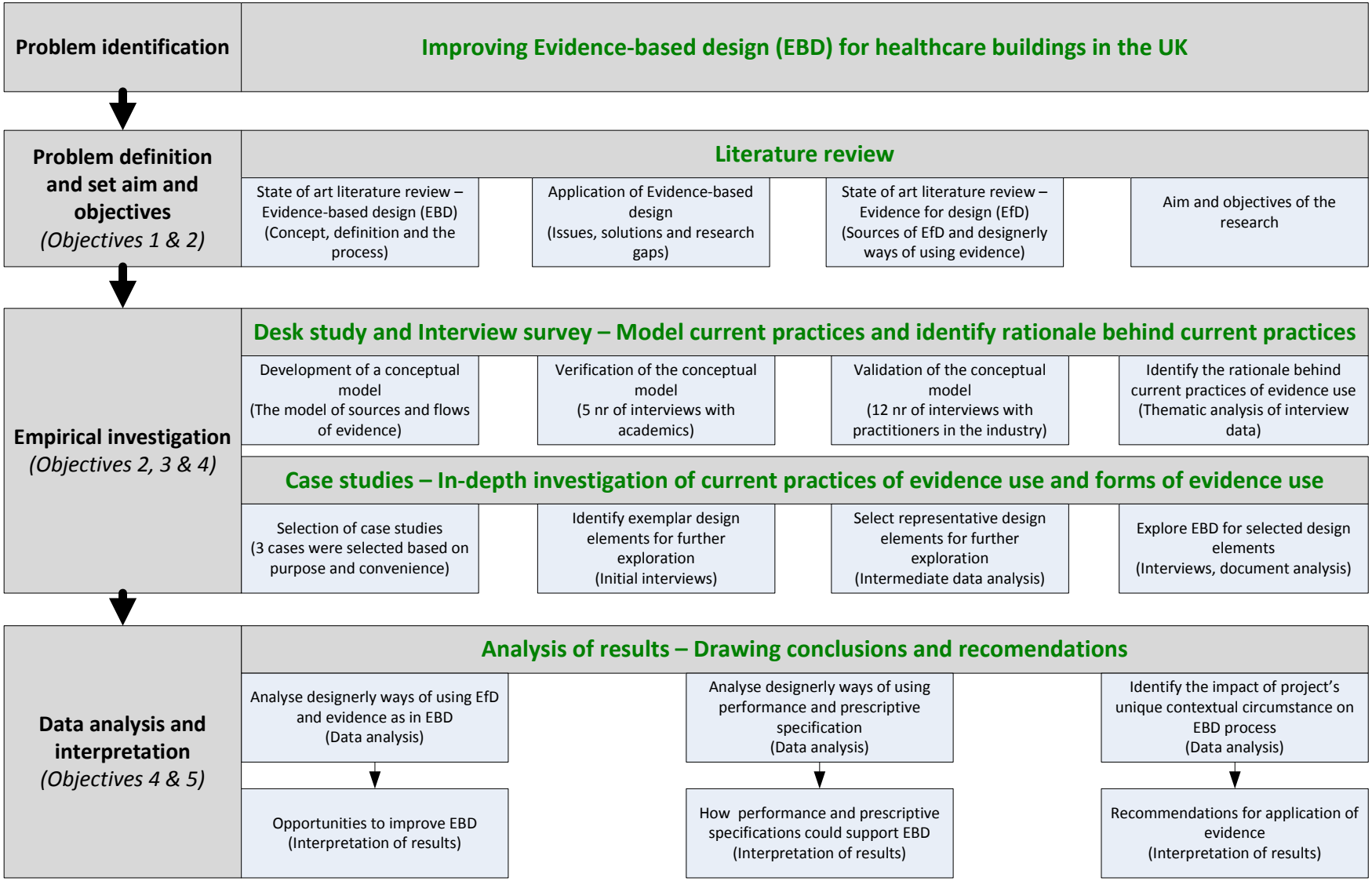


Figure 1-1: Research flow diagram

1.7 STRUCTURE OF THE THESIS

This thesis consists of eleven Chapters as described below.

Chapter 1 – introduction

This Chapter presents an introduction to the research and to the thesis. The Chapter begins by giving an introduction to the context and the background to the research. This is then followed by a justification of the thesis which describes the origination of the research based on an existing research project and development of thesis concept based on research gaps. This Chapter then presents the research aim and objectives followed by an overview of research design. A guide to the thesis is presented in this section.

Chapter 2 – Research methodology

This presents details of the research methodology and justification behind selected research methods. The Chapter begins with an introduction to the philosophical stance of this research. It then presents an overview of research designs and the rationale for the design of this research. The last two sections present actual details of data collection and data analysis procedures for the first two phases of the research.

Chapter 3 – Literature review part I – Evidence-based design (EBD)

This Chapter states and discusses the first part of the literature review. Literature related to Evidence-based design, including origin, concept and process are presented and discussed in the first section of the Chapter. The second section discusses application of Evidence-based design and establishes research gaps.

Chapter 4 – Literature review part II – Evidence for design (EfD)

The fourth Chapter states and discusses the second part of the literature review related to evidence for design. Based on existing literature, this Chapter discusses and clarifies the definition of evidence as in EBD and generic EfD. Chapter goes on to identify sources of EfD used in the current healthcare design practices. This Chapter also discusses literature related to how designers use EfD gather through knowledge and experience and EfD gathered through codified knowledge sources and available in the forms of prescriptive and performance specifications.

Chapter 5 – The model of evidence-based design

In order to clarify EBD and EfD this research developed a conceptual model of Evidence-based design and Chapter five present the details of this model. The Chapter begins with a justification of the need for a model for EBD. It then presents the initial development process of the model. Verification and validation procedures are then presented with the verified and the validated versions of the model. Finally, this Chapter presents the rationale behind the current practices of evidence use, based on the interview data analysis.

Chapter 6 – Case study process

Chapter six presents details of data collection and data analysis procedures for the case study design.

Chapter 7, 8 & 9 – Case study A, Case study B and Case study C

These three Chapters present and discuss results of three case studies respectively. Chapters begin with an introduction to the case study. The second sections present use of different types of evidence and timing of evidence use. The third sections present and discuss the form of evidence use in the current practices, in relation to evidence that insists prescriptive design solutions and evidence that insists performance criteria. The final sections present and discuss the impact of project specific circumstances on the process of EBD in each case study.

Chapter 10 – Cross-case comparison and discussions (within the context of safe model and emergent framework for composition of performance and prescriptive specifications in the healthcare design guidance)

The tenth Chapter further interprets the model and the results of the case studies in a form of a discussion. This section also relates the results of this research to the findings of the previous researches. The importance and the uses of model are presented in the first section. The sections further discuss the results of the evidence use in the current practice, based on the results of the cross case comparison. This Chapter finally draws summative insights into the opportunities to improve EBD and presents a framework for effective SGaTs to support EBD.

Chapter 11 – Conclusions and recommendation

This Chapter presents the conclusions and recommendations of the research. The Chapter begins with a discussion of how the objectives of this research were achieved. This is then followed by a discussion of contributions to the knowledge and implications of the results to academia and designers. This Chapter also discusses the limitations of this research and recommendations for further research.

CHAPTER 2. RESEARCH METHODOLOGY

2.1 INTRODUCTION

Research methodology is the overall process of how research is undertaken to achieve aim and objectives. It is governed by philosophical assumptions of the research (Saunders et al., 2009). The methodology covers research approach, research design and data collection and data analysis methods used during empirical phases (Bryman, 2004; Sounders et al., 2009).

This Chapter presents details of the research methodology adopted in this thesis. The Chapter begins with a discussion about the research philosophy and states philosophical assumptions of this research. The third section reports and discusses research methodology. This section reviews forms of reasoning and research designs in general. It also presents research designs used in this research and the rationales behind the selection of these designs chosen to achieve the aim and the objectives of this research. Section four reports and discusses details of data collection methods. This section first provides a review of data collection methods that could be used during this research and presents details and discusses data collection methods used for each phase of this research. The latter part of section five presents details of data analyses. The overall process of data analysis and specific techniques used during data analysis were first described and further details of the actual data analysis process were then provided. Details of the data analysis process for case studies are not presented in this Chapter.

2.2 RESEARCH PHILOSOPHY

Research is a systematic investigation to search for new knowledge (Oxford dictionary, 2012). This journey of search for new knowledge is influenced and bound by important philosophical assumptions about the way in which a researcher views the nature and development of the knowledge (Saunders et al., 2009; Bryman, 2004; Easterby-smith et al., 2002) specifically related to:

1. ontology (nature of reality);
2. epistemology (nature of knowledge); and
3. methodology (particular ways of knowing that reality).

Researchers' philosophical stance in relation to the above issues guide the subsequent research process by help in clarifying the research design; understanding whether a research design might work, or not, and identifying and/or creating new research designs outside his/her past experiences (Easterby-Smith et al., 2002). Establishing and stating these assumptions also helps subsequent readers to recognise easily the rationale behind researchers' approaches to research.

2.2.1 Ontological realism and relativism

Ontology is the nature of the reality of the phenomenon being investigated. Guba and Lincoln (1994) further described this as *'what is the form and nature of reality and, therefore, what is there can be known about it*'. Ontological assumptions vary between realism and relativism. Realists claim reality is real and apprehensible and they believe there is just one existing true reality, which is independent of social actors. Relativists deny a single objective reality and claim multiple, local and specific realities dependent on and constructed by social actors (Lincoln and Guba, 1994 & 2013). Both these extremes have weaknesses in their assumptions and hence have earned criticisms. Some scholars have argued non-existence of naive realism or naive relativism (Burr, 1998; Sayer, 1992; Michell, 2003). As a result of understanding and the revelation of the weaknesses of two extremes, many novice researchers now, increasingly, take a stance in the middle of the continuum.

2.2.2 Epistemological objectivism and subjectivism

Epistemology is the relationship between knower and what can be known (Guba and Lincoln, 1994). Similar to ontology, epistemological stance varies between two extremes of objectivism and subjectivism. Objectivists claim knowledge can be acquired straight forwardly, reliably and

with valid measurements (Newton et al, 2011) like viewing through a 'value free one way mirror' (SOBH and Perry, 2006). In contrast, subjectivists claim that reality is constructed by actors in the society in which the research problem exists and which can then be reinterpreted by researchers investigating the problem (Guba and Lincoln, 1994). Some scholars stand in the middle of the continuum.

2.2.3 Scientific methodologies and interpretive inquiries

Based on realism and objectivism assumptions, scientific methods are grounded in hard sciences and believe in falsification principles (Guba and Lincoln, 2013). On the other hand, supported by relativism and subjectivism assumptions, some researchers conduct interpretive inquiries, referred to as hermeneutics methodologies which involve subjective interpretation. Schwandt (2007) defined Hermeneutics as, '*where the act of interpreting an utterance, text, or action is defined as a kind of exegesis (a clarification and subsequent explication of meaning that at first appears strange and puzzling), we imagine it to be a kind of critical analysis or explanation using the method of the hermeneutic circle'* (Schwandt, 2007). Both methods are well used by researchers, irrespective of the fact that they both have earned criticisms. In order to overcome the weaknesses of two extremes, some researchers now use mix methods for research (Creswell, 2007; Johnson and Onwuegbuzie, 2006; Sale et al., 2002) or adopt methodological pluralism (Dainty, 2007).

Philosophical assumptions about all these important issues altogether construct research paradigms. Bryman (1988, cited in Dainty, 2008) defined a paradigm as a '*cluster of beliefs and dictates which for scientists in a particular discipline influence what should be studied, [and] how research should be done'*. Table 2.1 shows key research paradigms and their ontological, epistemological and methodological assumption. Positivism has been a long standing part of research philosophical history and social constructivism emerged later to overcome the inapplicability of positivism to some research issues (Lincoln and Guba, 1994; Dainty, 2008). Today, both social constructivism and positivism are widely held paradigms. However, both possess weaknesses and criticisms toward their assumptions despite their long standing nature. These two key paradigms have competed for methodological primacy and scholars often terms this as a 'paradigm war' during the 1980s (Datta, 1994; Johnson and Onwuegbuzie, 2004; Denzin and Lincoln, 2011).

Table 2-1: Philosophical assumptions of key research paradigms (source : Guba and Lincoln, 2013)

	Ontology	Epistemology	Methodology
Positivism	Naive realism – 'real' reality but apprehensible	Dualist/objectivist; finding true	Experimental/manipulative; verification of hypotheses; chiefly quantitative methods
Post-positivism	Critical realism – 'real' reality but only imperfectly and probabilistically apprehensible	Modified dualist/objectivist; critical tradition/community; findings probably true	Modified experimental/ manipulative; critical multiplism; falsification of hypotheses; may include qualitative methods
Critical theory	Historical realism – virtual reality shaped by social, political, cultural, economic, ethnic, and gender values; crystallized over time	Transactional/ subjectivists; value-mediated findings	Dialogic/dialectical
Constructivism	Relativism – local and specific co-constructed realities	Transactional/ subjectivists; co-created findings	Hermeneutical/dialectical
Participatory	Participative reality – subjective-objective reality, co-created by mind and given cosmos	Critical subjectivity in participatory transaction with cosmos; extended epistemology of experiential, propositional, and practical knowing; co-created findings	Political participation in collaborative action inquiry; primacy on the practical; use of language grounded in shared experiential context.

New research paradigms have emerged to withstand these weaknesses against positivism and constructivism. A number of specific research paradigms such as radical structuralist, radical humanist, critical realism, direct realism, and pragmatism have continually evolved over time (Creswell, 2007). Critical realism, (Sayer, 1992; Archer, 1995) for instance, is a post-positivist paradigm, which emerged to offer an alternative to naive positivism and answers the constructivists' rejection of positivism (Sayer, 2000; Danermark, 2002; Archer et al., 1998).

Unlike many domains which have established practices, construction management is a relatively new research domain which draws theories from both the natural and social sciences (Amaratunga et al., 2002; Dainty, 2008), which are then applied to the particular built environment context and requirements (Fellows and Liu, 1997). Therefore, many different theories of knowledge or paradigms compete for methodological primacy for construction management research (Dainty, 2008).

2.2.4 Philosophical stance taken in this thesis

This research aims to develop new knowledge opportunities to improve EBD within healthcare built environment designing and to develop a decision support framework to guide how evidence could be better expressed within design SGaTs to support EBD. A majority of research

evidence is contained in research journals and evidence databases (see Chapter 3). According to the previous scholars due to several reasons (see Chapter 3) research evidence generation by designers is limited and research evidence generated within research institutions are disseminated into the process of designing via indirect paths. Exploring this indirect application of research, and identifying how the concept of EBD is applied in the UK's healthcare sector, therefore formed a key research question for this research. It was expected that exploring the event taking place in the actual practice would give an idea as to the amount of research evidence use during healthcare built environment designing in the UK.

Previous literature revealed (see Chapter 4) that evidence contained in research journals is not a primary source of evidence for designing, and designers gather evidence from variety of sources. It was claimed that designers have different levels of preferences for evidence gathered through different sources. Yet, identifying the rationales behind those practices is important in suggesting improvements for EBD. It was expected that these rationales would then be helpful in identifying mechanisms that could bring a positive or negative impact for research evidence application.

Project activities are bound and controlled by a number of stakeholders, including paying clients, users of building, developers and regulatory bodies (Tzortzopoulos et al., 2009). Therefore, it was assumed that a universal solution for EBD that could be applied in all the projects, irrespective of project-unique circumstances, would not be available. However, making changes to social structures associated with EBD practices could bring a positive or negative impact for research evidence application. For instance, procurement arrangements could be considered as one such social structure. Recent P21 and P21+ procurement frameworks encourage generation of new knowledge and sharing them between other organisations. A pragmatic epistemological stance was adopted to identify these mechanisms and social structures that could have an impact on EBD practices.

Altogether, the stance taken in this thesis is therefore similar to the principles of critical realism. Critical Realism (CR) is a philosophy derived primarily from the work of Bhaskar and his colleagues (for example: Bhaskar 1978; Archer 1995). It has since been adapted, developed and described further by other scholars (for example Archer 1995; and Sayer, 1992). Researchers in organisational management and construction management have adopted this world view (Ackroyd and Fleetwood 2000; Fleetwood and Ackroyd 2004; Reed 2008; Easton 2010). Ontologically, CR assumes a stratified reality that comprises three strata: 'empirical'; 'actual'; and 'real'. The empirical layer is the socially construed (not constructed) reality observable by

individuals, while the actual layer is the events that exist in time and space. The real layer consist of the social objects possessing a structure and tendencies/mechanisms that are causally efficacious to the production of empirical events (Bhaskar 1978) (see Figure 2.1). Therefore, CR is an advanced alternative to interpretivism, which often stops the search at socially constructed empirical reality.

Mechanisms play a major role in CR's explanation; these are particular ways of acting (Sayer 1992) or what an entity is capable of doing, or being acted upon, if it is triggered and not prevented by other events (Bhashkar 1978). Mechanisms necessarily exist by virtue of their object's nature (Sayer 1992). Social objects have necessary relationships with their mechanisms. However, the relationships of mechanisms to actual events are contingent upon 'conditions'.

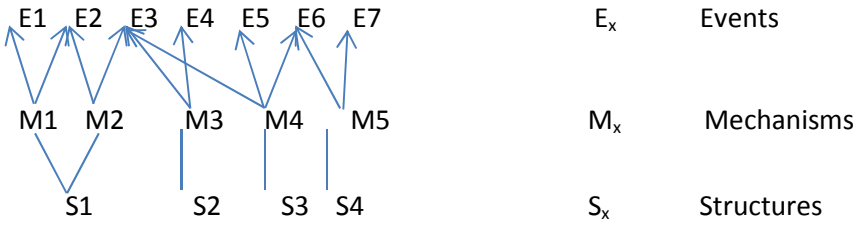


Figure 2-1: Events, mechanisms and structures (source: Sayer 1992)

These are conditioning of causal mechanisms which turns (or fails to turn) causal potential (mechanisms) into a causal outcome (Pawson and Tilley, 1997). The existence of a mechanism does not guarantee the occurrence of a particular empirical event; it could flourish or be suffocated by contingent conditions. Epistemologically, CR does not assume privileged access to the 'real' strata of reality (structures, mechanisms and contingent conditions). Bhaskar's classic example for this is that, irrespective of our (early) perception, that the earth is flat; the earth has always been spherical.

The intention of CR research in social science is not merely to provide an external description but to identify opportunities for change. Yet, identifying events at the empirical level provides a good starting point. Researchers need to hypothesise social objects and their tendencies/mechanisms that have the capacity to produce actual events. Identification of a hypothesis for social science phenomena is often considered to be easier than in natural sciences since we have 'internal access', through practice, to many of the structures, mechanisms and reasons and beliefs similar to our own which may function as causes (Sayer 1992). Further, even though natural sciences have a flat ontology over the time (since the universe began), scholars acknowledge the temporal nature of single realities for social

phenomena. Bhashkar (2008), in his transformational model of social activity, acknowledged this by explaining the emergent properties of social structures. Archer (1995) and Mutch (2010) have explained this temporal dimension through the 'morphogenesis' nature of critical reality. Sayer also (1992) acknowledged the ability to redefine social structures and change the mechanisms/tendencies of social objects by introducing radical changes. From this stance, CR's analysis could identify opportunities to redefine social structures to incorporate better mechanisms that result in more favourable empirical events.

Explicit literature on how to analyse data by a CR method is limited (Bygstad and Munkvold 2011). Sayer's (1992) explanation is that the reason for this is that CR is more concerned about ontology over epistemology, and that CR researchers takes a pragmatic approach in search for reality. But, Bygstad and Munkvold (2011) also highlighted that this could act as a barrier to novice researchers to follow CR. Therefore, this paper contributes to CR methodology by adding an exemplar application of CR to a construction management research, as described in the next sections.

2.3 FORM OF REASONING

Form of reasoning is a main part of the research approach. Literature identifies three main forms of reasoning: inductive reasoning, deductive reasoning and abductive/retroductive reasoning (Saunders et al., 2009; Briman, 2004; Blaikie, 2007; Easton, 2010; Sayer, 2004). The inductive approach refers to the way in which a researcher starts his/her research by data collection and then moves towards theory -building through that data. If prior knowledge of the phenomenon is lacking, or if this knowledge is fragmented, an inductive approach is considered more suitable to build such knowledge (Saunders et al., 2009; Hsieh and Shannon, 2005). If a research is started with theory and moves from theory to data, or involves theory or hypothesis testing, it is referred to as a deductive approach. A deductive approach is suitable when existing theory or prior research knowledge of a phenomenon exists, but is incomplete or would benefit from further research to test theories or expand understanding (Saunders et al., 2009; Hsieh and Shannon, 2005). Research can encompass one or both of these approaches for different phases of the research.

Abduction or retroduction was identified as a form of reasoning by early works of C.S. Peirce. Abduction/retroduction uses inductive and deductive forms of reasoning iteratively within the approach. According to Peirce as stated in the commens dictionary of Peirce's terms, 2003 (Bergman and Paavola, 2003) abduction/retroduction refers to studying facts and devising a

theory to explain them. Specifically, it involves '*adaption of a hypothesis on probation'* and uses empirical data to validate them. It is different from the deductive approach since probationer hypothesis is derived after immersing in the empirical data, not using theory at the beginning. Peirce describes it as '*an act of insight flashes instantly while observer immersing in the data*'. Scholars symbolise this to *'akin to finding the right key for the lock'*, where keys are plausible theoretical analogies that are assumed to be causing actual events of phenomenon (Reed, 2008; Easton, 2010). Therefore, in this method, researchers construct, apply and test those plausible theoretical and models one at a time by several data collection rounds to uncover the best explainable, real and unobservable mechanisms, or structures, which cause observable phenomenon (Reed, 2008).

Form of reasoning is often associated with the research paradigm adopted for a particular research. For instance, scientific and positivists' researches use deductive reasoning to test theories, and interpretive and constructivists' research use inductive reasoning to develop theories/hypothesises. Abduction/retroduction has later been adopted by many scholars (to name few Richardson and Kramer, 2006; Dubois and Gadde, 2002; Reed, 2008; Easton, 2010; Sayer, 2004; Blaikie, 2007) in grounded theory researches and by critical realists' researches. Critical realists' adopt abduction/retroduction to explain events (results) by postulating (and identifying) the mechanisms which are capable of producing them those events (Sayer, 2004).

A combination of all three forms of reasoning was adopted in this research as required at different research designs. These specific instances are identified in the section of research design.

2.4 RESEARCH PROCESS

This research was initiated through EBLE (Nurturing an Evidence-based Learning Environment); a major research project undertaken by the School of Civil and Building Engineering of Loughborough University. A comprehensive literature review was then undertaken to explore the research domain and research question further and this review is presented in Chapters 3 and 4 of this thesis. During the literature review, the following objectives were identified.

1. To establish a state of art literature review for evidence-based design for healthcare building and to identify conceptual linkages between evidence-based design, evidence for design and designerly ways of using evidence.
2. To explore the current practice of evidence use within designing for healthcare buildings in order to identify how the concept of EBD is being applied.

3. To identify opportunities to improve research-based evidence use during designing for healthcare buildings.
4. To explore how design team use performance and prescriptive specifications during designing for healthcare buildings.
5. To explore the project-unique circumstances that impact EBD processes and how designers reflect on these circumstances.
6. To develop a decision support framework to guide how evidence could be better expressed within design SGaTs to support EBD.

The last objective was associated with doing a desk study to incorporate results achieved through other objectives to develop a decision support framework. Literature related to research designs was reviewed to identify the most appropriate research design to achieve the rest of the four objectives.

2.5 RESEARCH DESIGN

Research design is the structure or framework that guides research method(s) (used in data collection) and the analysis of subsequent data (Bryman, 2004). Research design links together the elements of the methodology adopted for a study; relating the paradigm to the research strategy and then the strategy to the methods for collecting empirical data (Denzin and Lincoln, 2005). Literature reveals a variety of defined research designs: experiment; survey; case study; archival research; grounded theory; action research; history; phenomenology; and ethnography (Saunders et al., 2009; Bryman, 2004; Yin, 2009; Fellows and Liu, 2008; Creswell, 2007). A researcher should select an appropriate research design after careful consideration of intentions and capabilities of each design and comparison of designs with research aim, objectives and resources availability. The following is a brief discussion of intentions and capabilities of a few selected research designs applicable to this research.

Scholars have discussed how to select an appropriate research design (Yin, 2009; Bryman, 2004; Saunders et al., 2009). The main criteria that needs to be considered while selecting the appropriate research method is the research problem and the best methodological fit (Bryman, 1989; Patton, 1990). This is because different research designs have strengths and weaknesses which can affect the robustness when applied to a particular phenomenon. Yin (2009) stated three aspects of the research methodology that need to be considered when identifying an appropriate research design. They are the form of research questions, requirement of the control over the phenomenon by the researcher to explore the circumstances and the

researcher's focus requirement of contemporary events. Yin (2009) further added and identified the suitability of five main research designs for different dimensions of the above three criteria (see Table 2.2). Research design of grounded theory and action research was not originally described in Yin's (2009) table. The table was updated to include these two designs, using relevant literature.

Table 2-2: Design of different research strategies (adapted from: Yin, 2009)

Strategy	Form of research question	Requires control over behavioural events?	Focuses on contemporary events?
Experiment	How, Why	Yes	Yes
Surveys	Who, What, Where, How many, How much	No	Yes
Archival analysis	How, Why	No	Yes/No
History	How, Why	No	No
Case study	How, Why	No	Yes
Action research	How, why,	Yes	Yes
Grounded theory	How, what, So how, So what, who, why	No	Yes

These are only primary uses of each research design. Scholars have adopted these research designs for alternative purposes as well. For example, there are instances where researchers include few open ended questions (*how* or *why* questions) in questionnaire surveys. O'Cathain, and Thomas (2004) have identified difficulties of incorporating open ended questions within questionnaire surveys and how open ended questions could be used effectively. Further, case studies have been used in both quantities and qualitative researches to address *Who, What, Where, How many, How much* questions, as well as *how and why* questions (Flyvbjerg, 2006). Yet, the selection of a research method also depends on external constraints, such as cost and time (Ghauri and Gronhaug, 2005; Saunders et al., 2009).

Based on the literature on various research methods and their uses (refer to extended literature review on Appendix I), it was decided to use three research designs to achieve the aim and objectives of this research. The Table 2.3 presents details of the research designs selected for four stages of this research and the following discussion contains the rationale for these selections.

Table 2-3: Details of research designs adopted in the research

Stage	**Research design**	**Purposes**	**Contributing to objectives**
1 a	Desk study - Developing a model	1. To represent the sources and flows of evidence for design (EfD) during healthcare design process; 2. To distinguish sources and flows of evidence for EBD; and 3. To determine direct and indirect routes for EBD.	2
1b	Interviews with academics	1. To verify the conceptual model	2
2	Interview with the stakeholders in the industry	1. To validate the conceptual model by identifying sources and the flow of evidence for design (including research evidence) used by designers; and 2. To identify the rationales behind using and not using evidence from different evidence sources.	2, 3
3	Case studies	1. To explore practices of evidence use in detail; 2. To explore practices for use of performance and prescriptive specifications in detail ; and 3. To explore the project-unique circumstances that impact EBD processes and how designers reflect on these circumstances	2, 3, 4, 5
4	Desk study	1. To develop a decision support framework to guide how evidence could be better expressed within design SGaTs to support EBD	6

2.5.1 Research design - Model development

The literature review of this research revealed the complicated nature of evidence-based design and the importance of a model to represent this complicated process in a meaningful way (see Chapter 5). Therefore, sources and flows of evidence model (SaFE model) was developed as a part of this research. The rationale behind the need for a SaFE model is discussed in Chapter five of this thesis. Specific objectives of the model were:

- to represent the sources and flows of evidence for design (EfD) during healthcare design process;
- to distinguish sources and flows of evidence for EBD; and
- to determine direct and indirect routes for EBD.

Based on the available resources (which were strong) and available time (which was limited) it was decided that a desk study could be used to develop the conceptual model. Resource circumstances were positive for a desk study, in several ways. First, a considerable amount of literature regarding evidence used during the process of built environmental designing was available to use to develop a conceptual model (Emmitt, 2007; CHD, 2010; Lawson, 2004; Demian and Fruchter, 2006). Second, researchers' personal experience of working in the construction industry was supportive in identifying sources and flows of the development process. Third, supervisors in this research have recently engaged in researches related to building information and were in a strong knowledge position. Finally, several scholars in the area of design management were based at the School of Civil and Building Engineering at Loughborough University. They indirectly acted as expert input into the development of the conceptual model during the verification process. Details of data collection and data analysis are presented in Sections 2.6 and 2.7.

2.5.2 Research design – Semi-structured interviews

The conceptual model developed through the desk study needed to be verified and validated. The purpose of the verification was to ensure that the model correctly represents assumptions made during the abstraction of actual system into a graphical model. The purpose of the validation was to ensure that the model is a reasonable representation of the actual system. Both these steps required discussing the content of the model with people who could provide insights in relation to the two issues mentioned above. In order to validate the model, semi-structured interviews were conducted with five academics in the School of Civil and Building Engineering at Loughborough University. Validation was achieved with the data from semi-structured interviews with stakeholders in the industry.

Since the model is a graphical representation a questionnaire survey is less useful for this purpose, since respondents might find difficulties in understanding the model without any explanation. During the verification processes, this research needed to identify current practices as well as rationales behind practices. A questionnaire survey is not suitable to obtain answers for this 'why' question. Tan (2002) stated that personal interviews are advantageous if probing questions are involved, visual demonstrations are required or when instant feedback is desirable. Further, interviews could easily accommodate open ended questions which were essential in this step. As stated earlier, surveys are widely used in deductive research approaches to expand the understanding of existing theories and knowledge (Tan, 2002). Hence, face to face interviews were selected as the most appropriate to get more informative and accurate

feedback. Case studies and similar research designs which could be used in in-depth investigations were rejected for this step, since the model intended to represent a generic view of practices.

2.5.3 Research design – Case studies

An in-depth investigation was required:

1. to explore practices of evidence use in detail;
2. to explore practices for use of performance and prescriptive specifications in detail ; and
3. to explore the project-unique circumstances that impact EBD processes and how designers reflect on these circumstances

An ethnographic design would have been beneficial for these three intentions. However, working so closely and observing a process and collecting data in several rounds is not be feasible for a full-time student at university. Also, it is hard to get permission from an external organisation to allow an external student to intervene and observe their domestic processes. For these reasons ethnographic study is not considered for this research. Grounded theory design also had the potential for conducting the fourth and fifth objectives of the research. However, many scholars state that grounded theory design takes a long time to complete and, therefore, may not be feasible due to the limited time available in a PhD study. Further, grounded theory is more suitable for theory building, which is not the intention of this research. Therefore, the option of a grounded theory research design is also rejected.

The next available choice was the case study approach since case studies allow a collection of rich data sets through intensive investigation. It also allows collection of data through various techniques such as interviews, observations, document analysis and in an unstructured manner similar to an ethnographic study. To a certain extent case studies can employ the strong features of ethnographic studies to support a rich collection of data. This research intends explore the project-unique circumstances that impact EBD. Case study design is appropriate in this sense, since case studies are suitable to gather in-depth details about phenomenon within the context. Accordingly, a case study design was selected to partly achieve objectives 2 and 3 and to achieve the fourth and fifth objectives of this research.

Several scholars have explained how case studies could be used in a variety of researches (Stake, 2000; Yin, 2003; 2009; Flyvbjerg, 2006; Gibbert et al., 2008; Eisenhardt, 1989). Stake identified three types of case studies, which he called *intrinsic case study* (interest is about the case itself),

instrumental case study (interest is about a preconceived phenomenon and case is used to study the phenomenon), and *collective case study* (instrumental case study extended into several cases). This research does not intend to study any specific case to explore it further. For instance, if the intention of the research was to explore a selected best practice or worst practice to learn from such instance, this method would have been appropriate. This research intended to explore practices of evidence use in general, uses of performance and prescriptive specifications during designing and the EBD practices under project-unique circumstances. Hence, principles of instrumental case study are more suitable for this research. Studying multiple cases is useful to arrive at generalised conclusions. Therefore, it was decided to study multiple cases (collective case study as in Stake) which are rich in data in relation to concerned phenomenon. This is similar to *multiple case studies* explained by Yin (Yin, 2009). Yin's works on case study research (Yin, 1994; Yin, 2003; Yin, 2009) is detailed and well recognised by the researchers. Hence, this case study was designed and conducted primarily based on Yin's case study design principles.

2.6 DATA COLLECTION

Specific data collection and data analysis techniques used to conduct a research together called research methods. Data plays an important role within a research by allowing testing of existing knowledge, or to expand existing knowledge. Therefore, data collection and analysis methods should be carefully selected to ensure that they would help to collect a rich set of relevant data and which will then be analysed appropriate to arrive at valid findings and subsequent conclusions. Lankshear and Knobel (2004) stated that effective research methods are those that aim towards a particular problem, which also provides some kind of explanation or interpretation instead of simply providing information. Further, selection of research methods is also framed by the philosophical stances of the researcher. This section presents an overview of research methods and research methods adopted for this research.

There are a few widely used data collection methods by researchers. These methods are suitable for different purposes. A research could be supported by a single data collection method or multiple data collection methods. Previous scholars (Creswell, 2003; Saunders et al., 2003;, Bryman, 2008) have acknowledged the importance of using multiple methods to collect data to ensure research is supported by a valid and reliable set of data that passes data triangulation principles. This research also used multiple data sources for each phase of the research to achieve these validity and reliability criteria. Appendix I contains an extended literature review of a few widely used data collection methods and how these methods were used in this

research. The next sub-section discusses the data collection methods used in the each phase of the research.

2.6.1 Model development

The initial conceptual model was generated based on the literature review, self-experience and the experience of supervisors of this research. Chapter five of this thesis presents the process of conceptual model development in detail, including the technique used for modelling. This section primarily discusses the process of model verification. An early and informal round of verification was conducted as a series of regular meetings with academic supervisors. These comments and improvement ideas were then incorporated in the model in order to make revised versions. Revised versions were again verified by showing revisions to the academic supervisors and colleague researchers.

Finally, a formal verification was sought for the model before presenting it to the industry. Focus group and interviews were identified as suitable data collection methods to verify the model. A focus group could have been more appropriate since it is synergistic, in that participants respond to each other and reveal insights on the model. However, it was difficult to agree on a time when all the participants could meet. Therefore, individual interviews were used to collect data to verify the model.

2.6.1.1 Interviews with academics – verification of the model

The purpose of the intended interviews was to verify the conceptual model to ensure that the model correctly represents these assumptions and abstraction of the actual system. It was expected that concerns would rise over many different aspects that have been, and have not been, considered during the initial desk study. Unstructured interviews were selected for this purpose of open comments on how to improve the model over various aspects. Unstructured interviews are interactive and open-ended, where participants are given considerable control over the course of the interview (Corbin and Morse, 2003). Further, unstructured interviews are shared experiences of interviewee and interviewer and see the “interviewer as a friend”, rather than an impersonal professional (Corbin and Morse, 2003). Therefore, this form of interview allows for clarification of the issues and a better understanding of the rationales of interviewees comments.

Sampling strategy

For this step a convenient sampling strategy was adopted to interview all the lecturers in the School of Civil and Building Engineering. All the relevant lecturers who have the background of

design and design management were considered and interviewed. Even though it appears like a weak sample due to the word 'convenient sampling', the sample included prominent scholars (Stephen Emmitt and Peter Demian) in the domain of design management. Therefore, this sample was an information rich sample.

Interview process

As shown in the Figure 2.2, as the first step, identified interviewees were contacted and the interview requirements and purpose of the interview explained. All the identified interviewees were agreed to participate and times were agreed to conduct interviews. The conceptual model was given to the interviewees prior to interview to enable them to have some insights. Finally, actual interviews were conducted. Interviews lasted between 30 minutes to 45 minutes. All the interviews were voice recorded. Some participants made illustrations on the model to clarify issues. These illustrations were properly saved to be used in later analysis.

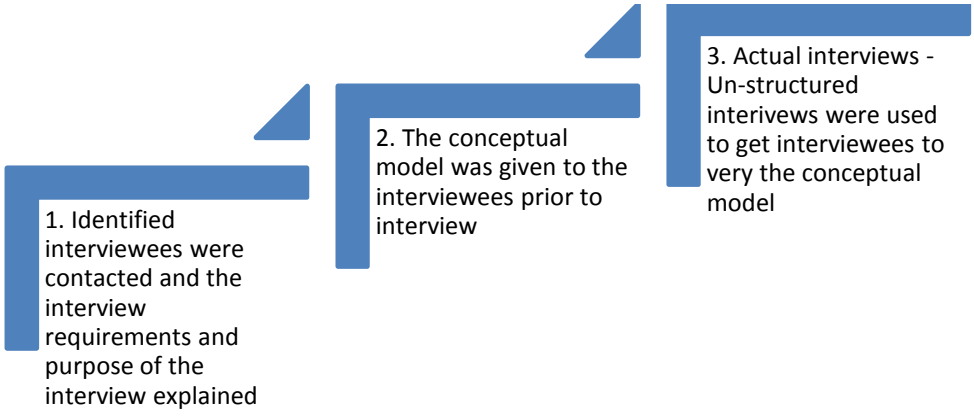


Figure 2-2: Interview process - Model verification

2.6.1.2 Interviews with the stakeholders in the industry

Type of interview

The purpose of these interviews was to validate the SaFE model, to identify current practices of EBD and to identify the rationale behind different practices. Unstructured interviews were not considered for this step since this would lead the interview conversation into various directions based on the issues of EBD as experienced by the respondents. As the aim and objectives of the research was already set at this stage it was important to control the interview conversation, in order to explore information in relation to specific aspects of the problem. This was even critical, since interviews were conducted with external professionals and the time they could spend was restricted. Similarly, completely structured interviews were considered as inappropriate. This

was because the model was primarily based on the literature and researchers' experience, and being open to contemporary EBD practices exist in the industry was important.

Semi-structured interviews were considered as most suitable for this step since this allows information to be obtained from respondents for pre-determined aspects of the problem. It is also identified that semi-structured interviewing is a very flexible technique for small-scale research with less number of participants (Simpson and Tuson, 2003). Even though the interviewer prepares a pre-determined list of questions, this flexible nature of semi-structured interviews unfolds in a conversational manner offering participants the chance to explore issues, they feel are important (Longhurst, 2003). Dainty (2008) in his systematic review of construction management research methods identified the exclusive use of semi-structured interviews.

Sampling strategy

As stated above, purposeful sampling is more appropriate for this research. The overall intention was to obtain data pertinent to generic practices of evidence use in the UK healthcare sector, based on the conceptual model. The model considered evidence use activities that evolve throughout the building lifecycle from briefing to post occupancy operation.

Hence, interviewees representing the four main stakeholders (healthcare clients, healthcare planners, Architects and healthcare constructors) were considered as appropriate participants. Senior or managerial level people were considered as more suitable to obtain information about current practice of evidence use since they are knowledgeable about overall practices of the process, as opposed to junior professionals who usually engage in activities of a single phase of the process.

A list of organisations and names for appropriate interview participants were identified using several healthcare construction related web sites. When required, further information of appropriate people within the organisations and their contact details were obtained from company web sites, and sometimes by making telephone inquiries. All the identified people on the list were then contacted to explain the purpose of the interview, and to obtain their consent and availability for an interview. Considering the resource availability a total number of the 12 earliest available respondents representing clients (N=3), healthcare planners (N=3), Architects (N=3) and constructors (N=3) were selected for the interviews and timing was agreed. All three contractors selected for the interviews were not constructors, as in traditional procurement routes, and were involved during initial design development stages and had exerted their discretion on design development as a result of new procurement routes. All three designers

had been working at the senior managerial level so that they had experience of overall design aspects, including structural and engineering services, not only architectural.

Number of interviewees

Considering the limited time and other resources available, this research questioned 12 interviewees (4 healthcare designers, 4 healthcare clients, 4 healthcare planners and 4 healthcare constructors).

Interview process

An interview instrument was developed based on the SaFE model and around the research gaps identified in the literature review (see Appendix C). The instrument was piloted with colleague researchers and academic supervisors to verify questions.

The SaFE model and questions of the semi-structured interviews were sent to agreed participants prior to interview. Interviews were conducted as semi-structured interviews with the aid of the interview instrument (see Appendix C). All twelve interviews, except one, were conducted within about three months (from December to February). One last interview with a client was delayed until the first week of April, due to the client's busy schedule. Ten interviews were conducted as face to face interviews whilst two were over the telephone. One interviewee insisted on a telephone interview due to his busy schedule, whilst the other one was a mutual decision to carry out a telephone interview, due to several postponements of the face to face interview. The duration of interviews varied from 45 minutes to 65 minutes.

2.6.2 Case studies

Case studies conducted within this research followed case study principles stated and described by Yin (2003 & 2009).

2.6.2.1 Case study design

Yin identifies four types of case study designs (see Figure 2.3). Single case studies are appropriate if the interest is about the case, or there is only one case available to study the concerned phenomenon. In all other cases, Yin recommends multiple case studies. There are two variants of multiple case studies. There are multiple case designs (designs where case is considered as a one single entity or unit of analysis) and multiple embedded unit designs (designs that have more than one embedded unit of analysis within one case).

The unit of analysis of the case study conducted in this research was evidence-based design, or application of evidence during the design process of selected projects/cases. The process of

evidence-based design is always associated with elements of the design, and a case could comprise a vast array of elements and sub-elements of design. Therefore, a particular case study could be comprised of a large number of embedded units. Parallels can be drawn with a study of the teacher-pupil relationship in a school. The relationships that exist between teachers and pupils are individual. One school may comprise a large number of embedded units that could be studied. Evidence-based design could be studied for different elements of the design such as design of patient rooms, ward layout, doors and windows, finishes. Therefore, this case study design inevitably falls into the fourth type of case study design (multiple case and embedded units) described by Yin (2009).

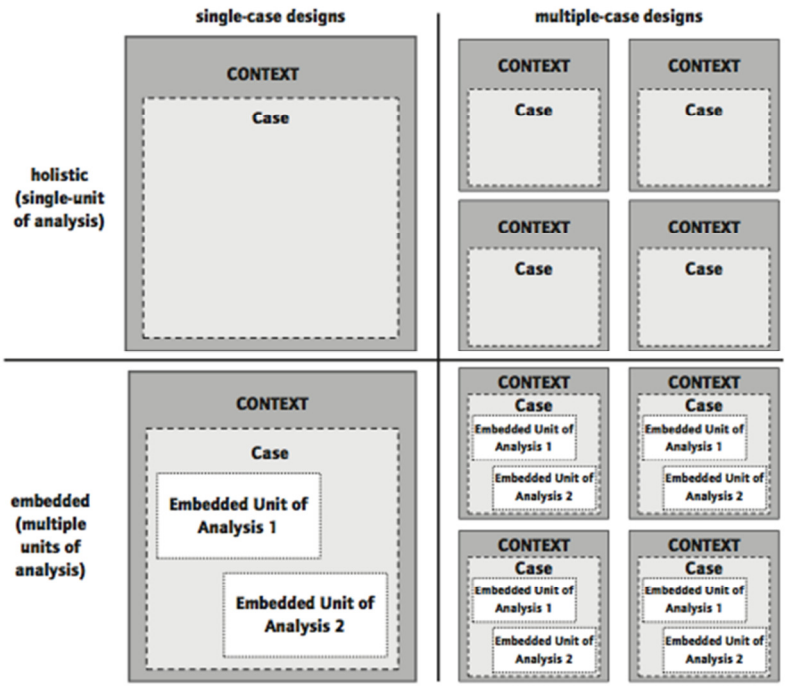


Figure 2-3: Case study design (Yin, 2009)

Due to the limited resources available, it is impossible to investigate all the elements of design or all the embedded units available within one case. The selection of appropriate embedded units or design elements in this particular research is important. This process is described in detail within Chapter 6 of this thesis.

2.6.2.2 Sampling strategy

Sampling strategy is another important element in research methods. The term 'sampling' is not commonly used in qualitative research. In this research sampling refers to the rationale for identifying participants and case studies.

Selecting participants for the survey, or sampling, is crucial for later analysis of data (Miles and Huberman, 1994). Correct sampling and carefully drawn questions make interview data and findings more reliable. Sampling strategies used in qualitative research are applicable for this research. Several scholars (for example, Miles and Huberman, 1994; Yin, 2009; Seawright and Gerring, 2008; Gibbert et al., 2008; Patton, 2002) have discussed sampling strategies used in qualitative research. 'Purposive/ purposeful sampling' is the primarily used sampling strategy in qualitative research as opposed to random sampling.' Patton (2002) has described purposeful sampling strategies comprehensively and has identified 16 different purposeful sampling strategies which are used in qualitative researches.

Number of cases

The number of cases that need to be studied depends upon the level of richness and complexity of the selected cases (Miles and Huberman, 1994). Eisenhardt (1989) suggested that four to ten cases are acceptable. The importance of increasing the number of cases is to increase the generalisation of the findings or resultant theories/hypothesises (Miles and Huberman, 1994; Eisenhardt, 1989). Considering the resources available in terms of time and money, this research involved investigation of three cases.

2.7 DATA ANALYSIS

Data analysis methods depend on the type of data gathered during data collection (Miles and Huberman, 1994). This study reviewed and used qualitative data analysis methods, since data gathered during each step was primarily qualitative. Several scholars have explained and discussed qualitative data analysis methods and techniques used within contemporary researches in general (Miles and Huberman, 1994; Grbich, 2012; Bryman and Burgess, 1994). In addition, some scholars have explained and discussed qualitative data analysis methods used for specific purposes, or within specific research designs. For instance, Ann Langley (1999) and her colleagues (Langley and Traux, 1994; Langley et al., 1995) have explained how to analyse qualitative data related to a process which they called '*theorizing from process data'* (Langley, 1999). Drawing from a systematic review of data analysis literature, Langley (1999) identified seven strategies for sense-making from data. They are *narrative strategy, quantification strategy, alternate template strategy, grounded theory strategy, visual mapping strategy, temporal bracketing strategy, synthetic strategy*. The author identified specific forms of results that are derived from each strategy and specific data needs to conduct each of type of analysis. Founders of grounded theory research design (Strauss and Corbin, 1997, 1998 & 2008; Glaser, 2005; Charmaz, 2006) have explained how to analyse data within a grounded theory research.

Yin (2003; 2009) has described how to analyse case study data. In order to apply these specific data analysis techniques the research needed to follow particular research designs, related to data collection, and the intended aim of the analysis is often dictated within the methods. Therefore, the data analysis of this research followed generic data analysis and presentation principles, explained and described by Miles and Huberman (1994), and case study data analysis as explained by Yin (2009). Miles and Huberman (1994) have comprehensively explained the data analysis process for qualitative data, starting from row data through data analysis to conclusion drawing and verification. Their book of '*Qualitative data analysis: An expanded sourcebook'* has gained a notable reputation and is heavily cited by researchers who handle qualitative data.

According to Miles and Huberman (1994 and 2014), qualitative data analysis consists of three major activities, namely:

1. data reduction/ data condensation;
2. data display; and
3. conclusions drawing and verification.

These can be concurrent activities which should be carried out during and after the data collection.

2.7.1 Data reduction/ Data condensation

Data condensation (Miles and Huberman, 2014) or data reduction (Miles and Huberman, 1994) refers to a process of selecting, focusing, simplifying, abstracting, and transforming the data that appears in written up field notes, or transcriptions (Miles and Huberman, 1994; 2014). Data reduction starts even before data collection when cases and questions that will be used during data collection are decided. During the data collection period data reduction can be in a form of writing summaries, writing memos, making clusters, where researchers select only the necessary data and store them for analysis. After the data collection period collected data may be further reduced to ease the analysis, using techniques such as abstracting, or coding data chunks, to give them a meaningful short phrase or a label. A thorough understanding of data content should be obtained by going through it several times in order to avoid erroneous abstracting, and to avoid losing the richness of data during data reduction.

As stated by Miles and Huberman (1994) '*thematic analysis'* is a widespread technique used in data reduction through coding large data chunks. Several scholars have explained the principles

of thematic analysis further (for instance, Boyatzis, 1998; Fereday and Muir-Cochrane, 2006; Ryan and Bernard, 2003). Principles of thematic analysis were useful throughout this research. Thematic analysis is a process for encoding qualitative information (Boyatzis, 1998). A theme is conceptual labels placed on discrete happenings, events, and other instances of phenomena (Strauss and Corbin, 1998). Another important entity of the process of thematic analysis is *codes*. Codes are the labels of condensed contents which allow the data to be thought about in new and different ways (Graneheim and Lundman, 2004). Codes are grouped into themes and these can then be grouped into higher level themes, if required. Initially, themes and codes may be generated inductively from the raw information, or generated deductively from theory and prior research. The former is called 'inductive thematic analysis', whilst the latter is called 'deductive thematic analysis'. Scholars acknowledge the possibility and existence of using a combination of inductive and deductive approaches. In an inductive approach to thematic analysis codes and subsequent themes are emerged within the data. This approach is suitable if there is not enough former knowledge about the phenomenon, or if this knowledge is fragmented (Lauri and Kynga, 2005 cited in Hsieh and Shannon, 2005). This approach often results in concept or theory development, or model building. Therefore, in this approach, data moves from the specific to the general, so that particular instances are observed and then combined into a larger whole, or general statement (Chinn & Kramer, 1999). One challenge of this type of analysis is the failure to develop a complete understanding of the context, thus resulting in non-identification of key categories. This can result in findings that do not accurately represent the data (Hsieh and Shannon, 2005). However, despite the above drawbacks, the author states many qualitative methods share this initial approach to data analysis. In contrast, in the deductive approach, codes and themes are pre-determined using existing theory and they are analysed within the contents/data. A deductive approach to thematic analysis is suitable when existing theory, or prior research, exists about a phenomenon that is incomplete, or would benefit from further description (Hsieh and Shannon, 2005). The primary use of deductive approach is to test theories or expand understanding (Hsieh and Shannon, 2005). Thus, during the process of the deductive approach data moves from general to specific (Burns & Grove, 2005). The main strength of this approach is that existing theory can be supported and extended (Hsieh and Shannon 2005).

2.7.2 Data display

The next step of data analysis is data display. A display is an organised, compressed assembly of information that permits conclusion drawing and action (Miles and Huberman, 1994). Visual

modes of data displays such as matrices, graphs, charts and networks are more commonly used by contemporary researchers over previous fashions of 'extended texts'. These are easily accessible, compacted forms of data displays (Miles and Huberman, 1994).

As stated earlier, a graphical model was developed to represent evidence (EfD) use during healthcare BE designing and to distinguish sources and flows of evidence for EBD. The model helped to represent simply the complex phenomena of evidence-based design. The rationale behind the model development and the process of model development are further explained in Chapter 5 of this thesis.

Principles behind some of the sense-making strategies (narrative strategy and quantification strategy) presented by Ann Langley were also partly used at this stage. As suggested by Langley (1999) narrative strategy is used as an initial step to analyse case study data. Narratives avoid over processing of data and preserve its richness. This method gives a primary focus on contextual details, which is an important element in presenting case study data. Therefore, this was specifically appropriate to use in the analysis of case study data.

2.7.3 Conclusions drawing and verification

The final step of qualitative data analysis is conclusions drawing and verification. This entails noting patterns, regularities, explanations, possible configurations, casual flows and propositions (Miles and Huberman, 1994). Verification intends to confirm the repetition of the process and conclusion by the researcher himself, or even by a peer colleague, in the research project to ensure validity of the results.

2.7.4 Details of data analysis - Model development

Interviews were tape recorded and transcribed. NVivo qualitative data analysis software supported data analysis of this research. However, NVivo was merely a supporting tool and the actual analysis was based on the data analysis principles explained earlier. Interview conversations of all five interviewees were broken down into several chunks of ideas which considered the topic or the point they were talking about. These chunks of data were then coded and labelled with meaningful short phrases of improvements, in order to represent the meaning of respective chunks for the purpose of 'data reduction' (Miles and Huberman, 1994). These are termed 'nodes' within NVivo analysis. NVivo facilitated preserving chunks of data as quotations to enable retrieval of a chunk relevant to any node if later required. These abstracted labels, or nodes, were then conceptually clustered into higher level nodes in order to group nodes representing related improvements. These conceptually clustered nodes were then

incorporated into a matrix for further analysis. A matrix allowed comparison of comments made by each interviewee under the same topic or improvement area. The conceptual clustered matrix was then expanded with two more columns to add comments by the researcher on each label, and to note down required changes that should be made to the model .

Five respondents identified 68 issues and improvement opportunities (see Table 2.4). Issues and improvement opportunities identified by respondents had overlaps and contradictions, in terms of the topic and concern regarding the issues. Therefore, data was thematically analysed in order to identify major improvement areas and concerns for the model. Nvivo software facilitated thematic analysis to make it easier and to avoid loss of data. Ten issue areas were abstracted as a result of thematic analysis. Ten themes and the corresponding nodes from different interviewees are included in Appendix C.

Table 2-4: Number of verification issues identified by interviewees during verification interviews

Respondent	Number of issues
Respondent 1 (R1)	10
Respondent 2 (R2)	19
Respondent 3 (R3)	22
Respondent 4 (R4)	7
Respondent 5 (R5)	10

Presentation made at the HaCIRIC steering group meeting did not add many comments to improve the model, but indicated/highlighted an appreciation of the importance of such a model.

2.7.5 Details of data analysis – Semi-structured interviews with stakeholders in the industry

Interviews were voice recorded and transcribed into worded documents for analysis. The primary focuses of the interviews were to:

1. to validate the conceptual model by identifying sources and the flow of evidence for design (including research evidence) used by designers; and
2. to identify the rationales behind using and not using evidence from different evidence sources.

Interviews were further structured so that practices could be identified in relation to four types of evidence sources (Type A sources, Type B sources, Type C sources, Type D sources), as identified by the conceptual model. The first step was to, read the transcribed data several times to familiarise with data. It was then realised that interview data also revealed categories of evidence which stakeholders consider during designing. This data could also be used to map and compare quality criteria considered by stakeholders against generic design quality criteria. Hence, analysis was expanded to the following third focus.

3. Identifying types of evidence used by stakeholders.

Preparation entailed reading the interview data several times, to ensure familiarisation with the data. All the transcripts were then uploaded into a NVivo project. This content was then grouped into the three major research questions listed above, and into sub-themes based on the four sources of evidence. Any other content that did not pertain to any of the focuses above were categorised as 'other' and grouped together.

2.7.5.1 Data analysis - identifying sources of evidence and methods of evidence collection (flows of evidence)

Data grouped into this category was further analysed based on the inductive thematic analysis principles discussed in the previous section. This data set was further grouped into four categories to distinguish evidence sources and evidence collection methods used for types A, B, C and D sources. Finally, while reading the data for each sub-category, emerging codes were identified for sources of evidence and evidence collection methods (see Figure 2.4).

Results of this analysis are presented in Chapter 5.

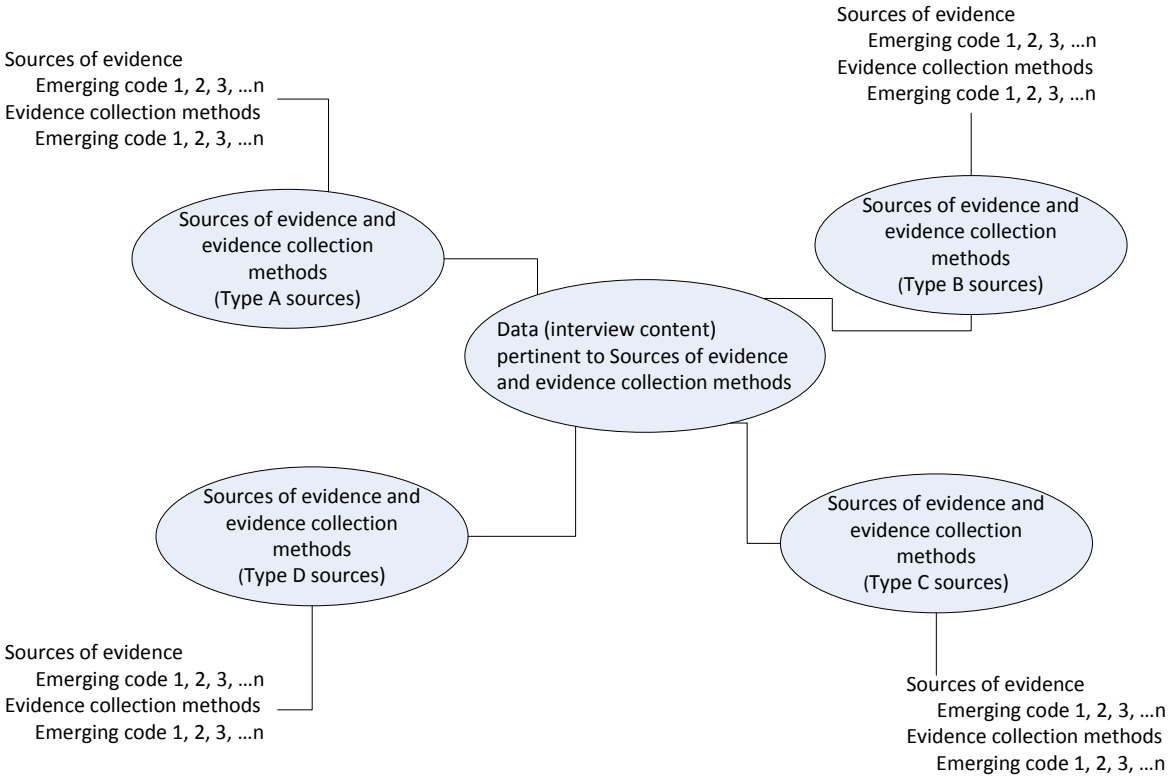


Figure 2-4: Thematic analysis for identifying sources of evidence and methods of evidence collection

2.7.5.2 Data analysis - Rationale behind current practices

Rationales behind current practices were identified based on the inductive thematic analysis principles described earlier in this Chapter. Rationale for using, and not using, evidence from four types of evidence sources were separately identified (see Figure 2.5 below).

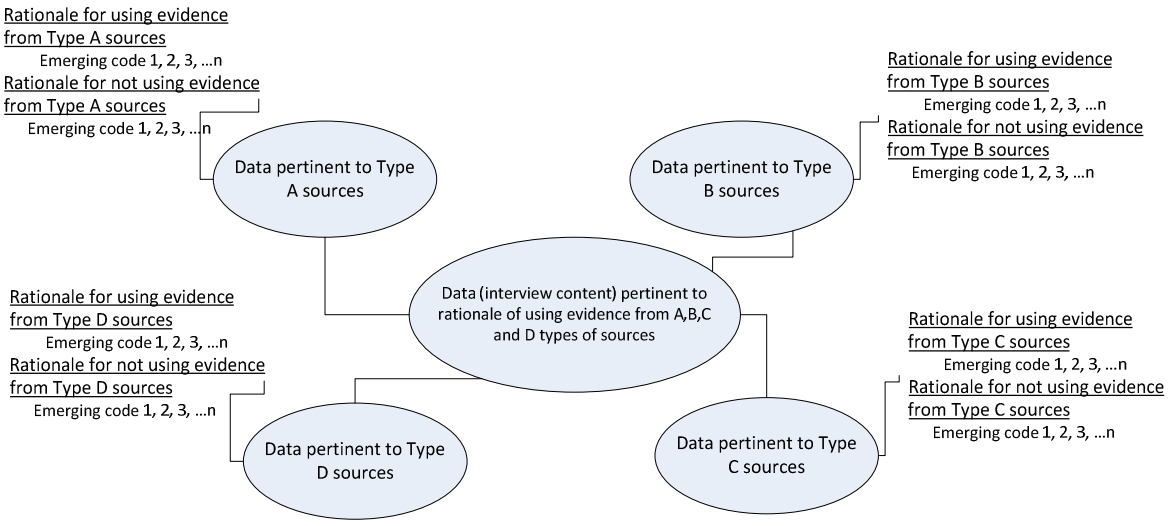


Figure 2-5: Thematic analysis for rationale behind current practices

2.7.5.3 Data analysis – Types of evidence

Data, in relation to types of evidence, was analysed both inductively and deductively. Inductive analysis was conducted to identify types of evidence mentioned by four types of stakeholders from four types of evidence sources. This allowed the identification of frequently considered types of evidence. Deductive analysis was performed to map categories of evidence revealed during the interviews against healthcare design quality criterions stated in AEDET. This allowed a comparison of quality focuses by four stakeholders.

Interview data, in relation to current practice of evidence use was gathered using a structured table template for all twelve participants (refer interview instrument in Appendix C). This facilitated data reduction pre and during interviews since participants were encouraged to talk about examples and related issues briefly. Therefore, using transcribed conversation these tables were completed directly within MS word documents. Data reduction during analysis for this section was minimal and representative short phrases were introduced only when participants had overly talked through a single data point.

2.7.6 Details of data analysis – Case studies

Details of the data analysis for the case studies are presented in Chapter 6 of this thesis.

2.8 VALIDITY AND RELIABILITY OF THE RESEARCH

Validity and reliability is an important element of any research which aims is to establish the 'credibility' of findings. Validity and reliability criteria are determined by the philosophical stance of the research (Gibbert, et al., 2008; Sayer, 1992; Denzin and Lincoln, 1994). For example, positivists identify four dimensions of reliability and validity. They are: *internal validity* (concerns credibility of the data analysis), *construct validity* (concerns to which extent a study investigates what it claims to investigate), *external validity* (concerns generalizability of results) and *reliability* (concerns absent of errors to be able to repeat the research to arrive at same results). It is obvious that criterion such as external validity is not applicable for a research conducted within an interpretivist's paradigm, since interpretivists do not intend to generalise. In response to this, in the 1980s, Guba and Lincoln substituted reliability and validity with the parallel concept of trustworthiness (Guba & Lincoln, 1981; Lincoln & Guba, 1985). Trustworthiness concerned four aspects: credibility, transferability, dependability, and conformability. The authors also identified specific strategies for demonstrating qualitative rigour. They include an audit trail, member checks when coding, categorizing, or confirming results with participants, peer debriefing, negative case analysis, structural corroboration, and referential material adequacy.

This research is primarily based on critical realists' assumptions. As stated earlier, critical realists believe in stratified reality and pragmatic epistemology. It makes sense, therefore, that internal and construct validity are applicable for this research. External validity is partly applicable for the critical realists' research because CR research is associated with stratified ontology. This research intends to generalise at an analytical level. Mechanisms and contingent conditions of EBD practices could be generalized for similar contexts. This is comparable with case study research principles proposed by Yin (2009). According to Yin, case study results are not expected to generalise at empirical level. However, analytic generalisation could be made. Finally, dependability criteria is more applicable for this qualitative research as opposed to the reliability criteria of positivists' researches. This ensured that the research was conducted without errors during data collection and analysis. Table 2.5, states measures taken during this research to ensure the reliability and validity of this research.

Table 2-5: Measures taken to ensure criteria

Criterion	**Principles**	**Measures taken in this research to ensure criteria are achieved**
Construct validity	Ensure the research studied what it meant to study.	This measure is primarily related to positivist researches and tries to ensure the research considered all related variables. Interviews Interview questions were structured around the key research questions and objectives. Case studies Case studies and embedded units of analysis were purposefully selected to ensure that the investigation follows its intentions.
Reliability of data	Data triangulation - Use multiple sources of evidence Establish chain of evidence Have key informants review draft case study report	Interviews Four types of stakeholders and three informants from each type of stakeholder were interviewed. Case studies Data was gathered through multiple sources, including informant interviews; document analysis; and observation. In addition, informants from both paying and user clients and designers were interviewed within each case study. Case studies findings were sent to the informants for their review comments.
External validity/ Generalizability	Use replication logic in multiple case studies.	Three case studies were conducted and 78 design elements were studied within three case studies.
Reliability/dependability	Take measures to ensure that the research was conducted without errors, during data collection and data analysis.	Data collection was conducted based on a case study process protocol. Analysis was reviewed several times to ensure, it was without errors. The process of data analysis was clearly stated in this thesis.

CHAPTER 3. LITERATURE REVIEW PART I - EVIDENCE-BASED DESIGN

3.1 INTRODUCTION

This Chapter presents the first part of the literature review enquiring into the domain of Evidence-Based Design (EBD). The Chapter begins by giving an overview of evidence-based design, describes the origin and background of EBD, discusses the definition of evidence-based design and establishes what constitutes evidence for EBD. The next section presents an outline of evidence-base for EBD. In particular this section provides details of the up-to-date systematic reviews of evidence on how built environments could improve health outcome of their users and the relationship between built environmental designs and health outcomes. The next section discusses evidence dissemination methods into the design process. A review literature in relation to the process of evidence-based design and the existing models of the EBD process are presented in the fifth section. The final section discusses issues related to the application of EBD and establishes the research gaps in the domain of EBD. Specifically, issues related to evidence generation, evidence base and evidence application are discussed in this section.

3.2 OVERVIEW OF EVIDENCE-BASED DESIGN

3.2.1 Origin and background

In general, the term Evidence-Based Design means designing built environments based on evidence to improve health outcomes. Making decisions based on evidence or evidence-based

practice can be traced back centuries. One of the earliest known examples is stated as James Lind's (a ship's surgeon in the British Royal Navy) discovery that fresh oranges and lemons prevent scurvy and his subsequent prescription of lemon juice to his ship's crew to prevent scurvy in 1747 (Baron, 2009). This example confirms the simplest meaning of evidence-based practice: the application of up-to-date knowledge to a wider population benefitting from such evidence. This concept later emerged in healthcare as a recognised practice known as Evidence-based Medicine (EBM). EBM is defined as the conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients (Centre for Evidence-based medicine, 2011). Today, EBM is a well-recognised practice in medical care.

Following the practice of EBM, the concept of Evidence-based Design (EBD) emerged in healthcare BE design practice. Therefore, EBD is often termed as the '*architectural parallel and analogue to Evidence-based Medicine'* (Hamilton, 2003; Lensch, 2008; Pati, 2010). The application of new knowledge in BE development is not new. However, the concept of EBD deliberately stands for evidence in relation to 'how improved built environmental features can improve patient and staff health outcomes'. In the literature, this effect is often termed as 'therapeutic nature of design' (Gesler, et al., 2004, Curtis et al., 2007; Devlin and Arneill, 2003). Throughout this thesis, the term 'therapeutic building evidence' is used to denote evidence related to therapeutic built environmental designs.

For a long time we have been aware that our surroundings affect our health. The desire to create healing environments can be traced back to ancient European medicine. For instance, the '*asclepieion hospital'* in ancient Epidaurus (in Greece) was built in the sixth century BC to support patient healing (CHD,2010a). The earliest known written therapeutic building evidence contained in the notes of Florence Nightingale (1820-1910), a British nurse who attended wounded soldiers during the Crimean War and who is identified as the founder of modern nursing. Her notes explain her knowledge (gained from her nursing experience) of how surroundings can affect healing. Quoted below are her notes on what she understood to be the healing power of one's surroundings.

> *"....I should be inclined to rank light in importance for the sick. Direct sunlight, not only daylight, is necessary for speedy recovery … I mention from experience, as quite perceptible in promoting recovery, the being able to see out of a window, instead of looking against a dead wall; the bright colours of flowers; the being able to read in bed by the light of the window close to the bed-head. It is generally said the effect is upon the*

mind. Perhaps so, but it is not less so upon the body on that account....” (Nightingale 1860/1969 cited in Rubin et al., 1998; Cama, 2009; Marcus and Barnes, 1995)

These notes of her experience prove early knowledge of therapeutic building designing. However, these ideas have not been systematically researched until relatively recently.

Architecture has taken human behaviour into account during designing for a long time and this has also been researched by scholars in behavioural architecture studies. For instance, in 1974, Jon T. Lang and his colleagues published a book about '*Designing for human behavior: architecture and the behavioral sciences*'. Similarly, in 1977, Clovis Heimsath published a book on '*Behavioral architecture: toward an accountable design process'*. The primary concern of these studies is the behavioural outcomes of users that could be influenced by the built environment. EBD is a step forward from behavioural architectural research in that the primary concern of EBD is the health outcomes of users and it considers a vast array of psychological and physiological outcomes that could be improved through built environments. A research undertaken by Roger Ulrich in 1984 was the first known research to produce evidence to support EBD. Roger systematically researched the impact of view on the nature of healing. He concluded that a 'view through the window may influence recovery from surgery'. Since then various researches have contributed to the knowledge of how buildings can improve the health outcomes of their users. Specifically, researchers have explored how to enhance patient safety, patient outcomes, staff performance and staff and patient satisfaction through various improved built environmental strategies (Codinhoto et al., 2009; Ulrich et al., 2008; Dijkstra et al., 2006; Rubin et al., 1998; van-den-Berg, 2005).

In summary, there are other processes, concepts, tools and philosophies that existed before EBD emerged as a concept. However, EBD is a step forward from these previously existed researches and approaches due to its intention to improve patient outcomes by applying substantiated evidence. Defining

3.2.2 Defining evidence-based design

As stated earlier, in simple terms EBD refers to designing built environments based on evidence to improve health outcomes. Several scholars have defined EBD in several instances. It was also apparent that the definition of EBD has developed gradually over the last decade. Examining the definitions of EBD, it was apparent that three key elements distinguish EBD from other related approaches: evidence, evidence application and intention of EBD. EBD emerged to the healthcare designing with the intention of improving health outcomes of health building users:

staff and patient. Section 2 of this Chapter reviews this intention in detail and section 3.3 reviews specific details of the health outcomes which EBD intend to improve. Definitions of EBD are consistent for evidence application and intention of EBD. But, literature reveals a debate for the definition of EBD in relation to evidence.

3.2.2.1 Definition of EBD - Evidence (Evidence for EBD)

As discussed earlier in the Chapter 1, the term evidence is used by scholars and designers more casually and clarifying the term would provide a strong base for this thesis.

According to the Oxford English dictionary (2013) evidence is, *'the available body of facts or information indicating whether a belief or proposition is true or valid'*. Adapting this definition to fit the context of designing, evidence for design (EfD) is:

> '*the available body of facts or information indicating whether a design proposition is true or valid'*.

This generic definition does not specifically emphasise the characteristics of evidence. But, within EBD literature, 'Evidence' for EBD is frequently tagged with the attribute 'best' and or 'credible'. What is 'best' or 'credible' has often been debated in EBD literature. Table 3.1 summarises selected explicit definitions presented by scholars to characterise 'evidence' for EBD.

Some scholars (for instance, Dijkstra, 2006; Salonen et al., 2013; Huisman et al., 2012) have been extremely strict as to what could be considered as 'evidence' and claim only the 'scientific research derived through randomised controlled trials' to be evidence. However, some scholars' definition of 'evidence' is loose. For instance, 'evidence from practice' or 'experiential evidence of practitioners' is vague and could mean any facts or information presently used by designers. Evidence for the parent concept: EBM often generated through scientific research derived through randomised controlled trials. Based on this principle that some scholars of EBD (for instance, Dijkstra et al., 2006; Stankos and Schwarz, 2007; The American Society for Healthcare Engineering, 2009) argue that evidence of EBD should be scientific research derived through randomised controlled trials similar to its parent practice of EBM. The best knowledge is generated through research. It is true that scientific research evidence derived through randomised controlled trial is high in rigour and credibility. However, the major drawback of this strict definition of 'evidence' is that it does not acknowledge the difficulties of deriving built environmental related research based on positivists' assumptions.

Table 3-1: Definitions of evidence presented by EBD scholars

Reference	Definition
Hamilton and Watkins (2009)	"….current best evidence from research and practice…."
Newhouse et al 2007 cited in Stichler 2010	"….best available scientific evidence with best experiential evidence of practitioners…"
Becker and Carthers (2007)	"……academic based and practice based research…"
Moore and Geboy (2010)	"….available evidence gleaned through the most up to date credible research conducted according to the highest standards of rigour appropriate for that given research approach…."
Moore and Geboy (2010)	"…..research based knowledge….."
Malkin (2008)	"……best available research evidence…."
Fischi (2006)	"…..preferably based on scientific research….."
Hamilton (2007)	"….more rigorous research evidence…."
Hamilton (2003)	"….best available information from research and project evaluations…"
Dijkstra (2006)	Evidence derived through "…..well-conducted controlled clinical trials…"

Several scholars have recognised the difficulties of generating scientific evidence within built environment researches (e.g. Moore and Geboy, 2010; Dvlin and Arneill, 2003). Dvlin and Arneill (2003) explained the difficulties of achieving experimental control in architectural research. Stankos and Schwarz (2007) explain the difficulties of identifying causal relationships between specific design intervention and health outcomes due to the complexity of separating single design intervention from other design interventions as well as separating health outcomes caused by built environmental interventions and other interventions. Also, there is a large number of independent and dependent variables associated with the built environment and health outcome researches (Ulrich et al., 2010). These are associated with different patient groups and different spaces in a hospital (Codinhoto et al., 2010). Finally, some environmental variables might have both negative and positive impacts on different aspects of outcomes. For example a view through a window and access to a garden is considered to be supportive of healing by improving physiological outcomes but at the same time this intervention could be negatively perceived due to the transmission of pathogens into the patient areas (Priya, 2010). Looking at these issues it is obvious that scientific research approaches are not always suitable for generating evidence for EBD. In some instances, mixed method researches would be beneficial as opposed to positivist research which generates rules and principles. Increasingly, built environment researches take post-positivist and other research paradigms with the support of qualitative research methods and mixed method research. These non-positivist researches are well-received as rigorous research by academic journals with high impact factors.

In the early stages of EBD, evidence has referred to evaluations of projects, well established best practices, and reliable observations. For an example, Hamilton in 2003 stated that,

> *"An evidence-based designer makes decisions ……. based on the best available information from credible research and evaluations of projects."* (Hamilton, 2003)

Similarly, Geboy (2007) refers evidence to:

> *'documented research and well-established best practices'.*

The main weakness of this type of definition of evidence is the failure to adhere to the original principles of EBD. If designers rely on best available information from evaluation of projects, the difference between EBD and normative practices of designing is questionable. Therefore, considering the evaluation of projects as evidence for EBD challenges the concept of EBD. There are two other major drawbacks in the definition of evidence. Firstly, post occupancy evaluation in the construction industry is considered to be poor, thus designers' experiential learning is often incomplete and anecdotal. Secondly, evidence for EBD is associated with user outcomes gained through built environmental interventions. Essentially, these improvements are associated with the psychological, behavioural, physiological and mechanical outcomes of users. Because designers lack the training for doing research (Joseph and Hamilton, 2008) it is challenging for designers to generate evidence of these types of user outcomes without systematic investigations. Therefore, this extreme of the definition of evidence have earned criticisms from scholars. For instance, Cama (2009) states that this poor definition has led to the misunderstanding that some designers believe that use of any type of post occupancy evaluation data from former projects is EBD. Hamilton and Watkins (2010) have also identified this misunderstanding among designers.

Based on the above rationale this thesis rejects above discussed two extremes of what constitutes evidence. This thesis acknowledges that evidence as any research based evidence gleaned according to the standards of research rigour generated by practitioners in the industry or researches within research institutions. Both scientific researches as well as interpretive researches are considered as generators of evidence, to the extent they are gleaned through credible research conducted according to the standards of rigour appropriate for that given research approach. This stance is similar to the definition of evidence for EBD presented by Moore and Geboy (2010) in their comprehensive paper: 'the question of evidence'. This definition admits both academia and designers as origins of evidence.

3.2.2.2 Definition of EBD - Application of evidence

As claimed by EBD scholars, critical application of evidence (for EBD) is an important element of EBD (Hamilton, 2004; Hamilton and Watkins, 2009; Stichler, 2007). Despite its importance, previous researchers have not explored 'critical application' in much detail. Hamilton and Watkins (2009) defined critical application as '*conscious, explicit and judicious use of evidence'*. It could be observed that this is merely a definition borrowed from evidence-based medicine. Further, research-based evidence base of EBD is only a subset of generic evidence for design (refer discussion in the Chapter 4 of this thesis). Therefore, designers cannot always rely solely on research-based evidence during designing but maximum use of such evidence. Due to the unique nature of built environment designs, EBD is not an instrumental application of evidence to confront problems and critical application is an important element in EBD (Hamilton, 2003; Hamilton and Watkins, 2009; Stichler, 2007). A little is known about how designers apply evidence in different project-unique circumstances and their reflective activities in these circumstances. It was expected that exploring this issue would help to identify best practice for gathering and applying evidence successfully.

In summary, EBD can be defined as the maximum use of evidence (evidence gleaned through credible research conducted according to the standards of rigour appropriate for that given research approach) and critical application of such evidence during the healthcare built environment designing to improve health outcomes of the users of such buildings.

3.3 EVIDENCE BASE

According to previous literature the current evidence base of EBD describing how buildings impact on health outcomes exceeds more than 1200 pieces of published evidence (CHD, 2008). Although a number of systematic reviews has been carried out on published evidence (for EBD), the contribution from designers to the EBD evidence base is largely unaccounted. This research does not intend to explore those evidences in detail, but summarises the available research evidence and design strategies based on secondary literature reviews.

3.3.1 The content of evidence base for EBD – systematic reviews of evidence

Several scholars have carried out systematic reviews of literature to identify and evaluate the research evidence base supporting EBD. Fourteen such generic systematic reviews could be identified within literature. Brief descriptions about each of the fourteen reviews are presented in Table 3.2. It is noticeable that there is a recent trend to conduct systematic reviews for

research evidence in relation to a particular space, care setting or a particular patient category. Some of the examples include:

- Lorenz et al., (2008)'s evidence review for improving palliative care at the end of life;
- National Association of Children's Hospitals and Related Institutions – NACHRI (2008) review of evidence related to the impact of the physical environment in paediatric care settings;
- Bartlett (2013) review to identify design features that are evidence-based which can be used to create an optimal inpatient psychiatric patient room; and
- Ulrich (2003) review of evidence related to the impact of single patient rooms on patient outcomes.

The number of these restricted systematic reviews is increasing and this thesis reviewed only holistic and generic reviews. Two of the systematic reviews identified in Table 3.2 were conducted in the UK. Dr. Michael Phiri and his colleagues at Sheffield University conducted a comprehensive review in 2006. The results of this review have informed SGaTs published by Department of Health, UK. Specifically, ASPECT (A Staff and Patient Environment Calibration Tool) was developed based on this review and the ASPECT tool has an additional evidence layer if designers want to see evidence supporting the design evaluation criteria included in the tool. In addition, this evidence was compiled into a 'Safe environmental database' for organisations involved in the designing to purchase. An evidence review conducted within the EBLE project in 2012 is a continuation of this previous review, by same authors, and in collaboration with Loughborough University.

Table 3-2: Systematic reviews of literature which identify the content of therepeutic evidence base (generic)

	Author(s)	Year	Title	Coverage	Country	Main findings	Other comments
1	Phiri M.	2006	Does the physical environment affect staff and patient health outcomes?	1965-2005	UK	Built environments if properly designed help * Infection control * Reduce accidents (slips, trips and falls), manual handling injuries including musculoskeletal disorders * Reduce medical errors, medication errors and adverse events * Reduce violence and damage to property and Views, nature and outdoors improves health outcomes	
2	Ulrich et al.	2004, 2008, 2010	A review of the research literature on Evidence-Based Healthcare Design	more than 600 studies	USA	Built environments improve * patient safety (reduced hospital-acquired infections, reduced medical errors, reduced patient falls), * other patient outcomes (reduced pain, improved patient sleep, reduced patient stress, reduced depression, reduced length of stay, improved patient privacy and confidentiality, improved communication with patients & family members, improved social support increased patient satisfaction), and * staff outcomes (decreased staff injuries, decreased staff stress, increased staff effectiveness, increased staff satisfaction)	
3	Codinhoto et al.	2009	The impacts of the built environment on health outcomes	92 papers	UK	Impact of ergonomics, fabric/ambient, art and aesthetics and services on psychological, physiological and physical outcomes of patient and staff	1163 abstracts were assessed, leading to 92 papers being reviewed
4	Rubin et al.	1998	An investigation to determine whether the built environment affects patients' medical outcomes	84 studies, 39 of which “weak study designs”	USA	Suggested Applications: quiet, music, and air quality 1. Quiet in the CCU 2. Music during minor surgery 3. Air quality 4. Exposure to daylight and sunlight	
5	Dijkstra et al.	2006	Physical environmental stimuli that turn healthcare facilities into healing environments through psychologically mediated effects: systematic review	30 out of 533 found	Netherlands	ambient features - sunlight, sound, odour architectural features - windows, spatial layout, interior design features - nature, television, seating arrangements "Predominantly positive effects were found for sunlight, windows, odour and seating arrangements. Inconsistent effects were found for sound, nature, spatial layout, television and multiple stimuli interventions"	"However, when scrutinising the effects of specific environmental stimuli, conclusive evidence is still very limited and difficult to generalise. The field thus appears to be in urgent need of well- conducted, controlled clinical trials”.

6	Schweitzer et al.	2004	Healing Spaces: Elements of Environmental Design That Make an Impact on Health		Canada	Personal space, The sensory environment (smell, sound/noise, temperature), fresh air and ventilation, light (natural and artificial), colour, viewing nature, experiencing nature, arts, aesthetics, and entertainment (visual arts/sight, music), positive distractions: humour and entertainment	A review of 185 journals from the 1950s thru mid-1997(78,761 published studies), , 109 studies were judged as having sufficient methodology, 84 were selected for this discussion
7	Huisman et al.	2012	Healing environment: A review of the impact of physical environmental factors on users	65 out of 798	Netherlands	This study demonstrates that evidence of staff outcomes is scarce and insufficiently substantiated. With the development of a more customer-oriented management approach to HCF, the implications of this review are relevant to the design and construction of HCF. Some design features to consider in future design and construction of HCF are single-patient rooms, identical rooms, and lighting	Out of 798, 65 articles were selected for review: fewer than 50% of these papers were classified with a high level of evidence
8	Phiri M. (EBLE Project)	2011	The Healthcare Environment Architectural Reference	600 research papers	UK	An extension of 1 above.	
9	Devlin and Arneill	2003	Health Care Environments and Patient Outcomes : A Review of the Literature		USA	the impact of the ambient environment (e.g., sound, light, art)	
10	Van den Berg	2005	Health Impacts of Healing Environments A review of evidence for benefits of nature, daylight, fresh air, and quiet in healthcare settings Agnes E.	1975-2005	Netherlands	Health benefits of nature - views of nature, gardens, indoor plants Health benefits of natural elements - daylight , fresh air, quiet on • Clinical outcomes (e.g., length of stay, medicine intake, infection rate, physiological stress measures, mortality); • Psychological outcomes (e.g., mood states, alertness, quality of sleep, subjective health and well-being). Concluded with Guidelines: 1. Install ventilation systems that allow a generous supply of fresh air. 2. Provide visual access to nature 3. Use sound-absorbing ceiling tiles 4. Be cautious with the application of daylight and lamps that mimic daylight in buildings 5. There is no need to avoid indoor plants in hospitals.	Studies that employed quantitative measures, studies that employed qualitative measures (e.g., content analysis of personal experiences of patients or staff) were excluded.

11	Salonen et al.	2013	Physical characteristics of the indoor environment that affect health and wellbeing in healthcare facilities: a review	214 publications	Australia	*Strong evidence on :* the acoustic environment, ventilation and air conditioning systems, the thermal environment, the visual environment (e.g. lighting, and views of nature), ergonomic conditions and furniture *In contrast,* the effect of special layouts and room type and floor coverings may be beneficial for one group and detrimental for another. Some of the physical factors may, in themselves, directly promote or hinder health and wellbeing, but the factors can also have numerous indirect impacts by influencing the behaviour, actions and interactions of patients, their families and the staff members.	A Pubmed search of the literature published from 1 January 1975 through to 10 August 2012 209 publications have been selected for this review,
12	Ulrich R.	1991, 1992	Effects of Interior Design on Wellness: Theory and Recent Scientific Research, How design impacts wellness		USA	Effect of interior design on 1)sense of control 2)social support and 3)positive distraction	

This updated evidence base is currently being developed into a web-based database. A systematic review carried out by Professor Roger Ulrich and his colleagues is also recognised as a comprehensive review of evidence: the results of this review are renowned among EBD scholars and designers around the world. Scholars from several other countries such as Netherland, Canada and Australia have also conducted generic evidence reviews. The debate about what constitute evidence is clearly noticeable within these reviews. For instance some reviews (e.g. Dijkstra, 2006; Salonen et al., 2013; Huisman et al., 2012) have been extremely strict as to what could they consider to be 'evidence' and have considered only the 'scientific research derived through randomised controlled trials' as evidence.

3.3.2 Relationship between built environment and health outcomes

Drawing from existing literature, Gesler (2004), showed the relationship between healthcare built environments (physical, social and symbolic environments) and patient and staff outcomes. Ricardo Codinhoto and his colleagues at Salford University (Codinhoto et al., 2009) conducted a systematic literature review to explore the nature of the relationship between health outcomes and the built environment. The results confirmed the existence of evidence to support a direct relationship between built environment interventions and the psychological, physiological and physical outcomes and an indirect impact due to links between three types of health outcomes. Results of this review are presented in a framework (see Figure 3.1). However, some elements such as therapeutic gardens and other landscaping features contributing to healing are not explicit within this framework. Ricardo's study would have been more useful if authors have indicated the strength of each relationship.

Based on their own systematic review of published research evidence supporting EBD, Ulrich and his colleagues (Ulrich et al., 2010) presented a more comprehensive model of participant and organisational outcomes of the healthcare built environment (refer Figure 3.2). This model is more comprehensive for two major reasons; firstly, the model details sub-categories for built environmental variables and user outcomes, which would enable a novice reader, who uses this model, to grasp the spirit of the existing research evidence base. Secondly, the model also acknowledges the impact of different user demographics and other control/confounding variables that impact on the main relationship between built environment intervention and health outcomes. Designers who apply evidence can use this model to interpret and evaluate the applicability of the evidence they have gathered when they are applying evidence in a different context. Researchers could use this model to frame their researches and identify relevant variables.

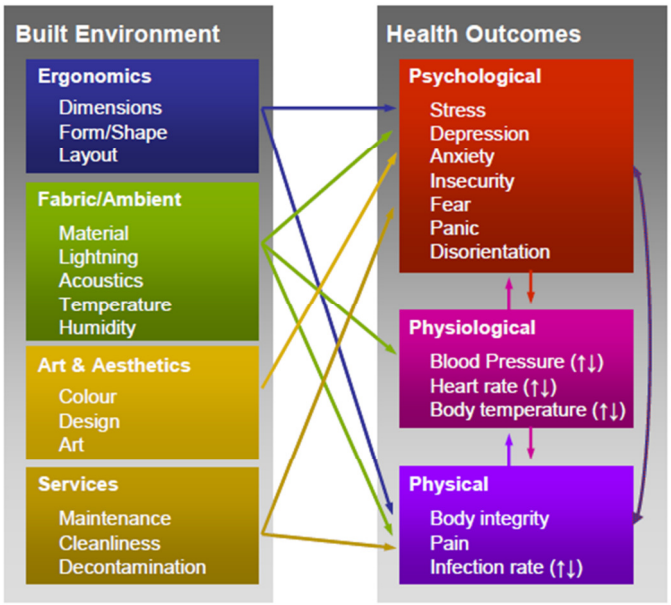


Figure 3-1: Knowledge areas and health outcomes framework (Codinhoto et al., 2009)

Applying evidence related to therapeutic building designs is more important for healthcare built environment projects than for any other sector. This is because the ultimate aim of this endeavour supports the goal of the core business of healthcare, which is improving the quality of care. In 2007 the NHS (Darzi, 2007) published dimensions of quality of care as *fairness*, *personalised*, *effective* and *safe care*. Products, services and environments in the health service should support improvement in these dimensions so as to increase the quality of the overall system. Looking into the above evidence there is an immense opportunity to contribute to quality of care in the NHS through properly designed built environments.

3.4 DISSEMINATION OF EVIDENCE

As stated earlier, research evidence could be generated by designers in the industry or by researchers at research institutions. Designers generate research evidence for project specific requirements. However, wider disseminating mechanisms for this type of evidence are limited. Research and other evidence generated by designers are mainly embedded into the tacit knowledge of designers who are involved in generating evidence. Some organisations store this evidence in internal repositories. Some of them are published as articles in industry and professional journals. Rarely though, some of this evidence is articulated into research papers and published in academic journals. Few local (UK based) and international databases were initiated to share evidence generated by designers.

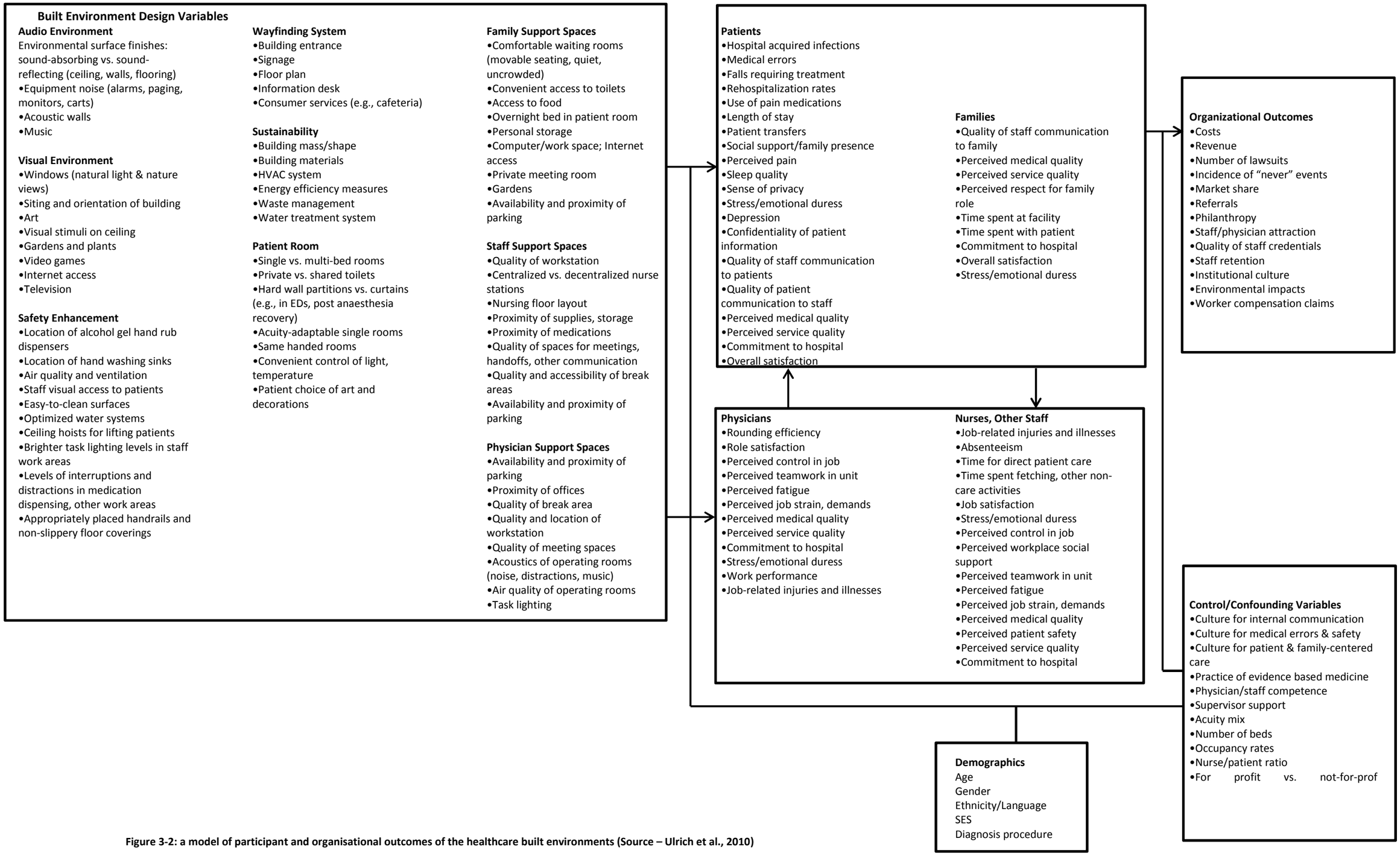


Figure 3-2: a model of participant and organisational outcomes of the healthcare built environments (Source – Ulrich et al., 2010)

Procure21+ framework in the UK maintain a database which facilitates storing and sharing of evidence generated within projects involved in the Procure21+ framework. Stakeholders in the Procure21+ are obliged to update the database with the evidence from their project. However, there is no guarantee that the evidence contained within them is of research standards. Therefore, the majority of the evidence base is composed of evidence produced at research institutions. These are initially shared and disseminated through journals and other publications and some of them may then be transmitted into evidence databases as discussed below.

3.4.1 Journals, magazines and other reports

Journals and other publications are the key mean of disseminating research evidence. Evidence published in these sources has its own inherent strengths and weaknesses. Peer reviewed journals adopt a reviewing procedure before publishing to ensure that the evidence contained in these journals is conducted in accordance with research standards. But, compliance with research standards for the content in other publications is doubtful since some of them do not have review procedures before publishing. Therefore, a cautious interpretation by designers is important when using evidence from this later type of published evidence. Journals and magazines dedicated to therapeutic building evidences are rare and published research are scattered throughout a large number of journals. Some of these are building related journals whilst some are medical and other discipline related journals. Furthermore, there are several practical issues related to accessing evidence contained in these journals and these are discussed in Section five of this Chapter.

3.4.2 Evidence databases

In responding to barriers associated with accessing evidence in publications, some evidence databases collect discrete research evidences scattered in publications and compile them into databases so that prospective users can retrieve them easily: whilst, as stated above, there are some databases which collect and disseminate evidence generated by designers. The following is a review of some of the databases disseminating therapeutic building evidence.

InformeDesign

InformeDesign is a searchable database of research summaries (RS) that are generated from refereed journal articles. These user-friendly RSs transform the research findings contained in the journal papers into design criterion and design rules. This database is developed and facilitated by University of Minnesota and funded by the American Society of Interior Designers. The database is not healthcare specific; however, currently (as at September 2013) the database

includes 113 research summaries related to healthcare facilities (InformeDesign, 2013). Additional details pertaining to evidence such as research method, research limitations and commentary are also added as descriptions along with the summaries to help users to evaluate evidence.

Safer environment database and 'HEAR'

Dr. Michael Phiri, Professor Brian Lawson and their colleagues at Sheffield University in the UK developed *'Safer environment database'* based on a systematic review (NHS Estates, 2005) of published literature. Scholars have evaluated published evidence for credibility criteria before inclusion into the database. The initial database consists of approximately 600 summarised evidences. This database was disseminated to designers on a Compact Disc (CD). The initial systematic review was updated in 2011 to incorporate evidence published after the first review. The updated evidence base will be published as the web-based database: HEAR - Healthcare Environment Architectural Resource.

Knowledge Repository – Center for Health Design

Even though not dedicated for the research evidence, knowledge repository maintained by the Center for Health Design is a centrepiece for all healthcare design research, papers, articles and references (CHD, 2014). The repository provides open access to easy-to-use key point summaries of the publications and allows users to search publications by types of publications, terms, design category, outcome category, environmental condition category or setting, and provides the number of references available for each defined category (CHD, 2014). Currently the database consists of evidence related to designing of hospitals, residential healthcare facilities, ambulatory care facilities, other healthcare facilities and non-healthcare settings.

IDEAs (Inspiring Design Excellence & Achievements)

IDEAs was conceived and developed by the University of Sheffield as a way of utilising the latest research evidence to support healthcare building design. This was hosted by Department of Health in the UK to support healthcare building design (IDEAs, 2010). Working with the latest evidence, IDEAs provides ideas for the design of healthcare places for patients, staff and visitors considering emotional and functional requirements of healthcare delivery. They are categorised into exemplar activities that people perform within healthcare places such as arrival and entering, receiving, waiting, circulating, consulting/examining and bed space. IDEAs provides information as pictograms, photographs and accompanying text to be used by designers and other users. This evidence base was not updated since 2011, and content can still be accessed through preservation by The National Archive (IDEAs, 2010).

These databases eliminate the barriers related to accessing evidence from publications but all of the databases have some form of weakness. Firstly, evidence gathered from publications and other sources are often abstracted by editors of the databases to produce research summaries. The accuracy of this subjective process of abstracting is questionable. This process may be negatively impacted by philosophical stances of editors of databases and their unfamiliarity with the original research may even result in incorrect abstractions. Furthermore, the databases disseminate summarised forms of evidence which may not necessarily be the preferred form of evidence for designers. Finally, databases assimilate academically written research into research summaries. This abstraction may result in reduction of some useful information contained in the original research publication. Further, issues related to copyright laws of original publications, when summarised versions are published also impact these evidence dissemination methods (Phiri et al., 2011).

3.4.3 Evidence informed standards guidance

Transmitting evidence (for EBD) into design SGaTs or evidence-informed SGaTs is an alternative mean of transmitting research evidence into practice. Several scholars (Tetreault and Passini 2003; Hignett and Lu, 2009; Chen et al., 2011; Phiri et al., 2011; Codinhoto et al., 2010; Lawson, 2010; Devlin and Arneill, 2003) have highlighted the importance and the potential of this strategy. Particularly in the UK, there is a great potential for evidence-informed SGaTs, because health care BE designing in the UK is governed by a long established centrally issued (earlier by Department of Health and now found on gov.uk) set of SGaTs. Several efforts have taken place to transmit evidence into design SGaTs in the UK. For instance, ASPECT (A Staff and Patient Environment Calibration Tool), is a healthcare design evaluation tool developed and based on evidence (for EBD) on how built environments can support the health outcomes of its users. Health Building Notes (HBNs) and Health Technical Memoranda (HTMs) are increasingly becoming evidence-informed. For instance, 'HBN 04-01 adult in-patient facilities' has incorporated evidence (for EBD) in relation to the benefits of single-patient rooms. This guidance has incorporated research evidence related to design and benefits of single-patient rooms.

Even though this approach shows great potential, there are several issues associated with this approach. Some of them are related to weaknesses in SGTs. SGTs are being criticised for their incompleteness, uncoordinated nature (Hignett and Lu, 2009), being out-dated and having too much duplication, fragmentation and non-standardisation (Chen et al., 2011). Furthermore, resources required to maintain and update SGTs have been an issue in the present economic situation. But despite these issues it was reported that SGaTs are well used and accepted by the

industry (Hignett and Lu, 2009). Therefore, it could be expected that evidence (for EBD)-informed SGaTs are an effective way forward for EBD if the existing weaknesses associated with SGaTs are eliminated. This research explored the use of SGaTs as a facilitator of EBD (rationale is discussed in the Chapter one). State of art knowledge in the area for this prospect is further discussed in the section six of this Chapter and in Chapter four.

3.5 THE PROCESS OF EVIDENCE-BASED DESIGN

Even though it is named design, the entire process of EBD has activities spread over the development life cycle of a facility and beyond. These activities are related to evidence acquisition, evidence application (design hypothesis development), performance measurement and evidence reproduction or validation. Several attempts have been made to describe the process of evidence-based design (Hamilton, 2003; Hamilton and Watkins, 2009; Cama, 2009; Stichler, 2007; CHD, 2008).

Three main models describing the EBD process can be identified within literature.

- Four level practice of EBD (Hamilton, 2003);
- EBD Litmus Ring (Cama, 2009); and
- Conceptual model for inclusion of evidence (Brown and Ecoff, 2011).

3.5.1 Four levels practice of EBD (Hamilton, 2003)

In 2003, Hamilton published a paper in which he proposed four progressively improving levels of practice for EBD (see Figure 3.3). The first two levels of Hamilton's model are related to evidence use and the latter two levels are related to performance measurement and evidence sharing. At the time of introducing this model in 2003, Hamilton claimed that most Architects' current practice falls within level one or below with reference to his model.

The model places evidence at the core and emphasise the importance of using research based evidence in EBD. Therefore, this may eliminate miss-use of the term 'evidence' and EBD. This model is beneficial because designers can use it as a benchmark to assess the progress of their practices and also the model encourages research evidence generation by designers as opposed to just using published research from academic journals. However, there are also a few weaknesses. One major drawback of this model is that it does not describe or guide users concerning specific processes or activities by which progressive levels can be achieved. In addition, the model allows designers to identify themselves as EBD practitioners while practicing merely at level one. In the model the level 1 practice is described as '….. staying current with literature…..and attempt to follow….'. This description does not define the specific

characteristics of 'literature or evidence' to which it is referring. Designers may therefore refer themselves as EBD practitioners at level one, without necessarily using research evidence. According to this model, 'hypothesize the expected outcomes of design decisions' has been identified as a level two practice. This is an important element of EBD which ensures the process of designing is focused on improving health outcomes. Based on this model, identifying a practitioner practicing at level one as an EBD practitioners contradicts the definition and focus of EBD.

Level 1 practitioners: These architects make a careful effort to design based on available evidence. By staying current with literature in the field, they attempt to follow the evolving environmental research related to the physical setting. They interpret the meaning of the evidence as it relates to their projects and make judgments about the best design for specific circumstances. An example is the use of design concepts based on benchmark reviews of other projects and interpretations of published research.

Level 2 practitioners: These architects take the next important step. Based on readings, they hypothesise the expected outcomes of design decisions and subsequently measure the results. These less subjective designs require new design methods. Architects must understand the research, interpret the implications and build a chain of logic connecting the decision to a measurable outcome, reducing arbitrary decisions. The potential for bias in gathering and reporting results means they must resist the temptation to report success and downplay failure.

Level 3 practitioners: In addition to following the literature, hypothesising the intended outcomes of design and measuring results, these architects report their results publicly. Writing or speaking about results moves information beyond the firm or client team. It subjects methods and results to scrutiny from others who may or may not agree with the findings. Level 3 practitioners must understand research methods and may seek advanced education to enable greater rigor.

Level 4 practitioners: Scholar-practitioners perform the same tasks: following the literature, hypothesising outcomes of design decisions, measuring results and reporting. These architects go further by publishing their findings in peer-reviewed journals or collaborating with academic social scientists. They subject their work to the highest level of rigorous review.

Figure 3-3: Four level model of EBD

3.5.2 The EBD Litmus Ring (Cama, 2009)

Drawing from self-experience in healthcare design, in 2009, Rosalyn Cama, an architectural and interior design practitioner in the US, developed a model to represent the process of EBD, which she calls '*EBD Litmus Ring'* (see Figure 3.4). She identified seven steps for EBD. One of the major strengths of this model is that Rosalyn has aligned the EBD process with the strategic objectives of the organisation which is particularly important for the healthcare as a sector. Project level objectives in a healthcare project may often represent generic construction project performance criteria. But the roles that facilities need to support in improving service outcomes are often considered in the strategic analyses.

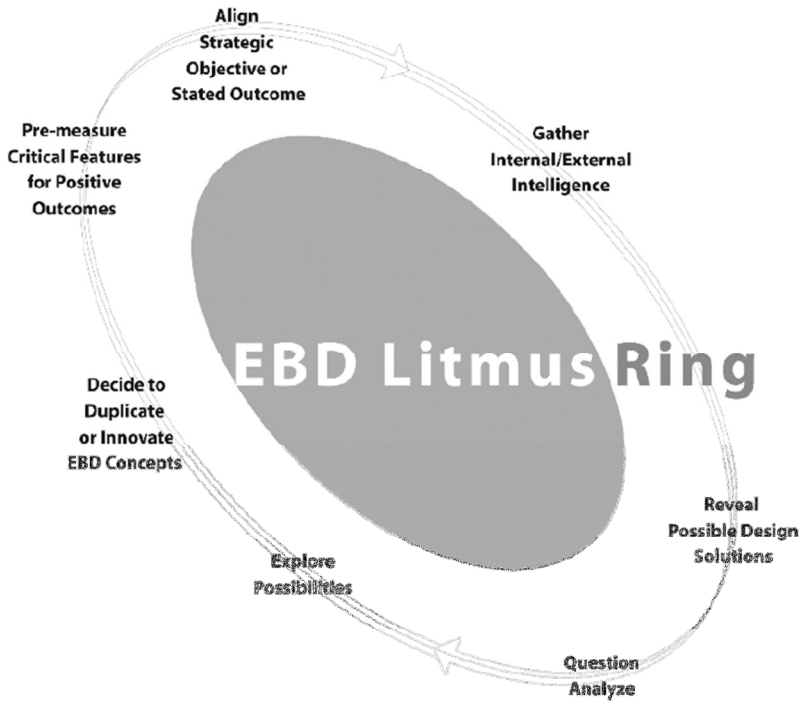


Figure 1.5
EBD Litmus Ring: Depicts an iterative process that aligns evidence-based design decisions with an institution's strategic directives after an informed, exploratory and translational design process that uses critical thinking skills. When the alignment does not occur then the concept should be dropped or modified until it does. *CAMA, Inc.*

Figure 3-4: Evidence-based design process (Cama, 2009)

For instance, the NHS is currently facing an issue of longer patient waiting hours in the Accident and Emergency Departments. These types of issues are often attended to during strategic definition of a project. Therefore, it is important to align project objectives with this type of strategic objectives as a starting point for EBD. The model identifies and describes specific activities associated with evidence gathering and evidence application, within the accompanying texts. This assists novice designers to adopt the process easily and convinces clients of the additional activities involved in the EBD process. As a result of this awareness clients may acknowledge and support the extra resource requirements required for EBD.

In her model, Rosalyn uses the term 'intelligence' (gather internal and external intelligence) as opposed to 'evidence'. This may support misunderstanding and misuse of the term 'evidence' and EBD. Identifying characteristics of research-based evidence and incorporating a better term to imply the content of research-based evidence could have improved Rosalyn's model. Rosalyn states the importance of pre-measuring the performance of the evidence-based solution to evaluate whether that would support the expected strategic outcomes (Cama, 2009). Rosalyn's model would have been more comprehensive if she had incorporated post occupancy performance evaluation into the process, which is an important step in EBD. POE is the mechanism which confirms whether the intended strategic objectives and project objectives are achieved or not. POE is also a mechanism for validating the evidence applied during the

designing phase and provides an opportunity for designers to learn evidence actively and contribute to the evidence base by sharing the lessons learnt.

3.5.3 Conceptual model for inclusion of evidence (Brown and Ecoff, 2011)

In 2011, Brown and Ecoff introduced a conceptual model for evidence-based decision making (see Figure 3.5). The model has been developed by deploying innovtion diffusion theory (Rogers, 2003), evidence-based practice models used in medical practice and evidence-based information cycel models (Brown and Ecoff, 2011). This model could be used to appraise and adopt evidence. According to the model a catalyst triggers the evidence-based decision making process; and the catalyst could be a problem, an issue or a concern such as new trend (Brown and Ecoff, 2011). For healthcare, single patient rooms or acuity adaptable room designs could be considered to be a catalyst. A project that considers adopting single patient rooms or acuity adaptable rooms into their design can go through the process identified by Brown and Ecoff to appraise the solution before adaption.

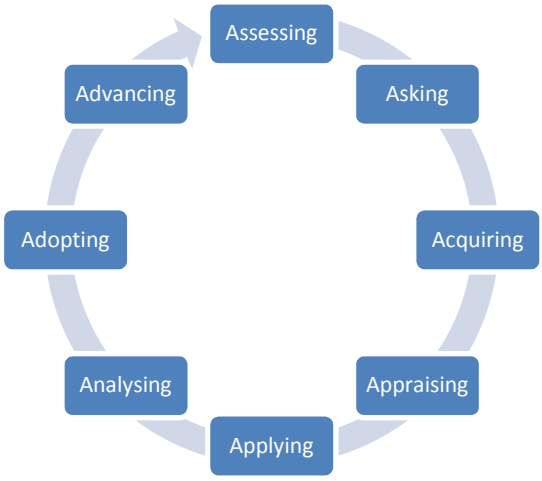


Figure 3-5: Systematic approach to evidence-based design

There are two main limitations of this model. Firstly, the model has been developed based on literature and it has not been validated for actual practice. Practical difficulties associated with applying the model in practice or whether it would be fit for purpose is yet to be understood. Secondly, the model is less useful for general day-to-day practice, because it needs to be triggered by a catalyst. Considering the vast amount of evidence that designers use during designing, it is fair to assume that designers cannot follow the procedure stated in this model for all the evidence. Therefore, the model can only be used for option appraisal or to evaluate innovative solutions emerging in healthcare design before adopting them.

3.5.4 Strategies of EBD proposed by Centre for Health Design

Drawing from interviews with Chief Executive Officers (CEOs) of healthcare design and construction organisations in the US, CHD proposed the following ten strategies for effectively implementing EBD (Zimring et al., 2008).

1. Start with problems and challenge existing paradigms.
2. Use an integrated multidisciplinary approach with consistent senior involvement.
3. Maintain a patient-and-family-centred approach.
4. Focus on financial operating impacts.
5. Take a broad and disciplined approach to participation and criteria management.
6. Establish quantitative criteria linked to incentives.
7. Use strategic partnerships to accelerate innovation.
8. Support and demand simulation and testing throughout.
9. Use a lifecycle perspective.
10. Over communicate.

The authors go on to explain further the importance of each strategy to implement EBD. These strategies are aimed at being used by CEOs of healthcare organisations, which CHD believes to be the most promising leaders for the EBD process. Therefore, strategies are focused more at strategic level of the organisation as opposed to the actual practice of designing. However, these do not necessary explain the process of EBD.

In summary, all these models have different intentions and could be used for different purposes. In all these models, too little attention has been paid to the actual project level activities involved in each stage of EBD. According to the definition of EBD, one of the most important elements of EBD which differentiates it from generic designing is the application of research-based evidence (originated from practice or from academia).

None of the existing EBD process models expands the aspect of evidence in EBD in detail. As acknowledged earlier, evidence (for EBD) could be generated by researchers in the research universities or by designers. These evidence can then be conveyed into the design process directly (designers access published evidence) or indirectly (designers'' use of research informed other evidence sources). Considering this complicated flow and origin of evidence (for EBD) and the misuse of the term evidence, a demonstration of sources and flow of evidence (for EBD) would be useful to take EBD forward.

3.6 APPLICATION OF EVIDENCE-BASED DESIGN – ISSUES AND RESEARCH GAPS

EBD emerged as a concept within academia. The concept promised betterment of healthcare built environment facilities. EBD attracted the attention of scholars at conferences and was also warmly welcomed by the government and clients of the healthcare sector. Despite all the popularity and recognition, application of research evidence during the actual design process appears to be limited (CHD, 2010, Neuckermans and Fontein, 2002). Published research is not a primary source of evidence for designing (Emmitt, 2007). (The next Chapter provides further details related to what designers actually use during the design stage.)

Scholars have identified several difficulties related to limited application of EBD. In a similar way to EBD, EBM faced many challenges during its early stages.

Viets (2009) mention that;

> *"…EBM has faced many challenges in adopting an evidence-based approach…… as EBM gained recognition, it faced a great deal of scrutiny……."*(Viets, 2009, p.77)

Therefore, it is anticipated that a similar live debate about EBD will continue in the early stages (Viets, 2009). Based on the previous literature, this section reviews issues related to application of evidence-based design. These are presented in three sections:

- Evidence (for EBD) generation related issues;
- Evidence (for EBD) base related issues; and
- Evidence (for EBD) application related issues.

3.6.1 Evidence (for EBD) generation related issues

As stated earlier, evidence (for EBD) could be generated by researchers at research institutions and by designers in industry. But, the former comprise the majority of the evidence base (for EBD). This section presents issues related to generation of evidence (for EBD) at research institutions. These are partly applicable for evidence (for EBD) generation by designers. Section 3.5.3 presents the specific issues related to evidence (for EBD) generation by designers.

3.6.1.1 Lack of funding for built environmental researches

Lack of funding for research has been an issue for the incomplete nature of evidence base (for EBD) (Nelson et al., 2005). Drawing on interviews with designers in the industry and academia, Nelson et al., (2005) concluded that funders should also finance the dissemination of results to

decision makers. Joseph and Hamilton (2008) explained this further and mentioned that the longer span of EBD researches make them less attractive for funding. Data for EBD researches need to be collected from related designing and performance phases of a facility during the operational phase. However, hospital developments often take many years (some may take up to 10 years or more) from inception to completion and conducting longitudinal researches are time consuming.

3.6.1.2 Complicated nature of EBD researches

Previous scholars reported difficulty in generating built environmental researches. Lawson (2010) stated that, *"...in EBD scientific evidence tends to be parametric and about individual issues such as lighting ...and attend to one problem at one time.....but trying to optimise each case is unlikely"* (Lawson, 2010 pp. 100). Codinhoto et al., (2010) also highlighted this issue. The framework published by Ulrich et al., (2010) is comprehensive in responding to this issue. Based on a systematic literature review, authors present a conceptual framework for the research in the domain of evidence-based design. This framework identifies types of built environment variables and resultant user and organisational outcomes. The framework also identifies different types of user demographics and other control/confounding variables that could have an impact on EBD researches. This framework is useful for researchers to identify the complicated nature of built environment research. However, identifying relevant independent and dependent variables for a particular design intervention and its impact is still crucial. For instance; decentralised nursing stations may have an impact on multiple outcomes such as patient observation, patient privacy and dignity and patient satisfaction.

Lack of measurement methods that relate to user outcomes and design interventions are also barriers to conducting EBD researches (Codinhoto et al., 2010). As a solution, Phiri (2011) at EBLE steering group meeting emphasised the importance of collaboration between built environment researchers and medical researchers in generating evidence for EBD. There is no apparent barrier for this collaboration and this type of collaboration may also be attractive in funding applications.

3.6.2 Evidence (for EBD) base related issues

Previous scholars have identified several issues relating to evidence (for EBD) contained in the evidence base which impediment EBD.

3.6.2.1 Incomplete nature of evidence (for EBD) base

Scholars claim that the present evidence (for EBD) base is not complete and comprehensive enough. Stankos and Schwarz (2007) have discussed this extensively in their paper: '*Evidence-based design in healthcare: a theoretical dilemma'*. The authors' major claim is that knowledge of how the built environment of a hospital affects patient and staff outcomes is not completely understood. Some scholars (for instance, Rubin et al., 1998; Dijkstra et al., 2006; Huisman et al., 2010) who systematically reviewed published evidence (for EBD) made the same claim that present evidence (for EBD) base is immature. This claim is based on the assumption that the evidence with the highest research rigour is derived through scientific research paradigms. Authors failed to acknowledge the possibility of adopting other paradigms within built environment researches. It is true that the existing evidence (for EBD) base is not massive though it is more mature than it is claimed to be by the authors above who rely only on positivist paradigms. Scholars who believe in broader criteria for the credibility of evidence found more than 1200 rigorous research contributing to therapeutic evidence base (Phiri, et al., 2011b, Hessler et al., 2011).

Furthermore, a constantly changing knowledge landscape has been identified as 'unsettling' for designers (Becker and Parsons, 2007). The validity of this claim is questionable, since research is underway to advancement for any discipline and should not be considered to be a barrier. It is also reported that fragmentation and sparseness of evidence base makes the task of searching for existing evidence (for EBD) challenging (Codinhoto et al., 2010). This may also prompt other issues relating to resource requirements for EBD. Research evidence bases provide a partial solution to this issue; however, due to the other issues associated with these evidence bases (see Section 3.2.3) this cannot be considered to a long lasting solution.

It is understandable that the current evidence (for EBD) base is not complete, but looking at the increasing number of research publications on the subject, it is apparent that the knowledge base is improving. Existing evidence (for EBD) base contains knowledge that could improve current practice in healthcare design and ignoring this knowledge would be harmful.

As McCullough (2009: p3) states:

> *"..... Because the building of healthcare facilities cannot be postponed while we create a body of knowledge that definitely supports evidence-based design. Many believe it necessary to balance what is available with common sense and establish the design features that are flexible and can adapt to new ideas as the research evolves.....".*

3.6.2.2 Form and format of evidence (for EBD)

Martin and Guerin (2007) stated that application of evidence (for EBD) has been difficult due to the format of the evidence (for EBD). Authors state that '*vocabulary and terms used in academic journal articles are written from researchers' viewpoints based on their knowledge of their own processes'* (Martin and Guerin, 2007). There are other design scholars who identified the need for reproducing evidence (for EBD) with an informed view of designers' friendly forms and formats of evidence (for EBD). For instance, Lawson (2010) and Chen et al., (2011) have suggested that evidence (for EBD) needs to be reproduced or articulated into design strategies. Lawson (2010) further explains this as;

> *"……. reproducing evidence to inform clients and architects about what sort of things they should do, what features of buildings they should control or elaborate and what sorts of qualities of environment they need to produce is beneficial"* (Lawson, 2010, pp.102).

Two types of solution have been proposed by scholars in responding to this issue. Firstly, developing a research summary data bases to represent existing research (see Section 3.2.3 for further details). Secondly, to produce evidence (for EBD) informed standards, guidance and tools to be used in practice (Tetreault and Passini 2003; Hignett and Lu, 2009; Chen et al., 2011; Phiri et al., 2011; Codinhoto et al., 2010; Lawson, 2010).

Research summary databases have been identified as better alternatives to searching for evidence (for EBD) as opposed to searching for evidence (for EBD) fragmented in several publications (Viet, 2009; Martine and Guerin, 2007). Some of the renowned databases are; Pebble project evidence, InformeDesign database, ripple database, environmental evidence database produced by Sheffield University and IDEAs database (refer section 3).

Transmitting evidence (for EBD) into design SGaTs or evidence-informed SGaTs is an alternative mean of transmitting research evidence into practice. The potential of SGaTs to convey evidence (for EBD) and SGaTs related barriers impeding this solution is discussed in the section 3.4. This research explored the use of SGaTs as a facilitator of EBD. Theoretical underpinnings from design knowledge literature were discussed and knowledge gaps were identified in the Chapter four.

3.6.3 Evidence (for EBD) application related issues

As stated earlier, the majority of the evidence (for EBD) is generated at research institutions and disseminated through the methods discussed in section 3.2.3. Previous studies have reported issues which designers face in accessing evidence (for EBD) (Hamilton, 2007 & 2010; Edelstein,

2008; Martin and Guerin, 2007; Devlin and Arneill, 2003). Specifically, issues related to designers' skills in understanding and interpreting research, designers' lack of preference for evidence published in research journals, lack of resources to access evidence (for EBD) and the nature of design products and problems were reported and described in this section.

3.6.3.1 Skills required to gather and apply evidence (for EBD)

Searching appropriate literature is a skilled task (Edelstein, 2008). Scholars have claimed that designers lack training for understanding research (Hamilton 2010; Martin and Guerin, 2007; Devlin and Arneill, 2003) and they are less familiar with evidence (for EBD) published in academic journals (Hamilton, 2007). In responding to this issue, a considerable amount of previous literature highlighted the importance of improving designers' skills in understanding research through the universities and other professional development routes (McCormick and Shepley, 2003; Martin and Guerin 2006 & 2007; Evans, 2009; Viets, 2009; Hamilton, 2010). In addition, Edelstien (2008) highlighted the need for design professionals to collaborate with experts in research, and seek new skills for searching, interpreting, and applying evidence (for EBD) to design. Edelstien's suggestion raises two questions. Firstly, design professionals collaborate with researchers to conduct built environment researches; but their main contribution is related to providing access to relevant data and their involvement during literature reviews is questionable. Secondly, it may require a considerable resource commitment if designers are to be seriously involved in research activities. In responding to the issue of lack of skills, Codinhoto et al., (2010) has developed a framework which project teams can use during project specific evidence (for EBD) collection. The framework guides designers or those with fewer skills and experience of how to gather evidence (for EBD) in literature searches. Drawing from evidence-based medical literature, Stichler (2010) has presented a framework to help designers evaluate the credibility of evidence. Codinhoto (2013), in his thesis, presented a conceptual framework (*taxonomy of evidence*) that can be used to classify evidence within the design domain. Designers engaged in the design process could use these as supporting tools to evaluate the evidence they use during designing.

3.6.3.2 Resources required to gather and apply evidence (for EBD)

Evidence published in peer-reviewed, academic journals are not easily accessible to designers and typically do not emerge using simple keyword searches (Martin and Guerin, 2006). Additional time required to read the literature is extensive (Lawson, 2010) and the cost of time required to access published research is rarely paid by clients (Hamilton, 2010). This is more crucial when the industry is working to tight time schedules (Sailer et al., 2009). It is also

reported that some designers lack resources such as the internet, computers to search evidence (Nelson et al., 2005).

Some of these issues are long standing, inherent weaknesses of the industry. Designers often work to tight schedules and with large workloads (Grol and Grimshaw 2003; Martin and Guerin, 2007); as a result, there is a perceived need to safeguard project hours for other tasks during the design process. It is also mentioned (Codinhoto et al., 2010) that health care BE designs are complex and involve large numbers of design elements and decisions. Review literature for an enormous number of design elements requires a considerable amount of time. In responding to this issue, Codinhoto et al., (2010) suggested that designers could do literature searches to support only critical decisions when the design involves a large number of design decisions. Explaining this further, Malkin (2008) suggested that designers could consult clients to understand what issues are most important, or identify critical issues based on hospital operational data (i.e. information from nurses, safety personnel and quality data). One other suggestion is a different configuration to the design team. Codinhoto et al., (2010) proposed that incorporating a researcher or someone with research skills into the design team or hiring a third party to carry out research literature searches and conduct the POE to complete EBD as a better alternative. However, this might discourage designers from learning and skills development in research use. Furthermore, the time and cost related issues discussed above would still obstruct the effectiveness of these two suggestions.

3.6.3.3 Designerly ways and Evidence-Based Design

EBD can gain insights from design knowledge literature. A considerable amount of literature has been published on design knowledge and the implications of designers' preferred ways of understanding and practicing EBD. In an article cited significantly '*Designerly ways of knowing*', Nigel Cross argues that designers have their specific ways of using evidence and design scholars often acknowledge the existence of this designerly ways of knowing (for instance, Lawson, 2004; Heylighen, 2000; Demian and Fruchter, 2006 a, b & c). Literature claims that designers prefer active knowledge (gathered by individuals working on their own and with direct and various experience of designs) as opposed to codified knowledge (knowledge which produced by some other person(s) and available in explicit codified forms) (Habraken 1997 cited in Martin et al., 2005; Lawson, 2004; Cross, 2007). Furthermore, in their research into design knowledge re-use, Peter Demian and his colleagues (Demian and Fruchter, 2005; 2006a; 2006b; 2006c and 2009) acknowledge that re-using knowledge from one's personal memory or experience is more effective than re-using knowledge obtained from an external digital or paper archive. They

explored designedly ways of using evidence from active knowledge, in order to use them in presenting codified knowledge effectively. Previous scholars have identified the forms in which designers store knowledge in their own memory and ways they use such knowledge during designing. It is reported that designers use precedents, stored as cases and design rules/principles, for different activities in the design process (Heylighen, 2000; Lawson, 2004; Krippendorf, 2008; Demian, 2004).

This issue is highlighted within the researches related to design knowledge and the impact of this structural barrier to EBD is less understood. Evans (2009), has suggested the importance of this issue within EBD. As stated previously, evidence for EBD stems from two origins. Published evidence generated within research institutions is a form of codified knowledge to the designers whilst evidence generated within the industry by designers is active knowledge for designers. Based on the above fact, it is reasonable to assume that designers prefer evidence derived from the latter route as opposed to the evidence generated by the former route. Furthermore, the importance of articulating or expressing evidence in designers friendly forms has also been raised by previous scholars (for instance, Lawson, 2004; Demian, 2004). Chapter four discusses this '*designerly ways*' (Cross, 2001) further.

3.6.3.4 Nature of built environment design

The design of a building is different from any other product for many reasons. Therefore, evidence generated from one context may not always suit the design problem in the next situation (Becker and Carthers, 2007). As a result, architects and other professionals who are engaged in built environment design are not in a position to cut and paste best practice from the past (Kamara et al., 2003), and EBD is not an instrumental application of scientifically developed knowledge and theory to confront problems (Moore and Geboy, 2010). In the early stages of the concept, designers have feared that evidence-based methods will limit creativity and bring cookbook architecture to produce dull, repetitious buildings stamped from a mould (Hamilton, 2003). It is now apparent that this is not the case and critical application of evidence is important as described in the definition of the EBD earlier in this Chapter.

Scholars have suggested the following solutions to overcome this issue.

- Interactive briefing as a part of the design process would help in identifying optimum design solution with minimum negative effects (Lawson, 2010).
- Conduct research and produce evidence while focusing on usefulness and the context in which it can be applied later (Stichler, 2011).

- Do mock-up simulations of design solutions so that expected outcomes can be hypothesised with greater certainty (Hignett and Lu, 2009; Health Facilities Scotland, 2011).
- Translating the needs of design professionals into prospective research questions (Hamilton, 2007).

These appear to be promising solutions, and some of these already exist in the practice (for instance, mock-up simulation). Yet, none of these solutions clarify critical application of evidence in detail. Considering the importance of critical application of evidence during EBD, identifying how designers apply evidence in project-unique circumstances and their reflective activities in project-unique circumstances would be beneficial for EBD.

3.6.3.5 Performance measurement and evidence (for EBD) sharing

Measurement is central to the concept of quality improvement in healthcare; it provides a means to define what hospitals intend to do, and to compare actual performance with the original target in order to identify opportunities for improvement (WHO, 2003). Post occupancy evaluation (POE) for performance measurement in the construction sector is generally considered to be poor (Emmit, 2007; Joseph and Hamilton 2008). Poor practices in performance measurement are barriers to research evidence generation by designers, leaving most of their knowledge anecdotal. Poor POE practices also prevent validation of existing evidence and evidence sharing.

The reasons behind the limited practices of POE in the construction sector are also equally applicable to healthcare built environments. In addition, few sector specific issues regarding lack of POE could be identified. Lack of resources is claimed to be one major reason for the poor POE practices (Nelson et al., 2005). Longer project duration of healthcare construction projects has been made POE complicated and resource consuming (Codinhoto et al., 2008; Joseph and Hamilton, 2008). Emmitt (2007) stated that designers who are involved in design development activities move away from the project when the design related activities are completed. By the time the facility is operational those who were involved in the design phase may even not working with the same organisation, or not remember relevant facts by the completion. This makes performance measurement difficult and prevents design teams learning at the facility operational phase. It is also reported that initial project objectives are sometimes changed over the development process making POE a complicated task (Emmitt, 2007; Stichler, 2011). Concerns about sharing performances were reported for both negative and positive performances. Sharing negative performance has been obstructed by adversarial relationships

between project parties and professionals reluctant to admit mistakes (Emmitt, 2007). Stichler (2011) reported that organisations do not share negative outcomes of their designs due to fears of liability, loss of reputation and fears of remuneration for sub-standard performance. Furthermore, Nelson et al., (2005) mention that designers hesitate to share positive lessons learned due to commercial sensitivity for their designs. Finally, performance measurement of healthcare projects involves performance in relation to health outcomes, which makes the POE process complicated. Presently, there are no precise ways of measuring health outcomes which are solely construed by built environment variables (Codinhoto et al., 2008; Sailer et al., 2009; sticher, 2007).

In responding to POE related issues, previous scholars suggested how to improve POE and overcome issues related to POE. Joseph and Hamilton (2008) have developed a performance measurement framework to guide POE and collect POE results in a standard format. This framework is now used in all Pebble projects to conduct performance measurement. Codinhoto et al., (2010) have also presented a performance measurement framework. This would be supportive in guiding POE; however, there is no evidence of how designers use these frameworks in general practices. Zimring et al., (2008) proposed the establishment of incentive criterions for designers/builders linking their design to the process of healing. The practicality of this suggestion is doubtful in an era where capital costs of projects are restricted. Currently, in the UK, healthcare projects procured through Procure21 and Procure21+ frameworks have an obligation to measure the performance of their projects and share them in the Procure21 and Procure21+ knowledge base. Furthermore, Chen et al., (2010) suggested an initiative to use every healthcare development project that operates under the NHS as a research scenario to collect and validate evidence. The practicality of this solution is also depending on the issues discussed above. However, it is worth to note that, the similar intervention, the Pebble project initiated by the Centre for Health Design, US is recognised within the healthcare design practice. As another solution, scholars have called for collaboration between construction professionals and medical professionals to improve performance measurement (HaCIRIC steering group meeting, 2011; Sailer et al., 2009). This would help in identifying means to measure health outcomes gained through built environment interventions and this would encourage research funding organisations to fund EBD researches. In responding to the issues of longer project durations, Codinhoto et al., (2010) highlights the need to identify responsibilities and a responsible person for the each step of EBD process until performance measurements are carried out. It is apparent that this solution could be achieved with comparatively fewer resource commitments.

3.6.4 Other issues

Literature revealed other issues which impact on EBD. Until EBD raised the importance of environmental quality and user outcome improvements that could be achieved through the built environment, the traditional priority of healthcare designing has been cost and clinical functionality (Gesler et al., 2004). Still, the clients' main focus remains largely on initial capital investment (Nelson et al., 2005). It is true that the capital cost of EBD is comparatively higher than traditional designs (Berry et al., 2004). However, a business case conducted for EBD (Fable Hospital) has identified that EBD is cost effective in terms of whole life cost and value (Berry et al., 2004). Authors have further identified that this extra capital cost could be repaid in a few years of operation. Explaining the same issue, Hamilton (2008) mentioned that a cultural change is required to alter the focus of built infrastructure designing from a traditional focus to a new focus. Zimring et al., (2008) have stated that a successful EBD process reflects an organisational ability to recognise its problems; an openness to change; willingness to measure performance and take actions accordingly. Cama (2009) also acknowledged the importance of a willing and able client who has a clear vision and is willing to empower a team.

In addition, the powers of different stakeholders have been identified as a key issue (Gesler et al., 2004). The most powerful stakeholder, the client in most cases, can manipulate decision priorities. Therefore, it is important to understand the value of EBD and to promote EBD within their projects (Tetreault and Passini, 2003; Nelson et al., 2005; Stichler, 2007).

3.7 CHAPTER SUMMARY

EBD is a promising practice in the healthcare designing sector at large. EBD is not an alternative practice to current practice, but it suggests improvements to the current practice by maximum application of research evidence. Scholars still debate the suitability of evidence derived through various methods to support EBD. Based on the nature of the built environment researches and the nature of their application, this thesis suggested the importance of evidence derived from all types of research paradigms to the extent they are gleaned through standards of rigour appropriate for that given research approach. Details of 12 systematic reviews of published evidence were identified and a trend of conducting systematic evidence reviews for a particular space, a care setting or a particular patient category was noticeable, as opposed to generic broader reviews. These reviews and secondary analyses have established direct and indirect links between built environment interventions and users' psychological, behavioural, physiological and mechanical outcomes.

Existing research evidence base is largely formed of research generated at research institutions. Literature reveals that direct application of published research by designers to be limited, confirming the importance of exploring the alternative routes that could be used to disseminate research evidence generated within academia into practice. Some of these alternative routes are visible within existing literature, yet a comprehensive review of how the concept of EBD is applied in the UK healthcare sector is not available.

The holistic process of EBD is well understood in the literature; however, previous scholars have paid too little attention to the actual project level activities involved in each stage of EBD. Literature reveals issues related to evidence (for EBD) generation, evidence base (for EBD) and evidence (for EBD) application. From the discussion above, it is apparent that some of the barriers relating to evidence (for EBD) generation and evidence (for EBD) application may be eliminated by investing in additional resources. Evidence (for EBD) base is not comprehensive, yet it promises to grow stronger over time.

In summary, literature review of EBD, emphasised the importance of exploring:

- how the concept of EBD applied in the practice (sources and flow of evidence for EBD); and
- how designers use evidence in the unique sector of the built environment and under project-unique circumstances.

CHAPTER 4. LITERATURE REVIEW PART II - EVIDENCE FOR DESIGN

4.1 INTRODUCTION

The first part of the literature review suggested the existence of designerly ways of using evidence and their implications on EBD. This Chapter presents the second part of the literature review which examines literature related to evidence for design (EfD) and design knowledge. This Chapter has two aims: firstly, it reviews the position of evidence-based design (EBD) within the EfD and explores the ways of incorporating EBD evidence base in to the process of designing. Secondly, it reviews the theoretical underpinnings of design knowledge that have implications on the knowledge gaps of EBD established within the previous Chapter.

The Chapter starts with a discussion that positions the EBD within the generic evidence for design (EfD). Specifically, the ways of incorporating the evidence base of EBD, into the inputs of designing, output and outcomes evaluation mechanism. Next, this Chapter reviews designerly ways of using evidence. Specifically, this section discusses ways which designers use different types of knowledge and their possible implications on EBD. This Chapter finally establishes the opportunity of standards, guidance and tools (SGaTs) as an effective means to convey evidence-based of EBD into the process of designing and discusses the prospect of articulating evidence-based of EBD into performance and prescriptive specifications.

4.2 DESIGNING

Scholars use the word ‘design’ interchangeably with ‘designing’. For this thesis the word design is used as a noun to denote the resulting output specification or plan for making a particular

artefact; while designing will be used as a verb to denote the human activity that results in a design. Designing can be anything from a music composition to designing a house or an aircraft. In healthcare, designing can refer to care models designing, patient journeys designing and building infrastructure designing and various professionals were involved in healthcare designing. The focus of this research is building infrastructure design and designing. Love (2002) identified several scholarly definitions for designing: 'creative genius', 'problem solving', 'searching in a solution space', and 'synthesis (assembling from parts)'. These definitions interpret designing from different perspectives. Based on the Lawson's (2004) definition for designing, this thesis considers designing as the human activities associated with knowledge transformation between clients and designers to identify the best suited built environment solution for the clients' requirements' and any stakeholder involved in these activities as designers (including clients and constructors).

4.3 EVIDENCE-BASED DESIGN AND EVIDENCE FOR DESIGNING

Before the concept of EBD, the term evidence was not frequently used in design literature. The more frequently used terms were*: design information; design knowledge*; and *design inputs*. Scholars in the area of designing often referred to them as 'design knowledge' (Lawson, 2004; Cross, 2001; Heylighen; 2000) whilst, construction management and design management scholars have used all three terms interchangeably (Emmitt, 2007; Demian and Fruchter, 2006; Austin et al., 2000). EBD introduced a specific definition for evidence (refer Chapter 3).

As established in the previous Chapter, evidence for design (EfD) is 'the available body of facts or information indicating whether a design proposition is true or valid' and evidence for EBD is a sub-set of EfD gleaned according to the highest standards of rigour appropriate for the research approach taken to generate evidence and indicating whether a design proposition (for improving health outcomes through the design) is true or valid'.

According to these definitions, design information and design inputs could form EfD to the extent that they indicate whether a design proposition is true or valid. Design information and design inputs could form evidence for EBD to the extent to which they indicate whether a design proposition is true or valid; are gleaned according to the standards of research rigour; and the proposition for improving health outcomes through the design. This distinguishes design information and design inputs that form evidence from non-evidence, such as stakeholder requirements and other information which frame designing. However, it is also worth considering whether there may be evidence behind some of the other design information and input that forms non-evidence.

Distinguishing EfD from evidence for EBD is easier in relation to the intention of evidence. But, it is hard to determine the credibility of the generic evidence for design used by designers generated through various means since the construction industry has poor POE practices. Further, healthcare designers and researchers face challenges to measure improvements of health outcomes derived through built environments. Therefore, these other evidence generated by the designers is often termed as anecdotal evidence to mean evidence which is '*not necessarily true or reliable, because they are based on personal accounts rather than facts or research'* (Oxford English Dictionary, 2013). This thesis in any mean does not imply that designers do not generate evidence for EBD and agree with the contemporary EBD scholars that research evidence generated by design team is a promising way forward for EBD. But, currently, the known evidence-base for EBD is primarily consisting of research evidence generated by researchers within universities and other research institutions.

The next question is the association between design knowledge and evidence. According to literature (Aamodt and Nygard, 1995; Oxford dictionary, 2013) Knowledge refers to '*learned information generated in the heads of people'*; information is '*data used during decision making and exists outside the human mind*'; and data refers to '*facts and statistics collected together for reference or analysis'.* According to this generic definition of knowledge, knowledge could form evidence for design in general or evidence for EBD to the extent they adhere to definitions of evidence for design in general or evidence for EBD stated above.

4.4 INCORPORATING EVIDENCE INTO THE DESIGN PROCESS

Evidence forms inputs to designing. Output and outcomes of designing is evaluated to verify and validate that the intended design prepositions are achieved. Conversely, evaluation criteria for design outputs and outcomes help designers to identify appropriate design propositions. Therefore, incorporating evidence into output and outcome evaluation criteria also encourages evidence use by designers. This section reviews inputs to designing, output and outcome of healthcare designing and discusses their contents of research-based evidence.

4.4.1 Inputs to designing

Even though the designers remain the primary contributor to the design, many other sources of information, knowledge and evidence (design inputs) contribute to designing (Emmitt, 2007). Previous scholars have studied inputs into designing in general and specifically for healthcare designing. Hamilton and Shepley (2010) identified that internet searches; research from medicine; nursing; management etc…; newspapers; magazines; documentary films; television

programmes; industry data guides; quality review data; infection control data and manufacturers' testing information to be sources of inputs for designers. The authors have not mentioned how designers identify this information and knowledge inputs, nor have they identified frequency of use or credibility of inputs coming from each source. Based on a questionnaire survey, the Center for Health Design (2010b) has identified sources of design inputs used by designers during healthcare designing (see Figure 4.1).

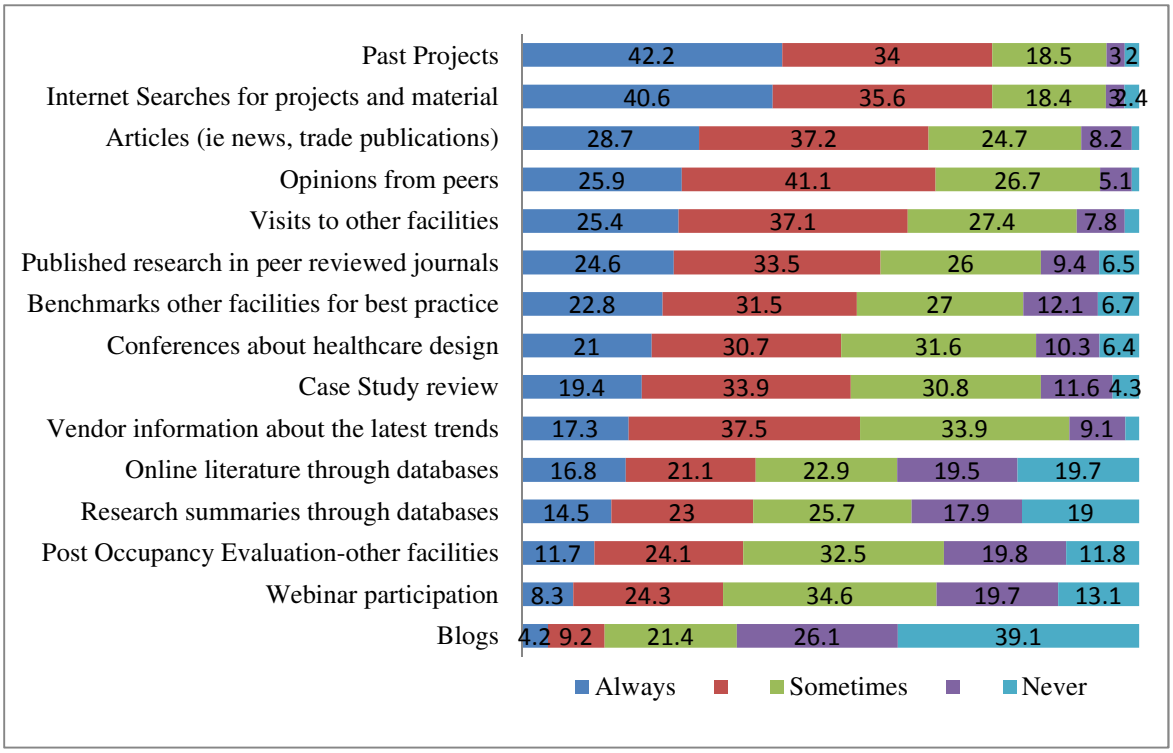


Figure 4-1: Usage of different information sources in process of designing (source: CHD, 2010)

Looking at the above results it is evident that designers seek information from a large number of sources, the most frequently used sources of information being *past project details* and *internet searches for projects and materials*. According to this research evidence contained in published research has not been a priority. This study has a few limitations. It has been a closed questionnaire survey. Specific evidence and information sources used in the UK healthcare sector have not been included in this survey. Therefore, the applicability of these results in UK practice is limited.

Generic literature related to deign knowledge and design management revealed following key sources of evidence used as inputs for the process of designing.

1. Inputs from the process of briefing
2. Inputs from organisations involved in the design development

3. Inputs from project evaluation data
4. Inputs from published research
5. Inputs from the people involved in actual realisation of the building
6. Inputs from Standards, guidance and tools (SGaTs)

4.4.1.1 Inputs from the process of briefing

The project brief provides initial inputs to start designing. The project brief contains information such as project values, project objectives and priorities and project requirements of the project (Blyth and Worthington, 2010). Information contained in the brief helps to identify the design problem. The project brief is an evolution of several previous versions of the brief. Project needs are first identified and they are codified into a '*statement of need*' which is then developed to prepare a '*strategic brief*' which reflects the client's core business needs. Based on the strategic brief a '*project brief*' is then developed with information in relation to specific site, its environment and project needs. The design team collect information from various activities to build a comprehensive brief by eliciting project requirements properly. User interviews, public consultation, activity survey on how space is used (Emmitt, 2007) surveys of existing buildings for building plans and data, visual survey for space and time usage and other buildings (Blyth and Worthington, 2010) are common methods of data collection during this process. The standard of research rigour of the inputs used during the process of briefing is not clear within the literature and a little is known about the uses of research evidence or other research-based evidence during the briefing process.

The requirements identified during this process are articulated into the brief as performance requirements together with evaluation mechanisms. These are termed 'performance specifications' and form an evaluation mechanism for post-project evaluation of the final building (Emmitt, 2007). Specific design solutions identified as suitable for incorporation into the design are included in the brief by way of 'prescriptive specifications'. Evidence used in performance or prescriptive specifications are not necessarily research-based evidence. Performance specifications allow designers to devise solutions to fulfil defined performance, in such cases the credibility of inputs used by the design team needs to be verified at project level. If prescriptive specifications are used credibility of the evidence on which solutions are based can be evaluated before they are prescribed.

4.4.1.2 Inputs from organisations involved in the design development

Designers use their own and the design organisation's own information and knowledge embedded in information and knowledge repositories, organisational routines, processes and

practices. An individual's knowledge and experience forms a great part of this category of evidence and information. Individuals learn from their own experience (referred to as active knowledge) as well as by actively engaging professional communities, user communities and through learning modes such as conferences and continual professional development activities are also acknowledged (Emmitt, 2007; Bertola and Teixeira, 2003). In addition, these could also contained in the company's standards details, internal project review reports and company regulations (Bertola and Teixeira, 2003). Emmitt (2007) stated that, design guides developed in-house and design typologies from previous projects are useful inputs. According to Heylighen (2000) individual's knowledge, is used in the concept/schematic design phases as well as detail and technical design phases and standard details are often used during detail designing to reduce re- production of working drawings to a copy-and-paste exercise. Use of active knowledge during different phases of designing are discussed further in Section 4.3 of this Chapter.

Design professionals are often criticised for not engaging in systematic project reviews and learning and feeding knowledge back into office procedures is limited (Emmitt, 2007); therefore, the credibility of this types of evidence is questionable. However, since designers are engaged in the external learning activities mentioned above, this could be used as a loop by which evidence (for EBD) can be conveyed into the process of designing; through designers.

4.4.1.3 Project evaluation data

In addition to their own organisational resources, designers look into third party project reviews and other industry reports (CHD, 2010). These include reviews of award won projects, landmark projects or even individuals gathering evidence during visits to such facilities. These can contain both anecdotal evidence as well as research-based evidence. If properly conducted, POE is a prospective mechanism to generate research-based evidence from actual practice.

4.4.1.4 Published research evidence

Research evidence forms the vast majority of EBD evidence base. These are mainly published in peer reviewed journals and sometimes in industry and professional journals. Scholars have reported that the use of research evidence published in academic journals is limited in use(CHD, 2010; Emmitt, 2007; Neuckermans and Fontein, 2002) and the reasons for this limited use are discussed in the previous Chapter. Emmitt (2007) emphasised the importance of gaining knowledge from published literature sources such as text books, professional journals, peer reviewed research journals and conferences. The author further states that "……*repetitive job functions can lead to complacency and lack of interest in learning, ……..constant questioning*

can help to keep knowledge fresh and relevant while stimulating innovative approaches to routine methods and procedures……." (Emmit, 2007, pp.159).

4.4.1.5 Inputs from the people involved in actual realisation of the building

Designers are the primary source of input into designing, although a successful design also relies on cooperation between manufacturers and suppliers of materials and components. Manufacturers help designers to detail some aspects of buildings, especially in circumstances where the detailing may be unfamiliar to the designer or design office (Emmitt, 2007). Designers also contact contractors for informal advice on detailing and technical issues with the aim of improving the buildability of the design (Emmitt, 2007). Based on these requests, and the designer's own details, the majority of design offices have typical details and specifications that are customised to the current project in order to save time and reduce the risk of failure (Emmitt, 2007). There are two limitations for inputs gathered from this type of source. Firstly, these stakeholders have different values that may not necessarily reflect the client's requirements or project values. For instance, manufacturers may consider cheap and durable materials when developing bathroom finishes and infection control may not necessarily be one of their criteria. Secondly, credibility of the information sources used by suppliers, manufacturers and constructors in their products and designs are not clear within the literature.

Gann et al., (1998) state that material and component producers carry out the majority of construction-related research with the aim of improving the performance of buildings for the benefit of end-users. Therefore, this source also demonstrates the prospect of supporting EBD. However, there are barriers to overcome. Larsson et al., (2006) state that lack of communication between product and component suppliers and designers engaged in the building development process hinders their capacity to develop new products within product and component supply organisations. Raising awareness among product and component suppliers on how built environments can improve health outcomes and recognising their efforts to research to support EBD.

4.4.1.6 Standards, guidance and tools (SGaTs)

The Department of Health, together with academia and other advisory bodies, has published a vast array of SGaTs to support designing. They include design standards, design guidance, design assessment tools, strategy tools, benchmarking tools, frameworks and databases. These guide all the different aspects of healthcare built infrastructure such as strategy planning, architectural designs, engineering services designs, safety at operations and assets management used in different phases of hospital developments. Key guidance for designing of buildings includes

Health Building Notes (HBNs), Health Equipment Notes (HENs) and Health Technical Memoranda (HTMs). HBNs primarily guide the initial phases of design while HTMs guide the technical design phase. Activity Database (ADB) is a design support tool developed by incorporating information guidance contained in design guidance into a computer aided programme. Tools such as, Building Research Establishment Environmental Assessment Method (BREEAM), Achieving Excellence Design Evaluation Toolkit (AEDET), A Staff and Patient Environment Calibration Tool (ASPECT), and Premises Assurance Model (PAM) are used for design and building evaluation purposes.

Designers use SGaTs to identify performance and prescriptive specifications for a project. Specific design solutions identified as suitable for incorporation into the design are included into the brief by way of prescriptive specifications. On the other hand, SGaTs guide designers in relation to the performance of output design by way of performance specifications. Even though the design is evaluated against the performance specification at the end of the process of designing, designers also use these to evaluate the intermediate design solutions they devise.

Literature reports several weaknesses of SGaTs (Hignett and Lu, 2009; Lindahl et al., 2010; Hignett and Lu, 2008; Moss et al., 2001). They include:

- having a large amount of uncoordinated regulation and guidance (Hignett and Lu, 2009);
- status of incompleteness (Moss et al., 2001);
- out-dated and not adapted for today (Moss et al., 2001);
- limit design freedom of designers (Hignett and Lu, 2008);
- having a number of different agencies who issue guidance on some aspects (National Audit Office, 2005); and
- duplication, fragmentation, non-standardisation (LaFratta, 2006).

For instance, LaFratta (2006) explained the extent of duplication of SGaTs as:

> *"for example, the HBNs offering over 1240 different room specifications, including 10 different pantry sizes, 6 different utility room sizes, and 88% of rooms less than 40m2" (LaFratta, 2006).*

LaFratta (2006) identified the reasons for these weaknesses. According to the author, lack of heavy and continuous investment by professional organisations to produce comprehensive guidance; the status of guidance which became advisory instead of mandatory following the introduction of new procurements routes such as PFI (Private Finance Initiative) and Procure 21; frequent and unpredictable changes in medical practices, clinical practices, technological

developments and the organisation of the healthcare sector; and technologies, policies and services are subject to shorter lifecycles than the relatively inflexible built assets that support them are the reasons behind the weaknesses of healthcare design SGaTs.

A few scholars have suggested the following measures to eliminate these weaknesses (Hamilton, 2011; Lu and Hignett, 2008; Chen et al., 2010).

- Facilitating a mechanism to update guidance to align with research evidences.
- Restructure advisory guidance so that it describes and supports achieving design evaluation criterions.
- Consider changing requirements (such as technology and policy changes) while producing guidance.
- Facilitate participation of all stakeholders and employ drivers that promote usage of such improved guidance.
- SGaTs being clear so as to strengthen the evidence used to produce them.

SGaTs show a great potential for transmitting research evidence into the process of designing. If converted into SGaTs in an appropriate form and format research evidence could be easily conveyed into the process of designing (see discussion in the section 5).

Through the above discussion it became understandable that the primary source of inputs for designing is not evidence generated through research. Designers gather evidence from several sources and due to the various reasons discussed above the credibility of these inputs gathered from many different sources is always a matter for concern. All of these sources have the potential to be improved or better informed by research-based evidence and facilitate EBD. Existing literature reveals a little about the current uses and the strengths and weaknesses of these sources as facilitators for EBD. Therefore, how these sources of evidence are used within actual practice and their strengths and weaknesses as EBD facilitators need further research.

4.4.2 Outputs of designing

Output specifications expected from healthcare built environments are expressed in design evaluation criteria contained in design SGaTs. If supported by appropriate evidence, these could indirectly facilitate EBD.

4.4.2.1 Design standards and guidance

As stated before, SGaTs contain prescriptive and performance specifications. Prescriptive specification provides direct inputs into the process of designing. Performance specifications

define evaluation criteria for design outputs. These could indirectly facilitate EBD if supported by evidence (as in EBD). According to Gesler et al. (2004) the main focus of the performance criteria has been functionality and safety and the therapeutic features are not greatly considered. However, this explanation appears to be based on the status at, or before 2004. It is apparent that recent HTMs and HBNs tend to integrate research evidence into specifications. For instance, HBN 04-01 - Adult in-patient facilities (NHS Estates, 2009) is supported by research evidence on how single bed patient rooms can improve health outcomes.

Other organisations such as the Design Council, UK and the Commission for Architecture and the Built Environment (CABE – now operated under the Design Council) have also produced design guidance to specify the output performance of design but they are not as widely used as those mentioned above. In addition, national level building standards and regulations are available for some areas of healthcare building designs such as fire regulations. Furthermore, the NHS Design Review Panel (DRP) was set up in 2001 to provide independent advice and guidance by reviewing designs at key stages during the design development process of major investment schemes. NHS DRP reviews a range of schemes across community and acute health sectors procured by PFI, LIFT or public capital. The panel is drawn from a pool of professionals who are familiar with NHS procurement and have a diverse range of expertise, not only in architecture, but in a range of fields including urban design, capital planning, engineering, NHS management or project management.

4.4.2.2 Design evaluation tools

AEDET (Achieving Excellence Design Evaluation Toolkit) and ASPECT (A Staff and Patient Environment Calibration Toolkit) are the two major healthcare specific design quality evaluation tools available in the UK. AEDET and ASPECT were developed initially in 2001 and revised in 2008. AEDET was developed based on the DQI tool, making Design Quality Indicators (DQIs) specific to healthcare. The AEDET evaluates a design against a 59 clear and non-technical evaluation criteria. At this junction it is worth noting that a healthcare specific version of DQIs is available to use. The design evaluation criteria in this 2014 version are similar to the AEDET criteria. Dr. Michael Phiri and his colleges at Sheffield University developed ASPECT based on research evidence on how design improves staff and patient outcomes. They contain design quality criteria in the form of a checklist where a panel of evaluators score the quality of particular buildings against each criterion. Evaluations are performed at the initial stage of designing, at the end of designing and during operation. The BREEAM healthcare tool is used to

evaluate sustainability of the design. Table 4.1 shows quality criteria for healthcare buildings identified by five key design evaluation mechanisms.

ASPECT is the most comprehensive design evaluation mechanism that incorporates evidence base of EBD into the process of healthcare designing. Status of other design evaluation mechanisms as a facilitator of EBD is questionable for two reasons. Firstly, examining the table it becomes apparent that healthcare built environment design evaluation approaches primarily focus on outputs of the process. In many tools undermine the consideration of health related outcomes, achieved through built environments (see highlighted criteria in Table 4.1). Secondly, with the exception of ASPECT these evaluation tools do not align with design strategies and evidence emerging from EBD (refer to Chapter 3). In addition, there are few generic drawbacks of these design evaluation mechanisms. Firstly, these are not for mandatory use in all instances. Secondly, the process of measuring compliance of the design against output performance criteria is time consuming. Thirdly, some of the assessment processes involve the qualitative judgement of reviewers; hence, legal actions against non-compliance are questionable. Finally, for the evaluation of the performance of the design occurs at the end of the construction process where it is difficult to make changes.

Table 4-1: Design Quality indicators from different sources

DQIs/AEDET (*Design Quality indicators)*	ASPECT (*Staff and Patient environment)*	NHS-Design Review panel (*Criteria for quality of place)*	CABE - Design review panel (*10 good points)*
Use	Staff environment	<u>Relationship to site and overall form</u> Sense of arriving; Massing; Form; Density; External space	Integrated design
Access	Views		Public open space
Space	Nature and Outdoors		A clear plan
Performance	Comfort and control	<u>Connections between internal spaces</u> Legible arrangement; Clinical adjacencies; Ease of access and communications; Segregated flows; Hierarchy of spaces; Patient, visitor and staff experience	Clear reception point
Engineering	Legibility of Place		Circulation and waiting areas that are places in their own right
Construction	Interior Appearance		Well-considered materials, finishes and furnishing
Character and innovation	Facilities	<u>Quality of internal spaces</u> Interior design; Views; Natural light; Spaces; Safety; Privacy and dignity;	Natural light and ventilation
Form and material	Privacy, company and Dignity		Adequate storage
Staff and Patient environment			Adaptability to future changes
Urban and Social integration		<u>External envelope</u> Treatment of elevations; materials; Finishes	Out of hours community use

4.4.3 Outcomes of designing

As stated earlier, the primary aim of EBD is to improve outcomes in the health service through the built environment. There are several outcome evaluator mechanisms in place for healthcare sectors; if supported by appropriate evidence, these could indirectly facilitate EBD. Therefore, it is important to review the extent to which current outcome evaluation mechanisms used by the health service acknowledge and measure the contribution from built environments.

4.4.3.1 NHS outcomes framework

The NHS outcomes framework contains measures to help the health and care system to focus on measuring outcomes of the health service (DH, 2012).

Indicators in the NHS Outcomes Framework are grouped around the following five domains.

Domain 1 - Preventing people from dying prematurely;
Domain 2 - Enhancing quality of life for people with long-term conditions;
Domain 3 - Helping people to recover from episodes of ill health or following injury;
Domain 4 - Ensuring that people have a positive experience of care; and
Domain 5 - Treating and caring for people in a safe environment and protecting them from avoidable harm.

A number of indicators that measure the performance of each domain have been introduced within the framework.

The recently introduced 11 point score card system (NHS, 2013) for use in performance measurement has set 11 priority areas (the five domains stated above and another six priority areas) against which healthcare organisations need to measure performance. The first two priorities in this system are 'satisfied patients' and 'motivated, positive NHS staff' which could be supported by built environments. It is the responsibility of individual organisations to set goals and strategies to assess how the performance for these priority areas could be improved.

4.4.3.2 NICE Quality Standards

The National Institute for Health and Care Excellence (NICE) provides national guidance and advice to improve health and social care. According to NICE (NICE,2014a) their role is to improve outcomes for people using the NHS and other public health and social care services by:

- producing evidence-based guidance and advice for health, public health and social care practitioners;

- developing quality standards and performance metrics for those providing and commissioning health, public health and social care services; and
- providing a range of information services for commissioners, practitioners and managers across the spectrum of health and social care.

These guidelines are aimed at medical practitioners and their procedures. NICE also produce technology appraisal guidelines to provide recommendations on the use of new and existing health technologies in the NHS. The contribution from built environments to achieving these outcome targets are not separately identified at this level.

The Quality, Innovation, Productivity and Prevention (QIPP) is one other project operated with NICE with the aim of bringing together quality and productivity information in one comprehensive, accessible and practical resource to show how health and social care organisations and institutions can improve quality and/or make efficiency savings (NICE, 2014b) . The Quality and Productivity Collection includes practical, quality assured examples in the form of QIPP case studies on quality and productivity related topics. Non-commercial organisations providing health services can submit their example to the QIPP collection if they can show examples that an organisation can save money (cash or productivity savings) and/or improve quality at no additional cost (NICE, 2012). Organisations can submit examples related to care provision and other supporting non-core activities such as back office efficiency, safer care and procurement. Again, many of these areas could be improved through innovatively designed built environment interventions, though no examples or case studies relating to built-environment intervention could be found in the present collection.

4.4.3.3 Care Quality Commission (CQC)

The Care Quality Commission is the independent regulator of health and social care in England. They check healthcare providers' compliance with the standards relating to 28 regulations contained in the legislation governing health and social care placing special emphasis on 16 essential standards that most directly relate to the quality and safety of care (CQC, 2010). Among the 16 essential standards, *Outcome 10: Safety and suitability of premises* is significantly related to the built environment. CQS describes regulations relating to the safety and suitability of premises (see Figure 4.2) cited from the Health and Social Care Act 2008.

15.—(1) The registered person must ensure that service users and others having access to premises where a regulated activity is carried on are protected against the risks associated with unsafe or unsuitable premises, by means of—

a) suitable design and layout;
b) appropriate measures in relation to the security of the premises; and
c) adequate maintenance and, where applicable, the proper—
    i. operation of the premises, and
    ii. use of any surrounding grounds,

which are owned or occupied by the service provider in connection with the carrying on of the regulated activity.

(Regulation 15 of the Health and Social Care Act 2008 (Regulated Activities) Regulations 2010)

Figure 4-2 - Regulation 15 of the Health and Social Care Act 2008 (Regulated Activities) Regulations 2010

Even though, *Outcome 8: Cleanliness and infection control* can be significantly impacted by the built environment interventions, specific acknowledgement in this regards in not contained in the CQS guidance.

4.4.3.4 National Patient Safety Agency (NPSA)

Through the National Reporting and Learning System (NRLS), the Patient Safety Division collects confidential reports of patient safety incidents from healthcare staff across England and Wales (NPSA, 2010b). Clinicians and safety experts help analyse these reports to identify common risks and opportunities to improve patient safety. Feedback and guidance on how to improve patient safety are provided to healthcare organisations which include alerts to address specific safety risks, tools to build a strong safety culture and national initiatives in specific areas such as hand hygiene, design, nutrition and cleaning.

Based on the information provided by the healthcare organisation to NPSA, causes of incidents fell into 11 categories. They are:

1. access, admission, transfer, discharge (including missing patient);
2. clinical assessment (including diagnosis, scans, tests, assessments);
3. consent, communication, confidentiality;
4. documentation (including records, identification);
5. implementation of care and on-going monitoring / review;
6. infrastructure (including staffing, facilities, environment);
7. medical device / equipment;
8. medication;
9. patient accident;
10. treatment, procedure; and
11. all others.

According to the latest data, 1% of total incidents (69 out of 6727) have been attributable to category 6 above which is directly related to built environments. Furthermore, poorly designed built environments can indirectly cause safety incidents under many of the above categories. For instance, poor lighting level in hospitals could contribute to medical and documentation errors or poor finishes could contribute to patient accidents. These indirect impacts of built environments on patient safety cannot be identified through the present NPSA analysis system.

4.4.3.5 NHS PAM: NHS premises Assurance Model

The NHS PAM is a management tool designed to provide assurance and a nationally consistent approach to evaluating the performance of NHS premises against a set of common indicators (NHS Estates & Facilities Policy Division, 2013). The model assesses the performance of premises over four criteria: effectiveness, safety and patient experience and efficiency; based on qualitative data gathered via Self-Assessment Questions (SAQs) and performance of efficiency (cost efficiency and spatial efficiency) through secondary quantitative data gathered through Hospital Episode Statistics (HES) and Estates Return Information Collection (ERIC) data and the analysis is performed by the National In-patient Survey and Patient Environment Action Team (PEAT). This is the only mechanism specific to built infrastructure which measures and manages the performance related to healthcare quality and safety. Criteria contained in this model are primarily outcome based. For instance a criterion related to patient experience and a criterion related to safety in this model is presented below.

> *"Integrate building-related patient experiences with communication and service and business planning systems and processes?" (a criterion related to patient experience)*
>
> *"Provide safe and portable water supplies"? (a criterion related to safety)*

This model is creditable for two reasons. Firstly, it quantitatively estimates the performance of premises at each stage so that they are comparable with national average performance. Secondly, this model utilises data collected by other mechanisms without imposing more administrative systems on individual organisations or for inspection organisations. One weakness of this approach is that the model only considers the management or operational phases of premises. During this phase of built infrastructure, making changes to improve the situation could be significantly expensive.

4.4.3.6 ASPECT: A Staff and Patient Environment Calibration Tool.

ASPECT is a healthcare built environment evaluation tool based on a database of over 600 pieces of research. The research and the ASPECT toolkit itself are set out under 8 headings. They are:

1. privacy, company and dignity;
2. views;
3. nature and outdoors;
4. comfort and control;
5. legibility of place;
6. interior appearance;
7. facilities; and
8. staff.

Each of these criteria is then sub-divided and altogether ASPECT contains 47 criteria to assess healthcare built environments. Some of these criteria are concerned with outcomes (for instance, privacy, company and dignity), whilst some are concerned with building output specifications (for instance, some sub criteria related to ease of use of place refers to whether patients and staff can easily open windows/doors).

In addition the Health Protection Agency (HPA) is responsible for controlling healthcare associated infections (HCAIs), while the Health and Safety Executive (HSE) has responsibility for virtually every form of workplace and activity.

In conclusion, NHS PAM and ASPECT are the only outcome evaluation mechanisms which is concerned with outcomes of the health service derived through BE. Other mechanisms which are currently in place have given significant priority to operational practices, but as mentioned throughout the discussion properly designed built environments can contribute in many ways to achieving the outcome performance expected in these tools. In the majority of instances setting strategies for achieving safety and quality outcomes, is the responsibility of the individual organisation. Therefore, it is the individual organisation that would recognise any opportunities for improving quality and safety through their particular healthcare built environment. However, improving built environments is not a recurring process. Quality and safety can be built into the infrastructure during its design and construction and thereafter during occasional refurbishment or renovation activities. However, every NHS organisation has a unique combination of patient needs, priorities, requirements and resources, including Estates & Facilities (E&F). This makes it difficult to have a single overall approach to the provision of E&F that produces optimal result for all NHS organisations (NHS Estates & Facilities Policy Division, 2013). Evaluating the impact that built infrastructure can have on health outcomes is difficult with the present knowledge and informing providers about the contribution built environment has on achieving outcome targets would be more effective. However, EBD could be significantly improve, if the ways to measure the contribution of BE on health outcomes are identified.

In summary, it is evident that quality and safety in the built infrastructure is embedded in the design primarily through design inputs. Therefore, EDB could be facilitated by incorporating evidence (as in EBD) into design inputs and by integrating evidence (as in EBD) into output specifications. The ASPECT tool is a good example which reflects facilitation of EBD through design output evaluation mechanisms. Due to difficulties associated with measuring the contribution of built environments to improving health outcomes, facilitating EBD through higher level health outcome evaluation mechanisms is challenging. Therefore, it is sensible to separate built environment related performance criteria, from frequently monitored high quality and safety outcome performance management mechanisms, and incorporate them into the input and output specifications of BE designing.

4.5 DESIGNERLY WAYS OF USING EVIDENCE

The practice of designing is different from other fields and it has its own 'd*esignerly ways'* of practice (Cross, 2001; Heylighen, 2000). Many researchers who have explored design knowledge usage have acknowledged this notion and have explored designerly ways to recommend improvement opportunities for design practices (for instance, Lawson, 1994 & 2004; Demian and Fruchter, 2006a, b and c; 2009; Cross and kruger, 2006). Similarly, this research explored designerly ways of using evidence as the basis for identifying the effective ways of incorporating evidence (for EBD) into performance and prescriptive specifications.

As stated earlier, before the concept of EBD, the term *evidence* was not frequently used in design literature. The more frequently used terms were*: design information; design knowledge*; and *design inputs*. Specifically, in design literature, the term 'design knowledge' is the frequently used term. Section three of this Chapter discusses the linkage between evidence and design knowledge and established that design knowledge could carry EfD and evidence as in EBD.

Knowledge is considered to be a dynamic human process in which personal convictions are justified in the search for truth (Nonaka, 1994) and can be best described and defined as specific to the context. According to scholars design knowledge is seen as difficult to define but easy to recognise by scholars' (e.g. Lawson, 2004; Heylighen, 2008). Therefore, a precise definition of knowledge is not very clear within design knowledge literature (Heylighen, 2008). Lawson (2004) states that:

> *"..... we can look at the information designers are given and the information they produce. From this we can attempt some inferences about the knowledge they may have used to transform the inputs into the outputs. .....". (Lawson, 2004, pp.3)*

The design profession tends to be highly secretive, and fails to incorporate generic and widespread knowledge management theories accepted in other fields (Doctors, 2004, cited in Heylighen et al., 2006). Heylighen et al., (2006) stated that this resulted in the design profession failing to claim a common knowledge base (a formal and codified domain of expertise claimed by a profession) whilst many professions such as medicine and law have knowledge bases. This suggests that the practice of architecture is different from other fields. In an article cited significantly '*Designerly ways of knowing*', Nigel Cross also claims that design has its own distinct things to know, ways of knowing them and ways of finding out about them (Cross, 2001). This argument is acknowledged by many other scholars in the domain of design knowledge (e.g. Heylighen, 1999 & 2000; Lawson, 1994, 2003 & 2004; Demian and Fruchter, 2005; 2006a; 2006b; 2006c and 2009), therefore, it is important to review design knowledge literature and identify the theoretical underpinnings that can have an impact on EBD.

4.5.1 Declarative knowledge and procedural knowledge

Literature reveals two main categorisations of knowledge applicable to designing. First, based on the application of the knowledge, knowledge has been categorised into declarative knowledge and procedural knowledge.

- Declarative knowledge (also called 'component knowledge') - knowledge about specific aspects of design (for example cost, aesthetics, safety) (Heylighen, 2008).
- Procedural knowledge- (also called architectural knowledge or concept knowledge) - knowledge about the way in which components are integrated and linked together into a coherent whole (Henderson & Clark, 1990).

4.5.1.1 Declarative knowledge and procedural knowledge in EBD

Both declarative and procedural knowledge supports the success of the designing. Revisiting the definitions of evidence and EBD (refer Chapter 3) it is obvious that evidence base of EBD is a form of declarative knowledge which contains knowledge about design strategies that would impact on health outcomes. A majority of the scholarly efforts into EBD are focussed on declarative knowledge and aim at generating new evidence, undertaking systematic reviews of evidence. Chapter 3 presents the details of component knowledge base of EBD.

Success of the EBD process is however dependent on the procedural knowledge as well and EBD scholars often emphasise the importance of critical application of evidence (Hamilton, 2003; Hamilton and Watkins, 2009; Moore and Geboy, 2010). Literature on EBD processes (see Section 3.5) provides some insights into procedural knowledge for EBD. All these models have different

intentions and could be used for different purposes, but a too little attention has been paid to the actual project level activities involved in each stage of EBD.

4.5.2 Active knowledge and codified knowledge

The second categorisation of knowledge is based on the generation and acquisition of the knowledge.

- Active knowledge (learned by experiencing or doing) - knowledge gathered by designers through actually designing by themselves or by vicariously experiencing any other existing designs to learn the knowledge embedded in those designs.
- Passive/Codified knowledge (externally available codified knowledge) - knowledge acquired by designers through secondary sources without directly engaging themselves during designing or vicarious experiences.

Earlier scholars had claimed that design knowledge is primarily composed of active knowledge or is learned only by doing (Schon 1987 cited in Martin, et al., 2005; and Kant 1966, cited in Heylighen et al., 1999). Contemporary scholars however, do not concur with this earlier view and acknowledge the use of both active and codified knowledge during designing as well as abilities of knowledge sharing and knowledge transfer (Habraken 1997 cited in Martin et al., 2005; Muller and Thoring, 2010; Bertola and Teixeira, 2003; Boling, 2010; Lawson, 2004; Heylighen, 2008).

Design knowledge could be generated by different stakeholders in the industry. Literature identifies three main groups who generate design knowledge.

1. Designers in the industry - Knowledge learned by the individuals who engage in the process of designing.
2. Regulatory authorities - Various regulatory authorities create codified knowledge to be included in standards, guidance, principles and legislations (Lawson, 2004; Heylighen et al., 1999).
3. Research institutions - Researchers in universities and other research institutes produce rigorous research knowledge which is included in books, journals and research databases (Neuckermans and Fontein, 2002).
4. Others

Knowledge in the first category above is active knowledge to designers. But this knowledge could be codified and shared with other designers through user communities, design organisations and professional networks in which they are engaged (Habraken (1997) cited in Martin, et al., 2005; Bertola and Teixeira, 2003). These are sometimes codified into

organisational standards, design details and best practices and may be published in other organisational publications (Lawson, 2004; Heylighen et al., 1999). Knowledge created by regulatory authorities and research institutions is passive knowledge to designers and they acquire such knowledge through codified knowledge stores.

Mulller and Thoring (2010) presented a comprehensive illustration of the generation of active and codified knowledge and knowledge transfer mechanisms between active and codified knowledge stores (see Figure 4.3). The diagram shows how data embedded in the design artefacts are transformed into active knowledge and eventually converted into codified knowledge. Firstly, individuals experiencing the design artefacts accumulate knowledge actively (A→B).

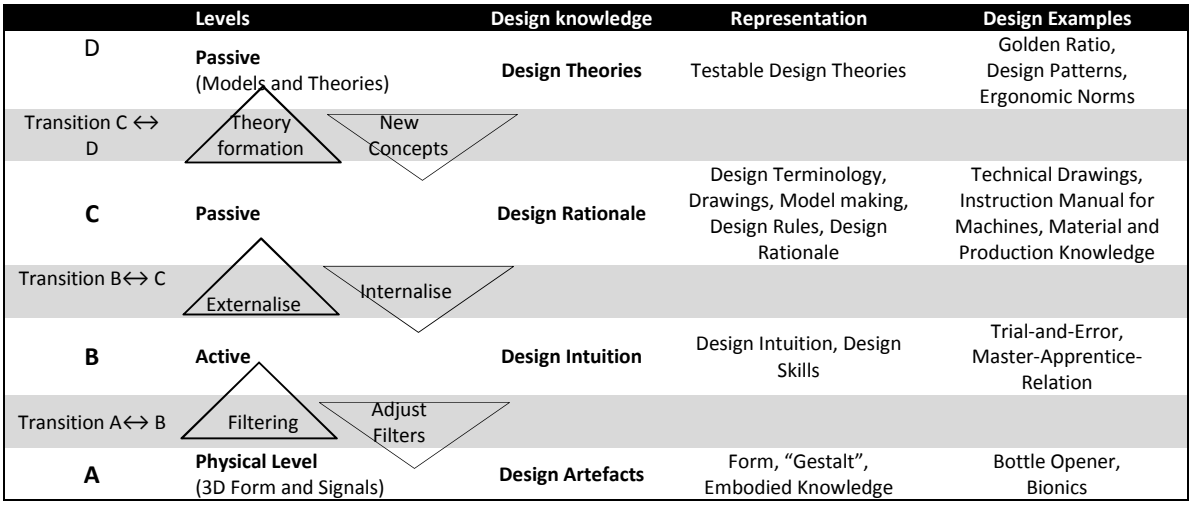


Figure 4-3: Framework for design specific knowledge (adapted from Mulller and Thoring, 2010)

Those individuals then codified the acquired knowledge into design rationales and design theories for others to use. It is also worth noting that some scholars argue for the non-existence of design theories (eg. Lawson 1994 & 2004). The four knowledge stores illustrated in Figure 4.3 are apparent within the UK's healthcare built environment designing. 'Level A' knowledge is comprised of knowledge embodied within existing healthcare buildings and related artefacts and 'Level B' knowledge is accumulated in the minds of individuals. SGaTs (HBNs, AEDET, and HTMs for example) are examples of rational design considered in level C. The distinction between design rational and design theories is not clear when it comes to BE design. Design strategies such as single room designs, which have been tested against many aspects of design and rules for space adjacencies, can be considered to be the content of level D even though they have not matured as theories.

4.5.2.1 Reasoning from active and codified knowledge

The other important aspect of knowledge is how designers reason from these two types of knowledge. Literature claims that designers prefer to use active knowledge over codified knowledge during designing (Habraken 1997 cited in Martin et al., 2005; Lawson, 2004; Cross, 2007). As stated earlier, the majority of the evidence for EBD is comprised of codified knowledge. Exploring how designers use active knowledge and codified knowledge would give useful insights into how evidence could be better integrated into the process of designing.

Reasoning from active knowledge

As stated earlier, active knowledge is the designers' most preferred form of knowledge. Understanding how designers use active knowledge would provide insights into how codified knowledge could be better incorporated into the process of designing in designer friendly forms. Active knowledge is mainly retrieved from 'precedents' (Boling, 2010; Lawson, 2004; Cross, 2007). Precedents are a form of knowledge embedded in individuals' memories as an episodic memory through direct and vicarious experience of existing designs (Lawson, 2004). Precedent is not about extracting disembodied lessons learned from previous situations and storing these as rules for future designing. They are stored as cases and designers reason from cases (Boling, 2010). Expert designers accumulate a vast numbers of precedents '*which is stored as having affordances that might come in useful at some point in design projects'* (Lawson, 2004, p. 456).

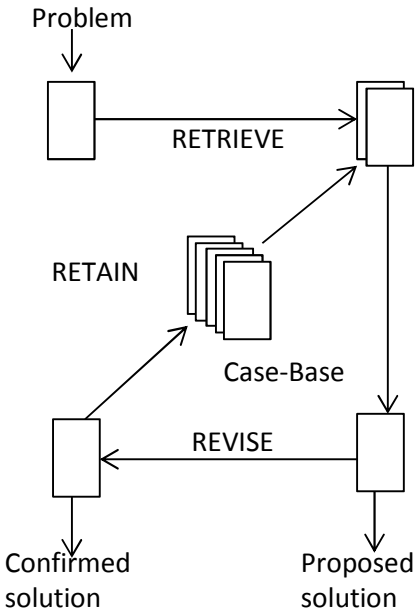


Figure 4-4: Case based reasoning (adopted from Ian and Srinath, 1997)

They then browse freely and associatively between multiple precedents in order to make relevant connections to create new design solutions (Oxman, 1994). Precedents are also helpful in finding the fit, if any, between the potential embodied precedent and the current situation (Lawson, 2004, Cross, 2004; Boling, 2010). Precedent based reasoning using active knowledge has also been termed case-based reasoning (CBR) in design literature. Diagram 4.6 illustrates how precedents (or cases in CBR) are retrieved whilst solving new design problems.

Heylighen et al., (1999) and Cross (1997) have identified five reasoning methods (Table 4.2) that show how designers use active knowledge to create new design solutions. They are cases, types, analogy, metaphorisation and heuristics.

Table 4-2: Reasoning methods used by designers (adapted from Heylighen, 2000)

Reasoning method	Description	Examples within healthcare
Cases	Concrete projects from the past encapsulate knowledge about previous design solutions in the form of architectural objects. These objects are concrete, full of detail and contain architectural knowledge as well as component knowledge.	Standard bathroom details
Types	Types in architecture can be seen as generalisations of design solutions that have reliably shown to be satisfactory in the past in the form of blueprints for future designs usually focussing on the spatial distribution of functions (ex: Examples of historically standardised types of the Roman villa, the Gothic cathedral, the Ottoman mosque)	Different ward layouts (ex: Nightingale wards, Nuffield ward, radial ward)
Analogy	Architects call in an existing form or form-giving construct as a point of departure for their design and the form of the latter is directly and structurally influenced by that of the former. The relationship between source and target is usually structural in analogies. (ex: Sydney opera house was strongly conditioned by the shape of sailing yachts entering Sydney harbour)	Alexandra hospital (Brighton, UK) designed as a ship in its exterior shape
Metaphorisation	This type of reasoning is iterative and helps in concept development, unlike analogy the relationship between 'source' and 'target' is semantic rather than structural (ex: Cataldo cemetery in Modena seems to be conceived as a city for the dead)	Great Ormond Street Children's hospital design
Heuristics	Rules of thumb derived by generalisation from past solutions. They can help evaluate architectural choices, act as sanity checks or first-order assessments and even function as teaching aids.	Decisions on number of toilets, number of theatres, waiting area space

In an investigation into design knowledge re-use Peter Demian, Renate Fruchter and their colleagues at Stanford University (Demian and Fruchter, 2005; 2006a; 2006b; 2006c and 2009) identified details of project level approaches in re-using previous designs. In this research authors found that the project context and evolution history of particular design solution is an important consideration during design knowledge re-use. Demian and his colleagues also appreciated that designers require additional resources to capture design knowledge and store them in the effective forms identified in their researches. This research suggested the

importance of the form of expression, tools and approaches used to store knowledge to promote effective re-use of the content (codified evidence) in external digital or paper archives.

According to Heylighen (2000) knowledge stored as precedents are more useful during the concept design phase to generate new solution forms through analogies, metaphorisation and types, while concrete cases and types are useful during the detail design phase. Design rules (heuristics) are more useful for evaluation purposes. In addition, rules are useful for design evaluation purposes in terms of warning designers about what cannot be altered, assuring them about stability (Krippendorf, 2008) and for analysing and evaluating existing designs Heylighen et al. (1999).

Reasoning from codified knowledge

Codified knowledge is primarily contained in the published literature, the design rationales (such as technical drawings, instruction manuals, and material and other product knowledge) and design theories (ergonomic norms). Where healthcare built environment designing is concerned codified knowledge is also contained in in-house (within organisations) technical drawings, standards and guidance and SGaTs published by such regulatory authorities as DH and BSI. There is little known about how designers reason from codified knowledge during the process of designing since it is not the preferred form of knowledge for designers. It has been claimed that knowledge produced by research centres and universities is under-utilised (Neuckermans and Fontein, 2002) and legislation is frustrating for the architects (Lawson, 2004). Codified knowledge is often regarded as little used during concept development or creation of new solutions because it does not tell designers what actions to take in specific new design situations (Boling, 2010; Heylighen et al.,1999; Norman, 2006 cited in Boling, 2001; Neuckermans and Fontein, 2002; Lawson, 2004). Similarly to heuristics, codified knowledge contained in design evaluation criteria can warn designers about what cannot be altered, assuring them about the stabilities.

4.5.3 EBD from a design knolwedge perspcective

Together these studies provide important insights into EBD. Based on this understanding it could be argued that both declarative knowledge and procedural knowledge of designing could be available in the forms of active knowledge and codified knowledge (see Figure 4.5).

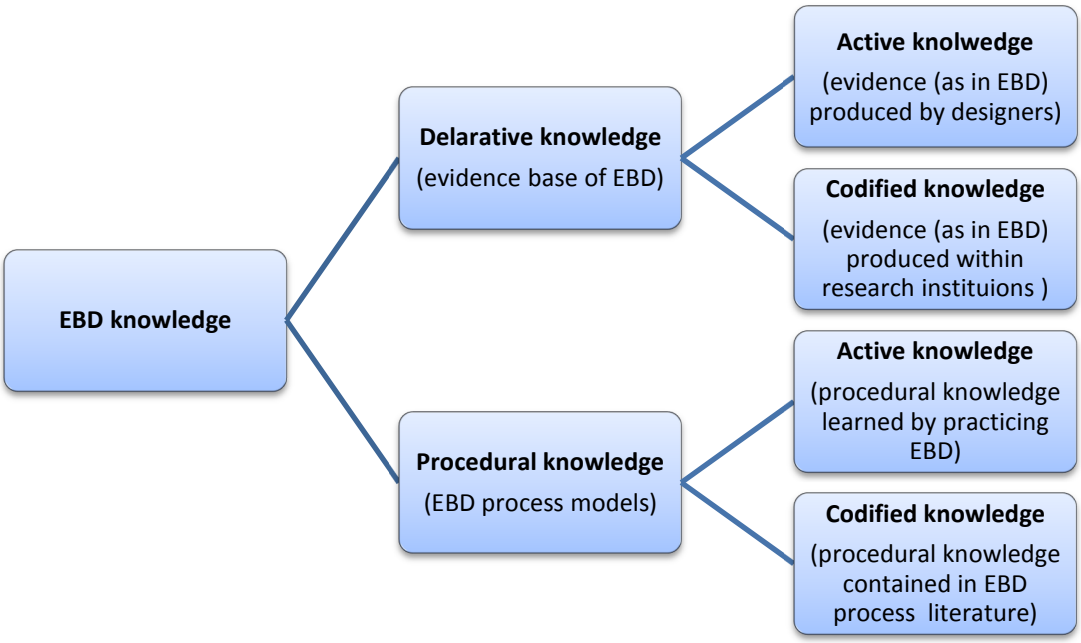


Figure 4-5: EBD knowledge

Declarative knowledge for EBD is the available evidence base for EBD and could be in the forms of active knowledge (if the designers generate evidence for EBD) and codified knowledge (research evidence base of EBD produced by researchers). According to the design literature, designers prefer to use active knowledge as opposed to codified knowledge. This implies that promoting designers to generate research evidence (practitioner driven research evidence generation) would be more effective than insisting designers to use codified evidence produced by research institutions (research institution driven evidence generation). EBD scholars have identified this opportunity and proposed solutions to improve the former way of facilitating EBD. For instance, Hamilton's (2003) four level model of EBD encourages designers to generate new research evidence to share with industry. Researchers (Joseph and Hamilton, 2008; Codinhoto, et al., 2010) developed performance measurement frameworks to guide POE and to assist designers to generate research evidence to facilitate EBD. The framework, proposed by Joseph and Hamilton (2008), is now used in all Pebble projects to conduct performance measurement.

But, as discussed earlier, the majority of the EBD evidence base is available in the form of codified knowledge created by research institutions and they are under-utilised by designers. The current codified evidence base of EBD exceeds 1200 pieces of evidence and is a substantial knowledge base that could improve current practice in healthcare design to assist in closing the quality gaps in heath service provision. Further details of this codified evidence base are presented in Chapter 3. Recognising the importance of the existing codified evidence base, this research explored how this codified research evidence base could be made available to designers.

The first effort for this endeavour was undertaken by EBD scholars who compiled the evidence contained in peer-reviewed journals and transferred it into evidence databases. Several databases have been developed for this purpose in the US and in the UK (Chapter 3). One other available opportunity for this purpose is to disseminate evidence through SGaTs. As stated earlier, the UK's healthcare sector is guided by an ensemble of SGaTs produced by DH. There is a promising potential to convey EBD evidence base into the process of designing through design SGaTs since they are well established in practice (Hignett and Lu, 2009; Lindhal et al., 2010). This opportunity was recognised by several scholars (Glen et al., 1998; Tetreault and Passini 2003; Hignett and Lu, 2009; Chen et al., 2011; Phiri et al., 2011; Codinhoto et al., 2010; Lawson, 2010) and is partly being implemented (for instance, ASPECT). Taking a step forward, this research explored how the codified evidence base of EBD could be incorporated into design SGaTs in the forms of performance and prescriptive specifications.

The Literature review reported in this section provides the understanding of how designers' reason using active knowledge and codified knowledge (see Table 4.2) and also some project level examples of how previous designs have been re-used (Demian and Fruchter, 2005; 2006a; 2006b; 2006c and 2009). It is important that, theoretical understanding needs to be considered when articulating evidence informed SGaTs, and this implication has previously been raised by scholars. Based on designers' preferences for reasoning from precedents, Lawson (2004) stated the importance of the descriptive story telling form to transmit evidence. Lawson expanded his suggestion by saying that evidence contained in standards and guidance in the form of design solutions are preferred by designers as opposed to generic rules. Boling (2010) emphasised the importance of providing context that allows independent transparency to convey the particular situation, and not the process, in deriving the general rule. Demian and Fruchter (2005; 2006a; 2006b; 2006c and 2009) stated the importance of incorporating details related to the context and evolutional history of the solution when disseminating best practice solutions. Evans (2009) suggested that producing evidence to support conjecture rather than rules would help designers to grasp the essence of evidence. It was expected that, exploring how designers use performance and prescriptive specifications during EBD would provide useful insights into how the codified evidence base for EBD could be effectively articulated into SGaTs in the form of performance and prescriptive specifications. The next section of this Chapter reviews literature related to performance and prescriptive specifications and their current usage within healthcare built environment designing.

The other aspect of EBD knowledge is the procedural knowledge of EBD. It is also acknowledged that the procedural knowledge of designing is better learned through active knowledge. Scholars (for instance, Lawson, 2004) claim the non-existence of design theories. Furthermore, design students are taught in design studios to encourage active learning of procedural knowledge. The implications of this notion to EBD have been previously suggested. Martin and Guerin (2006 & 2007) have recommended that design students need to be taught to practice EBD. EBD process literature provides procedural knowledge for EBD in the form of codified knowledge. The usefulness of EBD processes as procedural knowledge is questionable (see the discussion in Chapter 3 section 5). However, procedural knowledge for EBD is crucial for the success of EBD. Chapter 3 of this thesis presents a comprehensive review of issues related to the application of EBD, the majority of which may be improved by improving the procedural knowledge for EBD. It was understood that due to the nature of construction projects, application of EBD is a more project level task or responsibility based on individuals' approaches. Exploring project level practices for tackling EBD issues and recognising best practices is, therefore, beneficial for the improvement of EBD.

4.6 EVIDENCE INFORMED STANDARDS, GUIDANCE AND TOOLS

The contents of standards and guidance are generally known as specifications in construction management literature. Design specifications can be articulated into two main forms: prescriptive specification and performance specification.

British Standards (BS0 part 3 clause 8.5.4) defines prescriptive specification and performance specification as stated below:

> ***Prescriptive specification*** *- specifications which set down the characteristics of a product in terms of its size, shape, materials etc.,*
>
> ***Performance specification*** *- specifications which set down the characteristic functions a product has to perform such as carrying loads or resisting the passage of sound. In these specifications performance levels for the required functions are defined and a method of testing is given for each appropriate parameter.*

Prescriptive specification is a means of effectively re-using well accepted, reliable design solutions and this nurtures standardisation of designs. However, performance specifications allow designers engaged in designing to devise solutions that meet performance criteria, hence, nurturing innovation during designing. In actual application, a mix of prescriptive specification

and performance specification is used. A good balance between standardisation and innovation during designing is important to gain benefits from both approaches.

4.6.1 Prescriptive specifications in SGaTs

There are two types of standards containing prescriptive specifications: published standards and guidance and 'de facto standards'. De facto standards are not published or endorsed by any regulatory body, yet are repeatedly used during designing by tradition. Both these types of standards are used prominently in healthcare BE designing.

Published standards and guidance

These are standards and guidance provided by recognised regulatory bodies and could be categorised into *regulatory standards* (mandatory in use) and *consensus standards* (*voluntary or discretionary in use)*. Typical examples for regulatory standards are safety standards and environmental standards. HTMs issued by the Department of Health, UK contain regulatory standards that are mandatory to follow. For instance, *HTM 05-03: Part A - General fire safety contains* mandatory standards (see the quote below taken from this guidance).

> *"The management of fire safety training is dealt with in Health Technical Memorandum 05-01 and is a statutory duty under the Regulatory Reform (Fire Safety) Order 2005 and the Health and Safety at Work etc Act 1974"* (HTM 05-03: Part A - General fire safety, pp.9).

On the other hand, HBNs (Health Building Notes) are consensus standards that give "best practice" guidance on the design and planning of new healthcare buildings and on the adaptation/extension of existing facilities.

'de facto' standards

These are repeatedly used traditional design solutions. A de facto standard is a custom, convention, product, or system that has achieved a dominant position by public acceptance or market forces. They are widely accepted and used, but lack the formal approval of a recognised standards organisation or organisations (Allen and Sriram, 2000). Allen and Sriram (2000) further stated that de facto standards generally result from widespread consensus on a particular product or protocol that has a large market share. The famous example for a de facto standard is QWERTY1 keyboard.

'Nightingale Cruciform ward' developed by Nightingale Architects (UK) (Figure 4.6) is a good example of a de facto standard within healthcare BE. This type of ward is designed with four beds placed in each corner of a square room allowing better walking spaces and better patient observations. This can be considered to be a good example of a knowledge driven innovative design solution which later became a de facto standard.

Figure 4-6: Cruciform ward design (Nightingale Associates)

As stated earlier, application of standard design solutions from one context to other is difficult due to the nature of the built environment. Investigating how designers overcome this difficulty during the application of standard solutions is therefore an important research gap.

Standardisation through prescriptive specifications

Prescriptive specification promotes standardisation during designing. Standardisation is widespread and systematic use of processes and components with a background of successful practice repeated regularly in construction and engineering projects (Gibb and Isack, 2001; Edum-Fotwe et al., 2004). The benefits of standardisation have been acknowledged by many industries. In the report 'Rethinking Construction' (1998), the UK government called for standardisation to benefit the construction sector. With particular reference to healthcare projects, several scholars have specifically explored how standardisation of building design could benefit patient health and safety (Price and Lu, 2013; Hignett and Lu, 2009; Reiling et al., 2003; Henriksen et al., 2007). Healthcare built-environment standardisation literature is heavily focussed on space standardisation. Henriksen et al., (2007) explained (see quote below) how standardised patient rooms could bring these benefits.

> *"On entering patient rooms, providers should not have to waste time and effort in rediscovering the locations of needed equipment, controls, outlets, supplies, and patient information. Patient rooms can be standardized with respect to size*

> *and layout to enable quick access to supplies and equipment, to facilitate proper hand hygiene, to increase patient visibility, to allow more natural light, to reduce noise, to decrease patient falls, to allow easier access to records and care regiments, and to accommodate family members." (*Henriksen et al., 2007, pp. 69)

Henriksen et al., (2007) have identified other spaces in hospitals (in addition to patient rooms) which could benefit from standardisation. The authors stated that standardisation would be beneficial in emergency examination rooms, post-recovery rooms and diagnostic examination rooms and several other elements such as access to gases throughout the facility. In addition standardising equipment such as, monitors, infusion pumps, beds, medication systems, intravenous devices and assorted connecting devices, would also be helpful. Price and Lu (2013) identified meaning, drivers and barriers to space standardisation and potential spaces that could be standardised in the future. Price and Lu (2013) further cited details of case studies undertaken by Community Health Partnerships, UK to explore room standardisation. The importance of standardisation for health service providers is also reported (Henriksen et al., 2007).

Drawbacks of prescriptive specifications

Scholars have identified the drawbacks of prescriptive specifications. Foliente (2000 cited in Sexton and Barrertt, 2005) stated that '*improved and/or cheaper products may be developed, yet their use might not be allowed if construction is governed by prescriptive codes and standards*'. Scholars have also claimed that prescriptive specifications inhibit innovation (Tassey, 2000; Martins and Terblanche, 2003; Roy et al., 2005). This argument has been criticised by Gann et al., (1998) and Edum-Fotwe et al., (2004). Gann et al., (1998) by analysing British Building Regulation Part L which set minimum thermal performance levels for buildings, identified that the type of prescriptive specifications contained in regulations still stimulate innovation at product and component level. However, the author made it clear that prescriptive specifications might play a different role in other contexts. Edum-Fotwe et al., (2004) described how innovation could be supported by standards (see Figure 4.7).

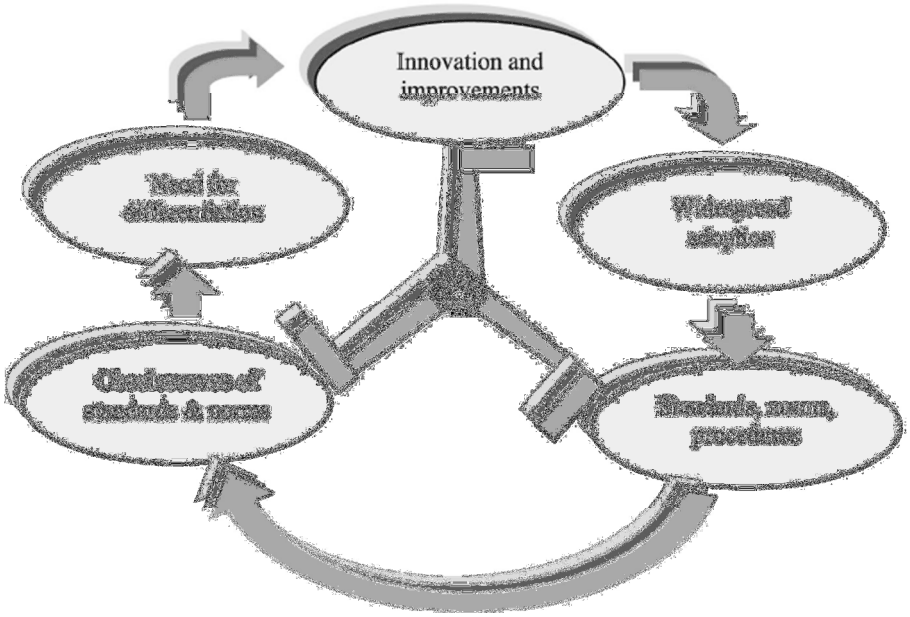


Figure 4-7: The perpetual cycle of innovation and improvement (source - Edum-Fotwe et al., 2004)

According to Edum-Fotwe et al. (2004) innovative solutions become standards, norms or procedures after widespread adoption and obsolescence of existing standards and norms; which then prompts the need for innovation and improvements. However, this cycle would work for complete solutions widely accepted by industry. For instance, the recent innovation of single patient rooms will go through this cycle; although it is questionable whether small scale innovations could be implemented by this cycle.

Prescriptive specifications, which describe products or components, are more similar to *precedents* or *cases* which designers used during designing. Therefore, this type of specification will be well used if they are conveyed to the designers with the appropriate details to facilitate similar reasoning as designers use with active knowledge.

4.6.2 Performance specifications in SGaTs

Performance specifications support performance based approaches to building. The CIB working commission W060 (cited in Meacham et al., 2005) states that the performance approach is 'a practice of thinking and working in terms of ends rather than means'.

Averill (1998) defined performance specification as:

> *'quantification of the level of performance which a building material, assembly, system, component, design factors, or construction method must satisfy in order that the building meets all the goals established by society and the client'* (Averill, 1998, pp.18).

The term ‘quantification’ in the above definition is loose. Sexton and Barrett (2005) further describe this as the level of performance required of the building attributes are defined, described or specified. Combining two definitions together, performance specification could be defined as:

> *‘the level of performance required of the building attributes are defined, described or specified which a building material, assembly, system, component, design factors, or construction method must satisfy in order that the building meets all the goals established by society and the client’*

With performance specifications, many combinations of different building parts can be innovatively created and/or procured for which it can be demonstrated that the specified attributes will satisfy the required level of performance (Sexton and Barrett, 2005).

According to literature, performance specifications offer the following benefits (Gann et al., 1998; Haberecht and Bennett, 1999; Sexton and Barrett, 2005; Averill, 1998).

- Stimulate/stifle innovation (Gann et al., 1998; Sexton and Barrett, 2005);
- Building owner may benefit through the lower, total cost of building construction and operation (Averill, 1998);
- The design team is allowed to pursue more innovative architectural designs (Averill, 1998; PeBBu, 2013c);
- The opportunity for superior building quality because the process allows a choice between a large range of approved materials and systems (Haberecht and Bennett, 1999); and
- Encourages better fitness for use of the building (PeBBu, 2013c).

Stimulating innovation is the key benefit of performance specifications. Innovation is important to improve patient health and safety and efficiency of the process, by filling knowledge gaps. Further, failure to use available science is costly and harmful. It leads to overuse of unhelpful care, under-use of effective care, and errors in execution (Berwick, 2003). This may even lead to death, disability, or permanent discomfort (Lansisalmi et al., 2006). Moreover, the healthcare sector faces constant changes in terms of care delivery models, technology and medical advances; as a result built environmental designs need to be changed. However, extreme use of innovative solutions may be unsafe in a risk adverse field like healthcare; therefore, the right mix to produce standards and guidance appropriate for two approaches needs to be identified for healthcare buildings.

A few disadvantages of using performance specifications were also reported. They are:

- evaluation of the design could, potentially, become more difficult and time consuming (Averill, 1998; Baark, 2001; CIB, 2004);
- places undue burden on contractor or designer to provide proof that they have met the required performance (Bowen and Thomas, 1997); and
- as a result of above three, new innovative technologies may be ignored by the design team and contractors (Baark, 1997).

According to design knowledge literature, performance specifications which describe the performance expected of the end product are more comparable with design evaluation rules used by designers. They are primarily used for design evaluation and partly used as a framework during designing. Furthermore, these externally imposed design rules may be less favoured by designers.

Performance based regulatory systems for buildings are primarily supported by performance specifications. Two CIB task groups (Task Group TG11 and Task Group TG37) were established to explore and improve the performance based regulatory systems. TG11 was established in 1992 with the objective of providing information to assist those countries developing performance based regulatory systems and producing an outline of a practical approach to performance-based building regulatory systems (Bowen, 1997). TG11 was disbanded in 1997 after completing its task. Following on the work of TG11, the Inter-Jurisdictional Regulatory Collaboration Committee (IRCC) was formed. In 1999, CIB TG37 was established aiming to complement IRCC. IRCC focused on policy issues of introducing performance based regulatory systems whilst, TG37 supported IRCC objectives by exploring issues in more detail and from a technical perspective (IRCC, 2009; CIB, 2004). TG37 together with IRCC published their researches related to creating standards in a performance environment; understanding the implications of quantitative and qualitative performance criteria in performance-based regulations; application of acceptable solutions; investigation of the concept of multiple levels of performance within building regulations; and developing *the Performance System Model:* a conceptual framework for understanding the role of various stakeholders in promoting performance based regulations (CIB, 2004). TG37 was completed in 2004.

TG37 admitted that a performance based regulatory system could use both quantitative and qualitative performance criteria, yet, they emphasised that 'the key to a truly performance-based system is a set of quantitative and measurable performance criteria appropriately linked

to the qualitative portion of the system (IRCC,2009). Therefore, some areas of building regulations such as energy conservation, structural design, sound insulation and several aspects of fire safety currently benefit from sufficient knowledge supporting the expression of performance criteria in quantitative and measurable terms, whilst, areas related to personal hygiene, human comfort and well-being, movement and access for and of humans, and some aspects of fire safety are unable to implement and benefit from performance based regulations (Meacham et al., 2005).

The Society of Fire Protection Engineers, along with several partner organisations, organise a regular conference (*International Conference on Performance-Based Codes and Fire Safety Design Methods*) to showcase state of the art performance-based code approaches and engineering design methods. The discussions at this conference are related to achieving specific aspects of the building performance through dedicated performance-based codes, regulations or standards. The main emphasis of the conference is the use of performance-based codes to achieve fire safety within building designs, whilst other disciplines, such as performance of structural engineering systems, were also considered during the conference. Similar to the finding of CIB task groups, difficulties associated with implementing performance based regulations for some aspects of building design is also reflected within the work of International Conference on Performance-Based Codes and Fire Safety Design Methods. Further, suitability of performance-based specifications for other quality criteria is not considered within the scope of this conference.

Funded by the European Commission and begun in 2001, the Performance Based Building Network (PeBBu, 2013a) is a thematic network which tries to improve some of the less understood areas of performance based regulatory systems. This network supports the enhancement of existing performance based building research and activities by networking with the main European stakeholders and other international stakeholders. PeBBu argues that the basis for all building activities should be the performance of the building in use rather than the prescription of how the building is to be constructed. PeBBu has a specific domain which emphasises the performance of indoor environments. Currently, the objective of this domain is restricted to performance criteria for healthy building and relates to: air quality, ventilation, thermal comfort, noise and light (PeBBu, 2013b).

Among, the initiatives discussed above, only the TG37 recognised the importance of prescriptive solutions. Bergeron (2003) studied how prescriptive solutions are established and assessed within existing systems. Even though CIB task groups and other initiatives described above,

established to promote performance based specifications for the construction industry, it was finally evident that prescriptive standards are essential within a regulatory system. TG37 identified prescriptive solutions as a way of ensuring the expected performance and safety of designs. Finally, based on a series of case study researches undertaken, TG37 concluded the importance of being sensitive to differences in the regulatory system from one country to another when approaching building design and construction as well as related codes and standards (CIB, 2004). Research related to implementation of performance specifications related to well-being and similar aspects needs ways to quantifies performance measurement for those aspects, particularly for the healthcare sector. Therefore, it is important to explore how these two types of specification are used when designing healthcare buildings and to identify how existing design standards could be improved within the UK.

In summary, the actual practice of designing relies is supported by a mixture of performance and prescriptive specifications as described above. A good balance between standardisation and innovation during designing is important to gain the benefit from both approaches. The opportunity to innovate can be considered to be declining across the levels of standardisation and vice-versa. Blyth and Worthington's (2010) diagram illustrates this aspect (see Figure 4.9).

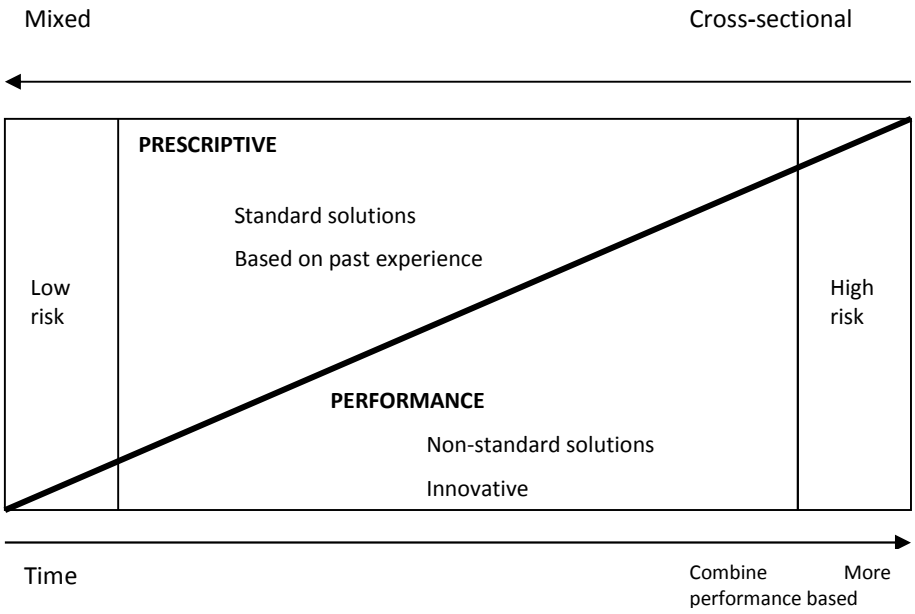


Figure 4.9: Performance and prescription scale of the brief (Adapted from Blyth and Worthington, 2010)

One of the limitations of current understanding is, however, to what extent and how designers use these two types of specification during designing. Understanding this is pre-requisite to recommending effective means for articulating evidence into the SGaTs.

4.6.3 Content of prescriptive and performance specifications in healthcare design SGaTs

Healthcare built environmental designing is guided by a set of SGaTs published by DH, UK and other regulatory authorities.

Design standards - Health Building Notes (HBNs)

HBNs are the primary design guidance available for healthcare BE designing. HBNs contain both performance and prescriptive specifications. For instance, HBN 04-01 - Adult in-patient facilities (NHS Estates, 2009) specify single patient rooms as shown below.

> *" ……The size of single-bed rooms ….. 23.5 m2, …….the minimum recommended clear space around the bed is now 3600 mm (width) × 3700 mm (depth), This represents the clear bed space and does not include space for fixed storage, preparation and worktops.". (HBN 04-01, pp.vi)*

Based on the contextual circumstances, the design team has the freedom to devise solutions to suit these performance specifications. Evaluation of designs to check compliance for these performance specifications is straight forward. In addition, the same guidance also provides exemplar designs for single patient rooms in the form of prescribed specifications (HBN 04-01, pp.36).

The same guidance contains some performance specifications where evaluation of compliance is not straight forward. For instance, below can be seen the guidance note regarding ceiling mounted patient hoists.

> *"If ceiling-mounted hoists are preferred, design teams will need to consider the potential conflict with medical service units and patient entertainment systems. Consideration should also be given to the "parking" of the hoist sling when not in use"* (HBN 04-01, pp.8).

HBNs are heavy in specific prescriptive solutions. For instance, the clauses shown below, from HBN 04-01, specify hand hygiene requirements.

> *"2.15 Antibacterial hand-rub dispensers should be provided at the ward entrance.*
>
> *2.16 Each single-bed room should contain a clinical wash-hand basin. The basin should be located to be highly visible to staff entering and leaving the room"*

Similarly, other HBN guidance specifies exemplar layouts for different spaces within a healthcare building.

Technical and engineering design standards - Health Technical Memoranda (HTMs)

HTMs are the primary technical guidance used in the healthcare built environment designing. They are mainly comprised of performance specifications. For instance, *Health Technical Memorandum 61 – Flooring*, specifies six categories of performance for floor finishes. The design team should first identify the category of finish suitable for each space. Then they should identify finishes for the building from a variety of finishes available on the market for each category. The guidance also identifies relevant statutory guidance issued by other regulatory bodies which the design team should comply. For instance, *Health Technical Memorandum 02-01: Medical gas pipeline systems* specify that:

> *".....Wiring systems for medical gas installations should be selected in accordance with BS 7671 wiring regulations with particular regard to the environment and risk from mechanical damage."* (HTM 02-01, pp.9)

HTMs refer to other national standards such as British Standards, The Construction (Design and Management) Regulations 1994 & 2000 and other related parliamentary acts which contain both prescriptive specifications and performance specifications.

Design evaluation tools

Design evaluation tools like AEDET and ASPECT are mainly comprised of performance specification. The design evaluation criteria contained in AEDET is shown below;

> *"C.01 - The building respects the dignity of patients and allows for appropriate levels of privacy and dignity"*
>
> *"D.01 - The height, volume and skyline of the building relate well to the surrounding environment"*
>
> *"E.01 - The building is easy to operate"*
>
> *"E.02 - The building is easy to clean"*

In summary, current healthcare design SGaTs contain both performance and prescriptive specifications; yet the effective composition between these two types of specification is not well understood.

4.7 CHAPTER SUMMARY

In summary, this Chapter positioned evidence and EBD within the generic evidence for designing (EfD). It was established that the evidence base for EBD is a subset of generic EfD. Evidence of EBD is characterised by its research rigour in generation and its intention to improve health outcomes of a buildings users. Evidence of EBD can be incorporated into the process of designing by inputs into designing and output and outcome evaluation mechanisms. Section four reviewed these possibilities and concluded that it is sensible to separate built environment related performance criteria from frequently monitored high level quality and safety outcome performance management mechanisms and incorporate them into the input and output specifications of built environments.

The fifth section of this Chapter presented a review of the theoretical perspectives of designerly ways of using evidence. Design knowledge could be in the form of active knowledge and codified knowledge. Even though designers prefer active knowledge as opposed to codified knowledge, the majority of best evidence concerned with EBD is presently generated by researchers and thus available in the form of codified knowledge. SGaTs provide a good opportunity to effectively convey codified evidence into the process of designing. SGaTs are an extensively sought source for design input by designers and have a long standing history in the UK's healthcare sector. SGaTs are comprised of performance specifications and prescriptive specifications. Performance specifications encourage innovation during designing while prescriptive specifications promote standardisation. The right mix of these two types of specification is important for ensuring that both innovation and standardisation are promoted appropriately as well as other advantages from both types of specification.

There is little known about how and in what proportions designers use the two types of specification during the designing of healthcare buildings in the UK. Acknowledging the existence of designerly ways of using evidence, it is important to explore how designers use performance and prescriptive specifications as a pre-requisite to recommending effective means of articulating evidence into the performance and prescriptive specifications through SGaTs.

Procedural knowledge of EBD is also crucial for the success of EBD. EBD process literature provides some insights into procedural knowledge of EBD. However, due to the nature of construction projects application of EBD is a more project level task or responsibility and is based on individuals' approaches. Exploring project level practices for tackling EBD issues and recognising best practice is, therefore, beneficial for improving EBD.

CHAPTER 5. THE SOURCES AND FLOWS OF EVIDENCE MODEL (SaFE MODEL)

5.1 INTRODUCTION

The review of literature in the previous two Chapters revealed the ill-use of the term evidence and complicated nature of evidence as in EBD within generic evidence for design related to sources and flows of evidence. A graphical model could represent this complicated process be in a meaningful way. A model for the sources and flows of evidence was, therefore, developed as a part of this research. This Chapter discusses the rationale for the development of this model, the process of the model development and its potential applications. In addition, using the model as a tool, this Chapter describes and discusses the current practices of evidence use and potential opportunities to increase the research-based evidence use.

Following the introduction to the Chapter, this Chapter next discusses the rationale for the development of the SaFE model and the modelling technique used to develop the model. The next section discusses the model development process: the initial development of the model; model verification and model validation. The fourth section provides further details of the current practice of evidence use based on model validation interview results. The last section discusses improvement opportunities for current evidence use practices.

5.2 RATIONALE FOR THE MODEL DEVELOPMENT

The word 'model' has different meanings. The Oxford dictionary offers five definitions, depending upon its use. Scholars develop models to represent complex phenomena simply (Kahru et al., 1997; Steele, 2000). A model can be expressed verbally, graphically or as a

statistical or mathematical equation. The importance of modelling is well recognised by scholars. Modelling explores relationships between variables hence helps to understand improvement opportunities for the phenomenon that is modelled (Baldwin et al., 1999). Models enable visualisation of the operations involved in projects, hence facilitating communication and understanding (Kahru et al 1997; Ahuja, 1976) and are supportive in process improvement and management (Kahru, 1997). The purpose of the SaFE model in this research is to represent the complicated process of source and flows of evidence in an understandable way.

Modelling the design process is not new. Asimov (Asimov, 1962) developed an early model of the design process. This model represents it in three linear steps (analysis-synthesis-evaluation-Figure 5.1).

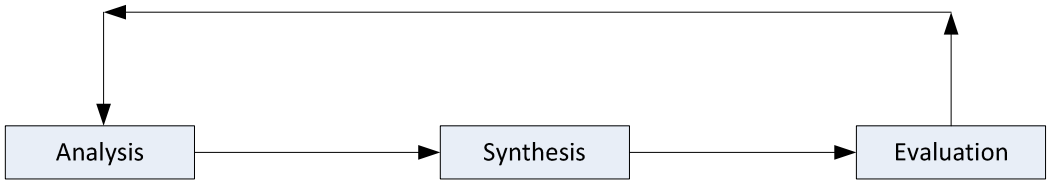


Figure 5-1 Asimov Design Process Model (Asimov, 1962)

Since then, several attempts were made to model the design process. Steele (2000) in his thesis provides a comprehensive description of types of design models and their purposes. Design process models can be of two types.

- Descriptive models (also called normative or 'as-is' models)
- Prescriptive models (also called positive or 'to-be' models)

Descriptive models describe the sequence of activities in the process, while prescriptive models attempt to persuade designers to adopt improved ways of working. Asimov's (Asimov, 1962) analysis-synthesis-evaluation model is an example of a descriptive model, whilst the RIBA plan of work (2007) is a prescriptive model. The specific focus of this research is the sources and flow of evidence and uses of evidence in its different forms but not the design process of EBD. Therefore, design process modelling literature was not reviewed further within this thesis.

Modelling design activity helps to simplify phenomena, thus aiding in understanding its complexities (Steele, 2000). Similarly, modelling can help the advancement of EBD by detailing the complexities that it involves. EBD scholars have used models in a variety of ways. Hamilton's *four level model of evidence-based design* is intended to benchmark the practice and progress of EBD (Hamilton, 2003). Roselyn Cama's *EBD Litmus ring* (Cama, 2009) prescribes a process for EBD at project level. Brown and Ecoff's (2011) *conceptual model of evidence use* can be used to

determine whether or not a new solution or evidence should be adopted. A detail discussion and evaluation of these models are provided in Chapter three of the thesis. The primary intentions of these existing models are to represent the process of EBD. They acknowledge the incorporation of research evidence as a key step to EBD; but they are less revealing about sources of evidence, the ways in which evidence are generated and their flow into the design process. This research fulfils this gap by developing a graphical model to expand the element of evidence in EBD. Further, existing models hardly take account of indirect ways of transmitting research based evidence into the design process. In this sense, there is a need for a descriptive model for EBD to clarify the sources and flows of evidence. It was expected that this model would help designers to identify different routes to the EBD based on their circumstances. Furthermore, researchers could identify research opportunities to improve the use of research evidence use and the practice of EBD. This thesis proposed a descriptive model for EBD, to address above limitations and intentions. Specific objectives of the model are:

1. to represent the sources and flows of evidence for design (EfD) during healthcare design process;
2. to distinguish sources and flows of evidence as in EBD; and
3. to determine direct and indirect routes for EBD.

The next sections of this Chapter describe the process of model development and details of the model.

5.2.1 Modelling technique

Several modelling techniques were used in the structured analysis of complex systems. The basis of all of these techniques is that they provide a means of decomposing relatively complex systems into interrelated sub-elements (Steele, 2000). The model proposed in this Chapter is particularly concerned with the complicated system of sources and flows of evidence for design. It is intended that modelling the information flows will lead to a greater understanding of that process (Austin et al, 1993; Kahru et al 1997; Ahuja, 1976). Selecting a proper modelling technique that fulfils the objectives and support the interests of the model is important for its success. Based on the previous literature, Court et al. (1996) have identified 18 criteria to evaluate modelling techniques. Using these criteria the authors evaluated 13 modelling techniques used in modelling information systems. Based on this evaluation, the authors identified that the data flow diagram (DFD), entity relationship diagrams, and IDEF 1 and IDEF1X diagrams are the most suitable techniques to model information systems. Bal (1998) also

identified these three techniques as the most commonly used information modelling techniques.

The Entity Relationship diagram technique was originally intended to be a supporting tool for database design (Chen, 1976) and is mostly used during software designing. After their extensive evaluation, Court et al. (1996) used IDEF 1 and IDEF1X diagrams to develop a new modelling technique, namely Information Access Diagrams (IADs). IDEF1 and IDEF1X are effective methods for documenting the information requirements of an enterprise (Idef.com; Bal, 1998) and are used frequently for business process modelling, in order to identify process improvement opportunities (Lin et al., 2002). Applications of these two techniques to model information systems in the design process could not be identified. The DFD technique was used by scholars to model the information systems in the design process. For instance, Sanvido and Norton (1994), Newton (1995), Hassan (1996) have used the DFD technique to represent the design process. IDEF0 diagrams were identified as a fairly good technique in the Court et al. (1996) evaluation. However, IDEF0 diagrams and its variants were used by a few scholars to analyse and represent the information systems in the design process. Austin, et al. (1998), Sanvido and Norton (1994) also used IDEF0 diagrams and its variants to model the design process. IDEF0 is a functional modelling method (idef.com), and the priority of the model is focused around its functions. The main focus of the SaFE model proposed in this thesis is based around evidence for design. Hence, the data flow diagram (DFD) (DeMarco, 1978) technique was preferred over IDEF0 diagrams in order to demonstrate evidence better. Specifically, evidence sources can be represented through data stores and evidence flows can be represented through data flows.

Figure 5.2 shows the major symbols in building the DFD based model of this research.

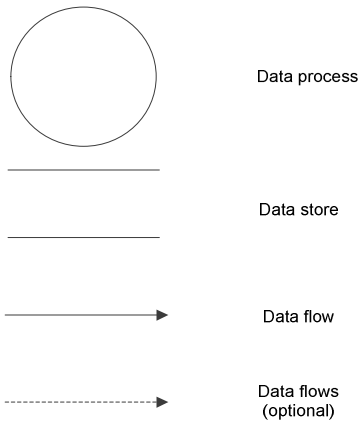


Figure 5-2: Key symbols used in DFDs (DeMarco, 1978)

These symbols are based on Tom DeMarco (1978)'s structured analysis symbols. In addition, a colour coding system was used to distinguish between diverse types of data flows (refer Section 5.3).

5.3 THE PROCESS OF MODEL DEVELOPMENT

A model could be, initially, developed based on the literature, expert opinion or based on the evidence from the people engaged in the actual system represented by the model. A valid model follows steps of model verification and model validation (Hillston, 2012). The initial conceptual model was developed as a desk study, based on the literature review, self-experience and the experience of the supervisors of this research. The model is a simplified abstract of a real system of sources and flow of evidence. With the comments from five un-structured interviews (lecturers and senior lecturers of the School of Civil and Building Engineering) the model was verified to ensure that the model correctly represents these assumptions and abstraction (Hillston, 2012). The final step in the model development is validation. The purpose of validation is to ensure that the model is a reasonable representation of the actual system. This model was validated using 12 semi-structured interviews with designers from the industry. The Figure 5.3 presents methodological details of the model development process and this section discusses the model development process in detail.

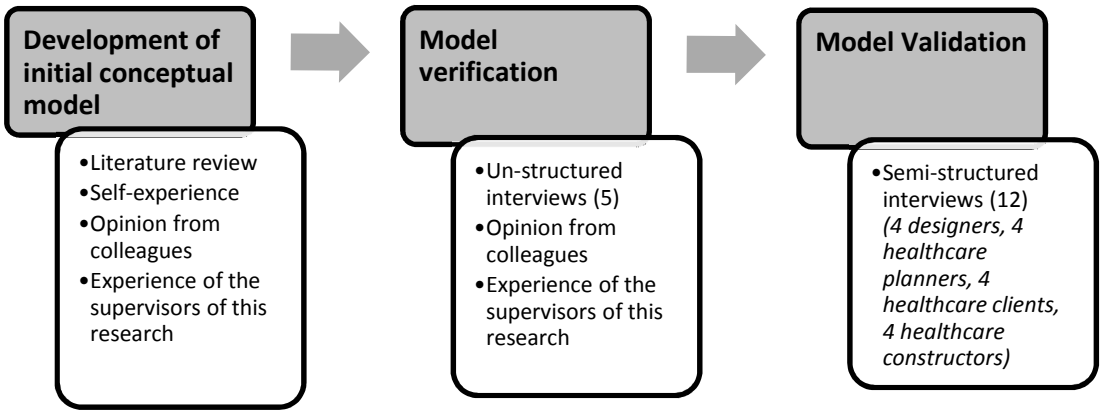


Figure 5-3: Model development process

5.3.1 Development of the conceptual model - The desk study

The initial conceptual model was developed as a desk study, based on the literature review, self-experience and the experience of the supervisors of this research. Initially, based on these, all the relevant processes, data stores and data flows were identified and plotted. The final version of the conceptual model is a result of development of the initial representation through several iterations. Specifically, this process involved the iterative steps of: identification of the source of

design evidence; identification of flow of evidence; identification of associated processes; and proposal of improvements. This section describes these steps in detail.

5.3.1.1 Identify the sources and flows of evidence

Designers rely on several sources of evidence during the stages of a building's design. A detailed discussion of these sources is provided in Chapter Four of the thesis. In summary, the following sources of relevant evidence were identified and were incorporated into the model (refer data stores of Figure 5.4).

- Evidence from the briefing process, including performance and prescriptive specifications;
- Published research from evidence databases, academic and industry journal publications, other magazines;
- Evidence from the members of the design team and their parent organisations - tacit knowledge; company's standards details; internal project review reports; company regulations);
- Standards; guidance and tools (SGT) - Healthcare specific SGT and other generic standards related to and applicable to construction;
- Evidence from the people involved in the actual realisation of buildings - details of innovative materials and features; and
- Evidence from project evaluation data - Industry best practices and post-project evaluation data contained in internal and external project reviews, other industry reports such as Award winning projects' reviews and landmark project reviews.

The next step was to identify and plot activities (data processes) that generate the evidence. This model does not represent all the processes of the building life-cycle. Only the relevant processes that produced the above evidence were identified and incorporated into the model. Self-experience and that of supervisors was considerably useful in this step. The design process was considered as the central process of EBD and all the above identified evidence inflows were then plotted in the diagram around the design process. It was soon realised that the design process could be de-composed into the two activities of designing and design evaluation, since they use distinct forms of evidence. Next, other processes generating evidence flow into these two sub-processes were identified. Accordingly, six associated processes which evidence for design were added to the model (see Figure 5.4).

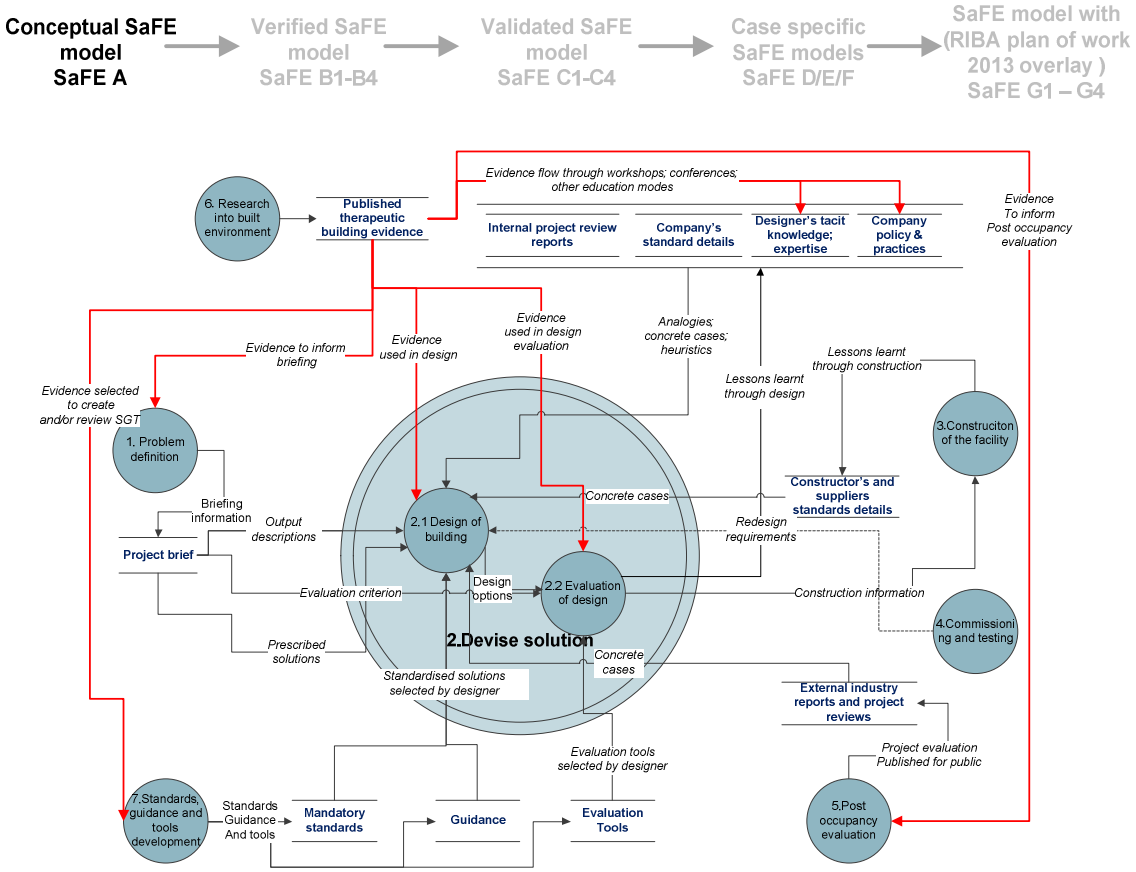


Figure 5-4: A pre-verified version of the SaFE model

5.3.1.2 Improvements

The following further improvements were made based on reflections from brainstorming sessions (self-evaluation and discussions with colleagues and supervisors).

Elaborating processes - During revisions and brainstorming sessions, two secondary processes (*briefing* and *SGaTs development)* were further subdivided into sub-processes. This was because they contained more than one important sub-process that is relevant to EBD.

Distinguishing EBD evidence flows - Data outputs from therapeutic building evidence sources were added into the above identified data stores. These data flows were then drawn in a red colour to distinguish from generic EfD flows. Finally, data flows of lessons learnt were further elaborated and specified in a green colour.

Improve representation - Information flows where their existence, or none-existence, was unclear were illustrated as intermittent lines. The inability to assign red to the share of construed rigorous evidence carried within the lessons learnt was a limitation of this pictorial model. Appendix A shows the final version of the conceptual model which was then used in verification.

5.3.2 Verification of the model

The next important step of the model development is verification of the model. Since a model is a simplified abstract of a real system, the model development process requires making assumptions and eliminating unnecessary details to focus on a specific aspect or a problem. The purpose the model verification is, therefore, to ensure that the model correctly represents these assumptions and abstraction (Hillston, 2012). In the actual system, many features are likely to be important. Not all them, however, should be included in the model. The few relevant features that are thought to play an essential role in the interpretation of the observed phenomena should be retained (Boccare, 2010). Explaining the model to another person, or group of people, can make the modeller focus on various aspects of the model and, therefore, discover problems with its current implementation (Hillston, 2012). Verification was undertaken through five un-structured interviews. Interviewees were selected from lecturers and senior lecturers of the School of Civil and Building Engineering who had knowledge and expertise in the building design process and design management. The methodology followed for these un-structured interviews is described in Chapter Two of the thesis. For this particular model, verification was also useful in understanding, whether the model was expressed in terminologies that are consistent with contemporary design literature.

5.3.2.1 Verification of interview results

An inductive thematic analysis was conducted for interview data based on the process described in Chapter Two. The resultant analysis followed 10 themes which explained interviewees' concerns regarding the model.

1. Representation of decision makers (4 respondents)
2. Value and hierarchy (2 respondents)
3. Representation of timing and sequence (5 respondents)
4. Representation technique of DFD (2 respondents)
5. Specific as opposed to a generic model (3 respondents)
6. Improvements to representation (5 respondents)
7. Need for more elaboration (4 respondents)
8. New entry requirements (4 respondents)
9. Improvements to labelling (3 respondents)
10. Need for simplification (4 respondents)

Table 5.1 summarised the issues identified under each theme and a discussion of how the model need to be changed, if necessary.

Table 5-1: Concerns idenified during the verification process

Concern	Description	Remarks
Representation of decision makers	Two interviewees claimed that not representing decision makers, roles and responsibilities of stakeholders as a drawback of the model. Whilst other three interviewees claimed that representing decision makers as not necessary and represent them in a different diagram if necessary.	The objective of this model is to identify evidence flows and the process in general. Representation of decision makers at this phase of the research is not required.
Value and hierarchy	Two respondents (R1, R3) claimed that present arrangement of the model represents some values and hierarchies. They emphasised that if the model reflect some hierarchies those should be accurate or if the model does not intend to reflect any value or hierarchy then the model should be rearranged. For an example respondent 1 said *".....when you put design in the middle, you are giving sort of value to it or it may be me misinterpreting this value....."*	The model originally did not intend to reflect any value or hierarchy for the processes other than illustrating rigorous evidence flows in red. Therefore, improvements to the model to remove unwanted values and hierarchies are to be done.
Representation of timing and sequence	Several issues in relation to representation of timing and sequence were identified by all respondents. All respondents claimed that a liner process diagram or an identifiable sequence for the process as important. For an example respondent 5 said, "*My first concern is about time dimension, problem definition happens before devising solution and construction and POE happens after the design, but your diagram is flat in that aspect".* Further there were concerns about numbering logic for processes which had made starting point of the model unclear (R2, R3). For an example respondent 2 said, *"Is it my starting point is research or is it here in problem definition?....."*	Rearranging the diagram to represent the sequence and making clear the starting point was therefore important.
Representation technique of DFD	Two respondents (R1, R3) insisted that the selection of DFD as the representation technique should be justifiable and since it impact readers' understanding. Respondent 3 emphasised that some of the draw backs of DFD technique (such as, a backward arrow might mean revisiting a failed process). She further pointed that they can be overcome using IDEF0.	Major concern of this model is given to evidence and that can be easily highlighted by data stores of DFD diagrams and not with IDEF0 diagrams. Therefore, it was decided to keep DFD as the representation technique.
Specific as oppose generic model	Three respondents raised issues about the model being specific: - to healthcare sector (R1); - to a particular design problem (R3) ; and - to architectural or structural design (R2) or being general.	Healthcare is different from other building types in terms of its uncommon spaces and the procedure of procuring a design. Further EBD is highly pertinent to the healthcare sector. Therefore, initial model need to be develop specific to healthcare but generic in terms of design problem and type of design.
Improvements to representation	Several generic issues in relation to representation ware identified. Those include, rationale for having different sizes for symbols (R2), logic of numbering the processes (R3,R5), keeping the process similar to a standard way of representing building development process (R1) and make starting point clear (R2,R3) so that diagram would be easily readable (R1, R2, R3, R4). Respondent 5 emphasise the need to follow an accepted way when sub dividing design process into sub-processes.	The model needs improvements in terms of its representation to make it easily readable.
Need for more elaboration	Few concerns were raised so as to level of elaboration of processes. Two respondents (R5, R3) insist that present level of elaboration as adequate. One respondent (R2) claimed that model may require to same level of elaboration for all the processes.	The model will be elaborated only for the activities related to EBD
New entry requirements	Several new entry requirements were identified during the interviews. Those includes, missed output from some of the sub-processes (R2), separation of lessons learnt (R2), tendering process (R2), representation of unclear research evidence flows (R5), feedback lessons learnt into research evidence base (R3,R5), evidence to inform feasibility evaluation (R2), showing manufacturers and suppliers separately (R4), POE and information from commissioning and testing back to design process as weak information flows (R4).	These need to be added
Improvements to labelling	Several improvement opportunities for labelling were raised. For instance renaming POE as POE data from previous projects (R3)	Improvements to labelling need to be made
Need for simplify (4 respondents)	All the respondents stand on the idea that the diagram is complicated and not easily self-readable due to too much of information.	The model needs to be simplified.

5.3.2.2 Improvements

Considering the results from the verification interviews and post-discussions the following improvements were made to the model.

2. ***A sequential diagram*** - The model was improved to represent the building development process in a sequential order, giving equal values to all processes.
3. ***Values for the processes and numbering logic -*** Facility development, facility operation, research into built environment and development of standards guidance and tools were identified as separate processes. They were numbered accordingly, to represent the sequence of facility development and the operational phases.
4. ***More emphasis given to evidence represented via data stores*** - The model was rearranged to give more emphasis to the data stores representing evidence, since they entailed the most important components of this model. Data stores were re-arranged into four types of sources. They are:

Type A sources.	Evidence captured by the project team non-shared (Organisational specific evidence);
Type B sources.	Evidence of best practices from the industry shared by other organisations (Shared evidence from the industry);
Type C sources.	Published research evidence ; and
Type D sources.	Standards, guidance and tools.

This enables readers to easily understand and represent forms of evidence used during facility development.

5. ***Model into three levels*** - The model was developed into three levels to make the diagram simple and less complicated.

   Level 0 - A further abstracted level above the original level to represent the logic of the model simply (refer Figure 5.5)

   Level 1 – Original developed level of the model without details of sub-processes of secondary processes (Briefing and SGaTs development) (refer Appendix D.2)

   Level 2 – Selected secondary process (Briefing and SGaTs development) were elaborated into sub-processes. (refer Appendix D.3)
6. ***Adding new entities*** – New entities were added to the model as identified during verification interviews.

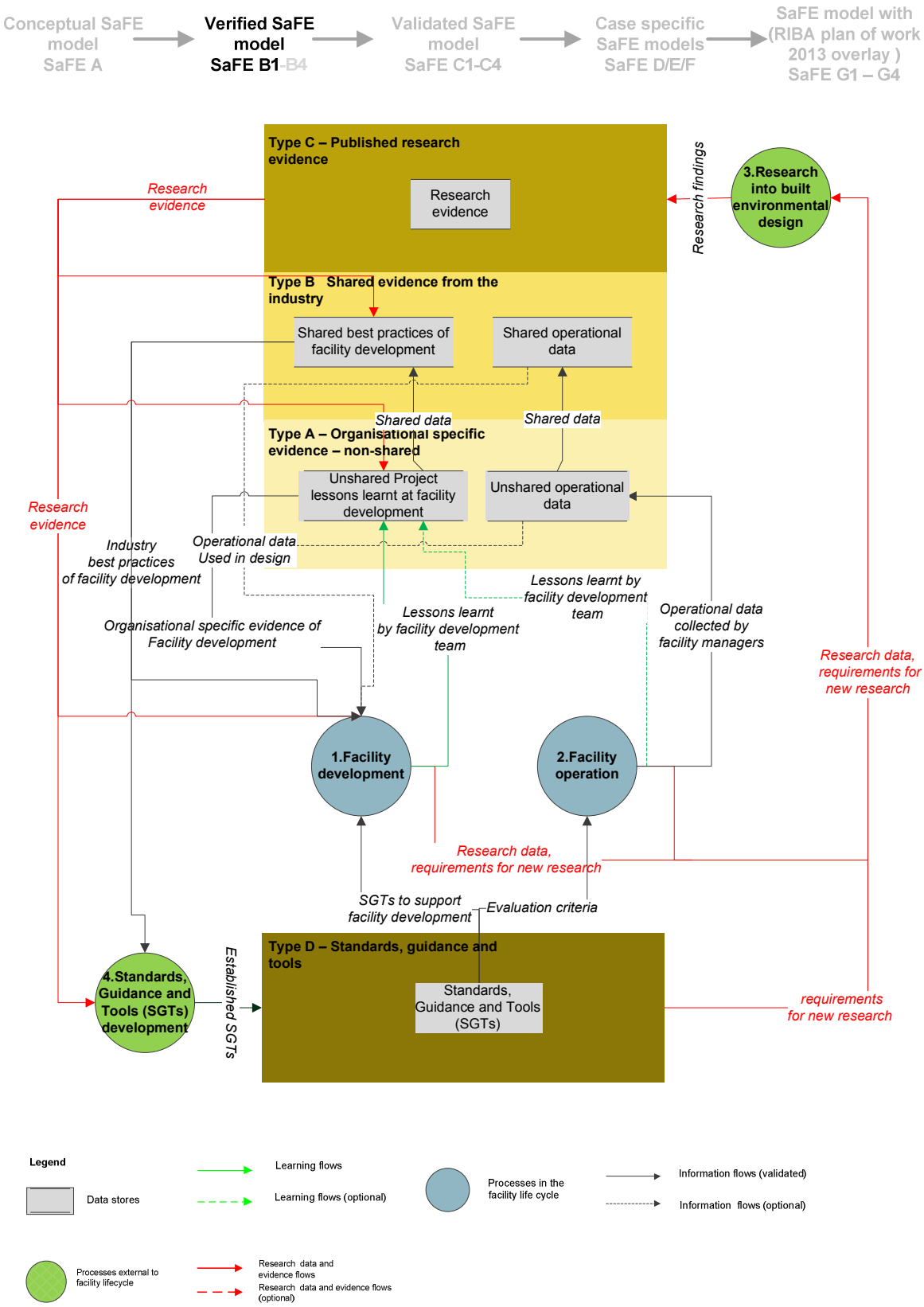


Figure 5-5: Conceptual model of EBD - Verified version - Level 0

Identification of decision makers and their roles and responsibilities was considered as unimportant within this model, considering its intention. The representation technique of DFD was retained due to its advantage of highlighting data stores representing evidence. Elaboration of process into a more detailed level is not feasible within this phase of the research and selected activities will be elaborated during the next phase. The verified model (see Appendix B) was then used during the validation process at the next stage.

5.3.3 Validation of the model

This model was then validated to ensure that the model represented the actual system in practice. The validation was done based on 12 interviews with stakeholders in the industry (4 healthcare clients, 4 healthcare planners, 4 healthcare designers and 4 healthcare constructors). It was also intended that interviews acquire further details behind the model and its entities. Methodological details of the validation interviews and the subsequent analysis of results are presented in the Chapter Two.

5.3.3.1 Sources of evidence and methods of evidence collection (flows of evidence)

Interview data was initially coded (grouped) to distinguish data that reveals about sources of evidence and evidence collection methods (flows of evidence) used by the four types of stakeholders. This selected data group was then analysed (based on the principles of inductive thematic analysis) to identify specific sources of evidence and flows of evidence. Table 5.2 summarises results of the thematic analysis. The table distinguishes sources of evidence and evidence collection methods used by four stakeholder types. Below is a detailed discussion of the results.

A. Type A sources of evidence - (Organisational specific evidence)

Knowledge and experience - It is apparent from this table that all interviewees have identified their own experiences; knowledge and data from their own past projects; and knowledge and data from supply chain partners and their past projects as key sources of evidence. One designer mentioned that his organisation has a '*Staff Project Experience Directory*' which lists the experience of the employees of the organisation to help employees to seek further evidence from employees who has specific knowledge, based on this directory.

Standard details libraries - It was mentioned that all three stakeholder types except client use libraries of standard details of building components.

Table 5-2: Sources of evidence

	Evidence from type A sources (Organisational specific evidence)	Evidence from type B sources (Shared evidence from the industry)	Evidence from type C sources (Published research evidence)	Evidence from type D sources (Standards, guidance and tools)
Healthcare Clients	- Knowledge and experience - client - Knowledge and experience - other members of the project team - Evidence from client own existing buildings) - Public consultation (meetings, drop in sessions) - Organisational policy, practices & standards - Internally developed design tools - Client's in-house research	- Evidence embedded in existing facilities - visits to other facilities (structured, unstructured, local, international, video conferences) - Expert opinion (individuals, organisations - SHINE, Community health partnership, CABE) - Evidence from supply chain partners - Written evidence of best practice (local and international) - Operational data from other facilities (by being a member of schemes)	- Collaborations with research institutions (HaCIRIC, other universities) - Well known research evidence reviews (Roger Ulrich's reviews) - Research published by other organisations (DH, NHS estates evidence, CABE, Design council, SHINE) - Journals (Health service journal, paediatric journal) - Built environmental conference attended by other members of project team	- Department of Health SGTs (HBNs, HTMs, HTNs) - AEDET - BREEAM - CABE design guides
Healthcare Contractors	- Knowledge and experience - contractor - Knowledge and experience - other members of the project team(3) - Evidence from contractor own existing buildings - In-house construction detailing	- Project reviews - Shared data libraries (P21+ database) DH evidence (cost analysis guidance, evidence from DH working groups) - Industrial and professional journals (Health service journal, Architect's journal, Construction news, Quarterly briefing) - Operational data from other facilities (by being a member of schemes) - Expert opinion (individuals) - Material manufacturers evidence	- Collaborations with research institutions (HaCIRIC) - Journals (Health service journal, other research journals, professional journals) - Conferences	- Fire regulations - CQC regulations - Guidance from professional bodies (RIBA, Royal college of nursing) - NICE guidance - Department of Health SGTs (HTMs)
Healthcare Designer	- Knowledge and experience - individual and parent organisation - Knowledge and experience - other members of the project team - Internal library of good practice - Organisational standard details - Database/library of products - POE data from previous projects (BREEAM, WRAP, POE data) - Design support tools with drawings library	- Project reviews - Shared data libraries (P21+ database) - Expert opinion - Peer opinion - Contractors and suppliers standard details	- Collaborations with research institutions (Reuben Foundation, Pebble project, SHINE, NHS estate, Kings fund) - Journals (Design and architecture, Architecture today, World health design, hospital developments, health service journal, IHEEM, Healthcare futures) - CPDs - Research published by other organisations (Architects for health, internet searches)	- AEDET - ASPECT - BREEAM - British standards - Department of Health SGTs (HBNs, HTMs, ADB) - HIS technical standards - ADB
Healthcare planners	- Knowledge and experience - healthcare planner - Knowledge and experience - other members of the project team - User consultation (workshops) - Operational data from healthcare planner own existing buildings - Internal library of standard details	- Evidence embedded in existing facilities - visits to other facilities - Contractor's standard details - Shared data libraries (P21+ database, AEDET, BREEAM) - Operational data from other facilities (by being a member of schemes)	- Collaborations with research institutions (Infection control network, Pebble project, clinicians collaborations with research, Universities) - Research published by other organisations (Center for Health Design, Royal college of nursing library) - Journals (Nursing journals, nursing standards) - Conferences (IHEEM)	- Department of Health SGTs (HBNs, HTMs, ADB) - AEDET - ASPECT

Operational data - Two clients mentioned that they have access to the operational data for their previous schemes, or buildings that they own. Healthcare contractors and healthcare planners accessed operational data through supply chain partners. Exceptionally, one healthcare planner accessed operational data from buildings because their organisation provides facility management service to healthcare buildings.

Internally developed design support tools – One client mentioned that they have an internally developed design support tool which helps to identify user needs. One designer (HD3) had an internally developed version of Activity Database (ADB).

The results are mostly identical with the data stores modelled into the conceptual model. In addition, it was identified that the design team use internally developed design support tools.

B. Type B sources of evidence (Shared evidence from the industry)

Shared data bases - The results reveal that P21+ data base was the most common method of accessing evidence from Type B sources. Clients did not mention P21+ database as an evidence store. The reason for this is that none of the clients interviewed were involved in P21+ projects.

Operational data from existing facilities – Clients have access to building operational data (at the operational phase) of existing facilities through the other buildings they own. The other three stakeholders hardly had access to performance data of facilities at the operational phase. Two of the stakeholders (a contractor and a healthcare planner) mentioned that they have access to operational data, for the buildings they own through the PFI scheme.

Expert opinion (peers and organisations) – Expertise from the external peers and organisations were another source of evidence. This includes evidence and support by organisations such as SHINE (or CABE. All the four types of stakeholders interviewed had access to evidence from these organisations because they are members of those organisations, or have another form of collaboration. One client mentioned that they made video conferencing with the people involved in the development of some land mark hospitals overseas for expert opinion.

Standard details from constructors and suppliers – According to the results of these interviews practitioners have accessed standard details of the constructors and suppliers.

Visits to existing facilities - Healthcare planners and healthcare clients do general and structured visits to other facilities to collect evidence. Notwithstanding the general and structured visits clients have done following up discussions, meeting with stakeholders of other facilities, and even video conferencing with the stakeholders of overseas' facilities.

Industry and professional journals – All the interviewees acknowledged that they subscribe to industry and professional journals and use evidence from those. However, it is uncertain whether to categorise them under Type B or C. Some of the articles contained in these professional journals may be peer-reviewed research. But, for this research these were categorised under Type B sources, since the articles in those journals not necessarily peer reviewed.

Results suggested few changes to data stores at Type B sources of the conceptual model. They are evidence embedded in the existing facilities and industrial and professional journals.

C. Type C sources of evidence (Published research evidence)

All the interviewees mentioned several type C sources of evidence. However, it is questionable whether all these sources contained research based evidence. For instance, interviewees named industry and professional journals as the journals to which they refer to access research evidence. As stated earlier, evidence from these journals could be better categorised as Type B sources evidence.

Research journals and conference - Stakeholders acknowledged the value of research published in journals. For instance, one constructor (HCon1) stated that,

> *"……this is an instance where we can start to learn about the robustness of the research by experience ……. in a research journals they are peer reviewed and they are robust they are substantiated by lots of good quality data….."(HCon 1)*

However, stakeholders, other than clients, had not subscribed to any research journal. Clients had access to peer reviewed research journals for medical purposes. All four types of stakeholders mentioned that they attend conferences.

Research published by external organisations and research accessed through collaborations with research institutions - All four types of stakeholders acknowledge that they access research published by other organisations. All four types of stakeholders mentioned that they have collaborations with universities and other research institutions that allow them access to research evidence.

These results suggest changes for the data stores in Type C sources of the model. The model could be modified to include real data stores, such as peer reviewed journals, conference proceedings, research databases of external organisations and research institutions as data stores.

D. Type D sources of evidence (Standards, guidance and tools)

Results reveal a prime use of evidence from D sources (SGaTs) produced by many healthcare related regulatory authorities. Stakeholders have used SGaTs for many purposes despite them having many issues regarding SGaTs. All stakeholders were extremely positive about having SGaTs maintained by a central authority and that they be preserved for the future. For instance;

One constructor (HCon1) mentioned that:

> *"…I think it is shame if we don't have them anymore, I think somebody should pay to do them or somehow they should kept up to date."*

Another designer (HD1) mentioned that:

> *"…..not comply with any of these SGTs, that is sort of a scenario that we desperately want to trying avoid….".*

In summary, these results reveal several facts. First, from the results it is apparent that evidence from Type A sources is rich and comprehensive, despite criticisms they have received. Knowledge and experience of all supply-chain partners contributes to the evidence sourced from Type A sources. The fruitfulness of recent inspirations for a collaborative working environment and knowledge sharing between supply chain partners is reflected in this result.

Second, it was apparent that clients had sought evidence from many sources, as opposed to other stakeholders. There are two possible explanations for this result. It could be suggested that because the client is the ultimate user of the building the resultant building would play a great role in supporting the core business of the organisation for a long period of time. Therefore, clients may be more vigilant and careful about a one off investment. It could also be that, since the client is the least experienced stakeholder in the team in building development, they may be more attentive in seeking evidence from as many methods and sources as possible. One health planner's (HP2) statement supports this hypothesis.

> *"…..we do it all the times than that the NHS does. Probably it is the first time for them to be involved in design. So they don't have basic knowledge……" .*

Third, research journals are being accessed by clients, but hardly any other type of stakeholder. Therefore, it may be more effective to publish therapeutic building evidence in related medical journals as opposed to construction related journals. Finally, results also give some insights into the debate of who (research institutions or designers) should generate evidence for EBD.

According to these results, it seems both alternatives have possibilities for taking EBD forward. Results reveal that all stakeholders search evidence published in industry and professional journals. Therefore, it is fair to assume that stakeholders are capable to use rigorous evidence contained in the peer reviewed journals, if the barrier between peer reviewed journals and stakeholders is removed. On the other hand, collaborations with research institutes by all stakeholders encourages the internal generation of rigorous evidence. But, it was also apparent that evidence generation from the operational phase of the facility is limited to a client activity.

5.3.3.2 Validated version of the model

Interviewees agreed that the model represents actual systems in the practice. The model was modified to incorporate a few minor changes identified during interviews. The following key improvements were made to the model, based on the above discussion.

1. New evidence stores

Few new evidence stores were added to Types A and B sources. 'Libraries of standard products', 'knowledge and experience of users' and 'internal research' were added as type A sources of evidence. 'Knowledge and experience of the general public', 'knowledge and experience of peers', 'knowledge and experience of experts', and 'evidence embedded in existing facilities' were added as new data stores to Type B sources.

2. Type C sources - evidence stores elaborated

Specific data stores of type C sources were not included in the model before validation. With the results of validation interviews, specific data stores of type C sources were added to the model. Specifically, data stores of 'research evidence from research institutions', 'well-known research evidence reviews', 'research published by external organisations', 'journals' and 'conferences' were added to Type C sources.

3. Type D sources - sub-processes

Interview results revealed types of organisations that designers consider in order to gather design SGaTs. But, data stores in Type D sources were left generic without reference to specific organisations that produce those standards, guidance and tools.

Interviewees also acknowledged that level 1 of the model is complicated due to the content. Since the model has an abstracted version at level 0, and because of the importance of a detailed level model, further abstraction was not considered for level 1 of the model.

The validated version of the model can be found in Appendix D and implications of this model are discussed in the Chapter 10.

5.3.3.3 Reproduction of case specific SaFE models

Using the Case study data, bespoke versions of the SaFE model for Cases A, B and C were produced to identify the behaviour of the model during different project unique circumstances (see Section 6.4.1.4 for methodological details).

5.3.3.4 RIBA plan of work 2013 overlay for the SaFE model

It was intended that this model will be used and championed by the people engage in the design process. In order to support this implementation effectively, an overlay of RIBA plan of work (2013) was added to the model.

Figure 5.6 shows the development of the model from the initial conceptual model to the last addition of RIBA plan of work overlay. Each version of the SaFE model is given a key, which will then be used throughout the thesis to ease the understanding by allowing readers to track down the development of the SaFE model.

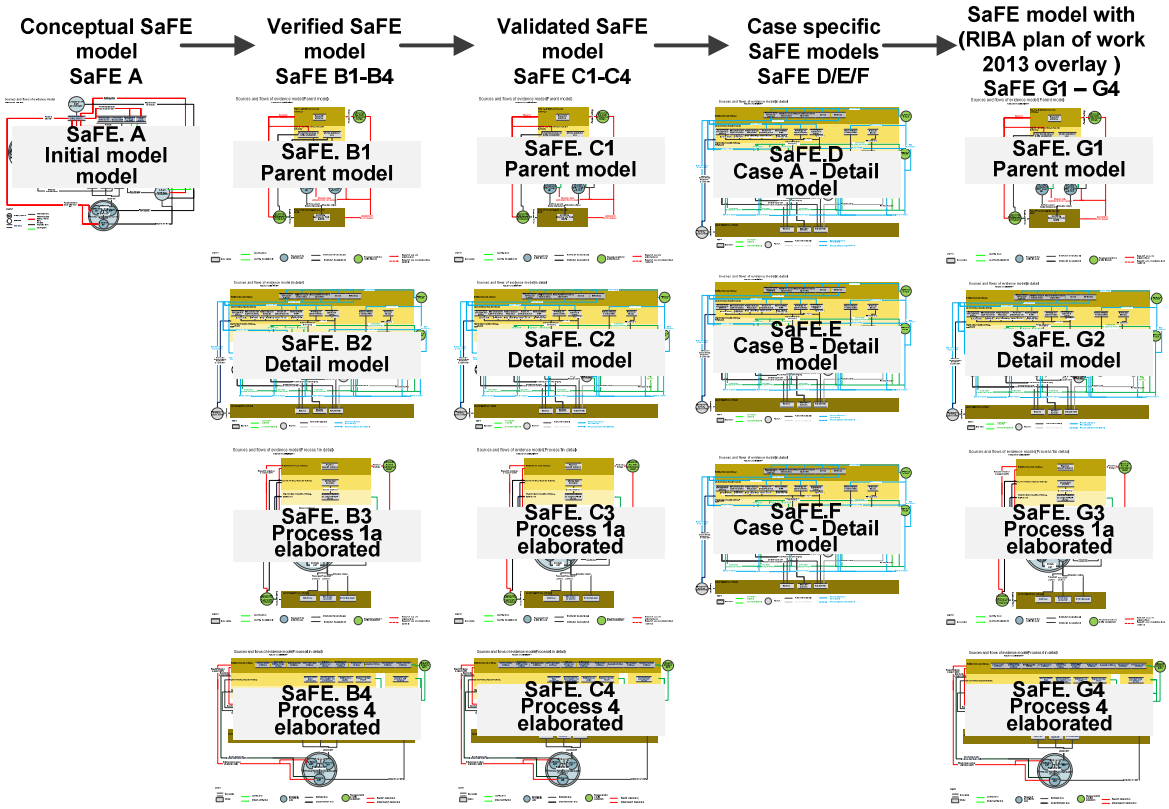


Figure 5-6: Key development stages of the SaFE model

5.4 Beyond the model - further details of the current practices of EBD

During these semi-structure interviews, informants were free to speak about anything they construed as evidence and give examples of evidence they use generally. Interview data revealed an outlook in relation to performance criteria which the design team intended to achieve with the support of evidence. This section state and discuss these results. However, these results need to be interpreted with caution, since interviewees were not questioned directly about the performance criteria they consider during evidence gathering.

5.4.1 Uses of evidence through inputs to designign, output and outcomes specificaitons of designgn

A closer examination of the data revealed that stakeholders pursue evidence in relation to:

- building inputs (e.g. evidence of better materials, components, and standard design details);
- building related performance outputs (e.g. evidence of better levels of natural light and view, efficient patient and staff flows, easy maintenance); and
- building related health outcomes (e.g. of patient experience, staff and patient satisfaction, infection control).

The Table 5.3 shows the composition of interview data in relation to three types of evidence identified above.

Table 5-3: Stakeholders' interest on sources of evidence

Category	Evidence	Type of stakeholder				Number of stakeholders
		HC	HCon	HD	HP	
Health outcomes	Infection control	*	*		*	3
	Patient experience	*			*	2
	Staff and patient satisfaction	*	*			2
	clinical user experience	*				1
	Customer satisfaction - the process		*			1
	Psychological outcomes (anxiety, stress, feel)		*			1
	Average length of stay		*			1
	Staff walking				*	1
Building related performance output	Patient flows	*	*			2
	Operational flows within theatres		*		*	2
	Care models and trends	*	*			2
	Natural light	*			*	2
	Carbon foot print	*		*		2
	Adjacencies	*				1
	what it can mean spatial terms means, what it means in clinical terms , what it may mean in staffing terms				*	1
	This section of the table is omitted purposely – please refer Appendix E.1					
Building related performance outcome	different ways of developing and laying out laboratory space				*	1
	dirty clean utility room standard room detail				*	1
	ward design				*	1

As revealed by interviews, the following are the highly sought evidence (sought by more than one type of stakeholder).

- Evidence of infection control, patient experience, staff and patient satisfaction (building related health outcomes)
- Evidence of patient flows, operational flows, care models and service trends, carbon foot print (building related performance outputs)
- Evidence of materials, components, specification and production information, constructability, engineering systems, room sizes, appearance, healthcare and NHS specific knowledge, operating theatre layouts, sustainability (building inputs).

These results may represent the contemporary focus of the healthcare sector in terms of building related performance. It could also be that evidence in relation to these categories populates the majority of evidence sources.

This analysis discloses insights into two interesting aspects. First, stakeholders collected evidence in relation to building inputs in majority of instances. Evidence in relation to building related performance output and building related health outcomes were less used compared to evidence in relation to building inputs. The reason for this could be that available evidence in relation to building inputs is greater than the other two types. If this is the reason, it is important that researchers focus on relating building design inputs to building outputs and health outcomes. This would increase practitioner's responsiveness to health outcomes that could be achieved through building design. It could also be suggested that stakeholders prefer to work on a solution driven approach as opposed to a problem driven approach. In other words, they prefer to identify a particular solution and evaluate the solution with evidence from its performance, in relation to the building output or health outcomes it could achieve. Second, results revealed that clients and contractors had sought all types of evidence from all four types of evidence sources. As stated earlier, there is no surprise that the client who ultimately owns the building has an interest in all types of evidence. The reason for the contractors' interest for all three categories of evidence may be the leading role given to the contractor by recent procurement arrangements. According to new procurement arrangements (PFI, P21+) the contractors' proposal for the tender needs to support the strategic goals of the client's business. This has shifted the contractors' focus towards performance of outputs and health outcomes as opposed to the more traditional focus of construction methods and materials. This also clarifies the reason as to why the practices of one of the contractors interviewed (Hcon3) is different to

two others. HCon3' background is traditional procurement routes and his interview conversation revealed his interest in evidence in relation to the building inputs.

Finally, this reveals the stakeholders' understanding about how buildings can support health outcomes. All clients interviewed and the majority of healthcare planners and healthcare contractors interviewed had considered health outcome related evidence. Interviews with designers did not reveal that they pursue evidence in relation to any aspect of health outcomes. This should not be taken as an indication that designers are not interested in evidence in relation to health outcomes, rather that semi-structured interview conversations revealed more about evidence channels and less about categories of evidence.

5.4.2 Evidence available for design quality criteria

Categories of evidence identified within interview data were mapped against AEDET (Table 5.4), to compare and contrast stakeholders' consideration for healthcare design quality criteria. AEDET is a tool developed to measure the quality of healthcare facilities. The tool derived was based on a widely used DQI tool. AEDET was criticised for the difficulties of its application procedure because it involved subjective judgement (Gesler, 2004). But the tool was not criticised for its content. NHS Estates suggest that: '*The criteria used in the toolkit may be adapted by Primary Care Trusts (PCT) and NHS Trusts, and incorporated into their specifications of design vision, philosophy and quality, to form an important part of their briefing, whether using exchequer funding or a PFI contract*' (NHS Estates, 2001, p. 3.).

Table 5-4: Map interview data with AEDET tool

	Criterion	Type A sources	Type B sources	Type C sources	Type D sources	Number of stakeholders
OVERALL					*	1
IMPACT: Character and innovation						
A.01	There are clear ideas behind the design of the building	*				1
A.02	The building is interesting to look at and move around in	*	*			2
A.03	The building projects a caring and reassuring atmosphere					0
	This section of the table is omitted purposely – please refer Appendix E.2					
I.06	Outdoor spaces are provided with appropriate and safe lighting indicating paths, ramps and steps					0
I.07	The fire planning strategy allows for ready access and egress				*	1
FUNCTIONALITY: Space		***	***	***	*	4
J.01	The design achieves appropriate space standards	**			***	2
J.02	The ratio of usable space to the total area is good					0
J.03	The circulation distances travelled by staff, patients and visitors are minimised by the layout			*		1
J.04	Any necessary isolation and segregation of spaces is achieved					0
J.05	The design makes appropriate provision for gender segregation					0
J.06	There is adequate storage space					0
PROCESS: PROCUREMENT		**	***	**		3
SUSTAINABILITY		**		*	*	3

The mapping was extended to criteria in ASPECT which is an elaboration of the 'Staff and Patient Environment' category of AEDET.

Results reflect that the quality criteria of healthcare buildings, as primarily expressed in AEDET and ASPECT, were fairly mentioned by stakeholders during the interviews. The majority of criteria were mentioned by at least two types of stakeholders. There are three criteria which stakeholders have collected evidence from all four types of evidence sources. They are: building express values of the NHS; building is easy to clean; and evidence of spaces.

There are 26 sub criteria (out of 58) that were not mentioned by any of the twelve interviewees. As explained earlier, this result should be interpreted with caution. These interviews did not intend to identify categories of evidence in detail. The data pertinent to this section is therefore taken for granted and the results should be interpreted accordingly. Non-availability of any interview conversation (data) relevant to a section, or sub-section, does not mean necessarily that stakeholders in the industry do not intend to achieve such criterion. It may be that stakeholders were talking about what they could easily retrieve from their recent experience. In this sense, a questionnaire survey to question stakeholders specifically about AEDET criterion, or specific questions during the interview regarding their adherence to AEDET criterions, would give different results.

Two major criteria (*Functionality - Access* and *Impact - Urban and social integration)* were less mentioned during the interviews. In addition to the above clarification, the other reason for not mentioning *Access* could be that, unless a project is a completely new scheme, parking may not be included in the project's work scope. The criterion: *Urban and social integration* is more related to the designers' and interviews with designers were less revealing about the categories of evidence.

Evidence from Types A and B sources were considerably used to pursue evidence in relation to AEDET criteria (25/58 from A and 20/58 from B). Evidence from Type C sources was approached for only 10 sub-criteria out of the 58. Among this 10, only two are related to staff and patient environment. Surprisingly, evidence in relation to 'Impact: staff and patient environment' was sought heavily from Type A sources.

5.4.3 Summary - Uses of four types of evidence sources

Type A sources were mostly used (by at least three types of stakeholders) to collect evidence in relation to materials, constructability, components and fittings and specification and production information. Type A sources were a considerably used to gather evidence by clients and

contractors than other two types of stakeholders. Type A sources were more attractive for evidence of building inputs and building performance outputs and, marginally, for evidence of health outcomes. Surprisingly, evidence in relation to how building could improve health outcomes of users was gathered extensively from Type A sources by clients and contractors. This could be because this evidence is grounded within the healthcare buildings at operation. Clinicians (who represent clients) are the first to be aware of them anecdotally. Florence Nightingale's awareness of this evidence is a good example of this. It may also be that stakeholders have acquired this knowledge through educational modes, such as conferences and other publications, and they later embed it s into their own knowledge.

Type B sources were used mainly(by at least two types of stakeholders) to collect evidence in relation to easy cleaning, functionality, components and fittings, engineering systems and operating theatre layouts. Similar to Type A sources, Type B sources were a considerably used to gather evidence by clients and contractors than other two types of stakeholders. Type B sources were more attractive for evidence of building inputs and, marginally, for evidence of building related performance outputs and evidence of health outcomes.

Type C sources were mainly used (by at least two types of stakeholders) to collect evidence in relation to infection control and healthcare, and NHS specific knowledge. Type C sources were favourite sources of evidence for clients, contractors and healthcare planners. As explained earlier these results need to be interpreted with caution. This does not mean designers do not use evidence at Type C sources. In fact, interviews with designers revealed more about evidence collection methods and not the categories of evidence. Type C sources were used extensively to gather evidence of building related performance outcomes and evidence of health outcomes. A closer look into types of evidence sought from Type C sources reveals that the majority of them are healthcare specific aspects that may not be rich in sources from Types A and B.

Type D sources were used mainly (by at least two types of stakeholders) to collect evidence in relation to room sizes and specification and production information. Type D sources were favourite sources of evidence for all four types of stakeholders interviewed. Type D sources were appealed for its evidence of building inputs and building related performance outcomes and, marginally, for evidence of health outcomes. Evidence in relation to how buildings can improve health outcomes was sought marginally from D sources.

5.5 OPPORTUNITIES FOR IMPROVEMENT

The model below, which was derived as discussed in the previous section, differentiates evidence flowing into the design process into four types of evidence sources (see Figure 5-7). Based on the model, following four strategies would increase the use of research evidence use during designing.

1. Increase the use of Type C sources– identifying the rationale for using evidence from four sources would help to determine how evidence from Type C sources evidence could be better transmitted into the design process.
2. Increase the use of evidence from Type C sources in producing Type D sources evidence – This could be done via improving the process of SGT development.
3. Increase the research based content of evidence in Type A sources - Improving learning from projects at their operational phase.
4. Increase the flow of research evidence from Type A sources to Type B sources – This could be done through improved knowledge sharing.

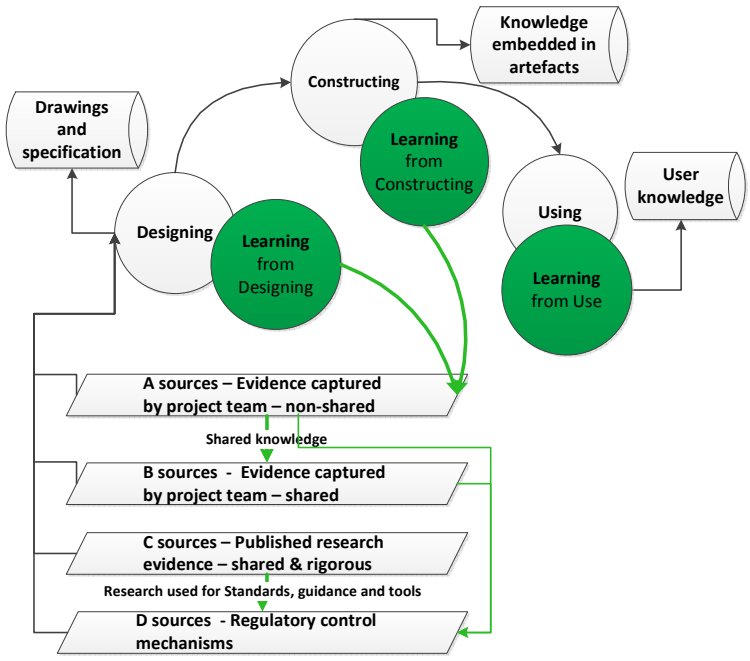


Figure 5-7: The process of evidence-based design

This research explored the first strategy above during the model validation interviews (see section 5.5.1 & 5.5.2) and the second strategy during case studies.

5.5.1 Mechanisms of evidence use

This research is influenced by critical realists' (CR) perspective (see Chapter 2 for further details). According to CR, researches identify mechanisms and contingent conditions of a particular

system in order to identify improvement opportunities to that system. Mechanisms are particular ways of acting (Sayer 1992) or what an entity is capable of doing, or being acted upon, if it is triggered and not prevented by other events (Bhashkar 1978). A systems ability to act in a particular way is contingent upon 'conditions'.

Based on the principles of inductive thematic analysis (see Chapter 2) rationales for the use, and non-use, of evidence from four types of evidence sources were identified (see Table 5.5). These were then classified as 'M' or 'C'. Themes that indicate a rationale for a mechanism were classified with 'M' and themes that indicate a rationale for a contingent condition were classified as 'C'.

Table 5-5: Rationale for using evidence from four types of evidence sources

Sources of evidence	Reasons for use	Reasons for not being limited to the source
Evidence from A sources - Organisational specific evidence	- weakness of other resources (M) - for evidence can only be found internally(M) - no faith in knowledge transfer (C) - strong resources found internally(C) - to make an added value to SGTs (M) - to understand what other sources to seek (M) - for project-unique issues (C)	- internal resources reflect their own interests (M) - take advantage of additional evidence (M) - inadequacy of internal resources (M) - incompleteness of internal knowledge (M)
Evidence from B sources - Shared evidence from the industry	- can bring expertise in (M) - to select the best available source (M) - inadequacy of internal sources - reliability (M) - to evaluate design (M) - obtain a lot of information (M) - the form and format of evidence (M)	- not tested (M) - unique nature of projects and systems (C) - lack of time (C) - access (C) - different languages (M)
Evidence from C sources - Published research evidence	- identify best practices (M) - difficulties in producing internally by project stakeholders (M) - characteristics of research (M) - have access through collaborations (C) - to justify the design decisions (M) - ability to afford the cost (C)	- discrepancies of evidences (M) - lack of evidence (M) - not available in a central place (C) - not enforced through SGTs (M) - not easily available (C) - unique nature of projects (C) - need to be supported by operational evidence (M) - cost and time (C)
Evidence from D sources - Standards, guidance and tools	- legal enforcement (M) - is involved in SGTs development (C) - advantages of standardisation (M) - characteristics of SGTs (M) - other (C/M)	- above SGTs is better (M) - for areas that are not covered by SGTs (M) - not always rigorous (M) - local contextual restrictions (C) - SGTs lagging behind the practice (C) - considered only as a brand (M) - cost (C) - other (C/M)

This exercise needed critical thinking. Some of the reasons (such as availability of time and money, availability of access) were categorised clearly as conditions. Similarly, weakness (such as incompleteness, inadequacy) of Type A sources were clearly mechanisms. This is based on the fact that mechanisms '*exist necessarily in virtue of the nature*' (Sayer 1992). But some were difficult to classify. For example, weakness in some of the evidence sources, such as 'evidences are biased', 'evidences are not up-to-date' were not easy to classify. Sayer's (1992) explanation

of the characteristics of mechanisms and conditions for social sciences was useful in determining the status in these situations. He states that some interventions are concerned with exercising mechanisms by manipulating the conditions in which they operate. Radical changes could alter social structures (necessary conditions) by virtue of which of the mechanisms exist (Sayer 1992). Accordingly, the reasons that remains largely unchanged over a considerable period of time, in other words those that need radical intervention to change them, were categorised as mechanisms. On the other hand, those that could be changed within a short period were categorised as contingent conditions.

Existing literature regarding evidence sources was considered to determine the time and effort needed for the change, or to determine whether the change would be radical or minor. For instance, EBD scholars suggest that the research evidence base is still growing and, thus, will remain incomplete for a considerable period of time. Even a radical change would not be able to remove this inherent tendency. Such reasons were therefore identified as mechanisms. The following mechanisms that were capable of influencing a particular source/type of evidence were postulated based on the above analysis.

1. Weaknesses of evidence source require the use of more than one source.

Interviewees revealed the weaknesses inherent in all four types of evidence sources. Evidence from Type A sources was recognised to be weak because evidence in Type A sources 'reflect their own interests' are 'inadequate', and 'incomplete'. Evidence from Type B sources was also identified as weak because it was 'not tested' and Type C sources with 'having discrepancies', being 'inadequate' and 'has limitations to results'. Evidence from Type D sources was described as 'some areas of design are not covered by any of them', 'not always rigorous', 'very loose' and 'not up-to-date'. These weaknesses necessitated stakeholders perusing evidence from more than one source. Therefore, a single source of evidence does not dominate the flow. Improving the rigour of evidence contained in all four types of evidence sources is therefore important to increase EBD during the design stage. Specifically, both feeding research evidence (Type C sources) into the SGaTs and other sources, and increasing the rigour of the evidence produce by project organisations, are important.

2. Sources that contain evidence that can be found only in one Type C sources confirm the use of Type C evidence sources.

Commercially sensitive evidence can be found only in Type A sources, and rigorous evidence contained mostly in Type C sources. For these reasons evidence from Type A and C sources are

inevitably sought by stakeholders, unless they are restricted by any contingent condition. This suggests the ability to increase the flow of rigorous research (Type C sources) evidence into the design process, by manipulating contingent conditions (see next section).

3. Evidence in user-friendly forms and formats encourages use.

User-friendly forms and formats of evidence were identified as reasons to pursue evidence from Type B sources. However, some of the evidence was considered less than useful since it is 'not written for the laymen' (Type D sources). These views suggest that evidence with user-friendly forms and formats tend to increase their usage. In this respect, databases of research summaries, which are developed to improve the form and format of evidence (for instance, the safer environment evidence-database developed by the UK's Department of Health and the InformeDesign evidence summary database developed by Minnesota University) has a better chance of increasing the direct flow of rigorous research evidence into the design process.

4. Evidence that is legally enforceable encourages use.

Legally enforceable evidence has a tendency of attracting use, but was found only in Type D sources (not even Type C sources.) Therefore, if the evidence from Type C sources can be transmitted into any other source to promote indirect-use, transmitting the evidence into STGs (Type D sources) offers a unique advantage.

5. Other compelling characteristics of evidence sources that encourage use.

Similar to where weakness in the evidence has a tendency to decrease usage, compelling characteristics associated with evidence has a tendency to increase it. In addition to the above major mechanisms, interviewees identified compelling characteristics associated with all four types of evidence sources. They identified evidence from Types A and B sources as 'reliable' since they experienced them directly, or indirectly. Evidence from Type C sources was acknowledged as 'rigorous' and that evidence from Type D sources as 'tested', 'well-structured', 'clear about what evidence it is based on, 'provide reference of where to look' and 'evidence that provides advantages of standardisation'.

6. Stakeholders tend to search evidence from various sources to add more value.

The above mechanisms are related to the nature of evidence and its sources. The rationale behind evidence use revealed the existence of organisational related mechanisms. Several interviewees acknowledged that they peruse evidence from every possible source to increase the value of their work to clients. Some of them also regarded maintaining a strong evidence

base internally to be a competitive advantage that makes them 'an organisation of choice' by clients.

Table 5.6 compares the impact of these six evidence use mechanisms on four types of evidence sources.

Table 5-6: Impact of evidence use mechanisms on four types of evidence sources

	Mechanism	A - Organisational specific non-shared evidence	B - Shared evidence from the industry	C – Published research	D–Standards, guidance and tools
1	Weaknesses of evidence sources	-	-	-	-
2	Source unique evidence	+		+	
3	User-friendly forms and formats of evidence		+		-
4	Legally/statutory enforced evidence				+
5	Other compelling characteristics of evidence	+	+	+	+
6	Stakeholders values and objectives	++	+	+	+

It was revealed that evidence from all four types of evidence sources contains weaknesses which necessitate using evidence from more than one type of source. All four types of evidence sources had some evidence which could be found in that particular source. It was revealed that the form and format of the evidence of Type D sources impedes use of evidence from those two types of sources. Evidence from SGaTs is used since they are enforced by a central government body. In addition, interview data analyses revealed compelling characteristics associated with evidence from all four types of sources which encouraged using evidence from these sources. Accordingly, this analysis did not reveal that evidence from one type of source was superior to other three. Due to weaknesses and strengths associated with evidence in each of four types of sources, and stakeholders willingness to use evidence from various sources, the importance of evidence from all four types of sources was confirmed.

These results which can be used to identify each type of evidence Type C sources could be improved. Eliminating rationales associated with not using evidence from a particular type of source, and incorporating rationales associated with using evidence from a particular type of source, could bring improvements to a particular type of evidence source. For instance, improving published research use (evidence from Type C sources) can be achieved by (refer Table 5.6) removing discrepancies of evidences, improving the available amount of evidence, disseminating evidence through a central database, enforcing evidence through SGaTs,

expressing evidence in user friendly languages and formats and by incorporating evidence of operational outcomes achieved through buildings.

5.5.2 Contingent conditions of practices

The existence of mechanisms does not guarantee the use of evidence from a particular source. The use, or non-use, may suffer, flourish or be suffocated by contingent conditions. The contingent conditions for using evidence from four types of sources (see Table 5-7) were identified through interview data analysis. '-' in Table 5.7 denotes that the particular condition has a negative impact on the designated type of source, whilst '+' denotes that the particular contingent conditions favour using evidence from that designated type of source.

Table 5-7: Contingent conditions of evidence use from four types of sources

	Contingent Condition	**A - Organisational specific non-shared evidence**	**B - Shared evidence from the industry**	**C – Published research**	**D–Standards, guidance and tools**
1	**Availability** of evidence	**+**		**-**	
2	Time and cost **resources** to access		**-**	**- +**	**-**
3	**Preferences** for active knowledge over passive knowledge		**-**		**+**
4	**Local** contextual **restrictions** , project-unique nature		**-**	**-**	**-**

Availability of evidence in a particular type of source encourages use or non-use of evidence from that particular type. This was identified as a key barrier for evidence in Type A sources. When the design team acquires a new project that was unfamiliar to them, they did not possess sufficient internal evidence to cope. In other cases the internal evidence base was identified as 'not large enough' leaving stakeholders with a lower number of similar projects to arrive conclusions. These reasons determined the need to seek evidence from other sources. Further, time and cost resources had an impact on seeking evidence from external sources (Types B, C and D). This was a significant issue for Type C sources. Since evidences were scattered in a number of journals and the time and cost to access them was a large burden on the project. Use of Type C sources evidence is attractive and occurs when these two barriers are not prominent. When healthcare clients have access to a great number of journals for medical purposes, they also search for therapeutic building evidence when they are involved in a building development project. This creates a flow of evidence from Type C sources into the design process. Similarly, the need to pay for standards and guidance was a barrier for D sources. Thirdly, lack of faith in current knowledge transfer mechanisms was a barrier to the use of external knowledge. Some interviewees expressed a preference for using the research evidence (Type C sources) and guidance (Type D sources) which they involved in production. This suggests the importance of

collaboration between academic institutions, those who produce standards, guidance and tools and stakeholders. Finally, local contextual issues can also prevent use of evidence from external sources, even the use of mandatory evidence in Type D sources. These are primarily site-related and service/care model related issues, such as the shape of available land, local building regulations and the type of patients treated in the facility. For project-unique issues, project teams are obliged to devise solutions based on knowledge and experience.

5.6 CHAPTER SUMMARY

The sources and flow of evidence model presented in this Chapter expands the element of evidence in EBD. This Chapter discusses the rationale for the development of this model, the process of the model development and its potential applications. The model identifies four types of evidence sources that are used during healthcare building designing and distinguishes evidence for EBD. The model could be used by researchers as a research road map. ICT tools developers could use the model to identify information flows related to EBD. Stakeholders in the design team could use this tool to benchmark their practices in relation to EBD. The model also helped to identify existing practices related to evidence (for EBD) use and improvement opportunities.

Use of published research evidence, directly from publications or from associated databases, appears limited. Stakeholders' engagement in post-occupancy evaluations of designs was identified as limited, causing difficulties in generating research evidence internally. Therefore, facilitating EBD based on evidence (for EBD) generated by practitioner is difficult and, at present, circumstances research evidence generated at research institutions drive EBD. Rationale behind the use and none use of four types of evidence sources were also identified. According to the results, use of published research use can be improved by removing discrepancies of evidences, improving the available amount of evidence, disseminating evidence through a central database, enforcing evidence through SGaTs, expressing evidence in user friendly languages and formats and by supporting evidence with operational outcomes achieved through buildings. This model confirmed a key proposition of this thesis; that evidence (as in EBD) informed SGaTs could improve EBD.

CHAPTER 6. CASE STUDY PROCESS

6.1 INTRODUCTION

Case study design was selected as the most appropriate research design for the third phase of this research. The rationale that supports the selection of case study design is discussed in Chapter two of the thesis. This Chapter describes the details of the data collection and data analysis for case studies. Followed by this introduction, section two discusses how the cases were selected and brief descriptions of the cases selected are also given in section. Section three provides details of the actual case study process which includes details and timings of the data collection process. Section four details and discusses the data analysis process adopted for this research under the following three main sections:

1. Analysis of practices of evidence use;
2. Analysis of practices for use of performance and prescriptive specifications; and
3. Analysis the project-unique circumstances that impact EBD processes and how designers reflect on these circumstances.

6.2 SAMPLING/ CASE SELECTION STRATEGY

For this research, cases were selected purposefully. Several criteria were considered in this respect. Firstly, since the main focus of this research is healthcare buildings, the cases selected for this study needed to be healthcare buildings. Secondly, selected cases needed to be completed buildings since the research required data related to the process of designing as well as the operational phase of the building to examine the performance of the design. Thirdly,

recently completed projects were considered to ensure access to people who were involved during the design stage of the facility because of their ability to provide the required details related to designing the particular facility. Finally, the existence of rich examples related to the use of performance and prescriptive specifications were considered as a criterion for selecting case studies.

Trust between the researcher and the organisations involved in the case study was important, since case studies required access to project specific data and information. Therefore, cases were identified through contacts that were aware of the former phases of this research, and related research work in the school of civil and building engineering. Industry partners of EBLE project was the first choice for this purpose. Through these contacts, four case studies were identified which satisfied the four criteria identified above. Two of them had similar characteristics in terms of type of hospital, site details and the organisations involved in the development process. Considering the time limitations only one of the two similar cases was selected for further studies. Table 6.1 summarises the details of the three cases selected for this research.

Table 6-1: Details of selected cases

Project name	**Case study A**	**Case study B**	**Case study C**
Type of the facility	A children's hospital	Non-critical elderly care and mental health hospital	Elderly care facility
Project value	£88m	£90m	£10m
Location	Central London	Ebbw Vale	Bradford
Type of construction	A new modular building within an existing hospital site	A new building on a new site	A new modular building within an existing hospital site
Funded by	NHS and Charity	WHE	NHS
Clients involvement	A team of clinicians from existing hospital dedicated to redevelopment programme	Members of the Health Board	In-house facility management team of the existing hospital
Purpose of the facility	To replace some old facilities and to increase the capacity	To replace a number of existing hospitals with three new facilities to be operated under a new care model	To increase the capacity to cope with winter pressure

6.3 CASE STUDY PROCESS

Once the cases were identified, each case study was taken through the following six data collection and analysis steps (Figure 6.1).

Figure 6-1: Case study process

6.3.1 Data collection step 1 and 2

As the first step, an initial visit to the hospitals was made to obtain an overview of the hospital by physically observing and speaking to the users. These meetings were also helpful to identify the background information of the project which could not be identified through web searches.

The second step was intended to identify suitable exemplar design elements for detailed study in the subsequent steps. As the research methodology stated, design elements that provide rich data in relation to using performance or prescriptive specifications during designing. Two words which are primarily used in academic writings are; performance and prescriptive specifications and it could have made it difficult if stakeholders were to identify exemplar design elements based on performance specifications and prescriptive specifications. On the other hand for many design elements, designing is supported by both performance and prescriptive specifications at different times and for different purposes. An indirect approach to question stakeholders was therefore considered. As identified in the literature, solutions devised were based on prescriptive specification results in standard solutions. These could be standard solutions prescribed in SGaTs or de facto standard solutions which are traditionally used in practice. Solutions were devised based on performance specification results in bespoke or innovative solutions. Based on these hypotheses, at step 2, during the interview with stakeholders they were asked to identify exemplar design elements for standard/traditional solutions and innovative or bespoke solutions.

Interviews with client's representatives and representatives from architect organisations were conducted to fulfil this step. All the interviews for this phase were conducted face-to-face and each interview took approximately an hour. Design elements identified from this step were then analysed through an intermediate data analysis process to identify design elements that are suitable for further study.

6.3.2 Intermediate data analysis – short listing design elements for further study

Interviews conducted during Step 2 revealed 16 exemplar design elements for Case Study A; 12 exemplar design elements for Case Study B; and 8 exemplar design elements for Case Study C. The initial examination of the data revealed that some of the elements were identified by interviewees representing all three cases, while some elements were recognised within two cases studies and some in one case study only. In total, 19 exemplar design elements were derived from the interviews.

Table 6.2 illustrates the 19 design elements derived. Details relevant to the grey coloured cells were not identified within the interviews at Step 2 and follow up telephone calls were made to the interviewees of all three case studies to identify details of the elements that could not be identified during the Step 2.

Table 6-2: Intermediate analysis - Identifying design components to further study

	Design element	Case Study A	Case Study B	Case Study C
1	Single bed room	Innovative/Bespoke	Innovative/Bespoke	Standard/traditional
2	On-suite bathroom	Innovative/Bespoke	Innovative/Bespoke	Standard/traditional
3	Clinical workstations	Innovative/Bespoke	Innovative/Bespoke	Standard/traditional
4	Window design/ ventilation strategy	*Could not be identified during the first round of interviews*	Innovative/Bespoke	Innovative/Bespoke
5	Communal spaces	Innovative/Bespoke	Innovative/Bespoke	*Could not be identified during the first round of interviews*
6	Ward layout	Innovative/Bespoke	Innovative/Bespoke	Standard/traditional
7	Outpatient area layout	N/A	Innovative/Bespoke	N/A
8	Bed head	Innovative/Bespoke	Innovative/Bespoke	*Could not be identified during the first round of interviews*
9	Service core design	Innovative/Bespoke	*Could not be identified during the first round of interviews*	*Could not be identified during the first round of interviews*
10	Theatre design	Standard/traditional	N/A	N/A
11	Isolation room	Standard/traditional	*Could not be identified during the first round of interviews*	*Could not be identified during the first round of interviews*
12	Finishes	Standard/traditional	Standard/traditional	Standard/traditional
13	Doors	Standard/traditional	Innovative/Bespoke	Standard/traditional
14	Water services	Innovative/Bespoke	*Could not be identified during the first round of interviews*	*Could not be identified during the first round of interviews*
15	Treatment rooms	Standard/traditional	*Could not be identified during the first round of interviews*	N/A
16	Other rooms - end of life room	End of life room – changing guidance	N/A	*Could not be identified during the first round of interviews*
17	Drug storage system	Innovative/Bespoke	Standard/traditional	Standard/traditional
18	Other M&E services	most of them followed HTMs	*Could not be identified during the first round of interviews*	*Could not be identified during the first round of interviews*
19	Designing for HAI		Designing for HAI	
		16	12	8

By the end of this intermediate analysis, a maximum of 8 possible representative (of whole design processes), and common (to all cases) design elements were selected for further exploration.

These 8 elements were selected to allow the maximum possible variety. A careful effort was made to select design elements related to the conceptual design phase and detail design phase; and elements related to architectural design and engineering design. This ensured that the subsequent results of this research are not biased by one particular type of design element. Table 6.3 summarises the eight exemplar design elements and the status of the elements (standard or traditional design (T/S) or innovative and bespoke design (I/B) in all three case studies.

Table 6-3: Selected design elements for further study

		Case A	Case B	Case B
Exemplar of innovation/bespoke design elements selected for further study				
1	Single bed room (including en-suite and bed head services panel)	I/B	I/B	T/S
2	Ward layout and clinical workstation	I/B	I/B	T/S
3	Window design and ventilation strategy	T/S	I/B	I/B
4	Communal spaces within the hospital	I/B	I/B	T/S
Exemplar standard/traditional design elements selected for further study				
1	Isolation room	T/S	T/S	T/S
2	Finishes (Floor, wall and ceiling)	T/S	T/S	T/S
3	Doors	I/B	T/S	T/S
4	Water service design	I/B	T/S	T/S

6.3.3 Data collection steps 3, 4 and 5

Steps 3, 4 and 5 were intended to gather details about the evidence-based design process of the 8 design elements. Interviews with representatives from the client, designer, and engineer and document analyses were conducted to collect a rich set of data for each case study for all eight elements. An interview instrument was used to guide the semi-structured interviews (see Appendix F.1). All the interviews were conducted face-to-face with the exception of two of the interviews; interviews with the engineer's representatives for cases A and B were conducted over the telephone. Interviews with client's representatives and designer's representatives took approximately two hours each. Interviews with engineer's representatives took around 45

minutes for each interview. With the permission of all the interviews the interviews were voice recorded.

Table 6.4 summarises the details of data collection steps 1 to 4 for all three case studies.

Table 6-4: Summary of data collection process for three case studies

		Interviews			Document review	Observation
		Person	Mode	Date		
Case study A	Steps 1,2	Client-trust Designer	Face to face Face to face	04-04-2012 05-11-2012	Drawings – floor plans Presentations Business case Space hierarchy diagram Photos of mock-up	Yes
	Steps 3,4	Designer Client Engineer	Face to face Face to face Telephone	20-12-2012 08-01-2013 25-01-2013		
Case study B	Steps 1,2	Client-health board Designer	Face to face Face to face	17-09-2012 06-11-2012	Drawings – floor plans presentations Terms of reference for single rooms Hospital operational manuals Derogation register Photos of mock-up Ventilation strategy – calculations	Yes
	Steps 3,4	Designer Client-health board Engineer	Face to face Face to face Telephone	18-12-2012 18-12-2012 03-06-2013		
Case study C	Steps 1,2	Designer	Face to face	09-11-2012	A report on the project Drawings – floor plans M&E service specification Photos	Yes
	Steps 3,4	Designer Client-trust Engineer	Face to face Face to face Face to face	13-02-2012 13-02-2013 13-02-2013		

6.4 CASE STUDIES – DATA ANALYSIS

Data collected during steps 3 and 4 were then analysed to:

1. understand practices of evidence use;
2. understand practices for use of performance specification and prescriptive specifications; and
3. understand the impact of project-unique circumstances for EBD process and how designers reflect on these circumstances.

This section describes and discusses details of the data analysis process for each of above three aspects of EBD.

6.4.1 Data analysis - Analysis of practices of evidence use

Figure 6.2 illustrates the data analysis process used to identify practices of evidence use.

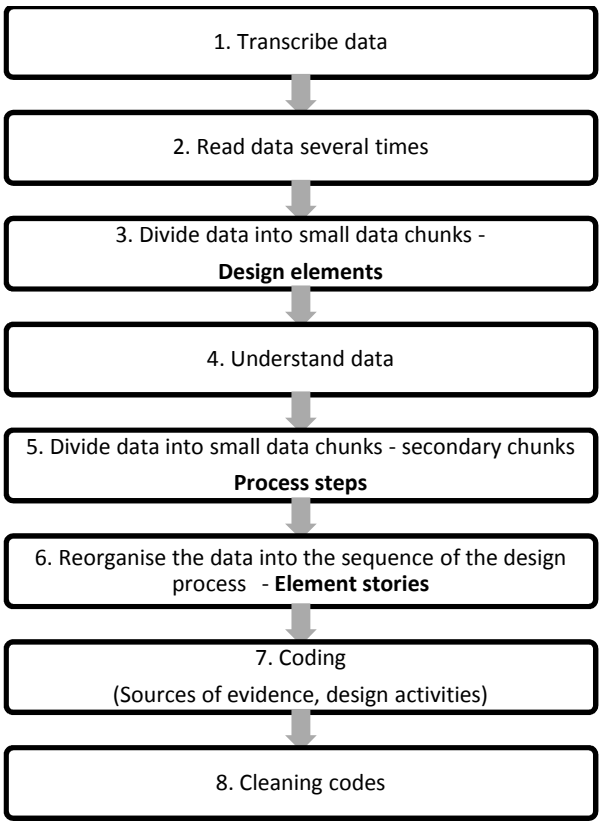


Figure 6-2: Data analysis process for evidence use and timing of evidence use

All the interviews were transcribed into word documents for use in the analysis. This data was then read several times in order to become familiarised with the data and the case.

Even though interviewees were questioned about the main 8 exemplar design elements they talked about sub elements within inquired 8 elements. Therefore, interview conversations related to each of the eight elements were categorised into further segments to identify the sub design elements revealed within the data. This initial categorisation revealed data in relation to 27 exemplar design elements for Case A; 25 exemplar design elements for case B; and 26 exemplar design elements for Case C (refer Table 6.5).

Another cycle of careful reading of the data ascertained that the data could be further divided into segments based on the steps of the process. Accordingly, data was then divided into further

smaller segments based on the steps in which they were involved. Each new step identified during the reading of data was taken out of the large segment and separated. The phrase 'steps of the process' is used here to denote the progress of the process and to distinguish a new step or element of evidence used from previous step. The two quotes below illustrate how 'identifying recessed PC' was separated from the next step of 'evaluating the solution'.

> Identifying recessed PC - *"….The idea or recessed PC – that was the Architect……..they suggested how about recessed screen, because they can get them, ……"* (a representative from the Client)
>
> Evaluating the solution - *"…..but later we found it is very difficult to find something that provide every need that we wanted, ……."* (a representative from the Client)

Each small data segment identified, based on process steps, were then codes a) for the step in brief, b)design element, c)design activity, and d)source of evidence (see Figure 6.3).

Data - interview converstaions		description in brief	Design element	Activity in the process	Source of evidence
all those research coming out of Roger Ulrich, we knew we want infection control, we knew we need to provide privacy, and we knew we did not want curtains because of washing them storing them and infection control,	SPR	privacy no curtains	Detail arragement inside the room	brief to the design team	research - roger Ulrich
we knew we want to have rooms same so that we need to have any major changes,	SPR	standard rooms	Detail arragement inside the	brief to the design team	knowledge and experience - client
we told architect we don't need any fixed furniture so either they got to be built into the structure, or we got to move them in and out, that is the basis we start.	SPR	no fixed furniture	Detail arragement inside the	brief to the design team	research - roger Ulrich
And other thing is we had directory included every things principles like door, walls, sinks to that sort of things so we specified, we don't need sharp corners, we had standard heights, we sort of help that process in that ways, we still get it 100% right but it helps. (repeated/specification)	SPR	standard height and location of fittings no sharp corners	Detail arragement inside the room	specify design in part	knowledge and experience - client - articulated into GOSH standards
detail design	SPR	detail design	Detail arragement inside the	devise a solution	knowledge and experience - design team
Mock-up	SPR	mock-up	Detail arragement inside the	evaluate the solution	physical mock-up
Mock-up evaluation –and we looked at the position of the patient television and if we have not done that in the mock up we would have had problems later on, and so again that allows us to do modifications easily without any major cost to the project later	SPR	change the position of patient television	Detail arragement inside the room	improve the solution - for mock-up results	physical mock-up

Figure 6-3: An example of coding for case study data

These small segments were then re-organised to represent the sequence of the process of designing for each element. The sequence was identified from the interviewee's information since they described the process of designing for each element as a story. In some instances, interviewees revealed information related to previous activities as they came into their mind. Also, data revealed by three informants (client's representative, designer's representative, engineer's representative) were transcribed separately and needed to be incorporated into a

one story for each design element (*element's story*). Therefore, these instances were identified and data were re-organised to represent the sequence of the process for each element. At the end, a total of 226 data segments for Case A, 213 data segments for Case B and 149 data segments for Case C were identified to represent 27, 25, and 26 element stories for cases A, B and C respectively (refer Appendix G).

The reason for encountering different numbers of process steps for three cases may imply the extent of evidence used during each case. It is evident that cases A and B have a similar number of instances of evidence used for the scope of design selected for this case study. However, Case study C has, comparatively, fewer instances of evidence used for the same scope. The reason for this could be the limited time they had for designing and the fact that part of the designing was done by a modular contractor who was contacted in this study.

Since, the data analysis was carried out using MS Excel retrieving data related to a particular code at a later stage of the analysis was a concern. Therefore, a labelling mechanism was used to relate data segments and codes. Each data segment was labelled to denote:

- the informant of a particular data chunk (D - for designer/design team, C - for client, E - for engineer, DA – document analysis);
- the case in which data belong to (A, B, C); and
- index number for the data segment within the case (1-266 for case A; 1-213 for case B; 1-149 for case C).

These labels were then tagged to codes derived from particular data segments. Accordingly, a label of 'A200D' means the particular coded content or code follows the 200th data segment of case study A and was composed of data from a designer. After initial coding was completed, it was realised that some duplications existed in coding (e.g. two codes to mean same). A cleaning step was conducted to remove all duplications. The section below presents a summary of codes for activities of the design process and sources of evidence as derived through this analysis.

At the end of the coding process, the story for a particular element described the stepped progress from identifying the design problem through designing to POE for the particular element. As the next step, process steps related to POE were removed from the element story and the development process was separately identified to make observations about evidence used during designing. These condensed the element stories into totals of 166, 147, and 122 process steps for cases A, B and C respectively (refer Table 6.5).

Table 6-5: Details of design elements identified within case study data

No	Main design element	Case study A - Sub-design element (27)		Case study B- Sub-design element (25)		Case study C- Sub-design element (26)	
1	Single bed room , en-suite & bed head service panel	A.1	Room dimensions (3)	B.1	Provision of single room (20)	C.1	Single room layout(9)
		A.2	Detail design inside the room(8)	B.2	Single room design(12)	C.2	On-suite(3)
		A.3	Room layout - what goes in(3)	B.3	On-suite vs Central(8)	C.3	Bed head services(5)
		A.4	Room layout – wardrobes(4)	B.4	En-suit - Size(5)		
		A.5	Location of en-suite(3)	B.5	Bed head service(5)		
		A.6	Bed head service panel (12)				
		A.7	Control of environment (2)				
2	Ward layout and nurse station	A.8	Ward layout(16)	B.6	Ward shape(4)	C.4	Size and shape of the ward(4)
		A.9	% of single bed rooms(9)	B.7	Ward layout(6)	C.5	Composition of single and shared bed bays(6)
		A.10	Nurse base-decentralisation vs central(9)	B.8	% single rooms(4)	C.6	Layout – other(14)
		A.11	Nurse base - level of decentralisation(5)	B.9	Staff base(8)	C.7	Layout - entrance to the ward(3)
		A.12	Recessed PC(4)	B.10	Computer at staff base(3)	C.8	Layout - no of nurse bases(1)
				B.11	Nurse call system – Sera(3)	C.9	Layout - location of the nurse base(3)
3	Communal spaces	A.13	Play area(7)	B.12	Day space(5)	C.10	Day rooms(4)
		A.14	Parents waiting space(4)			C.11	Corridors(2)
		A.15	Staff rest(6)			C.12	Waiting space(2)
						C.13	Stairways(2)
4	Isolation room	A.16	Isolation room(10)	B.13	Isolation room – provision(5)	C.14	Isolation room(4)
				B.14	Isolation room – location(3)		
				B.15	Isolation room – Layout(4)		
5	Finishes	A.17	Finishes – generic(6)	B.16	Floor finishes(7)	C.15	Floor finishes(8)
		A.18	Finishes - en-suite floor(3)	B.17	Wall finishes- En-suite(4)	C.16	Wall finishes(5)
		A.19	Ceiling finishes(7)	B.18	Ceiling finishes(8)	C.17	External walls(2)
						C.18	Worktop finishes(2)
6	Doors	A.20	Doors – generic(4)	B.19	Doors(9)	C.19	Doors – generic(8)
		A.21	Finishes – doors(3)	B.20	Doors – finishes(3)	C.20	Glass panels/smart glass(2)
		A.22	Doors - finger trapping solutions(9)	B.21	Doors-ironmongeries(2)		
		A.23	Single room door(3)	B.22	Vistamatic panels(4)		
		A.24	Not having smart glass(5)				
7	Water services	A.25	Water services(7)	B.23	Water services(3)	C.21	Water services design(5)
						C.22	Fittings - water services(5)
8	Ventilation strategy and windows	A.26	Ventilation strategy(3)	B.24	Ventilation strategy(3)	C.23	Ventilation strategy(9)
		A.27	Window design(11)	B.25	Design of the window(9)	C.24	Windows – generic(6)
						C.25	Summer temperature control(6)
						C.26	Window blinds/ windows(2)
Note - numbers within bracket at each element represent number of process steps supported by the element story for the particular element.							

6.4.1.1 Codes for sources of evidence

As stated above, each data segment for a process step was coded to identify the source of evidence on which a particular activity of designing is based. Based on inductive thematic analysis principles (refer Chapter 2) these codes were then thematically grouped into higher level codes. As a result 9 main sources of evidence were derived. Table 6.6 shows the details of the 9 main codes.

Table 6-6: Codes for sources of evidence

	Main code	Includes (sub-codes)	Excludes
1	Knowledge and experience	knowledge and experience of design team: client (including clinical staff), designer, engineer and constructor specialist staff within the hospital who were part of the design team throughout Trusts' standards and guidance compiled from previous experience	user consultation : views of staff who are not a part of design process evidence from suppliers of the project
2	User consultation	views of public, patients and families and staff who are not a permanently engaged in the design process	Specialist consultation included in expert opinion
3	Information from client	Briefing, hospital operational policy, other trust's requirements	
4	Evidence from the industry	Evidence from suppliers (including suppliers of the project) Evidence from trade shows,	Excludes visits to other facilities
5	Standards, guidance	Industry standards and guidance DH standards and guidance	Individual trusts' standards and guidance
6	Internally generated evidence	Research conducted by design team (client, engineer, designer), modelling, mock-ups, enabling works	
7	Research - external	Published research	
8	Visits to other facilities	Visits to national and international hospitals and other places	
9	Expert opinion	Opinion from people outside the project organisations, and in-house experts who were not a part of the design team but consulted when appropriate (ex-play specialists in Case A, elderly care specialists in Case C)	Talks given by Professor Roger Ulrich during Case study B were included in 'Research- external'
10	Constrained use of evidence	There were instances, where design activities were performed as a result of consequence of other activities, not necessarily based on any evidence	

The colour coding system used in the table above was adopted to easily distinguish the 9 main sources of evidence in subsequent analyses. This was particularly helpful to easily identify patterns of evidence use within large maps.

These inductively identified sources of evidence were compared with the sources of evidence identified by previous scholars of evidence-based design and scholars of design (see Table 6.7).

Table 6-7: A comparison of evidence sources identified within case studies with previous literature

	Sources of evidence for EBD – derived through this research	EBD Survey by CHD 2010	Design knowledge literature
1	**Knowledge and experience**	Past projects	In-house design guidance, Details of previous projects (Emmitt, 2007); previous cases; previously used concrete cases (Heylighen, 2000)
2	**User consultation**		User interviews, public consultation, activity survey on how space is used (Emmitt, 2007)
3	**Information from client**		Inputs from briefing process (Blyth and Worthington, 2010; Emmitt, 2007)
4	**Evidence from the industry**	Internet searches for projects materials, Published articles in magazines, vendor information about the latest trends, Benchmark other facilities for best practices, research summaries through databases, webinar participation, blogs	Detail designs for unfamiliar design elements (Emmitt, 2007)
5	**SGaTs**		SGaTs produced by DH (Hignett and Lu, 2009; Lindahl et al., 2010; Hignett and Lu, 2008; Moss et al., 2001)
6	**Internally generated evidence**		Surveys of existing buildings for building plans and data, Visual survey for space and time usage and other buildings (Blyth and Worthington, 2010)
7	**Research – external**	Published research in peer reviewed journals, conferences about healthcare design, case study reviews, online literature through databases,	Evidence from books and journals (Emmitt, 2007; Neuckermans and Fontein, 2002)
8	**Visits to other facilities**	Visits to other facilities , Post occupancy evaluations of other facilities,	Visual survey for space and time usage and other buildings (Blyth and Worthington, 2010)
9	**Expert opinion**	Opinion from peers	

Examining Table 6.7, it is evident that sources of evidence derived are based on case study data supplements of previous researches. The US based closed questionnaire survey conducted by CHD in 2010 did not identify evidence from user consultation, SGaTs and internally generated evidence as sources of evidence. Results of this research revealed stakeholders' use of SGaTs as expected. Design knowledge literature related to how designers use expert opinion could not be identified within the literature review of this thesis.

6.4.1.2 Codes for activities of the design process – timing of evidence use

As stated earlier, each data segment for process steps of elements was also coded in relation to their design activity. Based on inductive thematic analysis principles (refer Chapter 2) these initially identified codes were then grouped into higher level codes. For instance, *identify negative impacts* and *identify positive impacts* are two sub codes of the main code of *design evaluation*. Altogether 15 main design activities were derived during this inductive analysis. Table 6.8 presents details of the 15 design activities.

These included pre-design activities which aimed at problem definition and activities of design phases related to designing and design evaluation (RIBA, 2013). This categorisation, based on RIBA plan of work stages, was used in the analysis of the stakeholders' approaches to problem definition and designing (refer Section 6.4.2).

Table 6-8: Codes for timing of evidences use/ design activities

		Code (Activity)	Description remarks if any
1	Activities of Pre-design phase (Problem definition)	Analyse existing system	
2		Identify & process strategic requirements	
3		Identify project specific requirements	
4		Specify performance specification	
5		Specify prescriptive specification	
6	Activities of Design phase (Designing and design evaluation)	Identify possible ado(a)ption	Identify solutions internally or externally
7		Evaluate evidence	Evaluate evidence of selected specifications Evaluate evidence of considered solutions
8		Adopt the solution	Use without modifications
9		Adapt a solution	To make fit (as for a new use) often by modification
10		Reject the solution	
11		Construct a solution	To make or form by combining or arranging parts or elements
12		Devise a solution	Doing it, to form in the mind by new combinations or applications of ideas or principles
13		Detail design	
14		Improve the solution	
15		Design evaluation	Iterative activity often appears after activities 6 - 14

It is worth noting here that the activities: evaluate evidence and design evaluation appears iteratively several times during the whole process of designing. But, for the purpose of easy illustration, these were grouped together in this table.

These were then compared with the activities identified in the conceptual model and generic designing and EBD activities identified within previous literature (see Table 6.9).

Table 6-9: Comparison of inductively identified activities of designing with activities of designing contained in the SaFE model and previous literature

	Inductively derived activities of designing (form Case studies)	Activities of designing contained in the SaFE model	Activities designing (McMillan et al., 2001)	EBD activities	
				Cama (2009)	Brown and Ecoff (2011)
			Specify the business needs		
1	Analyse existing system		Identify problems with existing solutions		
2	Identify & process strategic requirements	Identify & process strategic requirements (1a.1)		Align strategic objectives	
		Option generation and appraisal (1a.2)			
		Feasibility and evaluation (1a.3)			
3	Identify project specific user needs	Identify project specific user needs (1a.4)	Assess stakeholder requirements Develop the requirements Determine project characteristics		
4	Specify performance specification	Specify Performance specification (1a.5.1)	Set requirements	Gather internal external intelligence	
5	Specify prescriptive specification	Specify Prescriptive specification (1a.5.2)			
6	Evaluate evidence (new)				Assessing
7	Identify possible ado(a)ption (identify internally or externally)	Designing (1b)	Generate initial concepts Transform and combine solutions Select suitable combinations Firm into concept variants	Reveal possible design solutions	
8	Adopt the solution (use without modifications)			Decide to duplicate or innovate	Applying the solution
9	Adapt a solution (to make fit (as for a new use) often by modification)				Advancing the solution
10	Reject the solution				
11	Construct a solution (to make or form by combining or arranging parts or elements)				
12	Devise a solution (doing it, to form in the mind by new combinations or applications of ideas or principles)				
13	Detail design				
14	Improve the solution		Improve details and cost options		Advancing the solution
15	Design evaluation	Design evaluation (1c)	Evaluate and choose proposal	Question analyse; Explore possibilities; Pre-measure clinical features for positive outcomes	Acquiring evidence; Appraising solution; Asking questions

By studying the table it is evident that EBD activities, inductively derived within case study data, are more detailed compared to previous literatures. These inductively derived activities could have been further categorised into higher level activities, in which case they would be fairly equal to generic designing activities. Evaluating evidence was identified as a new activity, and this was not previously identified within generic literature. However, EBD scholars have identified this as an activity within EBD.

6.4.1.3 Data display

A. Sources of evidence and timing of evidence use

The next step was to display sources of evidence and timing of evidence used in a meaningful way for readers. For this purpose, the process of designing for each element was separately analysed to identify (count) the frequency of use for each source of evidence and frequency of use of each source of evidence during the 15 design activities.

As stated earlier, the condensed element stories for Cases A, B and C were composed of 166, 147, and 122 process activities. Yet, for some process activities, more than one source of evidence was used (see the Quote below).

Label	Data segments (process step)	Element	Design activity	Source(s) of evidence
A122C	but later we found it is very difficult to find something that provides every need that we wanted and the other thing is when it comes to entering data staff find it very difficult to use the touch screen, they prefer key boards, so we had to allow for that as well,	Recessed PC	Evaluate the solution	Evidence from the supplier/ manufacturer User consultation

These instances were considered during the frequency count and counted as two instances of evidence use (as in above case). Eventually, 191, 184, 135 instances of evidence use could be identified for Cases A, B and C respectively. These were illustrated using bar graphs while identifying the number of instances (frequency) of using a particular source of evidence alone and the frequency of using them in combination with another source of evidence.

The frequency of using 9 sources of evidence during 15 design activities was illustrated in a table to ease observation of patterns of use of the 9 evidence sources.

One of the advantages of case studies is that rich sets of data related to a particular phenomenon are revealed. Transferring this set of data to the reader, with the details, could have been achieved if the element stories were presented using a ‘story telling technique’ or descriptive narratives (Langley, 1999; Sandelowski, 2000; Myers, 1997). However, a summarised

outlook of the practice of EBD was also essential to identify patterns and to draw conclusions to answer the objectives of this research. Therefore, the summarised outlook of evidence use is presented within the thesis and element stories are appended (refer Appendix G) for readers who would like to see further details.

B. Other dimensions of evidence

Some of the reasons for selecting a case study design for this research were previous literature claims that case studies are appropriate to understand 'how and why' questions within a particular phenomenon (Yin, 2009); and suitable for exploring processes or behaviours or those which are little understood (Amaratunga et al., 2002). In addition to 'what' (sources of evidence) and 'when' (timing of evidence) questions, case study data revealed answers for 'how and why' questions related to the current practice of EBD in the form of following dimensions.

1. Means of evidence gathering
2. Purpose of evidence
3. User channels of evidence
4. Availability of evidence
5. Suitability/relevance of evidence
6. Quality of evidence
7. Success of application

Reading the story for each source of evidence describing each of the dimensions above could exhaust reader. Further, it could confuse readers who are looking for answers for one particular aspect. Therefore, based on the data display methods explained by Miles and Huberman (1994; 2014), answers for these dimensions of evidence were summarised and presented within a table. The content of the table is supported by a follow up discussion explaining the noteworthy contents of the table.

Eppler (2006), in his book on managing information quality, identified 16 information quality criteria frameworks by analysing information quality criteria found in the previous literature. He categorised these 16 criteria into four information quality levels: relevance, soundness, process level quality, and infrastructure level quality. Case study data revealed that stakeholders were concerned about criteria related to relevance and soundness when gathering and applying evidence.

6.4.1.4 Bespoke version of the sources and flows of evidence model (SaFE model)

A bespoke version of the SaFE model was developed for each case study. Codes and sub-codes for design evidence sources were useful for this purpose. Firstly, existence of each and every entity of the SaFE model was first verified using each case's codes and sub-codes for design knowledge. Secondly, codes, sub-codes for design evidence and original case study data were compared with the entities of the model to identify the existence of any additional evidence source or means of merging the evidence into designing.

During the presentation, the original model was degraded to grey scale colours and entities of the model identified as exits in the particular case study were highlighted with the original colours.

6.4.2 Data analysis - Impact of project-unique circumstance on the EBD process

The three case studies have used a variety of approaches for evidence acquisition and evidence application. Interview contents was analysed based on the principles of inductive thematic analysis (Section 2.4.2.1) to identify the impact of contextual circumstances for EBD process and how designers reflect on these circumstances.

The results revealed how the project-unique circumstances have impacted the EBD process in each case and these are presented in Chapters 6, 7, and 8.

6.4.3 Data analysis - Analysis of practices of using performance specification and prescriptive specifications

The next step was to analyse how performance specifications and prescriptive specifications were used during EBD process.

6.4.3.1 Approach to designing

At the beginning of the research study it was hypothesised that solutions devised, based on performance specifications, result in innovative and bespoke solutions and solutions devised, based on prescriptive specifications, result in standard solutions. Therefore, four carefully selected design examples of bespoke/innovative designs and four carefully selected design examples of standard designs were further investigated for evidence-based design process of those elements (refer Section 2.3).

However, when the data was collected and the actual processes were known, it was realised that classifying the design based on the output was not the most sensible way to classify as was expected at the beginning. In many cases, output designs for a particular element ended up as bespoke designs even though they started with a standard solution. This is because the design team always modifies the chosen solution for reasons of improving solutions, to support additional functions or to modify solutions to suit the particular project requirements and circumstances.

Therefore, a deductive content analysis for data (Section 2.4.2.1) was adopted for this phase of the analysis. Based on the actual data revealed in element stories, each design element was re-classified to identify its initial form of evidence: prescriptive specification based designing or performance specification based designing. Prescriptive specification based designs are those where the solutions originally started with a standard solution. Performance specification based designs are those where the solutions are devised based on performance specifications. Since the whole story of the element is revealed within case study data, distinguishing prescriptive specification based solutions from performance specification based solutions was fairly easy.

Prescriptive specification based solutions were divided into a further two variants based on the origin of the solution. They are:

> ***Guided solution*** **(GS)** – solutions which were chosen from published standards and guidance; and
>
> ***Selected solution*** **(SS)** – solutions which were chosen from previous experience or from de facto standards but not from published standards and guidance.

The solutions derived, based on performance specification, were divided into a further two variants based their approach to designing:

> ***Devised solution*** **(DS)** – solutions originally devised by the design team to solve the design problem; and
>
> ***Constructed solution*** **(DS©)** – solutions constructed (rather than construed) as a result of other parts of the design (for instance the size of a single door was determined by the plant used for the ceiling hoist).

6.4.3.2 Approaches to problem definition

Element stories revealed that, irrespective of the approach taken during designing (prescriptive specification based designing or performance specification based designing), in some instances the problem definition activities were conducted to set design requirements to guide subsequent designing. Therefore, the approach to problem definition was identified for each element based on the element's story data. A careful reading of element stories revealed that for some elements these design requirements were derived through published standards and guidance or devised based on the knowledge and experience of members of the design team and user consultation. Whilst for some elements no pre-determined approach to problem definition could be found prior to designing. Based on these observations, the following deductive codes were determined at the beginning and an approach to problem definition was identified for each element.

> ***Problem definition based on guided specification (GP)*** – Problem definition based on the published SGaTs.
>
> ***Problem definition based devised specification (DP)*** – Problem definition based on the design requirements devised through the evidence other than SGaTs.
>
> ***No pre-determined approach to problem definition (-)*** – no pre-determined approach to problem definition could be found before proceeding to designing.

It was soon realised that the initial codes are too simple to represent the characteristics of design elements. Therefore, based on the initial codes new codes were developed as necessary. Details of codes arrived at by the end of the analysis are presented in the Table 6.10.

Table 6-10: Codes for approaches to performance setting and approaches to designing

Aspect	Code	Nick name
Approaches to problem definition	Problem definition based on guided specification	GP
	Problem definition based on devised specification	DP
	Problem definition based on guided and devised specification	GP + DP
	No pre-determined approach to problem definition	-
Approaches to designing	Guided solution	GS
	Guided solution significantly improved	GS+
	Selected solution	SS
	Selected solution significantly improved	SS+
	Devised solution	DS
	Guided solution + Selected solution	GS + SS
	Guided solution + Devised solution	GS + DS
	Selected solution + Devised solution	SS + DS
	Guided solution failed > Devised solution	GS > DS
	Selected solution failed > Devised solution	SS > DS

No other specific classification for approaches to design evaluation could be identified within the data. Design evaluation was an iterative activity performed throughout the process of designing based on all sources of available evidence.

6.4.3.3 Nature of design element

The type of design element for each element story was first labelled inductively based on its description. During further analysis the data suggested a link between the practices of performance and prescriptive specification use and the type of design element based on the phase of designing.

In order to observe these patterns, design elements were classified into pre and conceptual design phases and detail and technical design phases as stated in the Table 6.11.

Table 6-11: Classification of design elements

Phase of designing	Type of element
Design elements in the pre and conceptual design phases	Space/layout
	Composition
	Location
	Shape and size
	Provision
	Option appraisal
Design elements in the detail and technical design phases	E/services
	Facilities
	Finishes
	Components

6.4.3.4 Origin of the solution

For the elements where solutions are based on prescriptive specifications, the origin of the solution was also identified to verify some of the implications suggested during interpretation of the results. Prescriptive solutions identified from de facto standards were labelled as **dfSS** and solutions identified through industry evidence and external solutions emerging from the industry were labelled as **iSS.**

6.5 CASE STUDIES – PRESENTATION

As discussed in the Chapter 2 (Section 2.7), case studies provide a rich set of data that are supportive in understanding the phenomenon studying within the case studies. Yet, presenting a large amount of raw data within the thesis chapters may distract reader from focusing on pertinent points. Therefore, Chapters 6,7, and 8 presents analyses relevant to the key findings of the case studies while, comprehensive versions of case studies supported by narratives are presented in the Appendix J.

Table 6.12 summarise details of coding for Cases A, B and C.

Table 6-12: Summary of deductive coding for design elements

		Case study A						Case study B						Case study C					
No	**Main design element**	**Sub-design element (27)**		**Category of element**	**Performance setting**	**Approach to Design**	**Solution origin**	**Sub-design element (25)**		**Category of element**	**Performance setting**	**Approach to Design**	**Solution origin**	**Sub-design element (26)**		**Category of element**	**Performance setting**	**Approach to Design**	**Solution origin**
1	Single bed room , en-suite & bed head service panel	A.1	Room dimensions (3)	Shape and size	DP	DS(C)		B.1	Provision of single room (20)	Provision	-	SS	Research evidence	C.1	Single room layout(9)	Space/layout	-	GS+DS+SS	SGaTs + evidence from the industry + knowledge
		A.2	Detail design inside the room (8)	Space/layout	DP	SS+DS	In-house standards	B.2	Single room design(14)	Space/layout	->DP+GP	GS > DS	SGT solution abandoned	C.2	On-suit(3)	Space/layout	-	SS	Evidence from the industry
		A.3	Room layout - what goes in (3)	Space/layout	DP+GP	GS+DS	SGaTs	B.3	On-suit vs Central(8)	Shape and size	-	GS > DS	SGT solution abandoned	C.3	Bed head services(6)	Component	-	SS	Evidence from the industry
		A.4	Room layout – wardrobes (4)	Component	DP	SS	K&E	B.4	En-suite - Size(5)	Component	-	SS	K&E > evidence from the industry						
		A.5	Location of en-suite(3)	Location	DP	DS		B.5	Bed head service(5)	Space/layout	-> DP+GP	GS > DS	SGT solution abandoned						
		A.6	Bed head service panel (10)	Component	DP	SS > DS	K&E failed												
		A.7	Control of environment (2)	Facilities	DP	SS	K&E												
2	Ward layout and nurse station	A.8	Ward layout(16)	Space/layout	DP	DS		B.6	Ward shape(4)	Shape and size	DP	SS	K&E + evidence from the industry	C.4	Size and shape of the ward(4)	Shape and size	DP+GP	SS+	K&E + evidence from the industry
		A.9	% of single bed rooms(9)	Composition	-	GS+SS > DS	SGaTs + evidence from the industry solution abandoned	B.7	Ward layout(6)	Space/layout	DP	DS		C.5	Composition of single and shared bed bays(6)	Composition	-	SS+	K&E
		A.10	Nurse base-decentralisation (9)	Option appraisal	-	SS+	Evidence from the industry	B.8	% single rooms(4)	Composition	-	GS > DS		C.6	Layout – other(16)	Space/layout	-	DS	
		A.11	Nurse base - level of decentralisation(5)	Composition	-	DS		B.9	Staff base(8)	Space/layout	GP	GS+		C.7	Layout - entrance to the ward(3)	Space/layout	-	DS	
		A.12	Recessed PC(4)	Component	DP	SS+	Evidence from the industry	B.10	Computer at staff base(3)	Component	DP	SS	Evidence from the industry	C.8	Layout - no of nurse bases(1)	Provision	-	SS	Traditional solution (K&E)
								B.11	Nurse call system – Sera(3)	Component	DP	SS	Evidence from the industry	C.9	Layout - location of the nurse base(3)	Location	-	DS	
3	Communal spaces	A.13	Play area(7)	Space/layout	->DP	DS		B.12	Day space(5)	Provision	GP	SS	Traditional solution (K&E)	C.10	Day rooms(5)	Provision	-	SS	SGT+traditional solution (K&E)
		A.14	Parents waiting space(4)	Space/layout	DP	DS								C.11	Corridors(2)	Space/layout	-	DS	
		A.15	Staff rest(6)	Space/layout	DP	DS								C.12	Waiting space(2)	Provision	-	DS	
														C.13	Stair ways(2)	Space/layout	-	DS	
4	Isolation room	A.16	Isolation room(11)	Space/layout	DP+GP	GS	DH SGaTs	B.13	Isolation room – provision(6)	Provision	-	GS+	SGaTs	C.14	Isolation room – provision (4)	Provision	-	SS	Traditional solution (K&E)
								B.14	Isolation room – location(3)	Location	-	SS	K&E						
								B.15	Isolation room – Layout(4)	Space/layout	DP	GS+							
5	Finishes	A.17	Finishes – generic (6)	Finishes	DP	SS	Evidence from the industry	B.16	Floor finishes(9)	Finishes	GP	SS	Evidence from the industry	C.15	Floor finishes(8)	Finishes	DP+GP	SS	Evidence from the industry
		A.18	Finishes - en-suite floor(3)	Finishes	-	SS	Evidence from the industry	B.17	Wall finishes- En-suite (6)	Finishes	-	SS	Evidence from the industry	C.16	Wall finishes(5)	Finishes	-	GS+SS	Evidence from the industry
		A.19	Ceiling finishes (8)	Finishes	-	SS	Evidence from the industry	B.18	Ceiling finishes (10)	Finishes	DP	SS	Evidence from the industry	C.17	External walls(2)	Finishes	-	SS	Evidence from the industry
														C.18	Worktop finishes(2)	Finishes	-	SS	Evidence from the industry
6	Doors	A.20	Doors – generic (4)	Component	DP	SS	Evidence from the industry	B.19	Doors (9)	Component	->DP	GS > DS	SGT + K&E	C.19	Doors – generic(8)	Component	DP	SS	Evidence from the industry
		A.21	Finishes – doors (3)	provision	-	SS	Evidence from the industry	B.20	Doors – finishes (4)	Finishes	-	SS	Evidence from the industry	C.20	Glass panels/smart glass(2)	Component	DP	SS	Evidence from the industry
		A.22	Doors - finger trapping solutions(9)	Finishes	-	SS	Evidence from the industry	B.21	Doors-ironmongeries (2)	Component	-	SS	Evidence from the industry						
		A.23	Single room door(3)	Component	DP	SS > DS	Evidence from the industry	B.22	Vistamatic panels (4)	Component	-	SS+	Evidence from the industry						
		A.24	Smart glass (5)	Component	DP	DS(C)													
7	Water services	A.25	Water services (8)	E/Services	-	DS		B.23	Water services (3)	E/services	GP	SS+GS^{+}	K&E	C.21	Water services design(5)	E/services	GP+DP	SS	Traditional solution (K&E)
														C.22	Fittings - water services(5)	Component	-	SS	K&E
8	Ventilation strategy and windows	A.26	Ventilation strategy(3)	E/Services	-	SS+	Traditional solution (K&E)	B.24	Ventilation strategy (3)	E/services	GP	SS	K&E	C.23	Ventilation strategy(9)	E/services	GP+DP	SS	Traditional solution (K&E)
		A.27	Window design(12)	Component	-	SS+	K&E + evidence from the industry	B.25	Design of the window (11)	Component	GP	SS^{+}	K&E + Evidence from the industry	C.24	Windows – generic(6)	Component	-	SS	K&E
														C.25	Summer temperature control(6)	E/services	GP+DP	DS	
														C.26	Window blinds/ windows(2)	Component	-	SS	K&E

CHAPTER 7. CASE STUDY A

7.1 INTRODUCTION

The main data collection method for this research is case studies. Three case studies (which are anonymously referred as Case study A, B and C) were conducted. This Chapter reports and discusses evidence-based design practices of Case study A. A brief description of the case is provided followed by the report and discussion of the results of the case studies from three perspectives:

- Firstly, the data from Case study A was analysed to identify the sources of evidence used during case A, frequency and timing of evidence use and other selected dimensions of using evidence from different sources. Based on these results a bespoke version for the model of Evidence-based Design is generated for Case study A and presented in this section; also the changes that developed the generic model into the bespoke model are discussed.
- Secondly, the Chapter reports and discusses how performance specifications and prescriptive specifications were used during the problem definition and designing in Case study A.
- Finally, the impact of the project's unique circumstances on the Evidence-based Design process of Case study A and how designers reflect on these circumstances are reported and discussed.

The Chapter is then concluded with a summary account of the Evidence-based Design practices for the Case study A.

7.2 DESCRIPTION OF CASE

Case study A is a one phase of a redevelopment programme of a children's hospital located in London. The main purpose of the redevelopment is to improve the quality of the estate to avoid clinical quality being compromised. The project was mainly funded by a charity supporting the hospital and partly by the NHS. The hospital delivers speciality care for children from UK and around the world. The particular phase studied in this research is a nine storey building with 18,000m^2 floor area. The scope included procuring a new building to provide 92 beds, including 20 Cardiac Critical Care, two replacement theatres, two replacement interventional suites, a restaurant, kitchens and facilities management facilities (see Figure 7.1). This phase of the project was procured through the '*Develop and Construct'* procurement route where the client's consultants developed the design up to Stage C or D of RIBA plan of Work (RIBA, 2007) and handed over to a selected constructor to develop and construct. In this particular case, the designer who developed the design initially was novated to the project team as the designer for the selected constructor. The project (outline design) started in February 2006 and the building became fully operational in July 2011. The construction cost was £88 million for this phase.

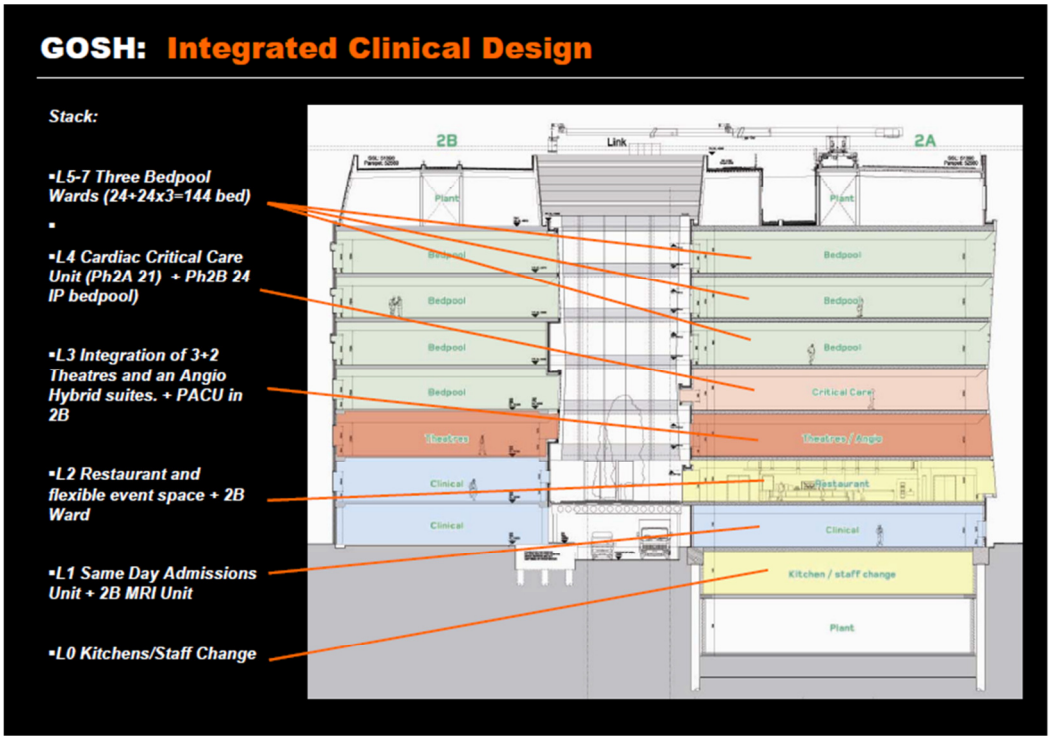


Figure 7-1: Cross sectional drawing of the Case study A

7.3 RESULTS - EVIDENCE USE IN CASE STUDY A

7.3.1 Frequency and timing of evidence use

Figure 7.2, shows the frequency of using evidence form the nine sources and none-use of evidence during the scope considered within Case study A. As stated in Chapter 6, for some design steps a combination of more than one source of evidence was used. Therefore, the frequency of use for a particular evidence source alone and frequency of using the source in combination with other sources were identified separately. Instances of constrained use of evidence were also reported.

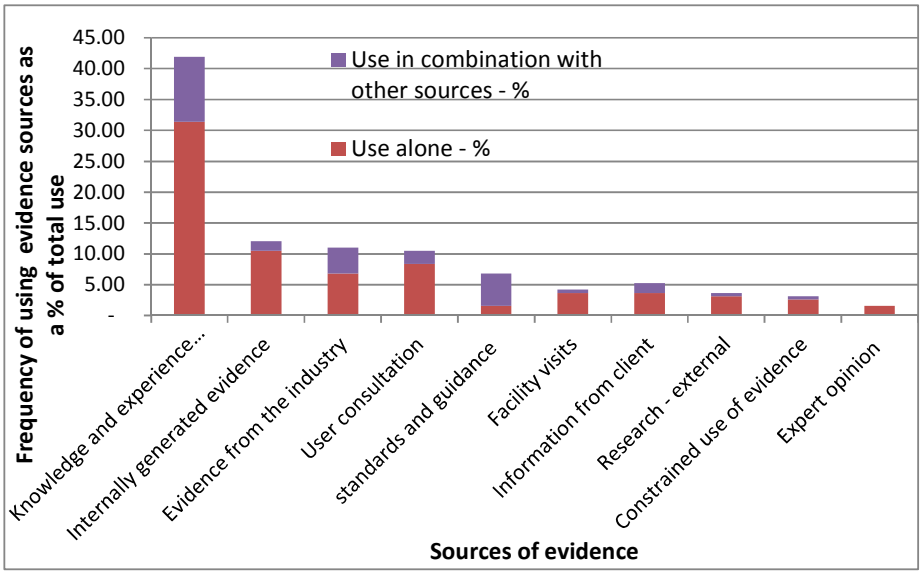


Figure 7-2 : Frequency of use for different evidence sources

Knowledge and experience was the most commonly used source of evidence for Case study A. The knowledge and experience of the design team members and their parent organisation were used extensively in all 27 design elements studied. There could be two reasons for the significant use of K&E during the design of Case study A. Firstly, as stated in the literature, knowledge and experience is an accumulated from learned evidence that was used during previous projects. Other than the client, parties engaged in the design team of Case study A had long established previous experience in designing healthcare buildings and other built environments. Therefore, it is possible that previously learned evidence from other sources is now reflected as K&E and not as its original source. Secondly, even though the client of Case study A does not have long standing experience in procuring healthcare buildings (compared to other parties), the project considered in Case study A was an intermediate phase of a major redevelopment, hence the client had experience in building design from the previous phases. The client's team on Case

study A was specifically formed to engage full time for the redevelopment activities. Therefore, they have added a considerable input during the designing of Case study A. Furthermore, design elements such as single bed patient rooms are being used in the private wing of existing hospital and knowledge and experience gleaned from them by the client was helpful in designing the new single patient rooms in this phase of the project.

Compared to K&E other sources of evidence were less used. For a better visual illustration of data related to other sources of evidence, this graph was re-plotted without K&E (Figure 7.3).

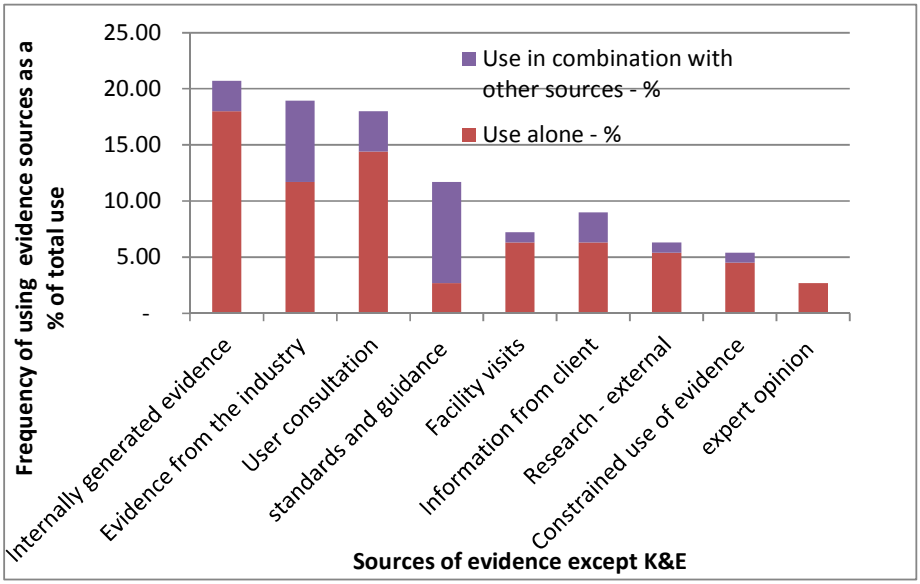


Figure 7-3 : Frequency of using different evidence sources except K&E

The next most frequently sources were 'internally generated evidence', 'evidence from the industry' and 'user consultation' at approximately 15-20% of the design activities. Standards and guidance, facility visits, information from the client, and external research were cited at 3-7%. Another interesting observation is that, during the use, internally generated evidence is less supported by evidence from other sources, whilst evidence from the industry and evidence from SGaTs are used in combination with other sources of evidence in a considerable proportion of situations.

Table 7.1 illustrates the timing of use for nine sources of evidence during the designing of Case study A. For the purpose of illustration, the total instances of using evidence for design evaluation were combined into one column in Table 7.1. However, design evaluation was an iterative process throughout the design stages. For instance, Figure 7.4 illustrates the process of procuring bed head service panels.

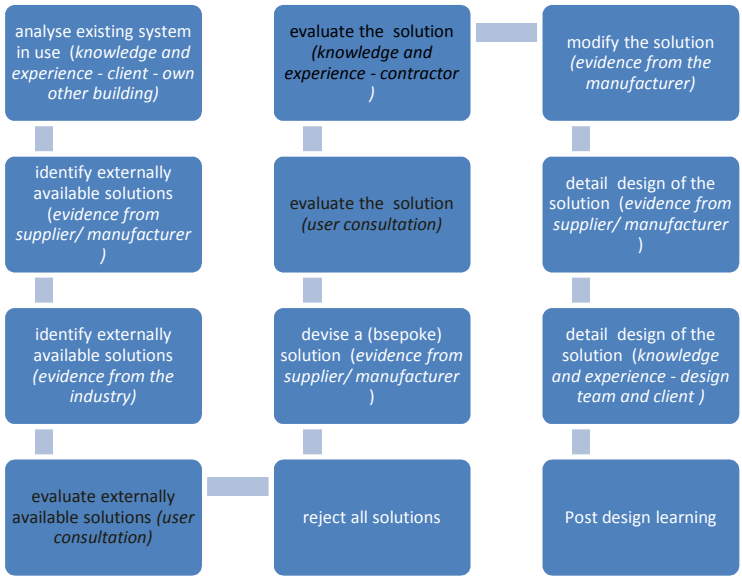


Figure 7-4 : Design process of bed head service panel

In this specific example, an initial design evaluation was undertaken for externally available solutions. All the solutions which were available from the industry were rejected and the design team then devised a bespoke solution with support from a selected supplier of bed-head service panels. This bespoke solution was then followed by another step of evaluation.

Table 7-1 : Timing of evidence use for Case A (Total number of instances - 191)

	Pre-design phase (Problem defining)					Design phase (Designing and design evaluation)									Total
	Analyse existing system	Identify & process strategic requirements	Identify project specific requirements	Specify performance specification	Specify prescriptive specification	Identify possible ado(a)ption	Evaluate evidence	Adopt the solution	Adapt a solution	Reject the solution	Devise a solution	Construct a solution	Detail design	Improve the solution	Design evaluation	
Information from client	-	1	6	-	-	-	1	-	1	-	-	-	-	-	1	10
Evidence from the industry	-	-	-	-	2	9	-	-	-	-	2	-	2	-	6	21
Internally generated evidence	-	-	2	-	-	1	-	-	-	1	1	-	-	-	18	23
Knowledge and experience stakeholders	2	-	5	2	1	11	2	2	2	2	10	-	2	9	30	80
User consultation	2	-	4	-	-	-	1	-	1	1	1	-	-	-	10	20
Expert opinion	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	3
Research (external)	-	-	-	2	1	-	-	-	-	-	-	-	-	-	4	7
Standards and guidance	-	-	-	-	1	4	-	-	1	-	2	-	-	2	3	13
Facility visits	-	-	1	-	-	1	4	-	-	-	-	-	-	1	1	8
Constrained use of evidence	-	-	1	-	-	-	-	-	-	-	1	2	-	1	1	6
Total count	4	1	15	8	5	26	8	2	5	4	18	2	4	14	75	**191**

According to the results in Table 7.1, K&E was used during almost all design activities. Internally generated evidence and evidence from user consultation were mainly used for design evaluation activities. Information from the client, evidence from visits to facilities and evidence from the industry were mainly used to identify design solutions and activities associated with early stages of designing. Evidence from SGaTs was used in both the early stages of designing but less frequently. These results imply that evidence sources may have their own particular ways of supporting the design process. This was analysed by a cross case comparison and presented in Chapter 10 of this thesis.

7.3.2 Other dimensions of evidence

Table 7.2 summarises the findings of Case study A relating to the use of nine sources of evidence. Details behind the practices of using evidence from the different sources are further discussed and presented as narrative stories in the Appendix J.

7.3.3 Reflections on the model

A bespoke version of the SaFE model for Case A was produced using the Case study data (Figure 7.5) based on the methodology explained in Chapter 6. The following discussion compares and contrasts the bespoke model of EBD for Case A with the generic SaFE model discussed in Chapter five.

1. Some of the data sources in the generic model were not used for Case A.

Data did not revealed instances where the design team used evidence that was derived from knowledge and experience in the public domain, knowledge and experience of peers, evidence from industry and professional journals, and any other written evidence of industry best practices; which are obtained from conferences, and peer generated evidence.

2. Specific data sources from published evidence.

The generic model was not explicit with regards to specific details about data sources which contain research evidence. Specific details regarding these sources were revealed during the case study and they were included in the bespoke model. These are published research evidence accessed through research institutions with whom the project team is collaborating; well-known research evidence reviews (systematic review done by Professor Roger Ulrich and his team); research published by external organisations such as DH, NICE (National Institution for Clinical Excellence); and research published in journals.

Table 7-2 : Uses of nine sources of evidence during the designing of Case study A

	Means of gathering evidence	Purpose of evidence	User Channel of evidence	Availability of evidence	Suitability /Relevance of evidence	Quality of evidence	Success of application
Information from client	* Client's brief * Trust's operating principles * Schedule of accommodation	* To identify project requirements * To identify demographic details of the prospective hospital	Client	Yes	No flaws were reported	No flaws were reported	No failures were reported due to evidence from this source.
Evidence from the industry	* Trade shows * Client's working collaborations with local and international hospitals	* To identify externally available solutions * To identify innovative solutions * To identify detail and technical detailing * To evaluate solutions	* Designer (for architectural solutions) * Client (clinical service solutions) * Engineer (for technical solutions)	(+) This was the second most used source of evidence (+) Due to the reputation of the project some suppliers and manufacturers themselves have approached the project	(-) modifications were made to solutions in few instances (-) one solution (Philips green light system) was rejected due to inapplicability	No flaws were reported	(-) Few snags related to some solutions identified from the industry were reported.
Internally generated evidence	* Research * Modelling * Physical mock-up * Testing through enabling work * POE of client own other facilities	* To evaluate products and solutions * To evaluate options * To aid detail design (using in-house standards)	* Members of the design team * Clinicians of the existing hospital * Facility management team of existing hospital (e.g. – infection control team)	(+) Internal research was considerably used (+) Had a dedicated redevelopment team and funding allocation for EBD	(-) These were purposely done for project specific problems	(-) Physical mock-ups : some of the weaknesses of the design were left due to testing conditions different from operational conditions (e.g. floor finishes of on-suit)	(-) Few snags were identified due to evidence from this source.
Knowledge and experience stakeholders	* In-house standards compiled from previous phase of the development * engage in designing and design evaluation activities	*Used during almost all types of activities of designing, but extensively to identify solutions, devise solutions and evaluate solutions	Members of the design team	(+) This was the second phase of the project – a good level of knowledge and experience was available	(+) In-house standards from recent and previous phase of same development (+) Private wing of the hospital has had few single bed patient rooms to learn from	No flaws were reported	No failures were reported due to evidence from this source.
User consultation	* User groups were formed to involve in design evaluation process (eg: single-room group; finishes group; art group) * A tool was developed to capture patient and family requirements (using existing patients and families at that time) * Comment on physical mock-up	* To evaluate the design * To identify user requirements, * To identify additional functions/ improvement opportunities * To analyse existing systems in use, * To identify current use of facility or parts of the facility, and * To collect data for new evidence generation	* Clinical staff, * Infection control team * Facilities management staff * Patients and families of existing hospital	(+) A considerably well user involvement was made (+) Building physical-mock up on the existing hospital site has positively impacted user consultation	(+) These were purposely done for the project	No flaws were reported	No failures were reported due to evidence from this source.
Expert opinion	* Direct consultation * invited presentations/guest lectures (eg DH presentation on Isolation room design) * Engage in designing and design evaluation	* To identify the design problem * To evaluate the design * To identify improvement opportunities	* Specialist staff within the hospital * Experts from DH	(+)In-house expertise was available within the existing hospital	No flaws were reported	No flaws were reported	No failures were reported due to evidence from this source.
Research – external	* Pebble project evidence * Roger Ulrich's evidence reviews * Research published by DH * Research published In peer reviewed journals and professional journals * Other	* To evaluate the design * To identify solutions * To guide design	* Clinical staff (peer reviewed journals) * Other members of the design team (other published research)	(+)Project team has had good access to this form of evidence – due to research culture of client and funding allocated for EBD	No flaws were reported	No flaws were reported	No failures were reported due to evidence from this source.
Standards and guidance	* DH standards and guidance * Industry standards and guidance	* To identify solutions * To improve innovative solutions * To evaluate solutions * To use as a starting point	Not Applicable	Yes	(-) Due to the project-unique circumstances, evidence from SGaTs was frequently used with improvements	(-) Was used in conjunction with other sources of evidence	No failures were reported due to evidence from this source.
Facility visits	* Visits to local hospitals and other places that are interest to children * Clinicians visits to American hospitals * International visits were video recorded to share with other members of the design team	* To identify up to date design solutions - To evaluate application of solutions learned from other evidence * To evaluate evidence * To identify children's preferences.	* International visits were done mainly by clinicians * Local visits (hospitals and other places) by other members of the design team	(+) Visits specific to this project (+) Clinicians invited by other hospitals around the world for clinical purposes	(-) Evidence adopted from facility visits was not suitable in some instances due to differences in operational conditions and care models of visited hospitals	(-) visits to PFI hospitals : operating regime of PFI hospitals are better than a non PFI hospital, therefore some of the characteristics of the finishes were not identified (eg: white wall finishes easily get dirty)	(-) Instances of minor failures in adapting evidence from other facilities were reported. These were mainly caused due to differences in contextual circumstance of different facilities.

Sources and flows of evidence model (Case study A)

Conceptual SaFE model SaFE A → Verified SaFE model SaFE B1-B4 → Validated SaFE model SaFE C1-C4 → **Case specific SaFE models SaFE D/E/F** → SaFE model with (RIBA plan of work 2013 overlay) SaFE G1 – G4

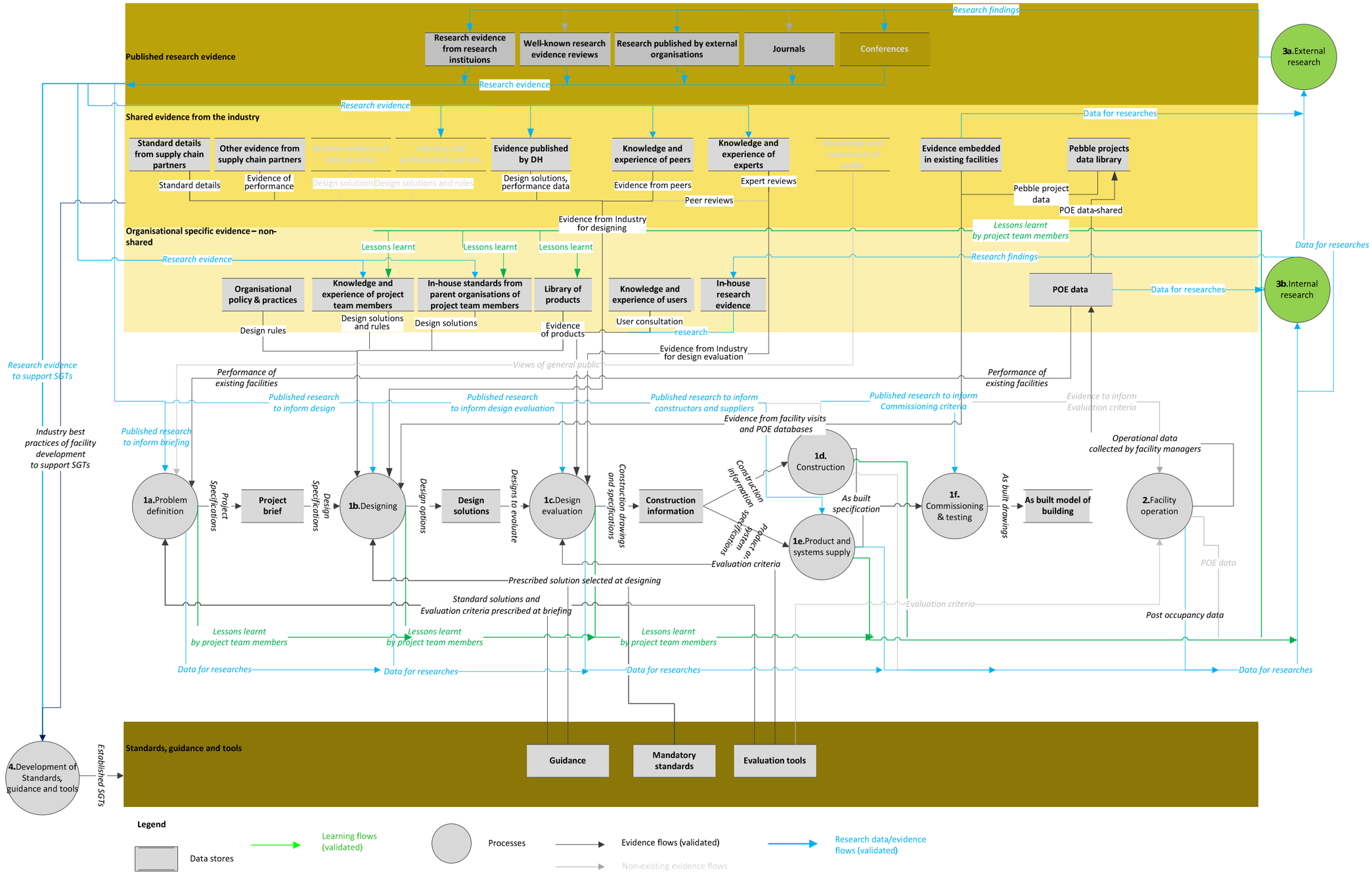


Figure 7-5 : The SaFE Model - Case study A

3. Invalidated evidence flows

The data collected was not adequate enough to validate evidence flows going into the phases of construction including products and systems supply and commissioning and testing. Due to the restricted time available for the research there was no opportunity to interview the constructor. Details of Post Occupancy Evaluation procedure were not accessible at the time of data collection.

4. Details of evidence flowing into the sub-processes could be identified.

For instance, several sub-processes for the main process of designing were identified. They are adopting a solution, adapting a solution, rejecting a solution, devising a solution, constructing a solution, detailed design and improving the solution. However, at this stage in the modelling process evidence flows into the sub-processes were not included.

7.4 IMPACT OF PROJECT-UNIQUE CIRCUMSTANCES ON THE EBD PROCESS

This section provides a detailed account of how the evidence-based design process of Case study A was influenced by project-unique circumstances and how design team reflected on these circumstances.

Interview contents were analysed based on the principles of inductive thematic analysis (Section 2.4.2.1) to identify the project's unique circumstances impacted on the EBD process. This analysis revealed eight circumstances unique to Case A that have impacted Case A's EBD process and how design team reflected on these circumstances.

1. Nature of the hospital and its care model
2. Patients' characteristics
3. Local departmental needs
4. Funding
5. Shape of the site
6. Operating conditions different to testing conditions
7. Culture of users
8. International evidence coming from different contexts
9. Other

Impact of these circumstances on the EBD practices of Case study A is further discussed and presented as narrative stories in the Appendix J.

7.5 USE OF PERFORMANCE AND PRESCRIPTIVE SPECIFICATIONS

Data revealed that evidence expressed in the form of performance and prescriptive specifications are used during problem definition, designing and design evaluation. Further details of the analysis are presented in Chapter 6.4.3. Distinct approaches for design evaluation could not be identified at element level. Designers used almost all sources of evidence to evaluate the design throughout the designing.

7.5.1 Prescriptive and performance specifications for problem definition

Pre-design activities conducted by the project team were considered as activities of problem defining. The project team in Case A involved in the following activities for defining design problem.

- analyse existing system;
- identify and process strategic requirements;
- identify project specific requirements; and
- specify performance and prescriptive specifications to guide consequent designing.

Examining Table 7.1 it is evident that approximately 17% (33 out of total of 191) of the project team's activities are related to problem definition. Identifying project specific requirements is the most frequent (50% of activities concerned in this phase) activity within this phase. Evidence from internally identifiable sources (information from client, knowledge and experience of stakeholders, user consultation and internally generated evidence) was used significantly (approximately 78% of instances). Evidence from the industry, externally published research, SGaTs and from facility visits were marginally used during problem definition activities.

Evidence for analysis of existing systems was gathered mainly by user consultation carried out by the client, and the client's knowledge and experience (example, existing bed-head service panels, availability of control of comfort for patients). These were then passed on to the other members of the design team. Involvement by other members of the design team in this activity was limited. Project specific requirements were used mainly to identify space requirements, user requirements and other requirements to support operation of the facility. Involvement by members from the Client, the Architect and the Engineer was apparent during this activity. Performance specifications were set based on evidence from published research and knowledge and experience of the Client, whilst, prescriptive specifications were set based on evidence from knowledge and experience, evidence from the industry, published research, SGaTs and visits to other facilities.

In summary, the results from Case A show that problem definition activities were mainly used to identify details of the design problem and design requirements. These activities were then used to specify design requirements expected within the subsequent design. These design requirements were primarily related to design output. In 24% of the instances (8 out of 33) prescriptive solutions were specified as a result of problem definition activities.

Another important finding was that health outcome related evidence was considered during problem definition activities. For instance, improved end user satisfaction by providing overnight accommodation for family, problems of having different types of bed-head service panels in different locations of the hospital and trust, importance of giving end users some control of their environment, reducing infection control, improving security, reducing nurses' walking distances and errors in reporting and improving patient observation were some of the health outcome related consideration made during problem definition activities.

Table 7.3 shows a summary of how problem definition approaches were used within Case A.

Table 7-3: Approaches to problem definition and approaches to designing for Case A

Base for problem definition		Approach to design								
		DS	DS ©	GS+DS	GS	GS+SS> DS	SS>DS	SS	SS+	SS+DS
GP	-									
DP	14	4	2				2	4	1	1
-	10	2				1		4	3	
GP+DP	2			1	1					
->DP	1	1								

Key :
GP – *Problem definition based on guided specifications,* **DP**- *Problem definition based on devised specifications*, '**-**' - *No pre-determined approach to problem definition*, '**-**' - *No pre-determined approach to problem definition*,
DS – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Adopt or adapt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach

Examining the results in Table 7.3, it is evident that in the majority of instances, designers devised specifications (DP) to define design problems. In a considerable number of instances no pre-determined approach to problem definition was made (-). Surprisingly, designers marginally used SGaTs alone or in combination with other sources of evidence during problem definition. Furthermore, any association between the approach to problem definition and the approach to designing is not obvious at this juncture.

7.5.2 Prescriptive and performance specifications for designing

Nine variant approaches for designing could be identified within Case A. Table 7.4 shows a summary of approaches to designing used within Case study A. Further details related to this deductive analysis are discussed in Chapter 6.

Table 7-4 : Design approaches used during the design of Case A

		Design elements in the pre and conceptual design phase						Design elements in the detail and technical design phase				
		Space/layout	Composition	Location	Shape and size	Provision	Option appraisal	E/services	Facilities	Finishes	Components	
DS	DS	4	1	1				1				7
	DS ©				1						1	2
	GS+SS>DS		1									1
	SS>DS										2	2
GS	GS	1										1
SS	SS					1			1	4	2	8
	SS+						1	1			2	4
A combination	GS+DS	1										1
	SS+DS	1										1

Notes : DS – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Adopt or adapt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach

According to the results in Table 7.4 the design elements that fall into the conceptual design phase are based on the approach of 'devising a solution' while the design elements of the detail/technical design phase primarily based on the 'selecting a solution' approach (SS and its variants). In approximately half of the elements (13 out of 27) designers used prescriptive solutions selected from the de facto standards or from the industry (SS and variants - 99%) and from SGaTs (GS and variants – 1%).

Instances of rejecting prescribed solutions identified within de facto standards (SS > DS) and instances of modifying prescribed solutions identified within de facto standards (SS +) could be identified. These imply that the design team has made a comprehensive effort during the adaption/adoption of prescribed solutions gleaned through de facto standards.

Solutions were originated mostly from industry and few from in-house (partner organisations of project) and SGaTs. The reason for seeking solutions from industry so frequently could be that the design team wanted to use the best solutions that industry could provide. This reflected by

the approach they adopted in selecting finishes. Both the Client and the Design organisation have experience of procuring building materials and yet they still conducted a comprehensive evaluation of all the finishes available on the market. The reason for the limited use of prescribed solutions contained in the SGaTs (GS) could be the specific nature of hospital buildings and specific nature of patient services required.

For the elements of the pre and conceptual design phase, SGaTs were used as a starting point. Prescriptive solutions identified from SGaTs were then modified and developed further to suit specific project requirements. The rationale behind these prescriptive solutions were elicited and preserved as design rules to support these modifications. It is also worth noting that the majority of the solutions identified externally for pre and conceptual design phases were eventually resulted in bespoke solutions, after modification. Surprisingly, the solution identified with SGaTs (GS) for technical design and detail design was followed with no or minor modifications. The design of the isolation room was primarily based on SGaTs.

For more than half of the elements (14 out of 26) designers have devised solutions (DS). Only, in a few of these instances, the solutions were partly identified from the prescriptive solutions contained in SGaTs and in some instances solutions were devised when initially selected solutions failed (SS > DS). Examining the results in Table 7.4, it is apparent that this approach was mainly (10 out of 14) used for the elements in conceptual design phase, specifically for space/layout, shape and size, location and composition. Only in two instances this approach was used to devise solutions in the detail design phase when initially selected solutions were failed (SS > DS). Even though this approach is not primarily used for elements in the detail and technical design phases, design of *the water service strategy* was devised based on internal research, K&E and evidence from other sources. Initiated within the client's research, the design team in Case A, has devised a bespoke strategy for water service to reduce legionella growth and for energy savings.

7.6 CHAPTER SUMMARY

This Chapter reported and discussed EBD practices in Case study A related to three main aspects:

- details of using evidence from nine sources during the process of designing;
- details of using performance and prescriptive specifications during problem definition and designing ; and
- impact of project-unique circumstances on EBD practices and how designers reflect on these circumstances.

K&E was the most frequently used source of evidence in Case A, and evidence from K&E was used during almost all of the 15 design activities identified in this research. The second most used source of evidence was internally generated evidence followed by the evidence acquired from the industry. It was also observed that internally generated evidence was frequently used alone whereas evidence from the industry and SGaTs was supported by evidence from other sources during use. This may imply applicability of evidence in project-unique circumstances. Results suggested that evidence sources may have a particular way of supporting during the design process. K&E was used during almost all design activities. Internally generated evidence and evidence from user consultation were mainly used for design evaluation activities. Information from the client, evidence from visits to other facilities and evidence from the industry were mainly used to identify design solutions and activities associated with early stages of designing. Evidence from SGaTs was less frequently used but they were used in both the early stages of designing as well as design evaluation activities. Other dimensions of evidence related to means of gathering, user channels for accessing, purposes of using, availability, suitability, quality and success of using that evidence were also identified to make sure this case study design provides a rich picture of Case A. This analysis supplemented the above results by providing further details of particular ways of using evidence sources and their applicability to the project's unique circumstances. A bespoke version of the SaFE model was generated for Case A. Some of the evidence sources identified within the generic model were not used in Case A, whilst case study data were useful in identifying specific details behind the evidence use practices. Furthermore, details of evidence flowing into sub-processes of designing which were not included in the original model could be identified.

Practices of using performance and prescriptive specifications were identified for problem definition and designing. For more than half of the elements (51%) the design team have devised specifications to define the problems. These activities were primarily based on evidence that could be sourced internally (K&E, user consultation, internally generated evidence). Within a considerable number of elements (37%) there was no pre-determined approach for problem definition. During the problem definition, both output specifications of the subsequent design as well as service outcomes that need to be achieved through the design, were considered. However, in later cases, the outcomes that needed to be achieved through the design were transformed into possible design interventions. Specifications from SGaTs were not much used during the problem definition in Case A.

A balance of using prescriptive solutions and devising solutions could be identified for designing Case A. The former approach was more prominent during the elements designed in pre and conceptual design phases, whilst the later approach was more prominent during the designing of elements in the details and technical design phases. Prescriptive solutions contained in SGaTs were marginally used, and for some instances they were used in combination with other approaches. From the results, it is apparent that evidence in SGaTs is more often used for identifying performance specification as opposed to identifying prescriptive solutions.

Practices of evidence use were reflected by the project's unique circumstances associated with Case A. Case A was special because of the type of the patient served within the hospital and the demographics of the patients. Case A was in a beneficial position related to funding and a specific allowance for EBD activities were included in the Case A's budget, which has given designers of Case A, opportunities to access and use research-based evidence. Other circumstances related to the shape of the site, less applicability to international evidence, culture of users, inability of simulating precise operating conditions during the testing phase have impacted EBD practices and the success of the resultant design.

CHAPTER 8. CASE STUDY B

8.1 INTRODUCTION

This Chapter reports and discuss evidence-based design practices of Case study B.

A brief description of the case is provided at the beginning. The middle sections are structured to report and discuss the results from Case study B from three perspectives:

- Firstly, the data revealed in Case study B was analysed to identify the sources of evidence used during Case B, the frequency and timing of use and other selected dimensions of using evidence from different sources. Based on these results a bespoke version of the model of Evidence-based design was generated for Case study B and is presented in this section along with an explanation of the changes made to the generic model.
- Secondly, the Chapter reports and discusses how performance specifications and prescriptive specifications were used during the problem definition phase and designing phase in Case study B.
- Finally, the impact of the project's unique circumstances on the Evidence-based design process and how designers reflected on these circumstances are reported and discussed.

The Chapter is then concluded by giving a summary account of the Evidence-based design practices for the Case study B.

8.2 DESCRIPTION OF THE CASE STUDY B

Case study B is a newly built hospital in Wales. It is a 'pathfinder' project which was delivered through the 'Designed for Life: Building for Wales' scheme. The project was funded by the Government and the hospital was built to support a new health service strategy. The previous strategy of the health board was to provide care in several district hospitals where both critical and non-critical care was provided under one roof. When the existing building stock became too old and began to incur considerable maintenance costs, the Health Board decided to invest money in new facilities. Having decided to replace a number of old buildings they have also used this opportunity to change the care model of the Health Board. Based on a new strategy, the Health Board procured three new non-critical care hospitals and one specialist and critical care hospital to replace several existing district hospitals. The hospital selected for Case B (see Figure 8.1) is one of three non-critical care hospitals provides care for mental health patients and elderly patients. The hospital is a 100% single-bed room hospital and the scope of the project includes 96 beds, an integrated mental health unit, a 15 room out-patient department, x-ray department, urgent care centre, therapies unit and birthing centre. The project cost was £60 million and work began in July 2008 and opened for operation in December 2010.

Figure 8-1: A graphical and actual view of Case study B

8.3 RESULTS – EVIDENCE USE IN CASE STUDY B

8.3.1 Frequency and timing of evidence use

Figure 8.2, shows the frequency of using evidence from the nine sources and the constrained use of evidence within Case study B. The frequency of using a particular evidence source alone and the frequency of using the source in combination with other sources were identified separately.

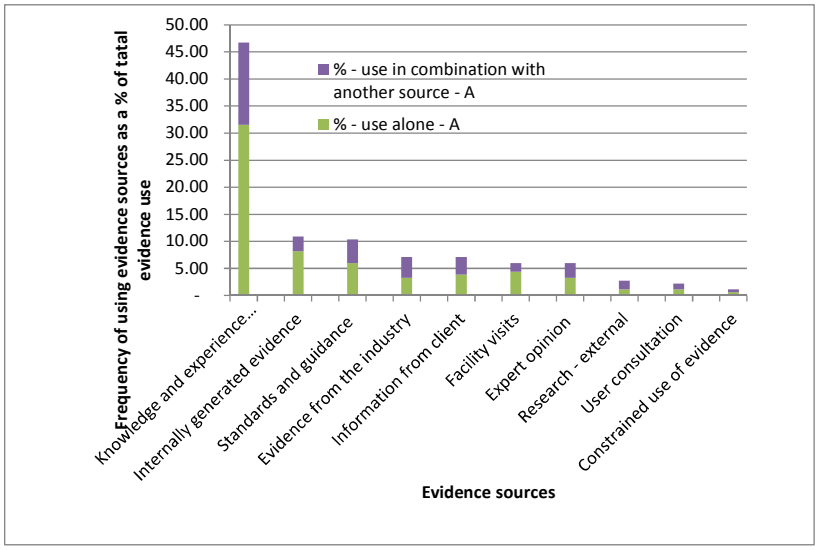


Figure 8-2: Frequency of use for different evidence sources for Case study B

The most and least used sources of evidence for Case B are K&E and user consultation respectively. For a better visual illustration of the details for other sources of evidence, the same data were re-plotted without K&E (See Figure 8.3).

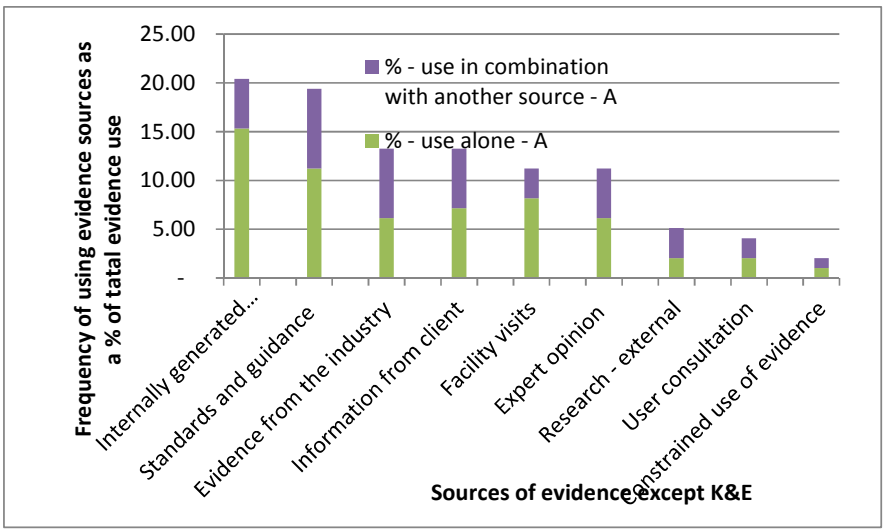


Figure 8-3: Frequency of use for different evidence sources without K&E

Examining Figure 8.3, it is obvious that evidence from six sources was fairly used in Case B and evidence from externally published research and user consultation were used less frequently. It can also be observed that internally generated evidence alone was used during designing whilst, evidence from all other sources were used extensively in combination with other sources.

Table 8.1 illustrates the timing of evidence use for Case B. Evidence use is highest during design evaluation. Almost all the sources of evidence are used during design evaluation with knowledge and experience being the highest and internal research second highest. Instances of using externally published research during design evaluation are not reported within the considered scoped of this case study. A fair use of evidence was noticeable for the activities of identifying solutions, evaluating evidence and devising solutions. It is worth repeating here that design evaluation was an iterative activity throughout the design process. For the purpose of easy illustration, the total instances of using evidence for design evaluation were combined into one column of Table 8.1. An individual account of the different evidence sources' use in Case B is discussed next.

Table 8-1: Timing of evidence use for Case Study B

	Pre-design phase (Problem definition)			Design phase (Designing and design evaluation)										Total
	Analyse existing system	Identify project specific requirements	Specify performance specification	Identify possible ado(a)ption	Evaluate evidence	Adopt a solution	Adapt a solution	Reject the solution	Devise a solution	Construct a solution	Detail design	Improve the solution	Design evaluation	
Information from client	-	3	3	2	-	-	-	-	-	-	-	-	5	**13**
Constrained use of evidence	-	-	-	-	-	-	-	-	1	-	-	-	1	**2**
Evidence from the industry	-	-	-	6	3	-	-	-	-	-	-	-	4	**13**
Research – internal	-	-	-	-	2	-	-	-	1	-	-	-	17	**20**
Knowledge and experience stakeholders	-	3	4	12	4	-	1	1	10	-	3	10	38	**86**
User consultation	1	-	-	-	-	-	-	-	-	-	1	-	2	**4**
Expert opinion	-	-	-	-	1	-	-	-	-	-	1	-	9	**11**
Research – external	-	-	-	1	2	-	-	-	1	-	-	1	-	**5**
Standards and guidance	-	4	2	6	-	-	-	-	2	-	1	-	4	**19**
Facility visits	-	-	-	2	8	-	-	-	-	-	-	-	1	**11**
Total count	**1**	**10**	**9**	**29**	**20**	**-**	**1**	**1**	**15**	**-**	**6**	**11**	**81**	**184**

8.3.2 Other dimensions of evidence

In addition to the frequency and timing of evident use the data revealed information related to other dimensions of using nine evidence sources (see Table 8.2 below). Details behind the practices of using evidence from the different sources are further discussed and presented as narrative stories in the Appendix J.

8.3.3 Reflections on the model

A bespoke version of the SaFE model for Case B was produced using the Case study data (Figure 8.4) based on the methodology explained in the Chapter 6. The following discussion compares and contrasts the bespoke model of EBD for case B with the original generic SaFE model.

From this bespoke SaFE model it is evident that some of the data sources in the generic model were not used for Case B. Data did not reveal any instances where the design team have used in-house standards from their parent organisations. Using POE data from previous projects, from any shared database or any instances of using written industry best practices was not evident. This could be attributable to two reasons. Firstly, the client organisation had no experience of procuring buildings of a similar nature, and secondly, since the hospital design is heavily innovative in terms having 100% single bedrooms, standard details for generic hospital may be less relevant. The design team have collaborated with WHE research on single-patient room, but any collaboration with any other research institution could not be found within the available data. Similarly, details of accessing evidence published in academic journals were not evident; the reason for this could be that the design team had adequate access to related research evidence through WHE research projects. However, failing to refer to evidence related to facility design for dementia and mental health patients was identified. There are discussed in the previous section of this Chapter.

As apparent in this model, the design team relied heavily on evidence from experts in several aspects of the design. Specifically, they have consulted community The Health Council, National Patient Safety Agency (NPSA), Design Council and Environmental Authority to gather evidence to design and evaluate the design.

Table 8-2: Uses of nine sources of evidence during the designing of Case study B

	Means of gathering evidence	Purposes of evidence	User channel of evidence	Availability of evidence	Suitability/Relevance of evidence	Quality of evidence	Success of application
Information from client	* Client's brief * Hospital operational policy documents * Schedule of accommodation * Board papers	* To identify project requirements * To evaluate solutions	* Client	Evidence from this source was available and no flaws were reported	No flaws were reported	No flaws were reported	No failures were reported due to evidence from this source.
Evidence from the industry	* Discussions with peers and colleagues of parent organisations	* To identify solutions * To evaluate evidence identified through other sources * To evaluate the design	* Clinicians * Health board * Other members of the design team	Evidence from this source was available and no flaws were reported	No flaws were reported	No flaws were reported	(-) Some of the solutions adopted were failed due to lack of evaluation before use
Internally generated evidence	* Research undertaken by Welsh Health Estates (WHE) * Clinical staff engage in research * physical mock-up * Performance modelling for * Engagement with research institutions	* To evaluate solutions	* WHE * Members of the design team and their parent organisations * Clinical staff	(+) Since this was the first single-bed patient room hospital in the Wales, the project team has involved in the parallel research activities conducted by WHE	(+) Physical mock-up : the evaluation of physical mock-up was structured, based on an initially identified set of performance criteria	(-)Physical-mock-up was built up in a non-hospital site, free transportation was provided for visits (-) Phase II mock-up for detail design was not evaluated by the comments of project team only	No failures were reported due to evidence from this source.
Knowledge and experience stakeholders	* Engagement in designing and design evaluation	Used during almost all types of activities of designing, but extensively to identify solutions, devise solutions and evaluate solutions and evidence	*WHE * Members of the design team and their parent organisations	(-)knowledge and experience from the clinical and other hospital staff was not available	(-) This was the first new-built single bed room hospital. (+) Architect was previously engaged in converted single bed room hospital projects	No flaws were reported	No failures were reported due to evidence from this source.
User consultation	* Phase I mock-up evaluation for the single room design	* To evaluate single room design * To evaluate existing system in use * To evaluate external evidence	* General public * Representative staffs from other hospitals within the health board	(-) User consultation was limited to evaluation of phase I of the physical mock-up of the single rom design. (-) By the time of design development hospital staff was not fixed.	(-) Any consultation of facility management staff was not revealed	(-) User consultation was conducted to evaluate Phase I mock-up of single room design only. (+) User consultation was conducted based on a structured evaluation method	No failures were reported due to evidence from this source.
Expert opinion	* Inviting expert organisations to evaluate design * Presenting the design at conferences	* To collect evidence * To evaluate solutions * To devise optional solutions * To guide detail design	* Community health council * National Patient Safety Agency * Environmental authorities * Experts from the conferences	(+) A significant consultation of experts for the design process could be identified (-) Opinion from clinical specialists was not sought	(-) No in-house clinical specialists were available since a new hospital	(-) the previous structure of care provision of health board was different to new proposed hospital which means to be specialised in non-critical elderly care and mental health. (-) Experts for these two types were not consulted externally	(-) Specific design features related to dementia was missed out of design (-) Window design was later modified to suit specific requirements of the mental health unit
Research - external	* Access to medical journals by clinical staff * Professor Roger Ulrich's visit funded by WHE * Healthcare related conferences * Research reports by DH and WHE	* To guide designing * To gather evidence	* WHE * Clinical staff * Members of the design team	(+) A good access to research was available due to the reason that this was the first single-bed patient room hospital in the Wales and WHE has conducted parallel research work/literature reviews	(+) These researches were project specific	(-) Published research related to design for dementia was missed out.	(-) Specific design features related to dementia was missed out of design
Standards and guidance	* Standards and guidance from DH * Standards and guidance from WHE	* To identify design requirements * To set performance and prescriptive specifications * To identify solutions, * To guide designing * To detail the design * To evaluate design * To use as a starting point to design.	DH WHE	Yes	(-) Some solutions identified within SGaTs were rejected either due to weaknesses of the solutions or due to their unsuitability for project-unique requirements.	(-) half of the instances, SGTs were used with combination of other evidence sources	No failures were reported due to evidence from this source.
Facility visits	* Physical visits * Internet searches for best practice hospitals	* To evaluate evidence obtained through other sources * To collect evidence * To identify solutions	* Client's representatives * Other members of the design team	(-) Visits to international facilities were limited due to funding constraints	(-) most of the single-bed patient rooms visited were multi-bed wards adapted to single rooms - this has made application of evidence difficult	(-) Critical applications was necessary	No failures were reported due to evidence from this source.

Sources and flows of evidence model (Case study B)

Conceptual SaFE model SaFE A → Verified SaFE model SaFE B1-B4 → Validated SaFE model SaFE C1-C4 → **Case specific SaFE models SaFE D/E/F** → SaFE model with (RIBA plan of work 2013 overlay) SaFE G1 – G4

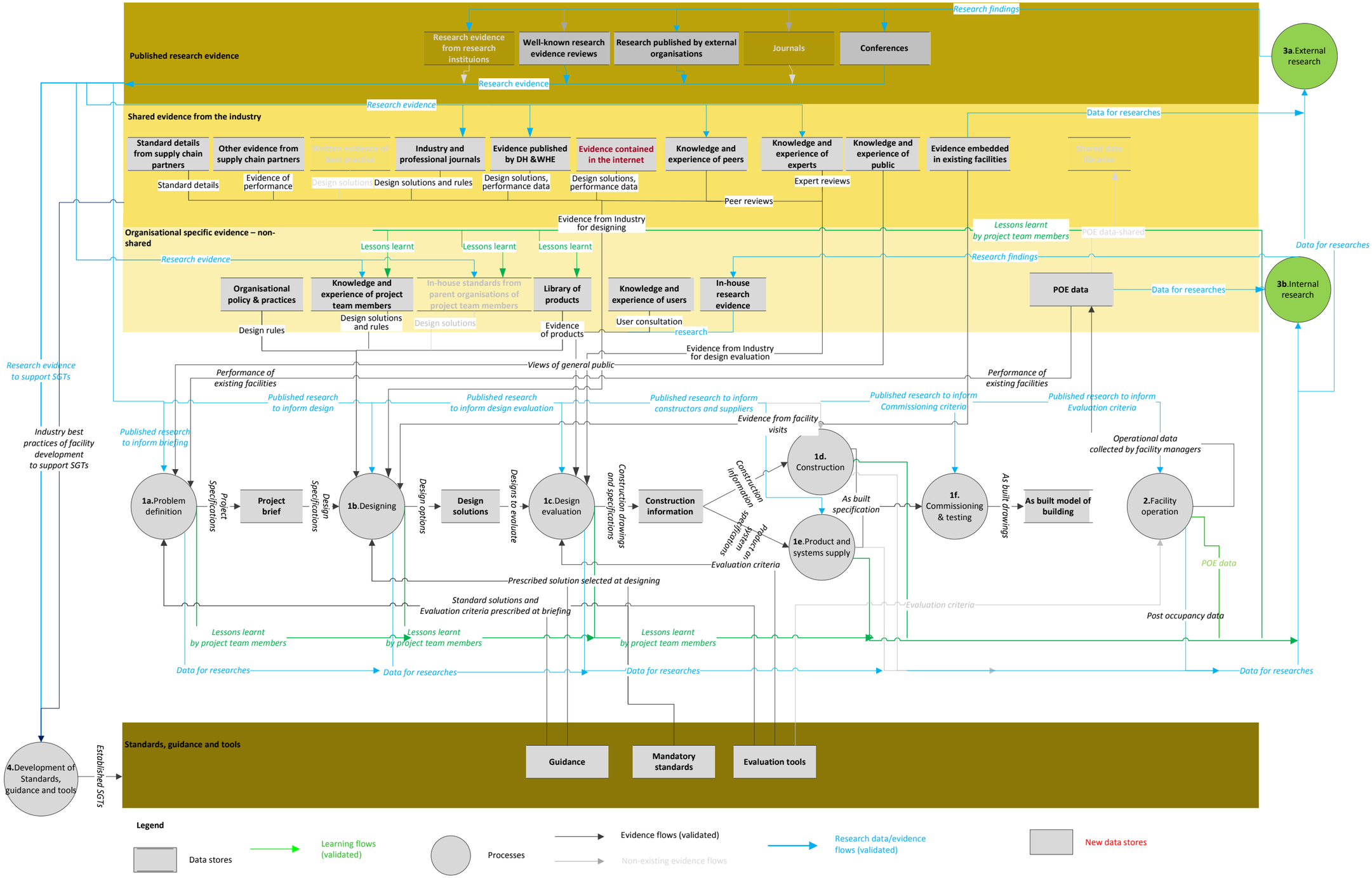


Figure 8-4: The SaFE model - Case study B

There are few evidence flows which could not be validated. Collected data was not adequate enough to validate evidence flows into the phases of construction including products and systems supply and commissioning and testing. Due to the restricted time available for the research, there was no opportunity to interview the Constructor. Details of Post Occupancy Evaluation procedure were not accessible at the time of data collection.

During the case study, details of evidence flowing into the sub-processes could be identified. For instance, several sub-processes within the main process of designing were identified. They are; adopting a solution, adapting a solution, rejecting a solution, devising a solution, constructing a solution, detail design and improving the solution. These details are described in Table 8.1. However, at this level of the model, the flow of evidence into sub-processes was not included.

8.4 IMPACT OF PROJECT-UNIQUE CIRCUMSTANCES ON THE EBD PROCESS

This section provides a detailed account of how the evidence-based design process of Case study B was influenced by project-unique circumstances and how designers reflect on these circumstances. The interview content of Case B was analysed based on the principles of inductive thematic analysis (refer Chapter 2) to identify project-unique circumstances impacted on the EBD process. This analysis revealed ten circumstances unique to Case B that has impacted Case B's EBD process.

1. Funding
2. Being the first project of its nature and non-availability of similar projects
3. Local departmental needs
4. Being part of a pilot project
5. Age group of patients
6. Culture of staff and other users
7. Issues while integrating with other technical systems
8. Operational conditions different from testing conditions
9. International evidence comes from different contexts
10. Other

Impact of these circumstances on the EBD practices of Case study B is further discussed and presented as narrative stories in the Appendix J.

8.5 USE OF PERFORMANCE AND PRESCRIPTIVE SPECIFICATIONS

The data revealed that evidence expressed in the forms of performance specifications and prescriptive specifications are used during problem definition, designing and design evaluation. Further details of the analysis are presented in Chapter 6.4.3. Distinct approaches for design evaluation could not be identified at element level. Designers used almost all sources of evidence to evaluate the design throughout the designing.

8.5.1 Prescriptive and performance specifications for problem definition

Pre-design activities conducted by the project team were considered to be activities of problem definition (refer to Table 8.1). Examining Table 8.1 it is evident that approximately 11% (20 out of total of 184) of the project team's activities are related to problem definition.

Two main focuses were prominent during problem defining activities in Case B. Firstly, a considerable effort was made to identify the operational outcomes that needed to be achieved through subsequent design changes. Reducing infection control and improving patient satisfaction were the two main operational outcomes expected from the design. Secondly, health outcomes that could be achieved through building elements were considered during problem definition activities.

Table 8.3 shows a summary of how problem definition approaches were used within Case study B.

Table 8-3: Approaches of performance setting and approaches of designing - Case study B

Base for problem definition	Total	Approach to designing						
		DS	GS+	GS>DS	SS	SS+	GS+SS	SS+GS^{+}
GP	6				3	2		1
DP	6	1	1		4			
-	11		1	2	6	1	1	
->DP	1			1				
->DP+GP	1			1				

Key :
GP – *Problem definition based on guided specifications,* **DP**- *Problem definition based on devised specifications*, '**-**' - *No pre-determined approach to problem definition*, '**-**' - *No pre-determined approach to problem definition*, **DS** – *Devise a solution*, **GS** – *Ad(o)apt a guided solution*, **SS** – *Ad(o)apt a selected de facto or innovative solution*, '$^{+}$' - *Significant moderations made*, **>** - *transition of approach*

Results from Table 8.3 reveal that in majority of instances, no pre-determined approach to problem definition (-) was made. Defining problems based on performance criterion gathered from SGaTs (GP) and defining problems based on devised performance criterions (DP) were used

in a similar number of instances. Similarly to Case A, any association between the approach to problem definition and the approach to designing is not obvious at this juncture.

8.5.2 Prescriptive and performance specifications for designing

Seven variant approaches for designing could be identified within Case B. Table 8.4 shows a summary of the approaches to designing used within Case study B.

Table 8-4: Approach to designing for different types design elements

Approach to the solution		Design elements in the pre and conceptual design phase						Design elements in the detail and technical design phase				Total instances of approach
		Space/layout	Composition	Location	Shape and size	Provision	Option appraisal	E/services	Facilities	Finishes	Components	
DS	DS	1										1
	GS>DS	1	1		1						1	4
GS	GS+	2				1						3
SS	SS	1		1		2		1		4	4	13
	SS+										2	2
A combination	GS+SS						1					1
	SS+GS+							1				1
Notes : DS – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach												25

Devising solutions (DS) approach was less frequently used in Case B. The reasons for this limited use could be associated with: need to incorporate innovation emerged into the market, design process lead by the architect, design team's style of designing, and weaknesses of SGaTs. Kruger and Cross (2006), claimed that some designers because of their style of designing spend more time identifying solutions. This could be applicable to the above result though no evidence to confirm this claim could be found.

Designing based on prescriptive solutions (GS, SS) was the most prominent (80% of elements) approach within Case B. The majority of the prescriptive solutions (for 83% the elements) were identified based on de facto standards and from innovative solutions emerging onto the market. According to case study data (refer to Appendix J), it is evident that a considerable number of prescriptive solutions were identified from innovative solutions that emerged from industry. Guided solutions were considered for nine elements. Due to the various reasons (see Appendix J for further details) some of the guided solutions were significantly improved; resulting in bespoke solutions (GS^{+}). In Case B, prescriptive solutions were used fairly for all types of design

elements within pre and conceptual design phases and detail and technical design phases. Yet, prescriptive solutions adopted for the design elements in the pre and conceptual design phase have eventually resulted in bespoke designs after improvements; while solutions adopted during the detail design phase were subjected to limited or no improvements.

8.6 CHAPTER SUMMARY

This Chapter reported and discussed EBD practices of Case study B related to three main perspectives:

- practices of using nine sources of evidence during the process of designing;
- practices of using performance and prescriptive specifications during the process of designing ; and
- impact of project-unique circumstances on EBD practices and how practitioners reflected on these circumstances.

K&E was the most frequently used source of evidence in Case B and evidence from K&E was used during almost all 14 design activities identified within Case B. The second most used source of evidence was internally generated evidence followed by the evidence from SGaTs. It was also observed that internally generated evidence was frequently used alone whereas evidence gathered externally was extensively supported by evidence from other sources. This may imply applicability of evidence in project-unique circumstances as well as designers' opinion related (lack of) credibility of the evidence gathered externally. Results suggested that evidence sources may have particular ways of support during the design process. K&E and information from the Client was used during almost all types of design activities. Internally generated evidence and evidence from expert opinion were primarily used for design evaluation activities. Evidence from visits to facilities and evidence from the industry were mainly used to identify design solutions and activities associated with the early stages of designing. In Case B, evidence from SGaTs was used mainly in the early stages of designing to identify solutions and they were fairly often used during design evaluation activities. Other dimensions of evidence related to means of gathering, user channels of access, purposes for use, availability, suitability, quality and success of using that evidence were also identified. This analysis supplemented the above results by providing further details of particular ways of using evidence sources and their applicability in project-unique circumstances. A bespoke version of the SaFE model was generated for Case B. Some of the evidence sources identified within generic model were not used in Case B, whilst case study data were useful in identifying specific details behind the means of generating and disseminating

evidence from some sources. Furthermore, details of evidence flowing into sub-process of designing could be identified.

Practices of using performance and prescriptive specifications were identified for problem definition and designing. No pre-determined approach for problem definition was prominent for the majority of the elements (44%) in Case B. Defining design problems based on specifications contained in SGaTs and by devising specifications based on evidence from other sources were equally (24% each) used. During the problem definition, both the output specifications of the subsequent design as well as service outcomes that need to be achieved through the design were considered. Therapeutic aspects of the building were considered during problem definition activities.

The most prominent approach (for 80% of the elements) for designing in Case B was designing based on prescriptive solutions. For nearly half of these instances, prescriptive solutions gathered through SGaTs were considered. However, in four instances, due to project-unique requirements and weakness of the solutions gathered from SGaTs, these solutions were rejected and the design team eventually devised solutions. However, the rationale behind these prescriptive solutions was identified and applied during subsequent designing. Designing based on prescriptive solutions was equally used for elements in the pre and conceptual design phases and detail and technical design phases. During pre and conceptual design phases prescriptive solutions gathered mainly from SGaTs, whilst during detail and technical design phases prescriptive solutions gathered mainly from de facto standards and innovative solutions emerging from industry.

EBD practices of using evidence from nine sources and using evidence during problem definition and designing reflected project-unique circumstances that were associated with Case B. Case B was special due to the fact that it was new-build to support a new care model of the Health Board, hence there were no specific staffs allocated for the proposed hospital at the time of designing. Practices of evidence use reflected circumstances associated with: non-availability of some of the evidence sources and mitigatory measures taken by the project team. Furthermore, the hospital was designed to serve non critical care for elderly and mental health patients. These circumstances had an impact on the EBD practices of Case B. Not reflecting on these circumstance has left the design with a few failures that could have been avoided. Case B was in a beneficial position relating to access to external research since it was a pilot project of WHE to establish single-bed patient rooms in Wales. Therefore, Case B had access to research resources used by WHE for this initiative. Funds were identified as reasonable, but the timing of funding

has impacted the EBD process of Case B. Other circumstances related to the shape of the site, culture of users, inability to create precise operating conditions during the testing have impacted EBD practices and the success of the resultant design in Case B.

CHAPTER 9. CASE STUDY C

9.1 INTRODUCTION

This Chapter reports and discusses evidence-based design practices of Case study C.

A brief description of the case is provided at the beginning. The middle sections are structured to report and discuss the results of case studies from three perspectives:

- Firstly, data used in Case study C was analysed to identify sources of evidence used during Case C, the frequency and timing of evidence sources used and other selected dimensions of using evidence from different sources. Based on these results a bespoke version of the model for Evidence-based design was generated for Case study C and presented in this section and the changes made to the generic model that helped to develop the bespoke model, are discussed.
- Secondly, the Chapter reports and discusses how performance specifications and prescriptive specifications were used during problem definition and designing in Case study C.
- Finally, the impact of the project-unique circumstances on the Evidence-based design process and how designers reflect on these circumstances are reported and discussed.

The Chapter is then concluded by giving a summary account of Evidence-based design practices for Case study C.

9.2 DESCRIPTION OF THE CASE

Case study C is a modular building. The building was procured through fast track for time in order to cater for forecasted winter pressure. The duration of the project was six months from inception to completion. One of the main objectives of the project was to ensure that patients can be treated in newly constructed wards in six months. However, the focus on a better patient and staff environment was not rationalised. It was mentioned that:

> "*The quality of the patient spaces and staff working environment has been critical to the design – with generous ward accommodation and large windows to maximise natural daylight and ventilation." (Estates director)*

The building was procured as a modular construction to suit the tight schedule. The scope of the project is 3,000 m^2, comprising ground floor clinical and non-clinical general accommodation, with the first floor incorporating two 28-bed wards. The ward comprises shared four bed bays, single-bed patient rooms, store rooms, kitchens, reception area and waiting areas. The total project cost £10million. The project was started in July 2008 and completed in December 2008.

9.3 RESULTS – EVIDENCE USE IN CASE STUDY C

9.3.1 Frequency and timing of evidence use

Figure 9.1 shows the frequency of using evidence from six sources and the constrained use of evidence during the scope under consideration within Case study C. The frequency of using a particular evidence source alone and the frequency of using the source in combination with other sources were identified separately. Instances of constrained use of evidence were also reported. The use of evidence from six sources is calculated as a % of the total number of instances of evidence use (135) studied within Case B.

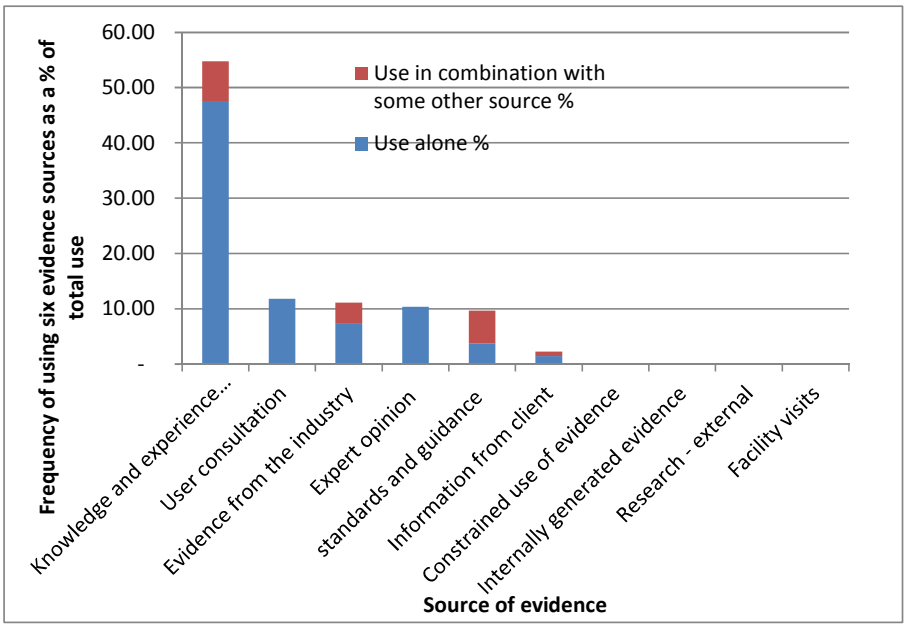


Figure 9-1: Frequency of use for different evidence sources for Case study C

Knowledge and experience was the most frequently used evidence source compared to other sources of evidence. For better visual illustration of details for other sources of evidence the same data were re-plotted without K&E (See Figure 9.2).

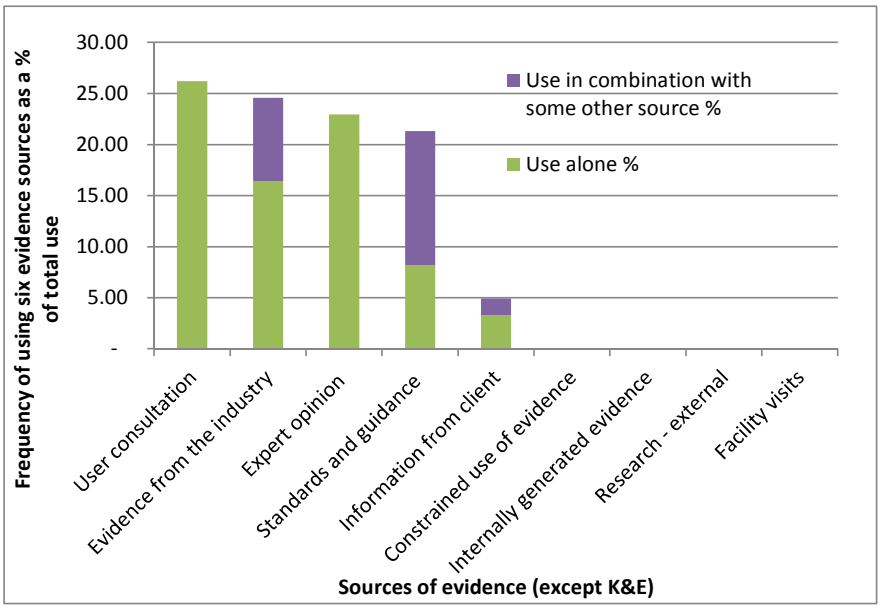


Figure 9-2: Frequency of use for different evidence sources without K&E for Case study C

According to the results in Table 9.1, evidence from user consultation, evidence from the industry, expert opinion, and standards and guidance were used almost equally. Data did not reveal any instances of using internally generated evidence, externally published research and evidence from facility visits. The Client for Case C had in-house standards and they were categorised under knowledge and experience in this analysis. It is also apparent that evidence

gathered internally (from user consultation and expert opinion) was used alone, whilst evidence gathered externally was supported by evidence from other sources.

Table 9.1 illustrates the timing of use of six source of evidence during the designing of Case study C.

Table 9-1: Timing of evidence use for Case Study C

	Pre-design phase (Problem				Design phase (Designing and design evaluation)										
	Analyse existing system	Identify project specific requirements	Specify performance specification	Specify prescriptive specification	Evaluate evidence	Identify possible ado(a)ption	Adopt the solution	Adapt a solution	Reject the solution	Devise a solution	Construct a solution	Detail design	Improve the solution	Design evaluation	**Total**
Information from client	-	2	-	-	-	-	-	-	-	1	-	-	-	-	3
Constrained use of evidence	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Evidence from the industry	-	-	-	-	-	8	3	-	-	-	-	-	1	3	15
Internally generated evidence	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Knowledge and experience	3	1	7	6	-	7	6	2	1	9	-	5	6	21	74
User consultation	-	-	-	-	-	-	-	-	-	-	-	-	3	13	16
Expert opinion	-	-	-	1	-	-	-	-	-	-	-	-	-	13	14
Research - external	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Standards and guidance	-	-	5	2	-	1	2	1	-	-	-	-	-	2	13
Facility visits	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3	3	12	9	-	16	11	3	1	10	-	5	10	52	**135**

9.3.2 Other dimensions of evidence

In addition to the frequency and timing of using six evidence sources, data revealed answers to 'how and why' questions in terms of following aspects. Table 9.2 summarises the findings of Case study C relating to the use of nine sources of evidence. Details behind the practices of using evidence from the different sources are further discussed and presented as narrative stories in the Appendix J.

Table 9-2: Uses of nine sources of evidence during the designing of Case study C

	Means of gathering evidence	Purposes of evidence	User Channel of evidence	Availability of evidence	Suitability/ Relevance of evidence	Quality of evidence	Success of application
Information from client	* Schedule of accommodation * Room data sheets	* To identify design requirements	Client and clinical staff	Evidence from this source was available	No flaws were reported	N/A	No failures were reported due to evidence from this source.
Evidence from the industry	* Involvement in designing * Visiting the pre-fabrication factories * Visiting facilities done by same modular builder	* To identify a suitable modular builder * To evaluate different products available with the selected modular builder and their supply chain partners. * To identify solutions * To evaluate solutions	Modular contractor and their supply chain partners	Evidence from this source was available	(+) Evidence from similar hospitals build by selected modular contractor was available.		(-) Shower tray used in the single rooms was well supported with the floor, and was damaged in use
Internally generated evidence	Instances of generating evidence specific to this project was not mentioned or identified through data. Yet evidence of therapeutic built environments (which generally originated within research) was considered during the design process.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Knowledge and experience stakeholders	* engage in concept development and design evaluation * Standard equipment and product list to be used as specifications	*To devise conceptual design * To devise project specifications *To evaluate solutions *To evaluate evidence acquired from the industry *To specify standards equipment	* In-house facility management team * Other members of the framework agreement	Yes	(+) The client has had previous experience on procurement of a modular building	(+) Client as the in-house facility management team was knowledgeable on operational phase of building as well	No failures were reported due to evidence from this source.
User consultation	* Design evaluation meetings	* To evaluate the design * To identify improvement to the design * To identify patient needs	* Clinical staff * Nursing staff	(+) This hospital was built on existing hospital site as a part of an expansion, the project was within the same site	No flaws were reported	(-) Any instance of consulting existing patients or general public could not be identified.	No failures were reported due to evidence from this source.
Expert opinion	* Design evaluation meetings	* To evaluate the design * To identify design requirements	* Elderly care specialist of the existing hospital	(+) Experts were available within existing hospital	(+) Hospital was designed for elderly care, elderly care specialists were available within existing hospital	No flaws were reported	No failures were reported due to evidence from this source.
Research - external	Instances of generating evidence specific to this project was not mentioned or identified through data. Yet evidence of therapeutic built environments (which generally originated within research) was considered during the design process.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Standards and guidance	* Standards and guidance from DH guidance	* To set performance and prescriptive specifications * To guide conceptual design	Not applicable	Yes	(+)Prescriptive solutions contained in the SGaTs were used as a starting points, and modifications were made	(-) Standards and guidance were used in combination with other sources of evidence	No failures were reported due to evidence from this source.
Facility visits	Not done due to time constraints – yet, previously completed buildings by the same modular builder ware known before	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

9.3.3 Reflections on the model

A bespoke version of the SaFE model for Case C was produced using the Case study data (Figure 9.3). The following discussion compares and contrasts the bespoke SaFE model for case C with the original generic SaFE model.

1. Some of the data sources in the generic model were not used for Case C.

Possibly, due to the time restrictions in Case C, the design team did not access external evidence sources frequently. The Data did not reveal any specific instances of gathering evidence from public knowledge and experience, written evidence of best practice, industry and professional journals, knowledge and experience of peers and shared data libraries.

Case C did not use internally generated evidence or externally published evidence. However, the Client had in-house standards and technical details that were compiled through previous experience which may have comprised some research-based evidence.

2. Invalidated evidence flows

The data collected was not adequate to validate the evidence flowing into the phases of construction including; products and systems supply and commissioning and testing. Due to the restrictions on the time available for the research, there was no opportunity to interview the modular builder.

3. Evidence accessed excessively from knowledge and experience and specialist consultation

Even though the project team had limited access to external evidence, due to time restrictions, they relied on a considerable amount of evidence gathered from the knowledge and experience and through consultation with internal specialist staff. According to the results of the POE, the project was considered to be a success except for few snags. Thus, it is apparent that the evidence collection had not been compromised by the lack of evidence from external sources. Furthermore, the Client had previous experience of procuring a modular building, for the same hospital. Therefore, the inability to demonstrate the strength of evidence flowing into the design process and not being able to relate the process to the output and outcome performance could be considered as a drawback in this graphical model.

Sources and flows of evidence model (Case study C)

Conceptual SaFE model SaFE A → Verified SaFE model SaFE B1-B4 → Validated SaFE model SaFE C1-C4 → **Case specific SaFE models SaFE D/E/F** → SaFE model with (RIBA plan of work 2013 overlay) SaFE G1 – G4

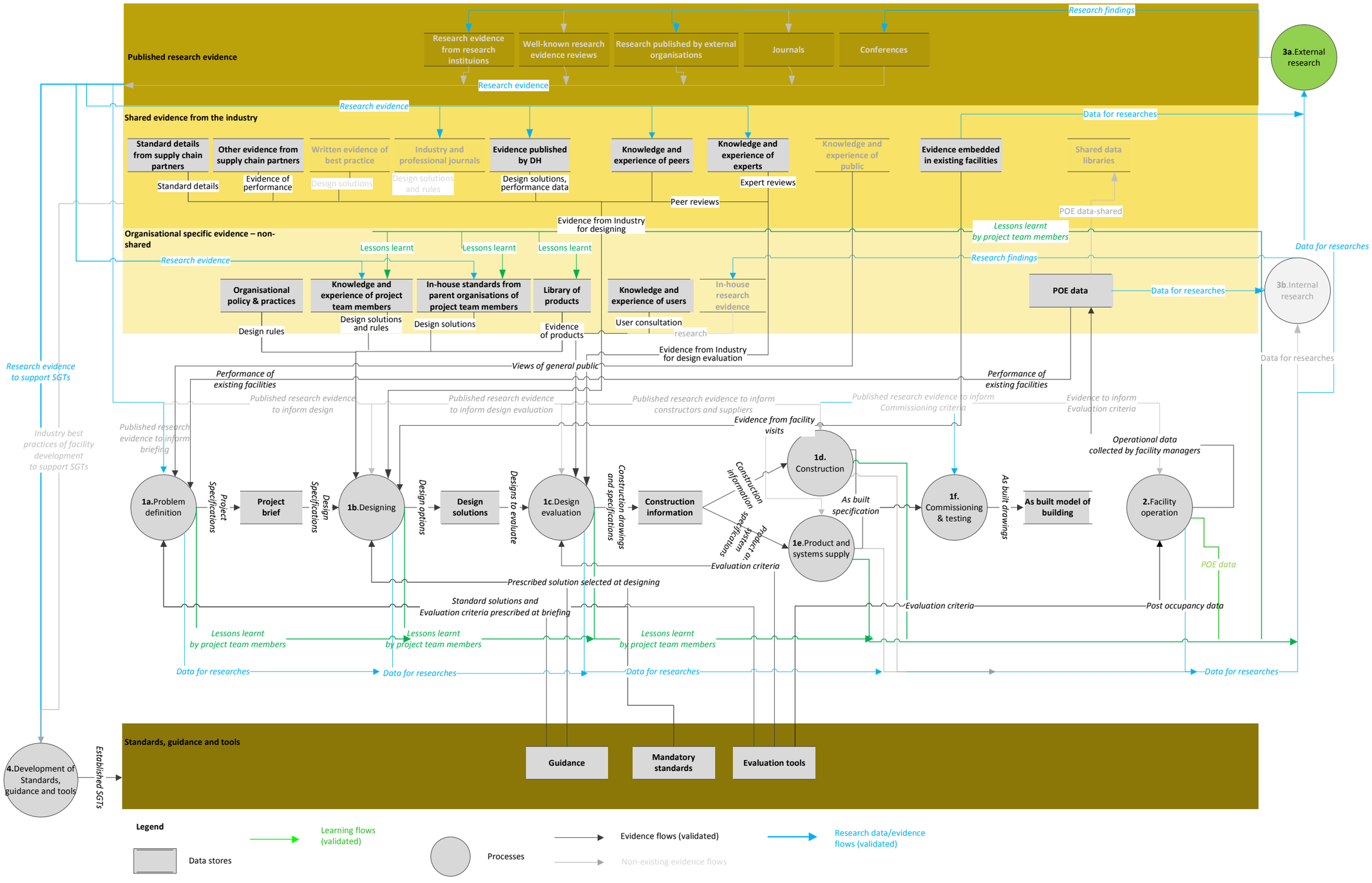


Figure 9-3: The SaFE model - Case study C

9.4 IMPACT OF PROJECT-UNIQUE CIRCUMSTANCES ON THE EBD PROCESS

This section provides a detailed account of how the evidence-based design process in Case study C was influenced by project specific project-unique circumstances and how designers reflected on these circumstances.

Interview contents from Case C were analysed based on the principles of inductive thematic analysis (refer Chapter 2) to identify how project-unique circumstances impacted on the EBD process. This analysis revealed six circumstances unique to Case C that have impacted Case C's EBD process.

1. Restrictions on bespoke designs due to modular systems
2. Local departmental needs
3. Incomplete previous knowledge
4. Previous experience
5. Enthusiasm and teamwork
6. Other

Impact of these circumstances on the EBD practices of Case study C is further discussed and presented as narrative stories in the Appendix J.

9.5 USE OF PERFORMANCE AND PRESCRIPTIVE SPECIFICATIONS

Data revealed that evidence expressed in the forms of performance specifications and prescriptive specifications are used during problem definition, designing and design evaluation.

9.5.1 Prescriptive and performance specifications for problem definition

Pre-design activities conducted by the project team were considered to be activities of problem defining (refer Table 9.1). According to the Table 9.1 approximately 20% (27 out of total of 135) of the project team's activities are related to problem definition. A considerably amount of effort was exerted for problem definition activities, irrespective of the limited time the project had from inception to completion. It was also observed that design requirements set during the problem definition phase were primarily focused on defining the output specifications of the design and the outcome of the health outcomes was a marginal concern.

Table 9.3 shows a summary of how problem definition approaches were used within Case study C.

Table 9-3: Approaches to performance setting and approaches to designing for Case C

Base for problem definition	Total	DS	SS	SS+	GS+SS	SS+DS+GS
DP	2		2			
GP+DP	5	1	3	1		
-	19	6	10	1	1	1
Key : GP – *Problem definition based on guided specifications,* **DP**- *Problem definition based on devised specifications*, '**-**' - *No pre-determined approach to problem definition*, '**-**' - *No pre-determined approach to problem definition*, **DS** – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach						

According to the results shown in Table 9.3, the most prominent approach (in 73% of the instances) to problem definition within Case C is, *No pre-determined approach to problem definition* (**-**). Defining the problem based on devised and guided specifications (GP+DP) were fairly used. Defining the problem based only on devised specifications (DP) was marginally used.

9.5.2 Prescriptive and performance specifications for designing

Five variant approaches to designing could be identified within Case C. Table 9.4 shows a summary of the approaches to designing used within the Case study C. Further details of the analysis are presented in Chapter 6.4.3. Distinct approaches for design evaluation could not be identified at element level. Designers used almost all sources of evidence to evaluate the design throughout the designing.

Table 9-4: Design approaches of different design element types

		Design elements in the pre and conceptual design phase						Design elements in the detail and technical design phase				
		Space/layout	Composition	Location	Shape and size	Provision	Option appraisal	E/services	Facilities	Finishes	Components	
DS	DS	4		1		1		1				7
SS	SS	1				3		2		3	6	15
	SS+		1		1							2
A combination	GS+SS									1		1
	SS+DS+GS	1										1
Key : **DS** – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach												26

Devise solutions (DS) approach was used marginally (27% of the elements) during the designing of Case C. Irrespective of the limited opportunity to devise bespoke solutions, devising a solution approach was triggered in following instances.

1. Analysis of the performance of existing solutions revealed drawbacks in existing solutions and new facets of problems.
2. New problems identified through user and specialist consultation during design evaluation.
3. For new and project specific design problems.

These results reveal that designing based on prescriptive solutions is the most prominent (for 73% of the elements) approach in Case C. According to the case study results (refer to Appendix J) a majority of these solutions originated from evidence from industry and in few instances de facto solutions were used based on in-house knowledge and experience. According to the data from the Client, most of these elements were successful during the operational phase and only few failures were identified.

9.6 CHAPTER SUMMARY

This Chapter has reported and discussed the EBD practices of Case study C related to three main aspects:

- practices of using evidence from six sources;
- practices of using performance and prescriptive specifications during the problem definition and designing ; and
- impact of project-unique circumstances on EBD practices and how designers reflected on these circumstances.

Case C gathered evidence from six sources. K&E was the most frequently (approximately in 55% instances) used source of evidence in Case C. The second most used source of evidence was evidence from user consultation, followed by the evidence from industry, expert opinion and SGaTs. Evidence from all these four sources were used almost equally (approximately 10% each). It was also observed that internal evidence sources (K&E, user consultation, expert opinion) were frequently used alone whereas evidence from industry and evidence from SGaTs were supported by evidence from other sources. Specific examples of using internally generated evidence or using externally published research could not be identified in Case C. Other dimensions of evidence related to the means by which evidence was gathered, user channels for accessing evidence, purposes for using, availability, suitability, quality and success of using that evidence were also identified and the findings provides a rich picture of evidence use practices

in Case C. A bespoke version of SaFE model was generated for Case C. Several of the evidence sources identified within the generic model were not used in Case C, access to evidence through internally available sources and through stakeholders of the design team were noticeable in the bespoke model of EBD for Case C.

Practices for using performance and prescriptive specifications were identified for problem definition and designing. No pre-determined approach for problem definition was seen for majority of the elements (73%). Problem definition was based on the specifications from SGaTs and devised specifications in approximately 20% of instances. Performance and prescriptive specifications identified during the problem definition phase primarily focused in defining output of the design and the health outcomes was seen as a marginal concern.

Using prescriptive solutions was the most prominent (69%) approach to designing in Case C. Devising solutions based were identified in only 7 elements out of 26 elements studied in Case C.

Designers devised solutions primarily for elements in the pre and conceptual design phases and they have adopted prescriptive solutions mainly for the elements in the technical and detail design phases, and fairly for elements in pre and conceptual design phases. Using prescriptive solutions from SGaTs was subtle in Case C and the majority of prescriptive solutions were identified based on evidence from K&E and other evidence sources.

EBD practices of gathering evidence from six sources and using evidence during problem definition and designing reflected project-unique circumstances that were associated with Case C. Case C was special for the type of construction and the project duration. Case C was procured as a modular building and the total duration from inception to completion was 6 months. Results revealed how EBD activities in Case C reflected on these two major circumstances throughout the process. Furthermore, the Client in Case C was the in-house facilities management team of the existing hospital and they had experience of procuring a modular building before, and the existing hospital had specialist consultants who engaged with the targeted patient group of Case C. These circumstances favourably impacted in the EBD process and mitigated many of the negative impacts associated with limited time duration. Any difficulty associated with the amount of funding was not reported, but the timing of the funding has impacted on EBD activities in Case C. In addition, enthusiasm and team work approach has contributed to the success of Case C.

CHAPTER 10. CROSS-CASE COMPARISON AND DISCUSSIONS (WITHIN THE CONTEXT OF SAFE MODEL AND EMERGENT FRAMEWORK FOR COMPOSITION OF PERFORMANCE AND PRESCRIPTIVE SPECIFICATIONS IN THE HEALTHCARE DESIGN GUIDANCE)

10.1 INTRODUCTION

This Chapter presents the results of the cross-case comparison and discussions of the research findings. The aim the chapter is to discuss the findings of the research in light of previous literature and to explore the implications of the results. The Chapter is structured in three sections based on the three research questions outlined in the Introduction (refer Section 1.4.2). Followed by this introduction section, the second and the third sections discuss how the concept of EBD is applied within the health care built environment sector in the UK, based on the SaFE model, the results from the model validation interviews and the findings from the case studies. More specifically, it presents sources of evidence used by the designers and discusses how the use of research-based evidence can be improved. The fourth section describes how performance and prescriptive specifications are used in problem definition and designing. Implications of these findings for articulating Standards, Guidance and Tools were then discussed. The fifth section discusses how the project-unique circumstances impact EBD processes and how designers reflect on these circumstances. The findings of this research were integrated in to a

decision support framework to guide SGaTs development to support EBD. The final section presents and discusses this framework.

10.2 THE SOURCES AND FLOWS OF EVIDENCE MODEL (SAFE MODEL)

As presented in Chapter 5, this research developed a model of EBD to represent how the concept of EBD is applied in the UK. Based on the SaFE model this section discusses the current practices of evidence use during healthcare built environment designing the UK.

The model identifies four types of evidence sources for design (EfD) (see Table 10-1) and the means of accessing this evidence.

Table 10-1 : Evidence gleaned through four types of sources

Type	Description	Sources of design inputs
Type A sources	Evidence captured by the project team non-shared (Organisational specific evidence)	Knowledge and experience Standard details libraries Operational data Internally developed design support tools
Type B sources	Type B sources. Evidence of best practices from the industry shared by other organisations (Shared evidence from the industry)	Shared data bases Operational data from existing facilities Expert opinion (peers and organisations) Standard details from constructors and suppliers Visits to existing facilities Industry and professional journals
Type C sources	Published research evidence	Research journals and conference Research published by external organisations and research accessed through collaborations with research institutions
Type D sources	Standards, guidance and tools (SGaTs)	SGaTs produced by various regulatory bodies

The SaFE model developed in this research (see Appendix D) is different to those of previous EBD models and EBD process literature (Hamilton, 2003; Hamilton and Watkins, 2009; Cama, 2009; Stichler, 2007; CHD, 2008) (refer section 3.5) for several reasons. Firstly, the model's key focus is evidence, which is one of the key elements which distinguish EBD from traditional designing. The term evidence is used by scholars and designers more casually and it was expected that clarifying the term would benefit EBD. This model fulfilled this requirement by distinguishing the sources and flows evidence for EBD from generic EfD. Secondly, previous models acknowledge the incorporation of research-based evidence as a key step to EBD; but they are less revealing about the ways in which these evidence are generated and flow into the design process. This model simplified and expanded the phenomenon of EBD in order to illustrate how the stages of the building life-cycle are connected during the generation of evidence to facilitate EBD in

several ways. This, combined with the graphical form and language, eases understanding and communication between researchers and designers. Data from model verification and Validation interviews confirmed this. Thirdly, previous EBD models barely focused on different methods used for gathering research evidence to support EBD. Previous scholars suggested that EBD is limited, based on the fact that designers' use of published research is limited. This model detailed how EBD is facilitated through indirect use of research evidence. Therefore, the model can be used to determine prospective routes to enhance research evidence use, which is useful for researchers, those involved in design development and policy makers. Researchers could identify research opportunities to improve the practice of EBD, whilst policy makers could use it to identify the implications of new policies on the EBD process. For instance, according to the model, discontinuation of SGaTs centrally published by the DH as recently contemplated, could remove an important channel of disseminating research evidence. Fourth, designers could use this model as a benchmarking tool to measure their progress in relation to EBD. As identified in the literature, Kirk Hamilton's four levels of the EBD (Hamilton, 2003) is also a simple benchmarking tool for EBD. Yet, his model is not comprehensive enough to describe or guide users on specific activities through which progress can be achieved. The model developed in this thesis contributes to existing knowledge by filling this gap, by identifying a variety of ways in which research evidence can be gathered during designing. In summary, the model has achieved its original intentions of representing evidence use during the healthcare design process; distinguishing sources and flows of evidence for EBD; and determining prospective routes for EBD.

Findings of the semi-structured interviews used to validate the SaFE model supplement previous research which identified evidence for design (Emmitt, 2007; Bertola and Teixeira, 2003; Heylighen, 1999 & 2000), by pinpointing healthcare specific sources of evidence. Sources of design evidence in the healthcare sector appear to be fairly consistent with generic evidence sources, except for research evidence and SGaTs. Further insights of current practices of evidence use could be identified, as follows:

i. Few new evidence stores were identified for Type A and B sources.
ii. Specific data stores for Type C sources were also identified and the model was updated accordingly. Specifically, evidence from research institutions, well-known research evidence reviews, and research published by external organisations were identified as sources of published evidence, in addition to previously identified research journals, conferences and research evidence databases.

iii. The results revealed that designers use SGaTs produced by few other organisations (for instance IHS, BSI) other than the Department of Health.

10.2.1 Evidence for design – discussion based on the interview survey

10.2.1.1 Research evidence use

Research evidence generation

The literature (Chen et al., 2010; Codinhoto et al., 2010; Stichler, 2011) suggests difficulties in evidence generation by designers due to the low practice of POEs in the industry. Contrary to expectations, this research found that healthcare sector has motivates for practitioner engagement in research due to PFI schemes. PFI schemes encourage healthcare stakeholders to engage in research as the private sector developers own and maintain built infrastructure for 30 years. In many instances these developers play another role in the building development process, such as the constructor or the health planner. This motivates developers to conduct POEs and generate evidence related to increasing the performance of buildings. However, this result must be interpreted with caution because developers may be interested in increasing the operational performance of buildings based on their values, (for instance, easy to maintain finishes, energy efficient plants) but they may not be necessarily interested in increasing performance related to health outcomes.

Use of published research

The research also revealed interesting findings related to the consideration of published research during designing. Unexpectedly, it was found that designers believe they access and use published research evidence, when in reality they don't subscribe to, or access by other means, research journals. Instead they rely upon Industry and professional journals, which are not necessarily the sources of research evidence. Further details of how they miss significant research could be identified during case studies and they are discussed in section 10.2.5.

Furthermore, in contrast with earlier findings (Martin and Guerin, 2007; Devlin and Arneill, 2003; Hamilton 2010; Codinhoto et al., 2010) there were no indications of difficulties associated with academic language of research publications. This can obviously be explained, in part, by the fact that designers (except clients) have a very limited access to academic research journals. Thus, they may not be concerned about the difficulties associated with academically written research publications. As suggested by Hamilton (2010) this research also revealed the designers' willingness to access published evidence, yet lack of resources (specifically the cost) may prevent, or hinder, the access to research evidence (Hamilton, 2010). This suggests the

importance of improving professional journals to incorporate research findings as well as facilitating access to research journals through alternative means, such as open access publishing. Surprisingly, clients (clinicians) were found to be the key stakeholder accessing research journals. This was because clinical organisations have access to research journals for medical purposes. The key sources of research evidence for other stakeholders are engagement with and/or support from research institutions who undertake the research. Furthermore, previous scholars have claimed that fragmentation and sparseness of the evidence base makes the designers' task of searching for evidence challenging (Codinhoto et al., 2010) and that those involved in the design process are unlikely to have time to read the literature (Lawson 2010). This finding provides useful insights into where the research relating to built environment interventions and health outcomes needs to be published. Implications of these finding related to the use of externally published research and internal research are further discussed in section 10.3.14 in combination with the results of research use identified during the case studies.

10.2.1.2 Use of SGaTs

As discussed within the literature review (refer Section 4.4.1), the design of the healthcare built environments in the UK is guided by an ensemble of SGaTs produced by the DH and other regulatory authorities. The Centre for Health Design research (CHD, 2010b) did not recognise the prospect that SGaTs can act as a considerable source of evidence for EBD. Irrespective of the weaknesses of SGaTs (Hignett and Lu, 2009; Lindahl et al., 2010; Hignett and Lu, 2008; Moss et al., 2001), this research found that SGaTs are well accepted by designers. Interviews revealed that all stakeholders were extremely positive about having SGTs maintained by a central authority and that they be preserved for the future. These results therefore justify and validate the prospect proposed early in this research: facilitating EBD through SGaTs. The interviews revealed the types of SGaTs used by designers and their support for facilitating EBD, but were not able to explore further details of how designers use SGaTs. Case studies were useful for identifying further details of how designers use SGaTs (refer to Section to 10.3).

10.2.1.3 Incorporating evidence into the design process

Literature revealed that evidence of EBD can be incorporated into the process of designing by means of input, output and outcome evaluation mechanisms, but it appears to be more sensible to incorporate them into the design input and output specifications of the built environment as opposed to the high level quality and safety management mechanisms of the health service. The results of this research corroborates this suggestion, and found that designers in the industry primarily use evidence embedded in the design inputs and output specifications. The results

suggest that it is sensible to focus more on input and output specifications of built environments, as opposed to higher quality and safety outcome performance management mechanisms.

Furthermore, the results reveal that the client and contractor stakeholders are most likely to seek evidence from across the four types of sources, i.e. the leaders of project teams are more concerned with collecting evidence from a variety of sources. Finally, the results revealed insights into the stakeholders' understanding of how buildings can support health outcomes. All the clients interviewed, and the majority of healthcare planners and healthcare contractors, considered health outcome related evidence. In contrast, none of the designers sought evidence in relation to health outcomes. This should not be interpreted as designers' lack of interest in health outcomes; it was because these short interviews revealed more about evidence sources and their channels and less about types of evidence.

10.2.1.4 Improvement opportunities for EBD

In addition to validating the SaFE model, data gathered through semi-structured interviews revealed rationales behind differences in evidence use by designers (see Section 5.8.1). These were analysed to identify the following mechanisms of evidence use:

1. Weaknesses of evidence sources require the use of more than one source.
2. Sources that contain evidence that can be found only in one source confirm the use of that particular evidence source.
3. Evidence in user-friendly forms and formats encourages use.
4. Evidence that is legally enforceable encourages use.
5. Other compelling characteristics of evidence sources that encourage use (e.g. evidence from Types A and B sources - 'reliable'; evidence from Type C sources - 'rigorous'; and evidence from Type D sources - 'tested', 'well-structured', 'clear about what evidence it is based on, 'provide reference of where to look' and 'evidence that provides advantages of standardisation').
6. Designers tend to search evidence from various sources to add more value to the project.

This analysis does not suggest that evidence from one type of source is superior to other three. Rather, due to the weaknesses and strengths associated with evidence in each of four types of sources and designers' willingness to use evidence from multiple sources. These findings also confirmed the importance of the availability of evidence through all four types of source.

These findings are consistent with those of other studies (see Section 3.6) that identified barriers associated with the application of EBD (Rubin et al., 1998; Dijkstra et al., 2006; Huisman et al., 2010; Martin and Guerin, 2007; Lawson 2010). Discrepancies of evidence, lack of evidence, difficulties associated with access and availability of evidence were identified as reasons for limiting the use of research evidence.

Confirming the claim of Codinhoto et al. (2010) these findings showed the association between fragmentation and sparseness of evidence base and the limited use of research evidence. The results validate the opportunity of using SGaTs as a mean of EBD facilitator suggested by those of other studies (Tetreault and Passini 2003; Hignett and Lu, 2009; Chen et al., 2011; Phiri et al., 2011; Codinhoto et al., 2010; Lawson, 2010; Devlin and Arneill, 2003) and support the idea that research evidence could be disseminated into designing through SGaTS. Results related to contingent conditions of evidence use (see Section 5.8.2) match those observed in earlier studies (Sailer et al., 2009; Lawson, 2010; Hamilton, 2010) in which lack of resources was claimed as a barrier in using research evidence. Supporting previous literature (Moore and Geboy, 2010) these findings also confirm the association between project-unique circumstances and application of evidence from different sources.

Literature revealed issues related to research evidence generation by designers (see Section 3.6.1). These issues could not be identified within the results of the interviews. Interviews revealed that internally generated evidence is preferred to external, probably due to a lack of faith in knowledge transfer mechanisms, yet this explanation cannot be verified from these interviews. Becker and Parsons (2007a) claimed that the constantly changing knowledge landscape is 'unsettling' for designers. None of the interviewees identified this as a barrier to EBD.

The results suggest that the use of published research can be improved by:

1 removing discrepancies between evidence sources,
2 improving the available amount of evidence,
3 disseminating evidence through a central database,
4 enforcing evidence through SGaTs,
5 expressing evidence in user friendly languages and formats and by
6 supporting evidence with results from operational outcomes achieved through buildings.

In addition, the interviews indicate that all four types of evidence sources have the potential for generating and transmitting evidence into the act of designing. Specific activities that could

improve research evidence content of all types of sources needs to be identified through further research. Designers' engagement in post-occupancy evaluations of designs was identified as limited, causing difficulties in generating research evidence internally. Thus, practitioner-driven evidence generation is difficult and, at present, it appears that research evidence generated at research institutions should drive EBD.

Results of this phase of the research validated the importance of the next phases of this research, which aims to identify how research evidence should be expressed within SGaTs.

10.2.2 SaFE model – Comparison of case studies

Based on the case study data, bespoke versions of the SaFE model were generated for each of the three cases. This helped in further validating the SaFE model presented in Chapter 5. A very few new entities for evidence sources and flows were identified during case studies and case studies were helpful in identifying further details evidence use behind the model.

Figures 10.1 and 10.2 show a cross-case comparison of the frequency of use of evidence from different evidence sources, as a percentage of total use. Table 10.2 presents a cross-case comparison of timing of using evidence sources during the 15 design activities.

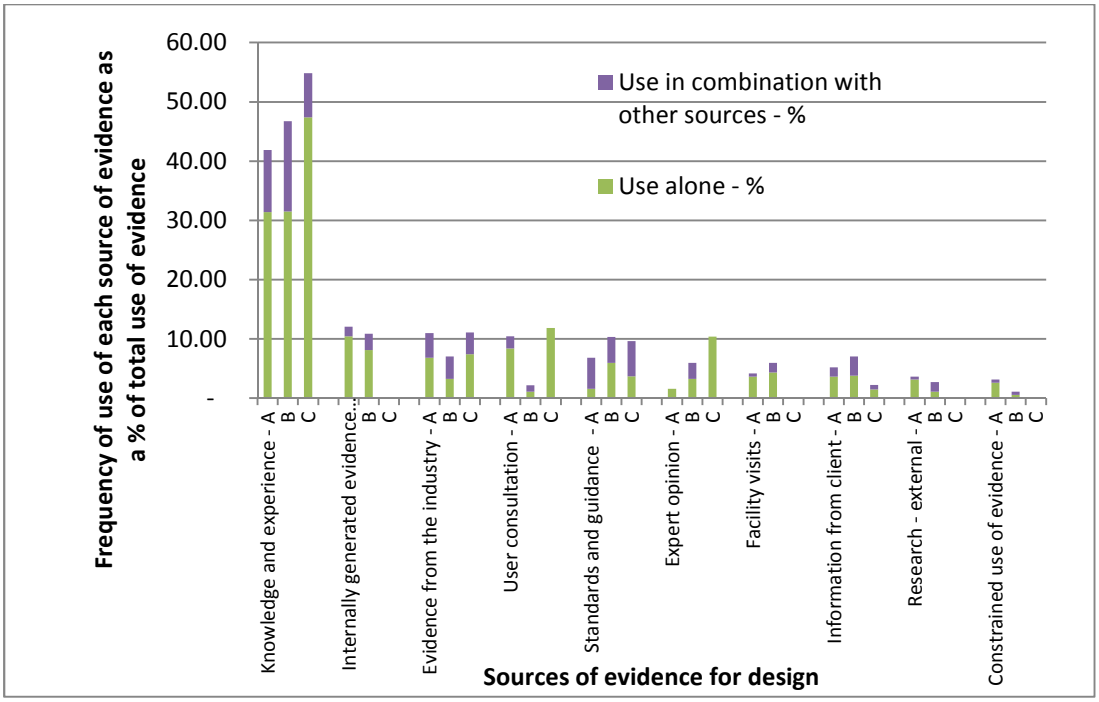


Figure 10-1: Comparison of evidence use in three case studies

Table 10-2: Comparison of process and timing of evidence use

	Analyse existing system	Identify & process strategic requirements	Identify project specific user needs	Performance specification	Descriptive specification	Identify possible ado(a)ption	Evaluate evidence	Adopt a solution	Adapt a solution	Reject the solution	Devise a solution	Construct a solution	Detail design	Improve the solution	Design evaluation
Constrained use of evidence - Case A	-	-	-	1	-	-	-	-	-	-	1	2	-	1	1
Constrained use of evidence - Case B	-		-	-	-	-	-	-	-	-	1	-	-	-	1
Constrained use of evidence - Case C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Evidence from the industry - Case A	-	-	-	-	2	9	-	-	-	-	2	-	2	-	6
Evidence from the industry - Case B	-		-	-	-	6	3	-	-	-	-	-	-	-	4
Evidence from the industry - Case C	-	-	-	-	-	8	-	3	-	-	-	-	-	1	3
Expert opinion - Case A	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1
Expert opinion - Case B	-		-	-	-	-	1	-	-	-	-	-	1	-	9
Expert opinion - Case C	-	-	-	-	1	-	-	-	-	-	-	-	-	-	13
Facility visits - Case A	-	-	1	-	-	1	4	-	-	-	-	-	-	1	1
Facility visits - Case B	-		-	-	-	2	8	-	-	-	-	-	-	-	1
Facility visits - Case C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Information from client - Case A	-	1	6	-	-	-	1	-	1	-	-	-	-	-	1
Information from client - Case B	-	3	-	3	-	2	-	-	-	-	-	-	-	-	5
Information from client - Case C	-	2	-	-	-	-	-	-	-	-	1	-	-	-	-
Knowledge and experience stakeholders - Case A	2	-	5	2	1	11	2	2	2	2	10	-	2	9	30
Knowledge and experience stakeholders - Case B	-	3	-	4	-	12	4	-	1	1	10	-	3	10	38
Knowledge and experience stakeholders - Case C	3	1	-	7	6	7	-	6	2	1	9	-	5	6	21
Research - external - Case A	-	-	-	2	1	-	-	-	-	-	-	-	-	-	4
Research - external - Case B	-		-	-	-	1	2	-	-	-	1	-	-	1	-
Research - external - Case C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Internally generated evidence - Case A	-	-	2	-	-	1	-	-	-	1	1	-	-	-	18
Internally generated evidence - Case B	-	-	-	-	-	-	2	-	-	-	1	-	-	-	17
Internally generated evidence - Case C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Standards and guidance - Case A	-	-	-	-	1	4	-	-	1	-	2	-	-	2	3
Standards and guidance - Case B	-	4	-	2	-	6	-	-	-	-	2	-	1	-	4
Standards and guidance - Case C	-	-	-	5	2	1	-	2	1	-	-	-	-	-	2
User consultation - Case A	2	-	4	-	-	-	1	-	1	1	1	-	-	-	10
User consultation - Case B	1	-	-	-	-	-	-	-	-	-	-	-	1	-	2
User consultation - Case C	-	-	-	-	-	-	-	-	-	-	-	-	-	3	13

Figure 10-1 illustrates that using evidence from knowledge and experience dominates other sources of evidence, making it difficult to identify the differences and similarities between other sources of evidence. Therefore, using evidence from sources other than K&E were re-presented in Figure 10.2 to reveal the differences between non K&E sources.

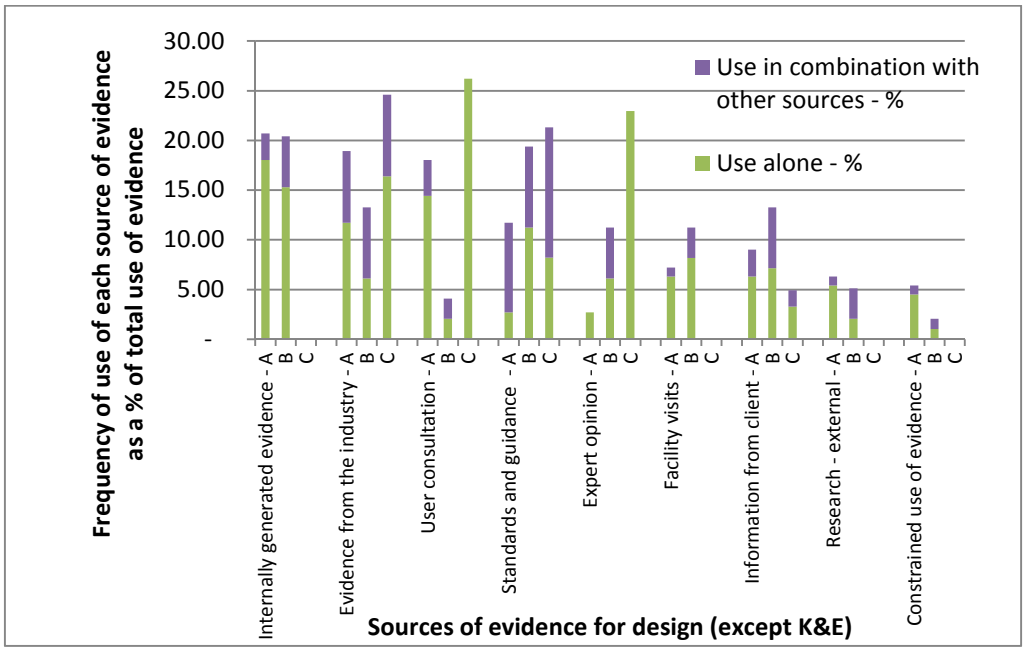


Figure 10-2: Comparison of evidence use in three case studies (without K&E)

The results in Table 10.2 and Figures 10.1 and 10.2 are revealing in several ways.

A. The most frequently used source of evidence is Knowledge and Experience (K&E).

K&E was used most frequently irrespective of the case's ability to access other sources of evidence. K&E was used throughout the designing for almost every type of activity. As stated in the literature review (see Section 4.4.1), prior studies have noted the importance of K&E during designing (Emmitt, 2007; Heylighen et al., 1999; Lawson, 2004). Findings from case studies suggest that K&E represents an accumulated store for evidence accessed through all other sources. There were instances where research evidence and evidence from the industry were reflected as knowledge and experience (see quotes below).

> *"……we told architect we don't need any fixed furniture so either they got to be built into the structure, or we got to move them in and out……."* (a representative from the Client- Case Study A)

> *"…….In York we did it (bed-head service panel) vertical, and I have done a hospital near xxx a vertical one, and few other facilities in other xxx were vertical as well,*

……, when you get it in vertical you get the sockets and gasses in the right position, close to the bed……" (a representative from the Client- Case Study C)

These findings complement previous literature that states that knowledge can be actively learned by doing, as well as experiencing artefacts, whilst passive knowledge could be gained through other educational modes (Habraken 1997 cited in Martin et al., 2005; Müller and Thoring, 2010; Bertola and Teixeira, 2003; Boling, 2010; Lawson, 2004; Heylighen, 2008).

For all three cases, K&E was an inevitable source of evidence in the instances:

- to support the application of evidence comes from other sources;
- as a complementary source of evidence for project-unique design problems; and
- where there is no evidence available from other sources, or no resources, to access other sources of evidence.

This result of the inevitable reliance on K&E implies the importance of disseminating research to individuals through knowledge sharing and knowledge transfer mechanisms. As discussed in Section 4.3, knowledge can form evidence for EBD, to the extent that knowledge can indicate whether a design proposition (for improving health outcomes through the design) is true or valid; and are learned from information gleaned through researches. Previous scholars have suggested that external research could be disseminated into K&E though Continuous Professional Development courses (CPDs), workshops, communities of practices and other educational modes. These findings also support previous researches which claim the importance of teaching EBD skills for students studying to become professionals in the construction industry (Hamilton, 2010; Evans, 2009; Viets, 2009; Martin and Guerin, 2006). If designers prefer to use their own K&E during designing they need to be competent in research skills to generate research, to undertake literature reviews and to interpret research to facilitate EBD through new research evidence generation and through learning existing published research.

B. Evidence from the industry was the third most used source of evidence.

Evidence from the industry (e.g. innovative solutions emerged to the industry) was predominantly used to identify solutions and to evaluate designs. Explicit reasons for this extensive search of evidence from the industry are not clear from case study data. It might be assumed that designers search evidence from the industry to identify up to date innovative solutions that could support better outputs and outcomes, this is discussed further in the Section 10.4.

Evidence from industry was used mainly for the design elements in the detail design phase. Some examples are finishes (in cases A, B & C); pre-fabricated en-suite units (in case C); bed head services panels (in cases B & C); computers at nurse station (in cases A & B); nurse call system (in case B); vistamatic/glass panels for doors (in cases A, B & C); and doors, door finishes and ironmongeries (in cases A, B & C).

Evidence from the industry was used in design evaluation for the following purposes.

- To obtain sufficient information about the solution that is going to be adopted;
- Compare solutions available in the industry; and
- Compare user and project requirements with the features of the solutions.

Solutions adopted from the industry were extensively evaluated, using other sources of evidence before adopting, adapting or rejecting. In many instances adopted/ adapted solutions were successful due to these extensive evaluation steps and subsequent improvements if necessary. But there are instances where these solutions had minor failures after adaption. The main reasons for these failures were as a result of a lack of evaluation in terms of:

- information on other associated systems, sub-systems or construction and integration methods (Cases A, B & C);

- solutions fit for the complexities and requirements unique to healthcare buildings (Cases A & B); and

- other project-unique circumstances (Cases A,B & C).

These are discussed in detail in the previous three Chapters.

These results show the significant role of evidence from the industry as a design input. Gann et al. (1998) identified the significant amount of research done by product manufacturers and suppliers. Yet, the purposes of these research activities were not clear within the literature. In contributing to this knowledge gap, this research revealed instances where materials and components manufacturers and suppliers have focused on research related to how health outcomes can be improved through built environments. For instance, during the design of case study A the lighting system developed by a light manufacturer to improve patient sleep was considered. All three case studies considered the acoustic properties of materials and floor finishes that prevent patient falls. Case study C has adopted sensor operated taps within the design to reduce infection control. Hence, it could be hypothesised that there is a prospect for facilitating EBD through product and manufacturers and suppliers. Therefore, it is important to

raise awareness of the therapeutic building evidence within product and manufacturers and suppliers in the industry.

The findings also corroborate with Larsson et al.'s (2006) claim that the lack of new product development, within product and component manufacturers, was due to the lack of communication between them and designers in the industry. This was evidenced within Case studies A and B. For instance, case study A has sought a solution to finger trapping at doors. The design team had done an extensive search for the available market products, but failed to find any suitable solution. Later, with proper communication with a selected door supplier they designed a bespoke door and a door frame solution to suit their circumstances.

C. Use of research evidence

Conducting internal research and engagement with external research was evidenced in Cases A and B. Due to the limited time available to procure Case C, instances of using published research evidence or internally generated evidence could not be found within the explored scope of Case C.

The findings of cases A and B support previous research that identified designers' preference for internally as opposed to externally generated evidence, (Habraken 1997 cited in Martin et al., 2005; Lawson, 2004; Cross, 2007). In cases A and B internal research use was the second most frequently used source of evidence.

According to the findings from the case studies designers generate evidence through '*research conducted by design team (client, engineer and designer), modelling, mock-ups and enabling works'*. Kim (2001) identified that designers believe research as site visits (88%), POEs (82%), behavioural observations (79%), questionnaires (77%), interviews (77%), literature review (66%), feasibility study (55%), programming (51%), schematic design (39%). Scholars stated the difficulty of assessing the research rigour of internally generated evidence. This issue was recognised within this research yet not explored any further nor was there an intention to do so. Stakeholders of cases A and B engaged in internal researches to find answers to project-specific questions. For instance, the client of the Case study A undertook research related to an innovative water services strategy which they implemented in Case study A. Case study B engaged in the research conducted on single-bed patient room design in collaboration with the Welsh Health Estates. Further, both cases A and B conducted research to identify thermal comfort of the single room for different window designs. Significant use of other types of internally generated evidence implies the designers' willingness to generate research internally.

Therefore, it is evident that these internal evidence generation activities could be improved to standards of research rigour if adequate support is provided to the design team.

The findings from case studies (A and B) revealed that designers used published research during designing. According to the findings, only the clinicians accessed published research; the findings did not reveal any instance where other members of the design team subscribed to any research journal. But, they accessed published research through secondary publications and databases, examples including research papers, reports and databases published by the Department of Health (DH) and other institutions. Explicit examples of using externally published research are fewer compared to specific uses of other evidence sources. The two most significant examples for significant use of published research are the single-patient room design and decentralised nursing station design (Cases A, B and C). The solutions emerged based on research evidence and gained wide popularity in the industry. These two innovative design solutions were also recognized as best practice within SGaTs. Even though SGaTs provided exemplar design layouts for the two situations, the designers adopted design principles behind these design solutions and devised their own bespoke versions for each solution. For instance, designers of the three case studies designed bespoke versions of single patient room designs while ensuring that the design facilitated the original design principles (such as, reducing infection control, increasing patient satisfaction, increasing patient privacy and dignity, improving sleep) behind the exemplar solutions provided in the SGaTs. Likewise, using research in the form of design rules or design principles was prominent in all three case studies (see Table 10-2).

In summary, designers generated new research evidence within the projects for their project-specific demands, whilst published and external research was used by designers as design principles/rules to guide and evaluate the design. These findings provide some insights into the scholarly consideration as to who should generate research (Codinhoto et al., 2010; Nelson et al., 2005; Hamilton, 2003). In general, therefore, it seems that research driven by both designers and academia is essential for EBD in present circumstances, since they used two types of evidence for different purposes. The results also imply the importance of improving collaboration between industry and academia so that research institutions can focus their research on the emergent demands within the industry.

Considering these previous scholarly claims and the findings from this research, there are several strategies that might be adopted to increase research use:

1 Evaluate cost/benefit of design and construction companies accessing and evaluating original research
2 Encourage use of open access publishing by academics
3 Increase the use of professional publications to regularly summarise new research findings (and reference original sources).
4 Protect the future of SGaTs, and create a mechanism to methodically capture the evidence.
5 Increase the collaboration between industry and research institutions.
6 Current circumstances dictate that the most sensible space to publish this type of evidence is in medical journals.

There is one other advantage associated with the sixth suggestion above. There are medical journals specific to disease categories, and the Healthcare sector now increasingly builds care buildings specific to disease categories (for instance, mental health, dementia or cancer care). If the research evidence is published and subsequently accessed through medical journals, this existing structure of medical journals would ease the challenge of fragmentation and sparseness of evidence base. The findings from the interviews with stakeholders revealed two examples of practitioner-initiated evidence collection specific to speciality diseases, as they become experts in building care facilities for that particular disease. PubMed and Medline databases reveal instances where built environment researches are published in medical journals, yet these are not necessarily published in journals specific to a disease category. Therefore, the results of this research encourage researchers to publish their results in medical journals specific to a disease category and that those medical journals accept built environment research findings. However, if the open access to research is well-established, this may not be the best solution.

These results are consistent with those from two previous studies which claim that design principles are more useful during design evaluation (Krippendorf, 2008; Heylighen et al., 1999) and this was evident in all three case studies. During the use of published research, designers analysed published research and identified design rules/principles behind those researches. They then used those design rules for design evaluation purposes. These results, therefore, imply the effectiveness of incorporating design rules to develop design evaluation tools, or design support tools as an effective mean of transmitting published research evidence into the design process.

D. Specific uses of different sources of evidence could be noticeable.

This analysis revealed specific uses for some sources of evidence. K&E and SGaTs were used throughout design for almost every type of design activity, whilst, some evidence sources were

either used at the early end of designing, to identify solutions, or at the later end of designing to evaluate solutions. For instance, evidence from the industry was sought mainly to identify solutions and occasionally to evaluate design, whereas, evidence from internal research, expert opinion and user consultation was mainly applied towards the latter end of designing, to evaluate and improve the design. Evidence from published research was used to set requirements for designing (as performance or prescriptive specifications) and evaluate other evidence. Facility visits were useful to evaluate, evidence gathered from other sources.

E. Similar patterns of evidence use

In all three cases similar patterns of use were noted for K&E, evidence from the industry, evidence from facility visits, SGaTs and user consultations (refer Table 10.1). This was noticeable in terms of both the frequency and timing of using evidence from these sources. A few exceptions could be identified due to project specific circumstances. Evidence from user consultation was limited in Case B since they had no permanent staff at the time of designing. This emphasise the validity of findings and consequent conclusions.

However, evidence from expert opinion was used differently in the three projects. Expert opinion was used extensively in Case C, possibly due to Case C's lack of opportunity to access external sources and the fact that expert opinion could be easily accessed internally. The reason for the low frequency for using evidence from expert opinion in Case A is because not many instances of using expert opinion fall within the selected scope of study for Case A. Literature revealed the importance of collaboration between design professionals and medical professionals to improve EBD (Codinhoto et al., 2010; Phiri, 2011; Hamilton, 2010; Nelson et al., 2005). Consulting experts' opinion in the medical profession is a means of achieving this collaboration. The effectiveness of this solution was evident in all three cases.

10.2.3 Project unique circumstances's impact on SaFE model

One of the key research questions was, '*impact of project-unique circumstance on EBD and how designers reflect on these issues during built environment designing?*' This was explored by analysing the impact of project-unique circumstances on the EBD process and the designers' reflection on those circumstances. The research revealed that EBD processes in all three cases were influenced by project-unique circumstances as discussed in detail in Chapters 6, 7 & 8. Table 10.3 summarises these circumstances in all three case studies to facilitate a comparison across cases.

Table 10-3 : Circumstances that have an impact on EBD approaches in the three case studies

Case A	Case B	Case C
▪ Nature of the hospital and its care model ▪ Patients' characteristics ▪ Local departmental needs ▪ Funding ▪ shape of the site ▪ Operating conditions different to testing conditions ▪ Culture of users ▪ International evidence come from different contexts ▪ Other	▪ Funding ▪ Being the first project of its nature and non-availability of similar projects ▪ Local departmental needs ▪ Being a part of a pilot project ▪ Age group of patients (Patients' characteristics) ▪ Culture of staff and other users ▪ Issues while integrating with other technical systems ▪ Operational conditions different from testing conditions ▪ International evidence comes from different contexts ▪ Other	▪ Restrictions on bespoke designs through modular systems ▪ Local departmental needs ▪ Incomplete previous knowledge ▪ Previous experience ▪ Enthusiasm and teamwork ▪ Other

Results in Table 10.3 shows that several common conditions and circumstances influence EBD practices, namely:

- Funding and time resources
- Patient characteristics and local departmental needs
- Context grounded nature of evidence (local vs international, different care models)
- Level of innovation and level of experience
- Operational conditions different from test conditions
- Incomplete nature of evidence to suit new design problems

10.2.3.1 Funding and time resources

The results confirm previous studies (Hamilton, 2010; Sailer et al., 2009; Joseph and Hamilton, 2008; Nelson et al., 2005) which identified lack of funding and time as a barrier for EBD. All three case studies revealed the influence of the project's capacity to access external evidence and to generate internal evidence specific to the project. Designers of cases A and B accessed published research through members of the client organisations (clinicians). There is no evidence of subscribing to any peer -reviewed journals by other members of the project team. Yet, they subscribed to industry journals and other magazines that are available free of cost, or at a relatively low subscription fee. Further, interviews revealed that the project teams conducted internet searches to gather research evidence. Therefore, it is fair to assume that the main reason for not subscribing to peer -reviewed research journals, by construction professional, is the cost associated with that option.

Similarly, in all three cases studies, generation of internal evidence was influenced by the availability of funding and time. Case study A had a significant amount of funding (specifically

allocated for EBD) and time. As a result the project team generated a significant amount of evidence internally. Case study B also had a considerable amount of funding (funded by Welsh Health Estates) and time and generated a considerable amount of evidence internally. Yet, some opportunities (e.g. mock up a whole ward and run for a year) were negated due to lack of money and time. Designers of Case study C did not generate any evidence specific to Case study C, due to the limited project duration. Finally, as identified through the literature (Nelson et al., 2005; Zimring et al., 2008) POE was influenced by the availability of funding. Cases A and B hired external consultants to conduct POEs. This restricted the project team's opportunities to learn actively from the building and its use. Since, Case study C had an in-house facility management team, they learned actively from the building and its use. Both Cases A and C have updated their internal standards based on the performance of projects.

10.2.3.2 Patient characteristics & Local departmental needs

Patient characteristics and local departmental needs have influenced the application of evidence. These findings support previous research, which claims difficulties of application of built environmental related evidence from one project to another (Becker and Carthers, 2007; Kamara et al., 2003; Moore and Geboy, 2010). Designers of Case study A devised bespoke design solutions (e.g. bed head service panel, doors and door frame, arts) due to unique requirements formed through their specific patient group (Children) and local departmental requirements. Moreover, they rejected several design solutions supported by therapeutic evidence, due to the unique requirements of children's care (e.g. Philips lighting system). Findings from case study B further support this idea, where designers devised several bespoke design solutions (e.g. en-suite design, low level window design), considering its targeted patient group (elderly and mental health patients). There are a few instances of disappointment in Case study B because of lack of consideration of their target patient groups during designing. The quote below provides an example of one of the disappointments.

> *"……for mental health we had a problem, we can't have open gaps, so we had to put a mesh so people outside cannot come and put any drugs in so we had to put this mesh at the end which is ugly, so windows are our problem to get the ventilation right, we can't have smaller windows because patient need to see out while sitting……"*(a representative from the Client)

Similarly, in case study C, some changes to the original solution were made to tailor the design to patient characteristics and local departmental needs.

Designers' skills for evaluating evidence and the critical application of evidence are therefore essential to the success of EBD. These results are consistent with previous researches which suggested difficulty in having a single, overall approach to the provision of its E&F that produces optimal results for all NHS organisations, since every NHS organisation has a unique combination of patient needs, priorities, requirements and resources (NHS Estates & Facilities Policy Division, 2013).

10.2.3.3 Context grounded nature of evidence (local vs international, different operational models

Data from both case studies A and B, revealed difficulties in applying evidence gathered internationally, or from facilities operating within different operational models. The former were associated with differences in care models between countries as well as the popularity, cost and availability of materials. There were also difficulties in applying evidence gathered from within the same country, due to the differences in their facility operational model and care model. This influence was visible, for the evidence collected through visits to facilities. In some instances, designers identified these differences during the application of evidence (e.g. Case A- shared bed bays for high dependency care patients, Case B – evidence gathered from single patient room hospitals). But, in some instances, there were disappointments due to some of the contextual details of the evidence not being traced well (e g. Case A – wall finishes, floor finishes, staff computers; Case B – nurse call system, wall finishes; Case C – infra-red taps, shower trays).

These results therefore confirm Demian and his colleagues' findings (Demian, 2004; Demian and Fruchter, 2005; 2006a, b and c; 2009) which raised the importance of project context and evolution history of solution (evidence) if these evidences are to be re-used effectively. Designers' of Case study A used an effective methodology for evidence gathered through site visits. These were carefully structured, which enabled focus on specific elements of the design. They conducted follow up data gathering (through re-visits, emails, telephone conversations) to gather more evidence on selected solutions (SS and its varients). In addition a mock-up evaluation and other evaluation methods were useful in validating evidence gathered externally.

10.2.3.4 Operational conditions different from testing conditions

All three cases showed instances of failures due to the fact that operational conditions are different from testing and evaluating conditions (e.g. Case A – en-suite floor, mechanical opening of window, parent waiting area; Case B – thermal performance of windows, day room; Case C – thermal performance of windows, en-suite shower tray). This suggests an inadequacy in current design evaluation methods. Interestingly, this could not be identified in the literature.

10.2.3.5 Refection on circumstances

As stated in Table 10.3 and the previous three Chapters, there are other project-unique circumstances that influence EBD. It could be observed that these project unique circumstances could be categorised into static circumstances which cannot be improved (for instance, patient characteristics and local departmental needs unique to the hospital; the context grounded nature of evidence) and variable circumstances which could be improved through additional resources (for instance, funding and time resources; operational conditions that are different from testing conditions; and level of evidence and experience available for designing). Reflecting on static and variable circumstances unique to the project is important for the success of the EBD process. Performance of the designs during the operational phase revealed that lack of reflection on based on static circumstances unique to the project, resulted in failures. In some cases failures were avoided by giving due considerations to these type of circumstances. For instance, Case A was successful by reflecting on requirements associated with children's care, and Case B's design has minor failures by not reflecting on some of the requirements associated with elderly care. This suggests the importance of providing some procedural guidance for designers, in order to identify and reflect on static circumstances unique to the project. However, not all projects are blessed with the best variable circumstances related to time and resources. Yet, Case B and C provide good examples of how to reflect on poor variable circumstances to avoid negative impacts they could result in. Moreover, incorporating procedural guidance is important to identifying these circumstances accurately.

10.2.4 Implementation of the SaFE model

The SaFE model was developed by the author of this PhD research and the research was funded by Loughborough University through EPSRC HaCIRIC (Health and Care Infrastructure Research and Innovation Centre) core grants. As the project intended, this model can be used and deployed for the betterment of the healthcare design practices as it intended.

The SaFE model at this stage is generic and intended to be used by several stakeholders. As stated in the Chapter 5, SaFE model could be used by researchers as a research road map. ICT tools developers could use the model to identify information flows related to EBD. Stakeholders in the design team could use this tool to benchmark their practices in relation to EBD.

The conceptual model was previously presented in the HaCIRIC International Conference, September 2012 and published in the conference proceedings. It is also expected that the validated version of the SaFE model to be published in research journals. This would trigger and enable researchers will use this model as a road map for future EBD researches.

Thinking about the future development of the model and its deployment in healthcare design practices, the champion for SaFE model will most likely to be designers, since it is most beneficial at the design stage of the buildings' life cycle. Further, the validation interviews with the stakeholders in the industry convinced that the model is understandable by the designers. It is expected that one person from a project may carry out both champion and facilitator role in using the SaFE model. In order to support the implementation effectively, a further version of the SaFE model was produced by over laying RIBA plan of work 2013 onto the validated version of the model (See Appendix K).

10.3 DESIGNERS' USE OF PERFORMANCE AND PRESCRIPTIVE SPECIFICATIONS

The design processes for each of the elements were analysed deductively in all three case studies, to identify how the designers used a performance and prescriptive specification during problem definition and designing. Prescriptive specifications referred to the specifications which set down the characteristics of a product in terms of its size, shape, materials and other dimensions and performance specifications referred to the specifications which set down the characteristic functions a product has to perform.

More specifically case study data were analysed to identify, problem definition approaches based on:

- specifications derived from SGaTs (GP);
- specifications devised, based on other evidence (DP); and
- no pre-determined approach to problem definition (-).

and approaches to designing:

- designing based on guided solutions (GS);
- designing based on de facto solutions (SS);
- devising solutions (DS); and
- constructing solutions (DSc).

The results for each case study are separately presented in Chapters 7, 8 and 9. This section presents a comparison of practices of the three case studies and discussion of results.

10.3.1 Approach to problem definition – problem definition based on prescriptive and performance specifications

Table 10.4 shows a summary of how designers in the three cases used the above two approaches and their variants during problem definition. It is evident that the three cases exhibit different approaches to problem definition.

10.3.1.1 No pre-determined approach to problem definition dominates approaches to problem definition

In all three cases, no pre-determined approach to problem definition (-) could be identified for a considerable number of elements. This could imply any of the following reasons or a combination.

1. Designers' familiarity with the design problem and their willingness to adopt existing solutions (from the instances where subsequent solutions are identified within guided solutions or de facto solutions);
2. The design team's willingness to exploit innovation elsewhere (from the instances where subsequently innovative solutions are identified within the evidence from the industry); and
3. Designers' style for problem definition and designing.

The design team's familiarity with the design problem and their willingness to use existing guided or de facto solutions could be assumed as a key reason to have no pre-determined approach to problem definition. This could be the reason why Case B used this approach more than Case A. The design problem in Case A was special and unique, in terms of the types of patients, the resultant hospital serves as well as the demographic details of the patients. Designers of Case A took extra effort to identify details of these unique circumstances and bring solutions accordingly. In Case B, the proposed hospital was not a speciality hospital and the parties involved in the design (other than client) had a considerable amount of K&E. Therefore, it could be assumed that Case B was in a better position to use previous known solutions. Case C was also in a similar favourable position due to the K&E of Client's and other parties involved in the designing related to building procurement and procurement of modular buildings.

Table 10-4: A comparison of problem definition approaches in three case studies

Case	Total number of elements	Approach to problem definition						Form of specification *(Content of performance specifications and prescriptive specifications)*	Focus of specifications *(content of output specifications and service outcomes specifications)*
		GP	**DP**	**GP+DP**	**-**	**->DP**	**->DP+GP**		
A	27	-	14	2	10 (2-DS; 1 - GS+SS>DS; 4 – SS; 3 – SS^{+})	1	-	Specifications identified through all approaches contained both performance specifications and prescriptive specifications	Specifications related building output and service outcomes were identified. Outcomes that need to be achieved through the design were then transformed into possible design intervention specifications
B	25	6	6	-	11 (1 – GS+; 2 - GS>DS; 1 - GS+SS; 6 – SS; 1 – SS^{+})	1	1	Specifications identified through all approaches contained mainly performance specifications and marginally prescriptive specifications	Specifications related building output and service outcomes were identified. Outcomes that need to be achieved through the design were further detailed to identify related design interventions that could be manipulated to achieve particular service outcomes
C	26	-	2	5	19 (6 – DS; 1 – GS+SS; 1 - SS+DS+GS; 10 – SS; 1 – SS^{+})	-	-	Specifications identified through all approaches contained both performance specifications and prescriptive specifications	Specifications considered during problem definition were primarily related to output specifications of the design. Service outcomes that can be achieved via design were incorporated into the design later during design evaluation activities.
		Key : **GP** – *Problem definition based on guided specifications,* **DP**- *Problem definition based on devised specifications*, '**-**' - *No pre-determined approach to problem definition*, , **DS** – *Devise a solution*, **GS** – *Ad(o)apt a guided solution*, **SS** – *Ad(o)apt a selected de facto or innovative solution*, '$^{+}$' - *Significant moderations made*, **>** - *transition of approach*							

However, Case C's considerable use of a 'no pre-determined approach to problem definition' could also be related to the time restrictions, and restrictions associated with limited choices within modular construction.

From a careful examination of the data, it is fair to assume that the second implication above: designers' willingness for innovation uptake as the most relevant reason for no pre-determined approach to problem definition. In a significant number of instances, externally identified innovative solutions were considered for incorporation into the design, without prior comprehensive approaches to problem definition. This finding corroborates the ideas of Nam and Tatum (1992) who challenged the enduring myth that "problem is the mother of construction innovation", or "owner's demands dictate innovation". Drawing from ten case studies Nam and Tatum (1992) stated that, many innovations were not emerged as demands from problems. The relative impact of these two reasons could not be verified within this research.

Finally, as Kruger and Cross (2006) claimed, these results could be associated with the designers' style of problem definition and designing. Drawing from a protocol study to observe an engineering design, they found that some designers spend more time on analysing and defining problems, while some designers spend more time on generating solutions. The authors' conclusion was that this was a personal style/approach to designing. Therefore, it could be assumed that designers of cases B and C, by their style, preferred to exert more effort to identify solutions than to define problems. Designers of Case A, by their style, preferred to exert more effort in problem definition. Designers of Cases A, B and C performed an 11-20% (A -17%, B – 11%, C-20%) of total activities during problem definition. This could be due to Case A designers' style is in exerting more effort on problem definition and Case B designers' preference is for exerting less effort on problem definition. The high amount of activities performed by Case C during problem definition is related to the fact that, due to procurement route they adopted, they identified set specifications early in the process and passed on to the modular builder. However, the data collected during these case studies is not sufficient to validate this third implication, nor was that the intention.

10.3.1.2 Use of specifications from SGaTs and devising design requirements during problem definition

Case A used specifications from SGaTs to define problems only for two elements, whereas this approach was moderate in Case B (24%) and in Case C (20%). Designers of the Case A devised design requirements during problem definition for more than half of the elements (55%). The

reason for limited use of specifications contained within SGaTs, and a tendency to devise specifications based on evidence from other sources, could be associated with the following or a combination thereof.

1. The case specific-nature of design problems;
2. Weaknesses of exiting SGaTs to provide specifications based on the case specific design problem; and
3. The designers' style of problem definition and designing.

All three case studies supported the first possibility, that designers have devised specifications to define problems when the particular design element needs to reflect case-specific circumstances. The ward layouts, children's play area in Case A, en-suite design and design of doors in cases B and C are some good examples. In all these cases, case-specific requirements were identified as specifications to govern subsequent designing. The resultant solutions were bespoke and supported project-unique circumstances.

Previous scholars have reported weaknesses associated with existing SGaTs. They include: having a large amount of uncoordinated regulation and guidance (Hignett and Lu, 2009); status of incompleteness (Moss et al., 2001); out-dated and not adapted for today (Moss et al., 2001); limit design freedom of designers (Hignett and Lu, 2008); having a number of different agencies who issue guidance on some aspects (National Audit Office, 2005); and duplication, fragmentation, non-standardisation (LaFratta, 2006). In supplementing previous literature, this research suggests that designers could be compelled to devise specifications since SGaTs are not always able to provide case-specific specifications. There were instances where non-availability of specifications within published SGaTs compelled designers to devise specifications (for instance design of the play area in Case A; design of single-bed room doors in Case B). Instances of devising supplement specifications, due to weak and less comprehensive specifications of SGaTs were identified (for instance Single room design of Cases A, B and C; the design of a bed head service panel in Case A; the design of doors in Case B). However, these results must be interpreted with caution because every NHS organisation has a unique combination of patient needs, priorities, requirements and resources that have to be considered during the design of built environments. Centrally-produced SGaTs cannot address this vast array of design problems unique to different organisations (DH, 2012). Within the current context, it is therefore the responsibility of the design team to explore unique design problems further, and to develop design requirements to guide subsequent designing.

Finally, as explained above, the amount of effort, which designers exert to devise specifications could be a result of their personal style of problem definition and designing (Kruger and Cross, 2006). In all three cases, specifications identified within SGaTs, or devised, based on evidence from other sources were transformed into a combination of prescriptive and performance specifications to govern subsequent designing. Data gathered during these case studies is not adequate to verify the proportion of these two types of resultant specifications.

10.3.1.3 Consideration of therapeutic building evidence

Another interesting observation is that in both Cases A and B, patient and staff health outcomes that can be achieved through the built environments were considered during problem definition activities and incorporated into design requirements set during problem definition. In Case C, due to the limited time available to them, health outcome improvement was incorporated during design evaluation activities. This implies that designers make an effort to achieve health outcomes through built environment interventions. Designing of single bed patient rooms in all three cases, designing of bed-head service panel in Case A, and designing of en-suites in Case C are a few good examples that explain this. In these cases, patient safety, infection control, patient and other user satisfaction, access to and view of nature, natural lighting, nurses' observation and nurses walking time were considered. However, there were instances where existing evidence was not identified. For instance, in Case B, designers were unaware of research evidence relating to designing of facilities for dementia. This result has an important implication for SGaTs generation. Providing guidance on how each element could be designed to support health outcomes would be well accepted by designers. This also suggests the importance of undertaking further research to explore ways in which to identify built environments' contribution to health outcomes.

In all three cases, problem definition activities were beneficial in devising bespoke solutions to the specific design problem in hand. Further, a focus of achieving health service outcomes through the built environment was initiated and incorporated into the process of designing during problem definition activities.

10.3.2 Approaches to designing – designing based on prescriptive and performance specifications

The data associated with specific building element stories was analysed to identify each element's approach to designing, based on the following categorisation and its variants. Further details related to this deductive analysis are discussed in Chapter 6.

- Designing based on guided solutions (GS)
- Designing based on de facto and innovative solutions (SS)
- Devising solutions (DS)
- Constructing solutions (DS©)

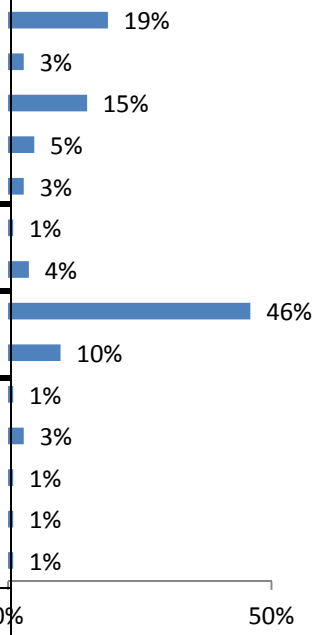
10.3.2.1 Frequency of using four approaches

This section compares and discusses approaches to designing in the three cases and Table 10.5 shows a comparison.

Table 10-5: Comparison of the three case studies in their approach to designing.

	Approach to design	Case A	Case B	Case C	Total	%	
DS	DS	7	1	7	15	19%	31 %
	DS ©	2	-	-	2	3%	
	GS+SS>DS	1	-	-	1	1%	
	GS>DS	-	4	-	4	5%	
	SS>DS	2	-	-	2	3%	
GS	GS	1	-	-	1	1%	5%
	GS+	-	3	-	3	4%	
SS	SS	8	13	15	36	46%	56 %
	SS+	4	2	2	8	10%	
A combination of approaches	GS+DS	1	-	-	1	1%	8%
	GS+SS	-	1	1	2	3%	
	SS+DS	1	-	-	1	1%	
	SS+DS+GS	-	-	1	1	1%	
	SS+GS+	-	1	-	1	1%	

Key : DS – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach



From Table 10.5 it is apparent that Case study A took a balanced approach, in terms of devising solutions based on performance specifications and the use of prescriptive solutions. Case B used significantly prescriptive solutions (SS or GS). These were mainly gathered through de facto standards and innovative solutions identified within the industry and a few through published standards (refer to Chapter 8). Case C has used mostly prescriptive solutions (SS or GS). These were gathered mainly through de facto standards and innovative solutions (refer Chapter 8). Case C also devised a considerable number of solutions (DS) based on performance specifications. Possible reasons for these differences were discussed in Chapters 6, 7 and 8, which identified that these practices are associated with:

- designers' effort for innovation uptake;
- strengths and weaknesses of SGaTs; and
- case unique circumstances that favour standard or tailor-made solutions.

Chapters 7, 8 and 9 also suggested the possibility of the implication of designers' style of problem definition and designing, but this could not be confirmed.

The results from the cross-case comparison presented in Tables 10.4 & 10.5 provide further insights gleaned from the individual case analyses presented. First, in total, the use of prescriptive solutions is more prominent than those of devising solutions. One of the main criticisms of EBD is that designers' fear that they might have to use prescribed solutions that would result in cook-book type Architecture (Hamilton, 2003). However, these results suggest that they nevertheless frequently use prescriptive solutions during designing. Further, the results reveal that prescriptive solutions used by designers are based mainly on evidence from external sources (evidence from the industry, published research) and are not always gathered from in-house sources or form SGaTs. Accordingly, designers fear that EBD related to prescriptive solution may be a myth. Results also suggest that EBD research findings integrated into design interventions may well be accepted by designers.

10.3.2.2 Modifications to prescriptive solutions

Second, in some instances (14%) these prescriptive solutions were significantly modified to achieve bespoke solutions and, in a few instances (9%), initially considered prescriptive solutions were rejected and alternative solutions were designed (GS/SS > DS). The previous three Chapters stated instances in which the final design was left with minor failures related to elements that adopted prescriptive solutions, without due consideration of project-unique circumstances. This emphasises the need for a comprehensive evaluation of prescriptive solutions, to identify their suitability for the design problem at hand, and to make improvements where appropriate. These findings are consistent with those of other studies (for instance, Hamilton, 2003; Cama, 2009; Viets, 2009; Evans, 2009) and stress the importance of a critical review of evidence. As suggested in the literature review, previous literature related to procedural knowledge of EBD is limited. Designers used different methods to critically apply evidence, based on their resource circumstances. However, it is apparent that their practices could be improved with appropriate guidance related to acquisition; generation and application of evidence (see the discussion in the section 10.5). Further, details presented within individual cases identified that, during these modifications, designers have elicited a design rationale behind prescriptive solutions (which then act as performance specifications) and used these to guide the design during modifications.

This suggests the importance of disseminating, where possible, rationales behind prescriptive specifications along with the solutions themselves.

10.3.2.3 Use of prescriptive solutions contained in the SGaTs

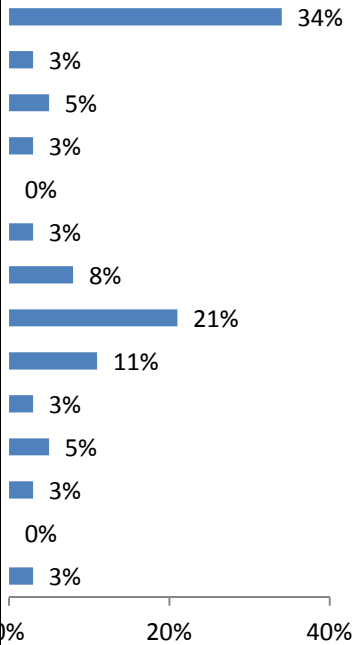
Third, these results reveal how designers use prescriptive solutions contained in the SGaTs. This approach was not dominant but in several instances prescriptive solutions contained in the SGaTs were considered, initially, before moving onto some other approach. Further, prescriptive solutions presented in SGaTs were a supporting source of evidence in several instances. Accordingly, these results suggest designers' willingness to consider prescriptive solutions contained in the SGaTs.

10.3.2.4 Designing approaches for pre and conceptual design phases and detail and technical design phases

The results suggested a linkage between the type of design element (pre and conceptual design, or detail and technical design) and the approach to designing (see Tables 10.6 & 10.7).

Table 10-6: Different approaches used for elements in pre and conceptual design phases

Approach to the solution		Design elements in the pre and conceptual design phase						Use of each approach as a %
		Space/layout	Composition	Location	Shape and size	Provision	Option appraisal	
DS	DS	9	1	2		1		34%
	DS ©				1			3%
	GS>DS		1		1			5%
	GS+SS>DS		1					3%
	SS>DS							0%
GS	GS	1						3%
	GS+	2				1		8%
SS	SS			1	1	6		21%
	SS+	1	1		1		1	11%
Combination of approaches	GS+DS	1						3%
	GS+SS	1					1	5%
	SS+DS	1						3%
	SS+GS^{+}							0%
	GS+DS+SS	1						3%



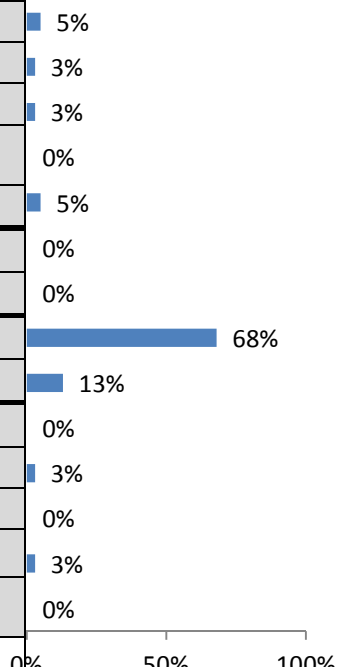
Key :
DS – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach

In the conceptual design phase designers devised solutions (DS) for the majority of the elements based on performance specifications. Prescriptive solutions used during the pre and conceptual design phase are mainly gleaned through published standards (GS). It is also apparent that modifications to prescriptive solutions are done, mainly, for the elements in the pre and conceptual design phases. Designers often transform prescriptive specifications, into performance specifications during usage, by eliciting the design rationale behind prescriptive solutions and use them as performance specifications to improve or modify existing design solutions or to generate new design solutions to suit project-unique circumstances.

Table 10-7: Different approaches used for elements in detail and technical design phases

Approach to the solution		Design elements in the detail and technical design phase				Use of each approach as a %
		E/services	Facilities	Finishes	Components	
DS	DS	2				5%
	DS ©				1	3%
	GS>DS				1	3%
	GS+SS>DS					0%
	SS>DS				2	5%
GS	GS					0%
	GS+					0%
SS	SS	3	1	11	12	68%
	SS+	1			4	13%
Combination of approaches	GS+DS					0%
	GS+SS			1		3%
	SS+DS					0%
	SS+GS^{+}	1				3%
	GS+DS+SS					0%

Key :
DS – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach



According to the Table 10.7, for the majority of the elements in the detail and technical design phase designers used prescriptive solutions, gleaned through de facto standards and innovation solutions within the industry.

Accordingly, a noticeable difference between the form of evidence used for the design of elements in the concept design phase, and design of elements in the detail design phase, is evident from the results, and these results are further discussed below.

A) Form of specifications used during pre and conceptual design phases

Several types of elements related to conceptual design were studied during these case studies. The majority include designing of space/layout related to design elements, and there are some design elements related to composition of spaces, location, shape, size and provision. The former mainly involve designing whilst, the latter elements are mainly about design decisions. The majority of design elements related to space/layout resulted in devised solutions (DS), in which the designers devised solutions to suit project-unique requirements. These findings support previous research related to knowledge used during conceptual design which has highlighted designers' preference for using active knowledge (evidence) during the conceptual design phase in order to devise bespoke solutions (Boling, 2010; Lawson, 2004; Cross, 2007; Heylighen et al., 1999).

As stated before, the reason for the heavy emphasis on devising solutions during the pre and conceptual design phases can be associated with the need to tailor-make a concept design to project-unique requirements. However, designers used prescriptive solutions prescribed within SGaTs during this phase, in many instances as a starting point. If exemplar solutions were available in the SGaTs the designers considered their application prior to devising bespoke solutions (for instance, Single room design - Cases A, B & C; En-suite Cases A & B; Nurses' station design – Cases A & B). In some instances designers have derogated from exemplar solutions presented in the SGaTs due to weaknesses of those examples (e.g. Single room design - Cases A, B & C; En-suite Cases A & B) and in some instance, practitioners derogated from exemplar solutions presented in the SGaTs due to project-unique requirements, circumstances and restrictions (e.g. En-suite Case B, Nurse station design Cases A & B). The literature was not clear as to how designers use cases (prescriptive solutions) contained in the codified knowledge sources during conceptual designing. The findings of this research fill this gap by identifying how cases (in codified knowledge sources) are used during concept development. In all three case studies, during the designing of single patient rooms, exemplar solutions prescribed in the HBN 04 were used as a starting point. Designers then analysed this exemplar solution to identify the

design rationale upon which the exemplar solution is based. Using these extracted rationales as performance specifications, they then improved the solution with evidence from other sources, in order to improve the design intentions embedded in the exemplar solution and to tailor the solution to project specific requirements.

These results suggest useful insights into how SGaTs need to be expressed to support pre and conceptual design phases. Such guidance is primarily expressed in HBNs. First, prescriptive solutions incorporated within HBNs, or similar guidance, are well accepted by designers. Yet, these prescriptive solutions often result in improvements to suit project-unique circumstances. During these modifications, designers elicit rationales behind the prescriptive solutions and use these as performance specifications. Therefore, it is important that prescriptive solutions contained in HBNs, or similar guidance, need to accompany design rationales or performance specifications in order for them to be used effectively. Results also suggested that performance specification may be well accepted within HBNs. The single room design of Case B provides an explicit example to explain this. Case B initially devised a '*Terms of Reference*' in which they identified performance criteria against which the subsequent design would be evaluated. Further, in some instances, designers derogated from prescriptive solutions due to weaknesses associated with those solutions. Therefore, it is also important that those exemplar solutions included in the SGaTs are validated with robust evidence.

B) Form of specifications used during detail and technical design phases

According to the case study results, (see Tables 10.3 & 10.4), the majority of the design elements in the detail and technical design phase have taken a solution-driven approach. These results are useful for the development of technical and detail design guidance (contained in present HTM standards or similar). The majority of solutions were adopted innovative solutions identified from to the industry, with considerable instances from de facto standards and a few solutions from published standards (GS) (refer Chapters 6, 7 and 8). Prescriptive solutions used during these phases were adopted with little or no improvements and modification. Details of case studies revealed that prescriptive solutions considered in this phase were often rejected if not suitable, as opposed to modifications (e.g. Case A - smart door vision panels, door protection strips; Case B – doors). Only in few instances within Case study A and Case study B, did the design team use modified solutions (e.g. Case A – bed head service panel, recessed PC at nurse station, finger trapping solution for doors; Case study B - door vision panels). In all the above instances, heavy engagement between designers in the project team and manufacturers was useful in devising bespoke solutions to suit design requirements. The reason for these limited

modifications to solutions in the detail design phase could be lack of communication between members of the project team and manufacturers who produce products and components.

Some minor failures were identified within the final design relating to elements that adopted prescriptive solutions, based on the evidence from the industry. (for instance Case A – recessed PCs at nurse station, floor finishes; Case study B – nurse call system; Case C – infra-red taps). The main reasons for these failures were related to the lack of evaluation of solutions before adoption (refer Chapters 6, 7 and 8). This further emphasises the importance of the critical application of evidence, irrespective of the type of element they involved, and the importance of guiding designers in critical application.

According to the results in Table 10.5, prescriptive solutions from SGaTs were less used for elements in the details and technical design phases. These results must be interpreted with caution. Designers of all three cases mentioned that they used technical and detail design standards (specifically HTMs) during the detail design phase and for the designing of engineering services. But these conversations were silent as to specific examples of prescribed solutions adopted from these published standards (GS); thus making the count for GS in the analysis low. Therefore, these results may be associated with the inability of HTMs to disseminate prescriptive solutions related to elements in the details and technical design phases.

These results suggest useful insights into how HTMs and similar guidance within SGaTs need to be expressed to support detail and technical design phases. This research revealed that performance specifications contained in HTMs are well-used by designers, and thus need to be continued to include performance specifications within HTMs. Second, designers adopted a considerable amount of prescriptive solutions during the detail and technical phases. Thus, HBNs can be improved to incorporate prescriptive specifications used as de facto standards, and to disseminate innovative solutions emerged into the industry. Some procedural guidance on how prescriptive solutions could be adapted during the detail and technical design phases could also be effective.

These findings related to how designers use performance and prescriptive specifications, during pre and conceptual design phases and detail and technical design phases could provide insights as to where research findings should be included. Based on the above discussion, it is obvious that research findings need to be supported, where possible, by both integrated prescriptive solutions as well as design rules. Further, previous literature revealed how designers use of evidence comes in the form of cases (or precedents) and design rules. Furthermore, scholars

(Demian and Fruchter, 2006; Lawson, 2004; Evans, 2009) have stated that active evidence comes in the form of cases useful during concepts development (search solutions that fit for new design problem) and detail design stages (as concrete cases). Yet, the literature was not clear as to how designers use cases contained in the codified knowledge. Findings from this research fill this gap by identifying how cases (in codified knowledge sources) are used during the detail design phase. In relation to technical and detail design phases, solutions gathered as complete solutions (cases) from SGaTs or from other sources, such as evidence from the industry, were used with almost no modifications.

10.3.3 Emergent framework – Composition of performance and prescriptive specifications in the healthcare design guidance

The first section 10.2 of this Chapter revealed how designers use evidence from different sources, including SGaTs. Section 10.4 revealed how designers use performance and prescriptive specifications during designing, together with several insights as to how guidance related to two phases (pre and conceptual design phases and the detail and technical design phases) needs to be expressed. Finally, section 10.4 revealed how designers reflect on project-unique circumstances during the application of evidence.

As identified within the sections 10.3 and 10.4 of this Chapter, specifications in the forms of prescriptive and performance specifications are well-used by designers for elements in both the pre and conceptual design phases, as well as the detail and technical design phases. Due to project-unique circumstance, prescriptive solutions used for elements in the pre and conceptual design phases were often subjected to modifications and improvements, in which the practitioner often elicited design rationale behind prescriptive solutions and used those as performance specifications. Therefore, guidance for this phase could be improved by providing further details of rationales behind prescriptive solutions and incorporating more performance specifications. Performance specifications contained in the guidance for elements in the detail and technical design phases are well-used by designers. However, these could be improved to incorporate more prescriptive solutions identified within de facto standards and innovative solutions emerged to the industry. Finally, the importance of providing some procedural guidance related to problem definition and critical application of evidence was highlighted in the second and third sections of the discussion.

Based on these results and discussions, this thesis proposes a framework for the generation of design guidance (see Figure 10.3). Prescriptive solutions contained in the SGaTs are well-

accepted by designers. However, they cannot drive the process of designing since they are often impacted by project-unique circumstances. Further, performance specifications gathered through SGaTs and other sources of evidence are well-used by designers in guiding design for the elements in the pre and conceptual phases, as well as the detail and technical design phases. Therefore, this framework proposes a performance specification driven specification with supplementary prescriptive specifications for published SGaTs. It is expected that performance specification could allow designers to design bespoke solutions, based on project-unique circumstances and designers could use prescriptive solutions as a starting point.

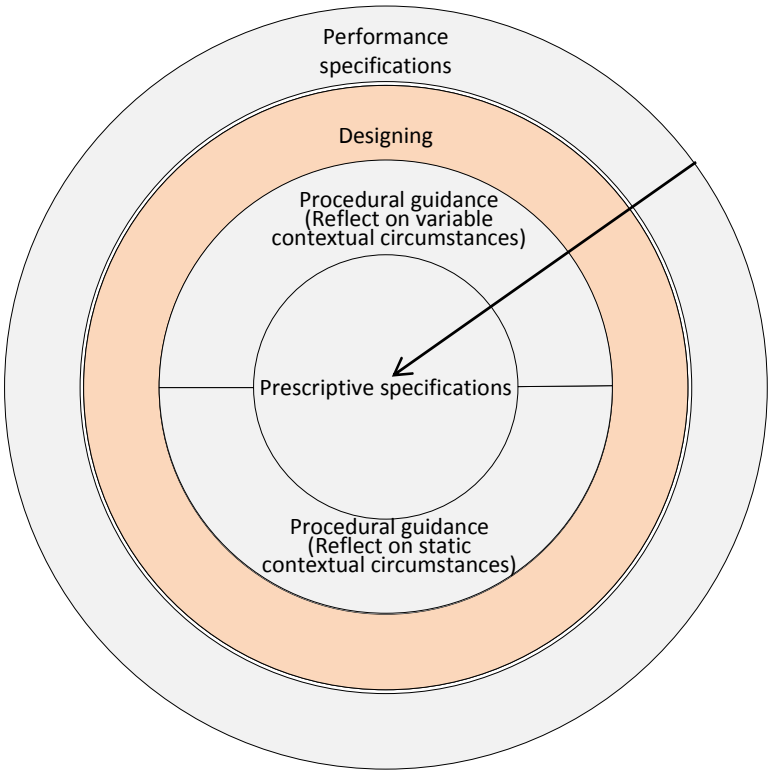


Figure 10-3: A framework for published SGaTs

Based on the results and discussions above, this research proposed another type of guidance for present SGaTs: procedural knowledge of EBD to guide designers in using two types of specifications during pre and conceptual design phases, and detail and technical design phases. It is expected that this type of guidance could be used to guide designers on problem definition activities in order to identify how proposed facilities can improve health service outcomes and incorporate these into the process of designing. Finally, this may also be used to guide designers on how to reflect on project-unique circumstances.

These results and the resultant framework are consistent with the work of CIB task groups TG37 and TG11. The findings from these two task groups (Meacham et al., 2005; IRCC, 2009; CIB,

2004) established the importance of performance specification for built environment design and suggested the effectiveness of a performance specification driven regulatory system for SGaTs. Their results were integrated by means of research findings into broader (country-wide) regulatory practices. In their recommendations, the task groups suggested the importance of being sensitive to the differences in the regulatory systems between one country and another when developing new approaches to regulatory practices (CIB, 2004). Moving a step further this research identified how designers use performance and prescriptive specifications for healthcare built environment designs.

10.3.3.1 Improvements for existing SGaTs

This framework proposes a performance specification driven SGaTs system for healthcare. As discussed above, the current SGaTs are largely performance specifications for elements in the pre and conceptual design phases (HBNs).

As observed in this research, performance specifications are significantly important during pre and conceptual design stages. Currently, these specifications contained in the HBNs. If looked at carefully, it was observed that existing HBNs are increasingly driven by performance specifications. Yet, it seems designers do not recognise this nature of specifications within HBNs, possibly due to the way they are articulated or structured. For instance designers of Case Study A compared different products for finishes against the performance specifications stated in HTMs (see Quote below).

> *"….we made a matrix to compare every type of finishes from floor, walls and ceiling tiles, right down to the level of plasterboards….. compared them against performance categories staged in HTMs…."* (a representative from the Designer of Case study A)

A similar approach was taken by designers of Case B during the evaluation of alternative solutions for single room design. Expending a considerable amount of effort, they produced a 'Terms of Reference' (ToR) comprised of 26 performance criteria against which subsequent designs for single bed patient room were evaluated. It is fair to assume that had the HBNs had articulated performance specifications for single-patient room design, similar to the way HTMs articulated performance specifications for finishes, designers of Case B could have utilised those, without spending time in preparation of ToR. Therefore, it could be expected that articulating HBNs similar to HTMs may improve the effectiveness of HBNs. On this basis, tools like ASPECT and AEDET are in a better position to guide designing at pre and conceptual design stages with performance specifications. But compared with the HTMs, these two tools are generic to the

whole building and cannot be used to evaluate individual spaces. Bespoke versions of AEDET and ASPECT tools for each space of the healthcare facility could supplement performance specifications for existing HBNs. For instance, Health Building Note 04-01 adult in-patient facilities could be supplemented with bespoke versions of AEDET and ASPECT for evaluated spaces described in the HBN 04. If this was available, designers of Case study B could have used this, with minor modifications, as opposed to spending a considerable amount of time in preparing a ToR.

According to the findings from the case studies, prescriptive specifications are significantly used during designing and problem definition (see Section 104.2.4). This framework proposes the opportunity of providing prescriptive specifications within detail and technical guidance (mainly HTMs). Existing published SGaTs provides prescriptive solutions, mainly within HBNs, and providing prescriptive solutions are rare within HTMs. This research confirmed designers' preference and acceptance of prescriptive solutions for design elements in the detail and technical design phases (guided in HTMs). In the majority of instances, prescriptive solutions were identified based on the evidence from the industry. Therefore, it is evident that HTMs could be supported with more prescriptive specifications for designers to consider during designing. It is - expected that this is a good way of promoting innovative solutions through SGaTs, since one of the primary reasons why designers adopt, or adapt, prescriptive solutions from industry is to bring innovation.

LaFratta (2006) reported difficulties in updating SGaTs to suit the rapid pace of development in the technology. Further, as stated by Fox et al (2000) and Gibb (2001), this research also confirmed that standardisation exists significantly at products and materials during the technical and detail design phases. Supporting SGaTs with an enormous amount of prescriptive solutions may therefore be impractical. Therefore, a quarterly or monthly briefing bulletin may be used to disseminate innovative solutions to the designers. Similar to the referencing system of present HTMs to other locations of relevant guidance, the solutions introduced within a regular briefing bulletin could be supported by referencing examples where the particular solution are implemented, so that designers can search for further evidence, if needed.

10.3.3.2 Procedural guidance for EBD

This research has also identified the importance of procedural guidance for EBD. Present SGaTs provide procedural guidance for some built environment related procedures. For instance, *Capital Investment Manual* (CIM) provides procedural guidance for trusts in commissioning a built environment facility and the guidance, '*A risk-based methodology for establishing and*

managing backlog' guides the facility management team of the hospitals in maintaining built environments within acceptable standards. As stated before, this type of guidance could provide designers with best practice guidance on problem definition activities, critical application of evidence and reflecting on project-unique circumstances. Differences in composition of designers and their skills, and competencies from project to project, could be observed. The availability of both architectural and clinical knowledge throughout the process and communication between construction professionals and medical professional in solving design problems is often a challenge. In supporting this issue, this type of guidance may bring a variety of other benefits to the process of designing. First, this would help members of the design team with the clinical back ground to identify values on which designing of built environments are based. Second, this would help members of the design team with a construction back ground to identify values of health care for a particular space within buildings. Third, this would help to identify best practices and provide details of resources available for EBD.

10.3.3.3 Further discussions

The framework above proposes performance specification driven SGaTs to guide healthcare built environment designing. Previous literature revealed advantages and disadvantages of performance specifications (Gann et al., 1998; Sexton and Barrett, 2005; Averill, 1998; Haberecht and Bennet, 1999; Baark, 2001; Bowen and Thomas, 1997). These case studies provide evidence to substantiate most of these advantages and disadvantages, as identified by the previous researchers. All three case studies provide examples where performance standards have stifled innovation (e.g. Case study A – water service design, single room design; Case study B – disposed nurse station design, single patient room and en-suite; Case study C – design of the ward entrance, single patient room design). Findings also complement the fact that performance specifications could help to achieve superior building quality (e.g. finishes in all three case studies). One of the disadvantages is that designers have done excessive work to prove that the design achieves performance criteria. The design of the ventilation strategy provides a good example to explain this. Engineers in all three case studies have modelled (computer aided modelling) performance of the ventilation and thermal comfort of several design options and their modified versions before the design is implemented.

In contrast with earlier findings, any instances of ignoring new technologies or innovative design solutions, due to heavy burden on the contractor or engineer to prove that system meets performance standards (Baark, 1997), could not be identified. It could be argued that the

designers' burden to prove compliance with performance criteria is an opportunity for engineering designers to be competitive in the industry, based on their competencies. However, ways of reducing the excessive work load of designers need to be identified. Further, this research extends the knowledge related to the use of performance specifications by identifying an additional drawback of performance specifications. The designs devised, based on the performance specifications, are often tested before construction and at the commissioning and handing over stages. But, if the actual operational conditions of these systems, products or components are different from the testing conditions then the performance of these systems, products or components may be disappointing at the operational phase (e.g. Case study A – en-suite floor finishes, wall paint, window and ventilation; Case study B – window and ventilation, nurse call system; Case study C – window and ventilation design, infra-red taps used in water services). Proposed procedural guidance could be used to guide designers as to how to overcome these difficulties.

As identified within the literature review, an effective balance between innovation and standardisation during designing is important for the success of healthcare built environments. It could be argued that the performance specification driven SGaTs proposed in this thesis would promote innovation. Previous literature revealed the importance of prescriptive solutions in achieving standardisation (Price and Lu, 2013; Hignett and Lu, 2009; Henriksen et al., 2007). It is expected that supplementary specifications, provided in the form of prescriptive solutions, would aid industry in achieving an appropriate level of standardisation. All three case studies reflected their awareness of the importance of standardisation and efforts in standardising spaces and components (Case A – bed head services, patient room, en-suite; Case B – Wales-wide standard patient room and en-suite; Case C – standard equipment, use same design for next projects). Further, results confirmed that prescriptive specifications provided within SGaTs were used as a starting point. In some instances, designers have used those prescriptive solutions after modifications, in order to suit project-unique circumstances, whilst in some instances these were ignored due their weaknesses. Thus, supplementing prescriptive specifications with design rationales to allow modifications, and validating prescriptive solutions for their credibility, would ensure that they are well-used by designers.

CHAPTER 11. CONCLUSIONS, RECOMMENDATIONS AND FURTHER RESEARCH

11.1 INTRODUCTION

The final chapter concludes the research and begins with a section stating how each of the six research objectives has been achieved. The next section states and discusses the conclusions of this research and, based on the conclusions, the third section states the recommendations for four types of stakeholders. The contribution to knowledge made in the domain of evidence-based design was discussed within the sixth section and the seventh section presents the implications for the practical application of this research for the development of design standards and guidance and for the EBD practices. The final section presents the limitations of this research and makes recommendations for further research.

11.2 ACHIEVEMENT OF OBJECTIVES

11.2.1 Achievement of the first objective

The first objective of this research was "*to establish a state of art literature review for evidence-based design for healthcare building and to identify conceptual linkages between evidence-based design, evidence for design and designerly ways of using evidence"*. This objective was fully achieved through the literature review and the incorporation of the findings into the SaFE model. The definition for EBD has progressed over time, yet there is still a debate among scholars regarding the epistemology of evidence for EBD (Section 3.2.2). Twelve inclusive systematic reviews of evidence (for EBD) were found in existing literature (Section 3.3) and a

new trend of conducting systematic evidence reviews particular to a space, a care setting or a particular patient category was noticeable. Alternative methods of disseminating published research into the design process could be identified, yet they need to be improved for the effectiveness (Section 3.4). Several EBD process models exist for different purposes, however too little attention has been paid to the actual project level activities involved in each stage of EBD (Section 3.5). Several barriers exist to the application of EBD related to evidence generation, evidence and evidence application and solutions for some of the barriers are suggested by previous scholars and being implemented (Section 3.6).

Evidence for EBD is a sub-set of generic evidence for design (EfD) (Section 4.3). Literature suggested implications of desginerly ways of using evidence on EBD. EBD could benefited by an exploration of how EBD can be impacted upon by: designers' need for both declarative knowledge and procedural knowledge (Section 4.5.1); designers' preferences for active knowledge and codified knowledge (Section 4.5.2); and designerly ways of using evidence for design (EfD) (Section 4.5.3). SGaTs content performance and prescriptive specifications, yet there is little known about the appropriate balance between the two types of specifications for healthcare designing (Section 4.6).

11.2.2 Achievement of the second objective

The second objective of this research was "*to explore the current practice of evidence use within designing for healthcare buildings in order to identify how the concept of EBD is being applied*". This objective was fully achieved through the literature review, the incorporation of the findings into the SaFE model, and the validation of the SaFE model. The design team generate and use: evidence from their internal sources (Type A sources); evidence of best practices from the industry shared by other organisations (Type B sources); evidence from published research (Type C sources); and evidence from SGaTs (Type D sources). Evidence from published research directly contributes to EBD by delivering research evidence through research journals; research published by external organisations; and research generated and/or accessed through collaborations with research institutions. Healthcare clients were found to be the key stakeholder accessing research journals, since they have access to research journals for medical purposes. The most common method of accessing research evidence for all other stakeholders was the engagement with research institutions. All other sources are informed partially by research–based evidence and has the possibility to facilitate EBD indirectly.

The sources and flows of evidence used by designers were identified through existing literature and incorporated into the SaFE model. This model was then validated through interviews with

healthcare planners, healthcare architects, healthcare constructors and healthcare clients (Chapter 5).

11.2.3 Achievement of the third objective

The third objective of this research was "*to identify opportunities to improve research-based evidence use during designing for healthcare buildings".* This objective was fully achieved by means of the results from semi-structured interviews with practitioners and by the results from the three case studies. Interviews identified that published research use can be improved by several strategies (see Section 5.5). Case studies revealed practitioners' preference for research evidence and the considerable efforts they made to access this evidence. According to the case studies, research evidence incorporated into design evaluation tools and performance specifications would be used effectively, since design team used published evidence mainly in design evaluation activities. According to case studies, design team engage in research to a certain extent (particularly the client) and they significantly generate evidence internally through several means (see Section 10.25), which could be improved to research-based evidence by facilitating resources for POE. Furthermore, design team keen to generate evidence to solve design problems on individual projects and to generate evidence to support project unique design problems. This could also be encouraged by providing adequate resources.

11.2.4 Achievement of the fourth objective

The fourth objective of this research was "*to explore how design practitioners use performance and prescriptive specifications during designing for healthcare buildings*". This objective was completely achieved through the results from the three case studies. The findings from the case studies revealed heavy use of prescriptive solutions as a starting point of designing, during all the phases of designing. These solutions were identified through innovative solutions emerged to the industry, through de facto standards and through published design standards and guidance. Designers often elicit design rationales behind prescriptive solutions and use these as performance specifications for subsequent improvements and modifications, or for complete new designing. Performance specifications contained in the design guidance for elements in the detail and technical are well used by practitioners. Further, there were instances which practitioners have devised performance specifications to govern designing. As stated earlier, practitioners have elicited performance specifications behind prescriptive solutions while modifying or derogating from prescriptive solutions to suite project unique circumstances. Therefore, performance specifications appear to be more governing for designing of elements in

both pre and conceptual design phases and detail and technical design phases while prescriptive specifications provides supplementary solutions for the beginning of designing.

11.2.5 Achievement of the fifth objective

The fifth objective of this research was "*to explore the project-unique circumstances that impact EBD processes and how practitioners reflect on these circumstances"*. This objective was achieved through the results from the three case studies. The results revealed several project-unique circumstances that influence EBD practices. Circumstances common to all three case studies were: funding and time resources; patient characteristics and local departmental needs unique to the hospital; context grounded nature of evidence (local versus international, different care models); level of innovation expected to attain within the development and the levels of experience of members of the project team; operational conditions that are different from testing conditions; and the incomplete nature of evidence and experience to suit new design problems. It was revealed that design team lack skills and guidance so as to how to reflect on project unique circumstances during designing. All three case studies adopted different approaches to deal with these circumstances (see Sections 7.6, 8.6 and 9.6). Further research is required to identify a comprehensive set of approaches to tackle these project-unique circumstances.

11.2.6 Achievement of the sixth objective

The sixth objective of this research was "t*o develop a decision support framework to develop a decision support framework to guide how evidence could be better expressed within design SGaTs to support EBD*". This was fully achieved through a desk study which incorporates the findings of the three case studies into a decision support framework. Improvements to existing healthcare SGaTs were identified based on designerly ways of using evidence in the form of performance and prescriptive specifications. These results were then incorporated into a framework that could be used during the development of healthcare design SGaTs. The framework proposes a performance specification driven healthcare building design SGaTs with supplementary prescriptive specifications for both pre and conceptual design phases and detail and technical design phases. The framework also proposes the need for procedural guidance for EBD to guide design team in gathering and applying evidence; and to guide design team on how to reflect on project unique circumstances. Section 10.5.1 discusses the ways in which current healthcare design SGaTs could be improved to achieve the framework proposed by this model.

11.3 CONCLUSIONS AND RECOMMENDATIONS

11.3.1 Facilitating EBD though generic evidence for design

Conclusion A - From the evidence from the three case studies it can be concluded that EBD could be significantly facilitated by evidence sources other than direct research evidence.

1. Designers use evidence from sources other than research for different purposes and according to the literature they all have the potential to convey research-based evidence into the design process (Section 4.4).
2. The findings of the three case studies confirmed that research-based evidence is embedded within other sources of design evidence (knowledge and experience, internally generated evidence, evidence from the industry, evidence from user consultation, evidence from standards and guidance, evidence from expert opinion, and evidence from facility visits) (Section 10.2.2).

The knowledge and experience of practitioners engaged in the design process is the primary source of evidence input used for designing followed by internally generated evidence and evidence from the industry (Sections 10.2.5.1 & 10.2.5.2). Furthermore, design practitioners use healthcare SGaTs mainly because they are enforced by DH and they are providing details for designing spaces unique to healthcare buildings.

3. Therefore, these three sources have the most potential for conveying research-based evidence into the design process.

The nine sources of evidence found to have specific uses and different intentions (Sections 10.2.4 & 10.3.1.4). These specific applications of evidence need to be considered when combining published research with other sources of evidence.

4. Therefore, built environments cannot be designed exclusively based on published evidence and informing research-based evidence into other sources of EfD is essential for EBD.

11.3.2 Need for both internally generated evidence and externally gathered evidence

Conclusion B – Based on the findings from the three case studies it can be concluded that EBD needs to be supported by both externally published research evidence and through internally generated evidence. Design practitioners understand the benefits of published research and

have the capability to use them for designing if they are made available to them (refer Sections 10.2.2 & 10.3.1.3).

5. Design practitioners acknowledge the importance of externally published research.
6. The academic nature of written evidence was not seen to be a barrier to accessing published research.
7. The direct use of published research-evidence is limited to the availability of opportunities to access such published evidence and designers use it when it is made available to them via the client and other open access sources.
8. In the present context, healthcare clients (clinicians) have the opportunity to access published research evidence contained in medical research journals. Design organisations involved in this research have not subscribed to any peer-reviewed research journals.

According to the findings from the three case studies,

9. Design team generate evidence to validate external evidence (including published research); to solve design problems on individual projects; and to generate evidence to support project unique design problems, thus internally generated evidence is essential for EBD (Section 10.3.1.3).
10. Design team prefer and generate evidence internally by various means, some of which includes research, and others which could be improved to research standards by facilitating adequate support (Section 10.3.1.3).

11.3.3 Performance and prescriptive specifications

Conclusion C – Based on the evidence from the literature review, interviews survey and from the findings of three case studies, it can be concluded that performance specification driven healthcare design SGaTs, with supplementary prescriptive specifications could improve effective use of evidence-informed SGaTs.

11. Due to the lack of existing knowledge about quantifying the built environments' contribution to health outcomes, incorporating evidence into design input and output specifications for the built environment, as opposed to the high level quality and safety management mechanisms of the health service, is more appropriate (Sections 4.4 & 10.2.3.1).

12. Prescriptive specifications are heavily considered during the designing for healthcare built environment at all phases, thus they play an essential role during designing (Section 10.4.1.1 & 10.4.2.1).
13. However, designers have designerly ways of using prescriptive specifications. Prescriptive specifications are a useful starting point for designing and as a way of bringing in innovative and best practice solutions. Yet, they often transform prescriptive specifications, into performance specifications during usage, by eliciting the design rationale behind prescriptive solutions and use them as performance specifications to improve or modify existing design solutions or to generate new design solutions to suit project-unique circumstances (Sections 10.4.2.2 & 10.4.2.4).
14. When designing elements in the detail and technical design phases, evidence in the form of prescriptive specifications is barely subjected to modifications or improvements due to the weakness of the evaluation procedures and lack of attempts to modify components or systems produced off site. This has resulted in failures (Section 10.4.2.4).

Based on these results this research offers a results driven framework which proposes performance specification driven healthcare design SGaTs with supplementary prescriptive specifications.

11.3.4 Procedural guidance for EBD

Conclusion D – Based on the findings from the literature review and from the three case studies it can be concluded that designers need procedural guidance to support evidence acquisition, evidence application and new evidence generation.

15. Design team need procedural guidance to avoid failures related to evidence acquisition, evidence application and new evidence generation (Sections 3.6, 10.3.1.2 & 10.4).
16. Procedural guidance for gathering and incorporating EBD evidence during problem definition activities is useful for incorporating such evidence early on in the design process (Sections 10.4.1 & 10.4.1.4).
17. Procedural guidance is needed for evaluating externally identified prescriptive solutions and to modify those solutions to suit project-unique circumstances (Sections 10.4.2.2 & 10.4.2.4).
18. The EBD process is influenced by several project-unique circumstances. Design team need procedural guidance on how to identify project-unique circumstances and how to reflect on project circumstances (Sections 10.5 & 10.6).

11.4 RECOMMENDATIONS

A number of recommendations can be made based on the findings of this research, and related to four conclusions. These recommendations are made having several audiences in mind, namely designers, healthcare clients (trusts), SGaTs developers and researchers.

Table 11-1: Recommendations based on the conclusions

Related conclusion	Recommendations	Stakeholders			
		Designers	Clients (Trust)	DH	Researchers
Conclusion A	**1.** Convey published evidence to design practitioners through educational modes such as continuous professional development programmes, research conferences and visits to best practice hospitals.	√	√		√
	2. Increase the use of published research to support SGaTs.			√	√
	3. Allocate funding and encourage products, systems and component manufacturers to generate products, systems and component to support EBD.			√	
	4. Increase the communication channels between design practitioners and products, systems and component manufacturers in the industry to facilitate development of bespoke solutions where appropriate.	√	√	√	
Conclusion B	**5.** Allocate extra time and money for designers to gather published research evidence.		√		
	6. Increase the use of open access publishing or disseminate EBD related publications through the Department of Health knowledge portals to increase construction professionals' access to published research.			√	√
	7. Publishing EBD related research in medical journals is recommended because this evidence would then be channelled to the design team by clients (Section 10.2.5).				√
	8. Encourage the supply chain partners of the industry to conduct more research and promote products and systems to support EBD			√	√

	Table 11-1: Recommendations based on the conclusions. Cont'd …				
Conclusion B – Cont'd	**9.** Facilitate funding and other resources to promote research undertaken by design and medical practitioners.			√	√
	10. Facilitate funding and other resources to do mock-up evaluations and other internal evidence generation activities of built environments design.			√	
	11. Facilitate resources and motivate design practitioners to engage in post occupancy evaluations.		√	√	
	12. Increase mutually beneficial collaborations between research institutions and design practitioners.	√	√	√	√
	13. Introduce building procurement and investment approaches that encourages internal evidence generation.		√	√	√
Conclusion C	Design guidance for pre and conceptual design phases (present HBNs) need to be improved by:				
	15. providing further details of the rationale behind the prescriptive solutions contained in the standards and guidance;			√	√
	16. incorporating more performance specifications based on published research; and			√	
	17. articulating specifications in a similar way to HTMs.			√	
	Design guidance for the detail design phase (present HTMs) could be improved by: **18.** providing more prescriptive solutions based on contemporary research and innovative solutions emerging from the industry; and **19.** providing procedural guidance to evaluate the solutions and opportunities to improve and modify solutions.			√	
Conclusion D	**20.** Introduce procedural guidance to existing published design SGaTs.			√	
	21. Encourage design practitioners to publish best practice case studies on EBD implementation.	√	√	√	√

11.5 CONTRIBUTION TO KNOWLEDGE

This work contributes to the existing knowledge for the use of evidence-based design in healthcare built environments in several ways.

11.5.1 Clarifying evidence for EBD and EfD

Before the concept of EBD emerged, the term evidence was not often used in design literature and was used without a specific definition of the term. EBD introduced a specific definition for 'evidence' to refer to research-based evidence. According to literature, design practitioners also use the term 'evidence' and 'research' lightly and this was confirmed in Phase II of this research (interview survey). It was suggested that this misuse resulted in design practitioners identifying themselves as EBD practitioners without necessarily practicing EBD which could lead to failures in achieving the benefits of EBD. By reviewing the definitions of evidence for EBD and generic evidence for design (EfD), this research distinguishes evidence for EBD from generic EfD (Section 3.2.2).

Even though this definition appears to be straightforward, due to the intense nature of EfD flows and their generation, identifying sources and flows for EBD evidence was a complicated task and needed further clarification. In responding to this issue, this research developed a graphical model to represent the sources and flows of evidence for EBD within generic EfD. The model is verified and validated and ready for use. Because the model identifies both direct and indirect evidence flows for EBD it contributes to EBD in two ways. Firstly, design practitioners could use this model to identify evidence flows for EBD, and thus, routes to becoming EBD practitioners. This may eliminate design practitioners using the term 'evidence-based' lightly and failing to gain the real benefits of EBD. They could also use the model as a benchmarking tool to assess their progress in EBD. Secondly, EBD scholars and policy makers could use this model to identify improvement opportunities for EBD. Currently, EBD scholars rely heavily on the direct use of research evidence as the way forward for EBD and encourage design practitioners to utilise published research and generate research during practical tasks. This model identifies alternative ways of conveying research evidence into the design process. EBD researchers could use this model to identify indirect routes to EBD and to explore them further to identify effective implementation strategies. Policy makers could use this model to identify strategies to improve EBD through policy level approaches and to identify the implications of EBD during policy changes. Furthermore, based on the model, this research also identified the rationale behind design practitioners use or none-use of evidence from the four evidence sources. It is expected that this result would help to improve utilisation of research evidence; if they were to be

incorporated into the rationales behind well used evidence sources and eliminated from the rationale behind little used evidence sources. These results may also be used to improve the use of healthcare design SGaTs.

11.5.2 Balance between performance and prescriptive specifications to support EBD

Previous scholars have identified evidence informed SGaTs as an effective way to facilitate EBD. Taking a further step, this research contributes to the existing knowledge of EBD by identifying how evidence could be effectively expressed in performance and prescriptive specifications to be used during EBD. Specifically, the results of this research confirmed the need for more performance specification driven SGaTs with supplementary prescriptive specifications. Previous researches into performance based regulatory systems have identified this as the appropriate way forward (CIB task groups: TG 11 & TG37). Yet they could not establish the benefits of a performance based regulatory system when the performance criteria are qualitative and not precisely measurable (similar to EBD) (Meacham et al., 2005). Furthermore, they concluded their research by emphasising the importance of being sensitive to differences in regulatory systems, code and standard between one country and another when developing design and construction standards. Results from this research contributed to knowledge by confirming the appropriateness of performance specification driven design SGaTs for healthcare built environments to support EBD.

11.5.3 Application of EBD

This research contributed to the EBD process literature by identifying project level practices to improve EBD. The success of EBD is dependent upon critical application of evidence and practitioners' ability to reflect based on project-unique circumstances. This research identified project unique circumstances that need to be considered and reflected upon during the practice of EBD. Specifically, this research identified and discussed static and variable project unique circumstances. Similar results from all three case studies revealed that these are common and generalisable factors which design practitioners need to consider during EBD. Design practitioners need to reflect on the static circumstances (such as patient demographics, site demographics) by identifying and using adequate amount of appropriate evidence. Design practitioners need to identify and change variable circumstances (such as resource circumstances) through project level approaches to mitigate negative circumstances. Best practice on how to reflect on static circumstances and how to mitigate negative impacts of variable circumstances were identified based on the best practices used in the three case

studies. It was evident that design practitioners in the three case studies used different approaches to tackle these two types of project unique circumstances. Therefore, further research would be useful for identifying further approaches which design practitioners could use to tackle project-unique circumstances. This is recommended as an area for further research.

11.6 IMPLICATIONS FOR PRACTICE

The findings of this research have implications for SGaTs developers, design team and researchers.

11.6.1Implications for the SGaTs developers

The results from this research suggest implications for SGaTs development. By analysing the way in which design practitioners use performance and prescriptive specifications, this research identified how SGaTs that guide the pre and conceptual design phases (current HBNs) and SGaTs that guide the detail and technical design phases (HTMs) could be improved to convey evidence effectively. Recommendations to achieve these improvements were also identified and presented in the Table 11.1. By exploring the process of evidence use, application and generation and the resultant performance of the design this research identified the need for procedural guidance for designers practicing EBD. The research further identified specific aspects of EBD processes which needed procedural guidance. These results were incorporated into a framework to guide SGaTs' development.

11.6.2Implications for the design practice

This research suggests implications for EBD practice in the following ways. First, this research developed a graphical model to represent sources and flows of evidence for EBD within generic EfD. Design practitioners could use this model to identify evidence flows for EBD, and thus, routes to becoming EBD practitioners. They could also use the model as a benchmarking tool to assess their progress in EBD. Second, results of this research suggest some implications in relation to how prescriptive solutions should be used in the detail and technical design phases. Prescriptive solutions used during the detail and technical design phases were adopted with little or no improvements resulting in minor failures. Two important changes to practice could be used to tackle this issue. A comprehensive evaluation process is required to ensure the selected solution will be successful during use. It is also important to communicate and engage with the suppliers and manufacturers of these solutions in order to identify the details of the solution, and to improve the fit for the design problem. Third, this research identified best

practice for evidence gathering and application and how practitioners could effectively reflect on project unique circumstances to eliminate the negative impact of those circumstances.

11.6.3Implications for the researchers

This research identified the effectiveness of prescriptive solutions and performance specifications during different phases of the designing. Researchers could use findings and recommendations made in the Table 11.1 while publishing their researches.

11.7 LIMITATIONS AND FURTHER RESEARCH

Previous studies were less revealing about the benefits of performance based regulatory systems for design solutions associated with qualitative and non-measurable performance criteria. This research confirmed the appropriateness of the performance specification driven SGaTs for EBD for healthcare built environments. The importance of improving outcomes for users of healthcare buildings is significant as the ultimate aim of the core business of healthcare is to improve the health outcomes of primary users (patients) of health buildings. EBD is now used in sectors other than healthcare, yet the primary focus of core businesses for those sectors is not improving the health of building users. Therefore, the results of this research may not be appropriate for other sectors and further research is needed to explore the appropriateness of a performance based regulatory system to improve EBD for other sectors.

This research identified approaches used by design practitioners in the three case studies to tackle project unique circumstances. However, the best practice identified within the case studies were not a saturated list of results and it was evident that design practitioners in the three case studies used different approaches to tackle project-unique circumstances. Therefore, further research would be useful for identifying additional approaches which design practitioners could use to tackle project-unique circumstances. This research identified a comprehensive set of project unique circumstances that impact on the EBD process. Based on an interview survey with practitioners from the industry, approaches to tackle project-unique circumstances could be identified.

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APPENDICES

List of Appendices

H.2 - POE data - Case B

H.3 - POE data - Case C

Appendix I: Extended literature review – Research methodology

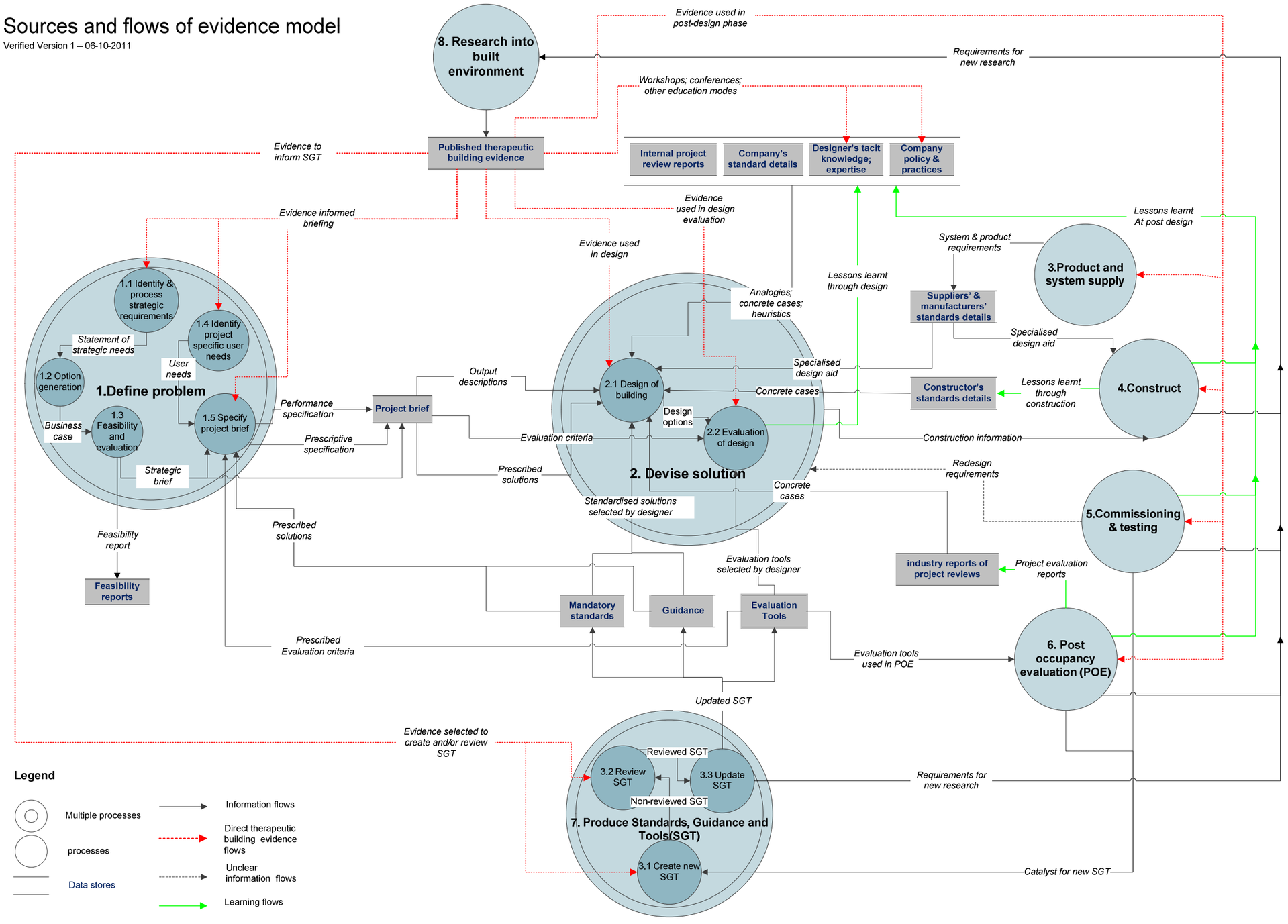
Appendix J: Case studies in detail

Appendix K: RIBA plan of work 2013 overlay on the SaFE model

Appendix A: The conceptual model of the SaFE

Sources and flows of evidence model

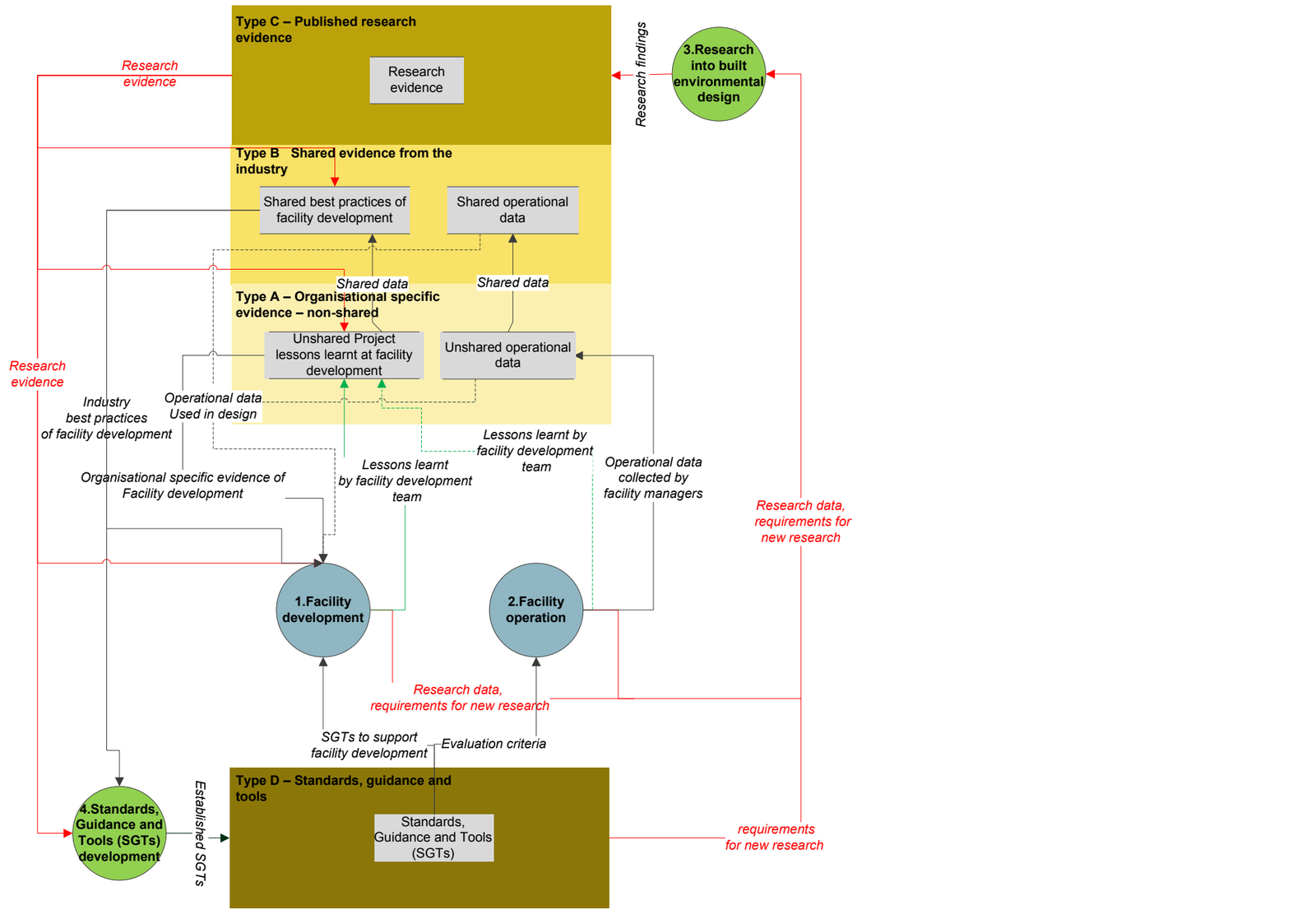
Verified Version 1 – 06-10-2011



Appendix B: The verified SaFE model

Sources and flows of evidence model(Parent Model – Level 0)

Verified version 1b 25/11/2011



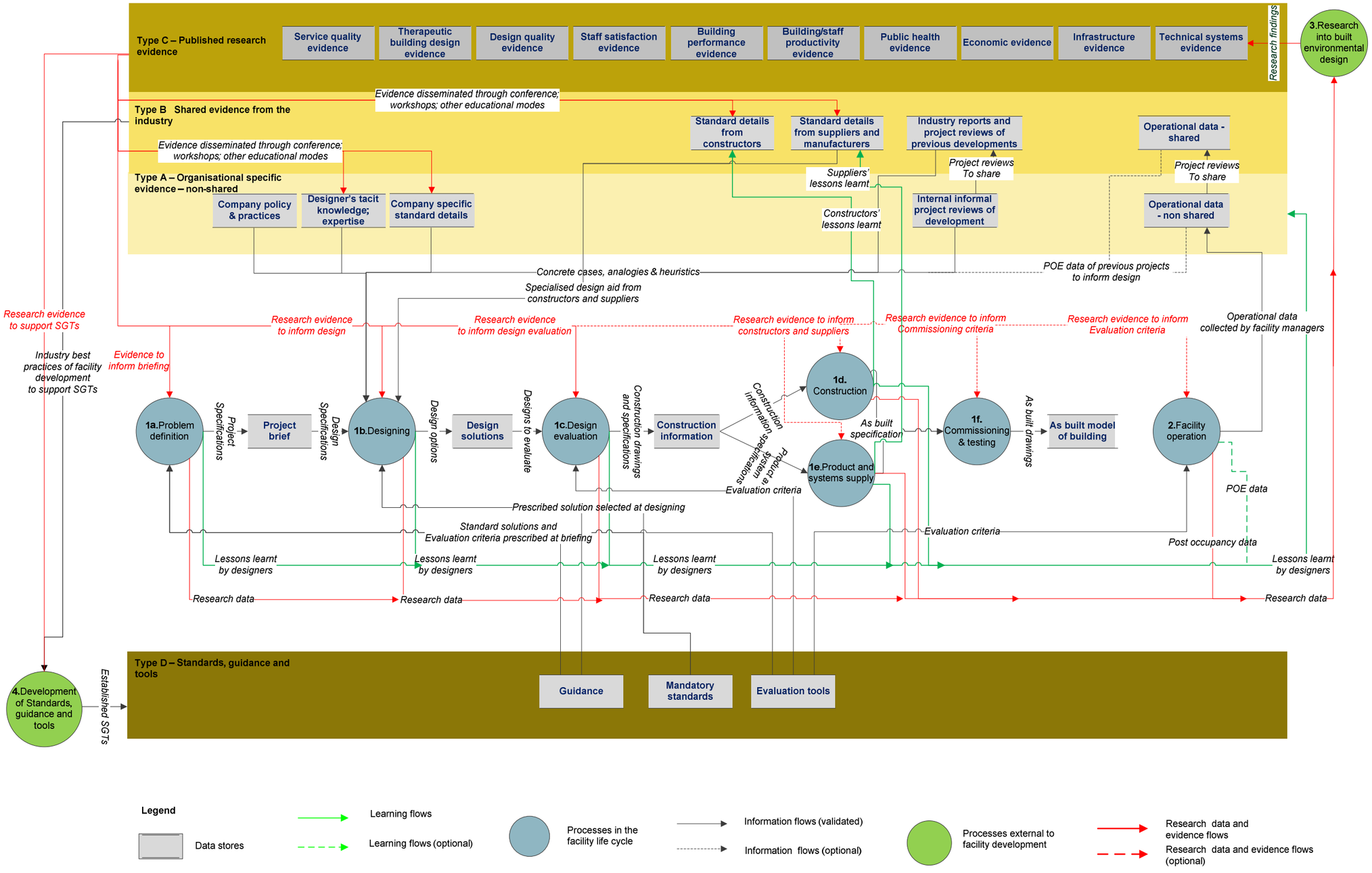
Legend

- Data stores
- Learning flows
- Learning flows (optional)
- Processes in the facility life cycle
- Information flows (validated)
- Information flows (optional)
- Processes external to facility lifecycle
- Research data and evidence flows
- Research data and evidence flows (optional)

Sources and flows of evidence model (Level 1)

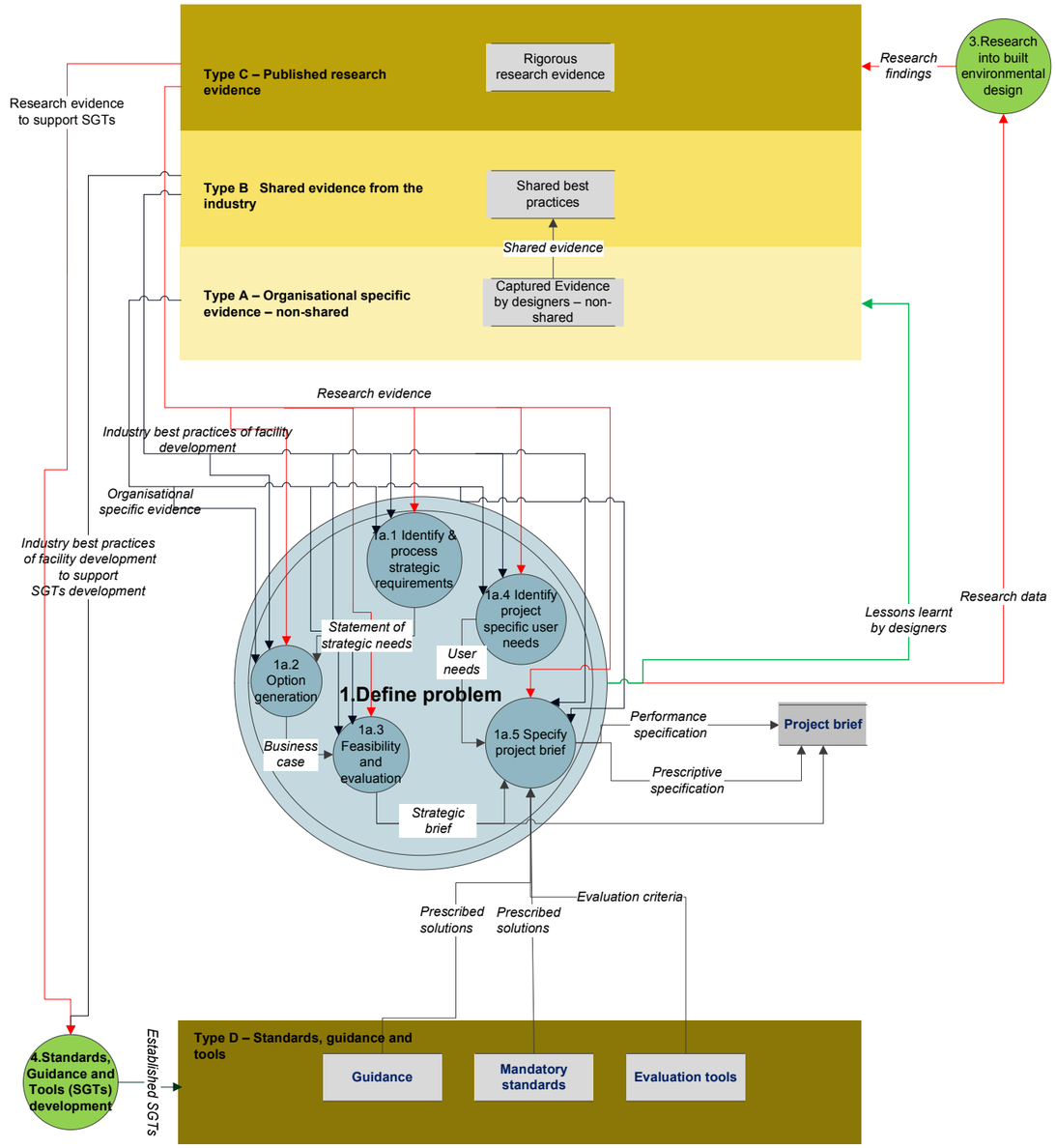
Verified version 1b 25/11/2011

Conceptual SaFE model SaFE A → **Verified SaFE model SaFE B2** → Validated SaFE model SaFE C1-C4 → Case specific SaFE models SaFE D/E/F → SaFE model with (RIBA plan of work 2013 overlay) SaFE G1 – G4



Sources and flows of evidence model (Process 1in detail – Level 2)

Verified version 1b 25/11/2011

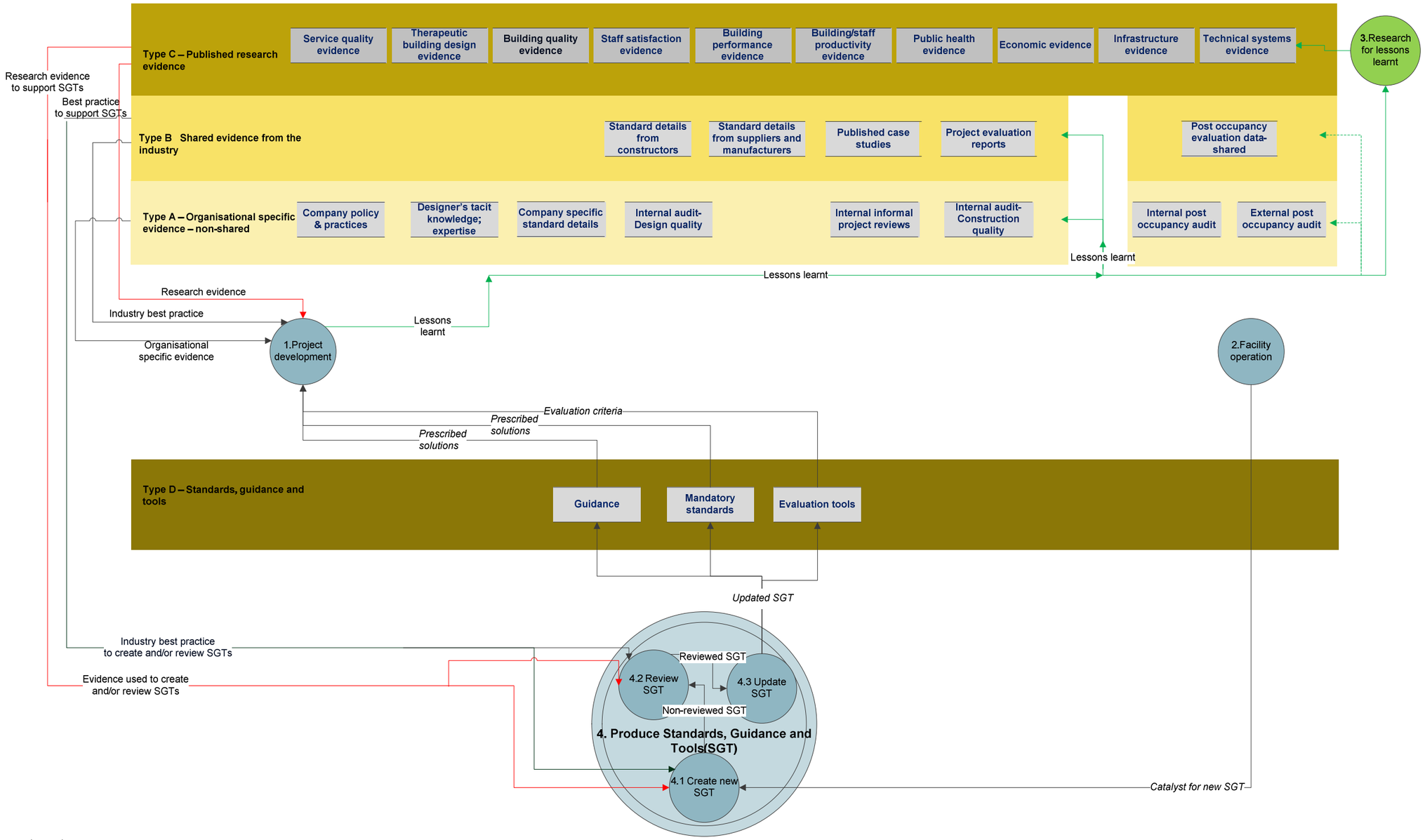


Legend

- Data stores
- Learning flows
- Learning flows (optional)
- Processes in the facility life cycle
- Information flows (validated)
- Information flows (optional)
- Processes external to facility development
- Research data and evidence flows
- Research data and evidence flows (optional)

Sources and flows of evidence model (Process 4 in detail – Level 2)

Verified version 1a 23/11/2011



Appendix C: The SaFE model validation – Interview instrument

EVIDENCE BASED DESIGN FOR HEALTHCARE BUILT ENVIRONMENTS IN THE UK

Main investigator: Nadeeshani Wanigarathna, School of Civil and Building Engineering, Loughborough University. Email: N.Wanigarathna@lboro.ac.uk; Telephone: 07413333269

Supervisor: Andrew Price, School of Civil and Building Engineering, Loughborough University. Email: A.D.F.Price@lboro.ac.uk

Supervisor: Simon Austin, School of Civil and Building Engineering, Loughborough University. Email: S.A.Austin@lboro.ac.uk

Purpose of the study

This interview is a part of a PhD study funded by The Health and Care Infrastructure Research and Innovation Centre (HaCIRIC) aim at Nurturing an Evidence Based Learning Environment for healthcare built infrastructure development.

Purpose of this interview survey is to validate the conceptual model of EBD developed through a desk study and to identify rationale behind the current practices of design process.

Section 1: Experience

1. Can you explain your experience for healthcare facility development in brief?
    a. How many years for healthcare?

Section 2: Evidence based design

1. What do you think Evidence Based Design (EBD) for healthcare is?
    a. From where do you collect evidence for a new project?
    b. From which phases of previous design, evidence are collected (Design/construction/Operation)?
    c. In which stages of the design evidence are used?
    d. Who (which parties) produce evidence for later use?
    e. How does evidence influence your work?

Section 3: Current practice of the healthcare design process

(Validation of the conceptual model of EBD and a discussion of issues around current practice)

1. What is your first impression about this diagram? (diagram is attached)
2. Four levels of evidence were identified so as to provide information to devise design solution.
    a. Are they accurate?
    b. Can you think of anything else?
    c. Are the contents of these four levels is accurate, what else should they contain?

Table: Current practices of evidence use from different types of evidence sources

	What evidence do you use for design particular to each type?	Why do you use, what are the advantages and problems of this type of sources?	How do you contribute to back to evidence of this type of sources?
Type A Sources Evidence captured by the project team non-shared (Organisational specific evidence)			Design Construction Operation
Type B sources Evidence of best practices from the industry shared by other organisations (Shared evidence from the industry)			
Type C sources Published research evidence	Subscribe any journal? Attend conferences?		
Type D sources Standards, Guidance and tools			
Any other			

3. Uses of evidence from these types of sources? And why?
    - Type A sources
    - Type B sources
    - Type C sources
    - Type D sources

4. Use of evidence at different phases – where is the effective place to incorporated evidence to design?
    a. Evidence to inform briefing – (client prescribing evidence/SGTs)
    b. Evidence to inform designing – (Designer itself use/)
    c. Evidence to inform design evaluation – AEDET/ASPECT
    d. Evidence to inform construction and supply team – (Specialised design aid)
    e. Evidence to inform commissioning criteria – (current practice)
    f. Evidence to inform POE criteria – (current practice)
    g. Evidence to inform SGTs

5. How evidence can be used in the problem formulation?
    Briefing
    a. Identify and process strategic requirements -
    b. Option generation –
    c. Feasibility and evaluation –
    d. Identify user needs –
    e. Specify project brief –

6. Research evidence - How research evidence is fed into the healthcare building design process?
    a. By educational modes (such as conferences, workshops)?
    b. Can research evidence be disseminated through constructors and suppliers?
    c. Which other ways can improve use of research evidence?

7. How do you verify and validate your design hypothesises?

Section 4: Improvements and further thoughts

8. Please comment on any other improvements you can think of to improve the use of rigorous evidence during design process?

9. What is your final and overall impression of this diagram and what are the other improvements you can think of for this diagram?

Appendix D: The validated model of the SaFE

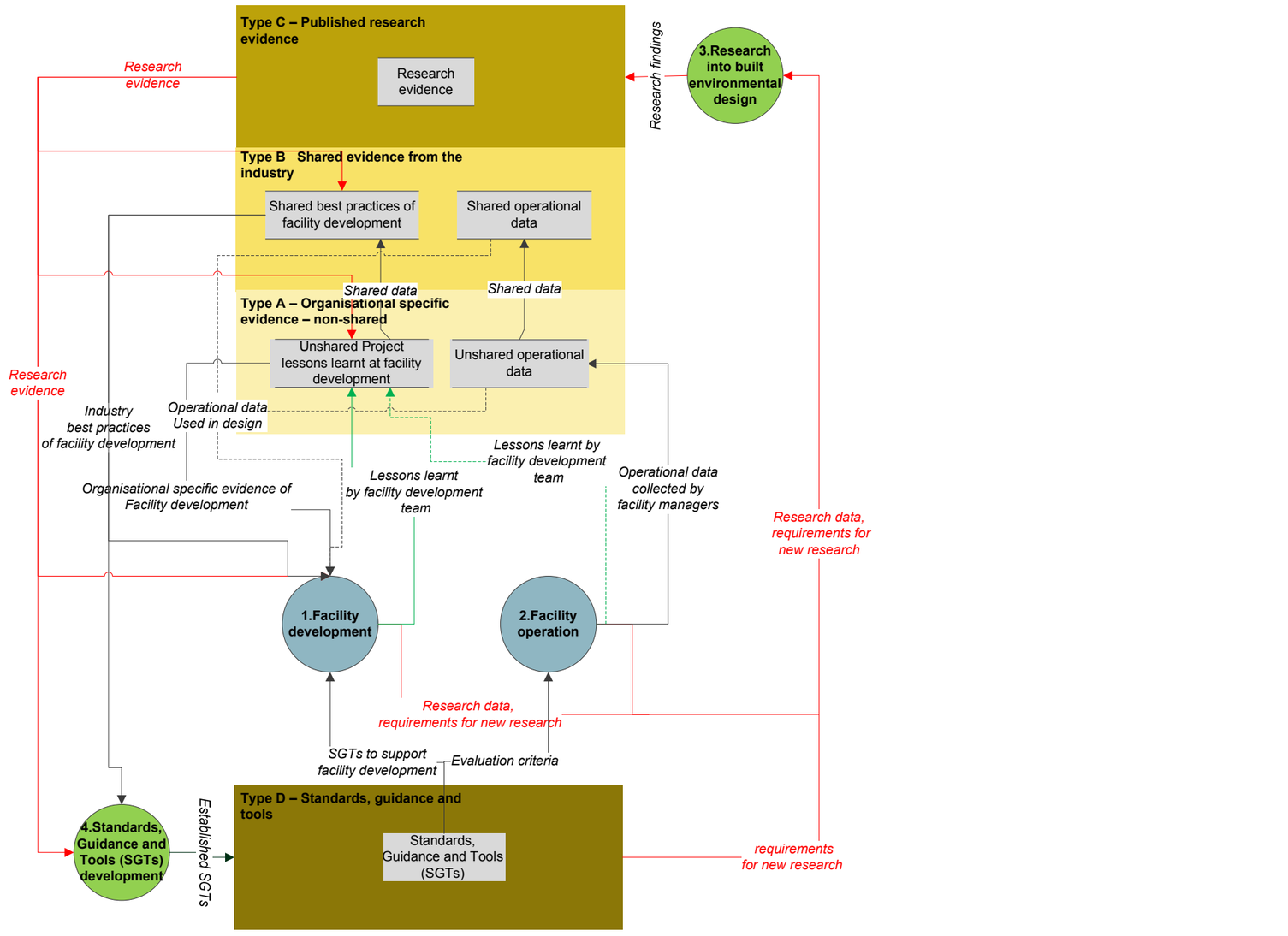
D.1 - Level 0 of the SaFE model

D.2 - Level 1 of the SaFE model

D.3 - Level 2 of the SaFE model

D.4 - SaFE models for Case studies A, B and C

Sources and flows of evidence model (Parent model)

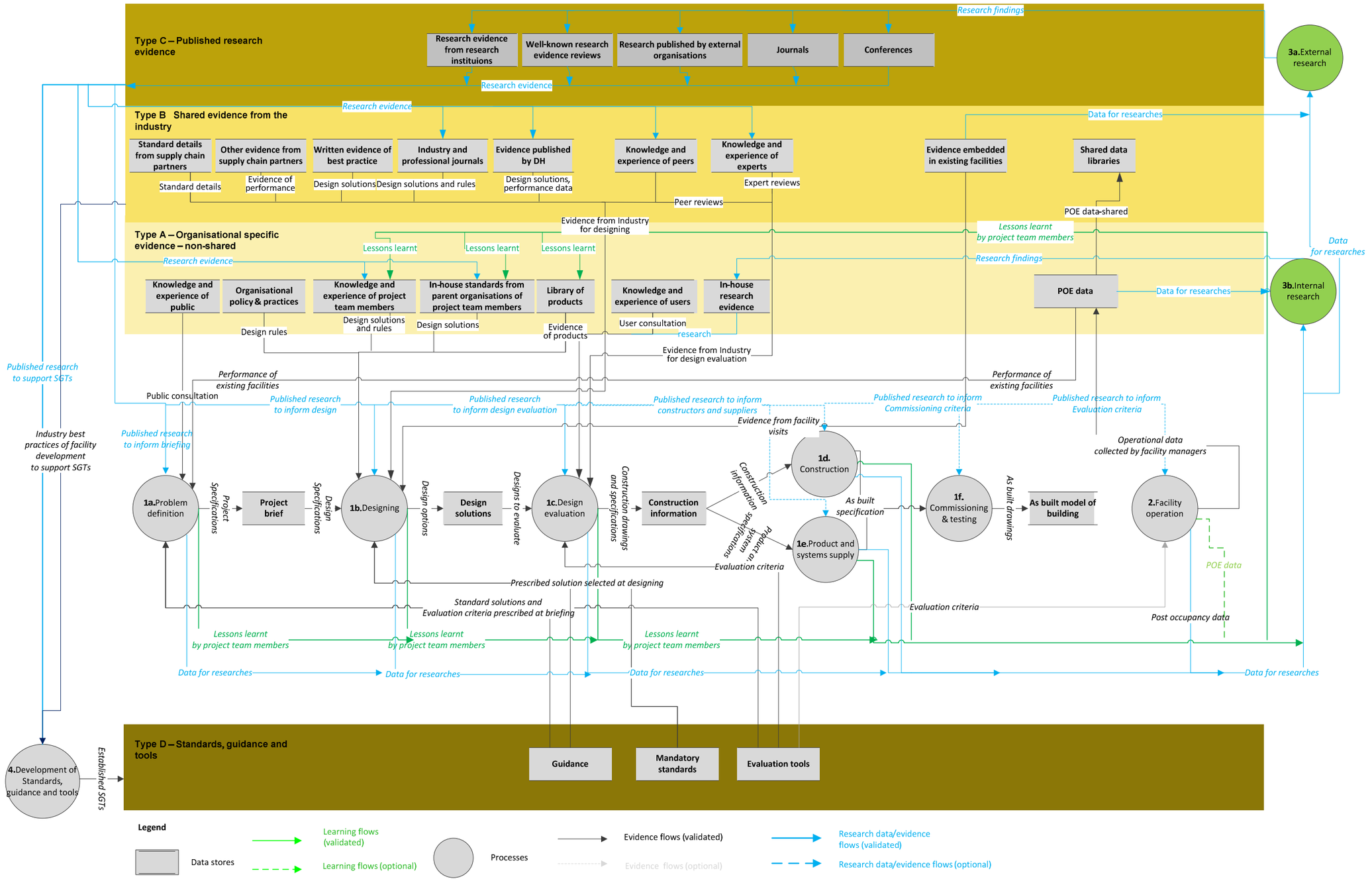


Legend

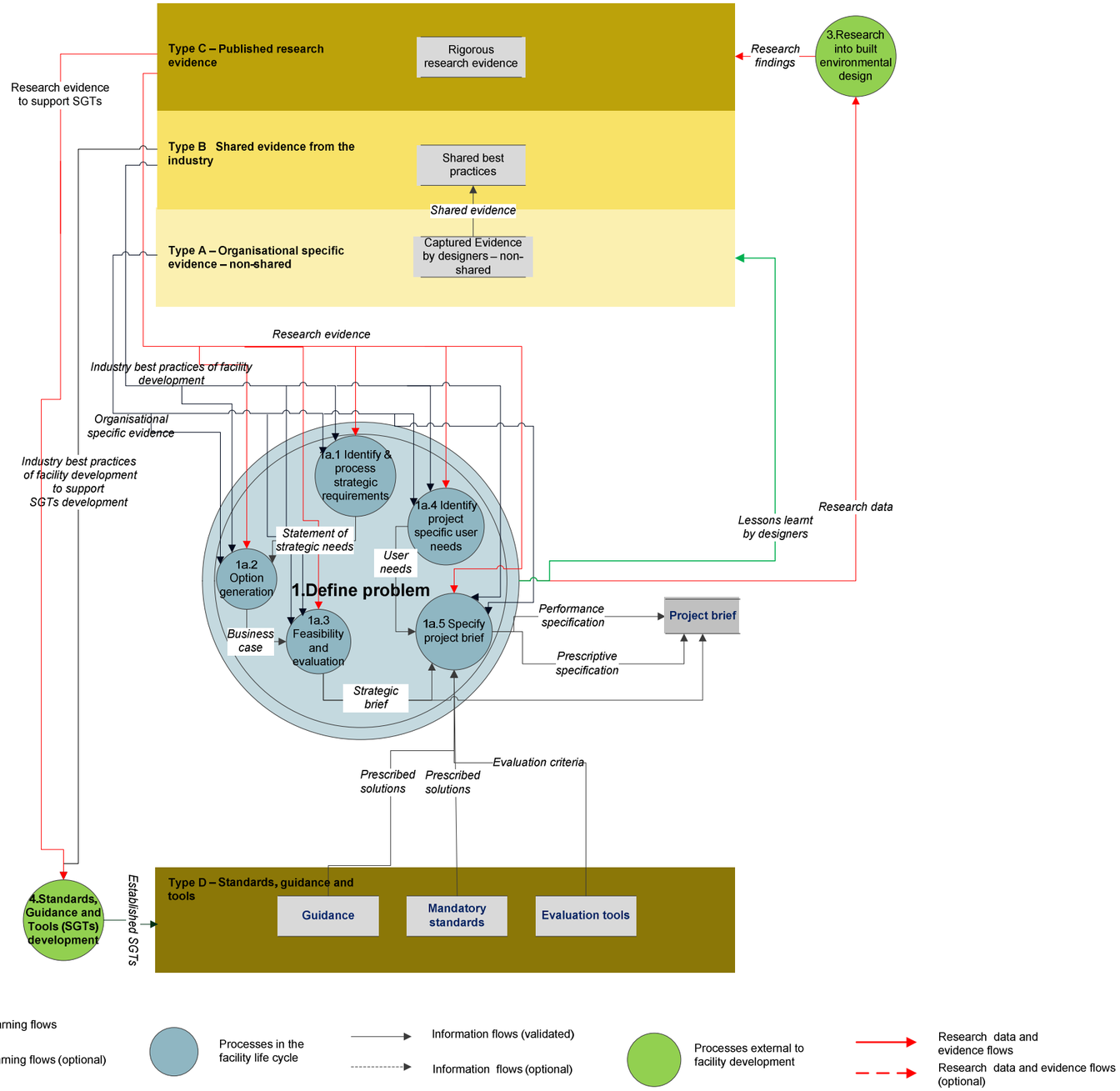
- Data stores
- Learning flows
- Learning flows (optional)
- Processes in the facility life cycle
- Information flows (validated)
- Information flows (optional)
- Processes external to facility lifecycle
- Research data and evidence flows
- Research data and evidence flows (optional)

Sources and flows of evidence model (In detail)

Conceptual SaFE model SaFE A → Verified SaFE model SaFE B4 → **Validated SaFE model SaFE C2** → Case specific SaFE models SaFE D/E/F → SaFE model with (RIBA plan of work 2013 overlay) SaFE G1 – G4

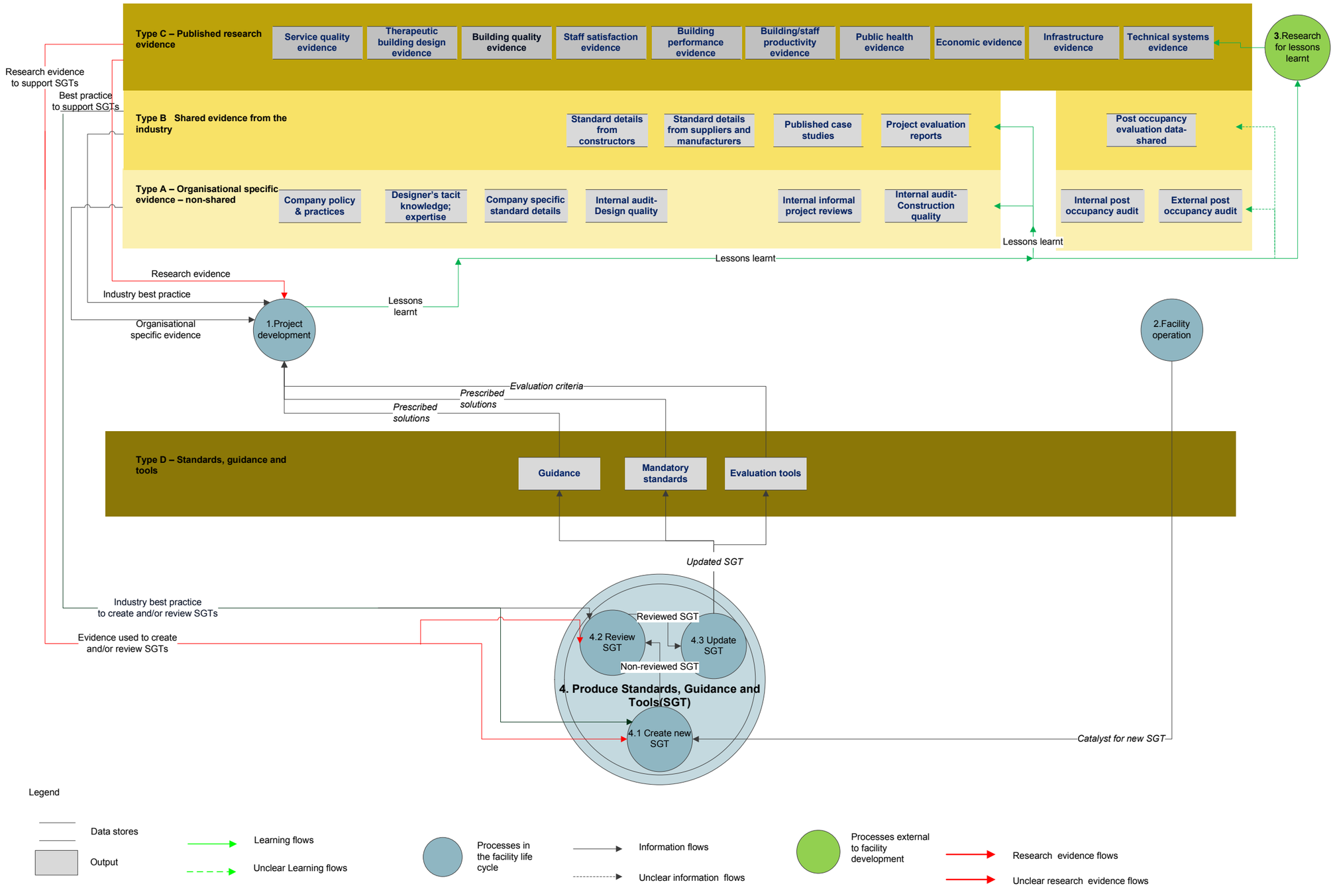


Sources and flows of evidence model (Process 1in detail)



Sources and flows of evidence model (Process 4 in detail)

Conceptual SaFE model SaFE A → Verified SaFE model SaFE B4 → **Validated SaFE model SaFE C4** → Case specific SaFE models SaFE D/E/F → SaFE model with (RIBA plan of work 2013 overlay) SaFE G1 – G4



Appendix E: Interview data analysis

E.1 - Interview analysis – Uses of evidence by four types of stakeholders

E.2- Interview analysis – AEDET mapping for evidence

E 1: Interview analysis – Uses of evidence by four types of stakeholders

Category	Type of evidence	Stakeholder				Number of stakeholders who considered the evidence type
		Healthcare client	Healthcare Contractor	Healthcare Designer	Healthcare planner	
Health outcomes	Infection control	*	*		*	3
	Patient experience	*			*	2
	Staff and patient satisfaction	*	*			2
	Clinical user experience	*				1
	Customer satisfaction - the process		*			1
	Psychological outcomes (anxiety, stress, feel)		*			1
	Average length of stay		*			1
	Staff walking				*	1
Building related performance output	Patient flows	*	*			2
	Operational flows within theatres		*		*	2
	Care models and trends	*	*			2
	Natural light	*			*	2
	Carbon foot print	*		*		2
	Adjacencies	*				1
	What it can mean spatial terms means, what it means in clinical terms , what it may mean in staffing terms				*	1
	Art and design	*				1
	View and access to nature	*				1
	How patients react to the space	*				1
	Public interest in the building	*				1
	Building performance	*				1
	Life cycle - maintenance of facility	*				1
	Functionality	*				1
	Comfortable environment		*			1
	Cleaning		*			1
	The ability to actually flow through facility		*			1
	Energy			*		1
	Acoustics			*		1
	Reducing sound				*	1
	Issue of staffing models				*	1
Inputs to designing	Knowledge and experience of materials	*	*	*	*	4
	Details of components and fittings (kerbs, bathroom fittings, doors, windows, ceiling)	*	*	*	*	4
	Specification & production information	*	*	*	*	4
	Constructability	*	*	*	*	4
	Details of engineering systems	*	*		*	3
	Room size		*	*	*	3
	Appearance	*	*			2
	Healthcare and NHS specific knowledge		*		*	2
	Operating theatres		*		*	2
	Sustainability	*		*		2
	AEDET ASPECT	*				1
	Intelligent storage	*				1
	Pharmacy	*				1
	Key themes of the design	*				1
	Height	*				1
	Colours	*				1
	Way finding	*				1
	Finishes	*				1
	Entrance	*				1
	Size of the windows	*				1
	Process of procurement - quality briefing	*				1

	coherence positively to locality	*				1
	Different layout of spaces		*			1
	Mental health unit		*			1
	Allow soft furnishes and carpets to certain areas		*			1
	Way of arranging this particular department			*		1
	Four beds ward design			*		1
	WRAP			*		1
	Future space needs				*	1
	Standard rooms				*	1
	Bathroom				*	1
	Room layout				*	1
	Single patient bedrooms				*	1
	Different ways of developing and laying out laboratory space				*	1
	Dirty clean utility room standard room detail				*	1
	Ward design				*	1

E 2: Interview analysis – AEDET mapping

	Criterion	A Type Sources	B Type Sources	C Type Sources	D Type Sources	
OVERALL					*	1
IMPACT: Character and innovation						
A.01	There are clear ideas behind the design of the building	*				1
A.02	The building is interesting to look at and move around in	*	*			2
A.03	The building projects a caring and reassuring atmosphere					
A.04	The building appropriately expresses the values of the NHS	**	**	*	*	4
A.05	The building is likely to influence future designs					
A.x6	Service innovation	*	*	*		3
IMPACT: Form and materials						
B.01	The building has a human scale and feels welcoming		*	*		3
B.02	The design takes advantage of available sunlight and provides shelter from prevailing winds					
B.03	Entrances are obvious and logically positioned in relation to likely points of arrival on site		*			1
B.04	The external materials and detailing appear to be of high quality					
B.05	The external colours and textures seem appropriate and attractive					
IMPACT: Staff and patient environment		**	*	**		3
C.01	The building respects the dignity of patients and allows for appropriate levels of privacy and dignity	*				1
C.02	There are good views inside and out of the building	*			*	2
C.03	Patients and staff have good access to outdoors	*				1
C.04	There are high levels of both comfort and control of comfort	*		*		2
C.05	The building is clearly understandable	*	*			2
C.06	The interior of the building is attractive in appearance	*	*			2
C.07	There are good bath/toilet and other facilities for patients	**			*	2
C.08	There are good facilities for staff, including convenient places to work and relax without being on demand					
IMPACT: Urban and social integration						
D.01	The height, volume and skyline of the building relate well to the surrounding environment					
D.02	The building contributes positively to its locality					
D.03	The hard and soft landscape around the building contribute positively to the locality	*				1
D.04	The building is sensitive to neighbours and passers-by	*				1
BUILD QUALITY: Performance					*	1
E.01	The building is easy to operate	**	*			2
E.02	The building is easy to clean	*	*	**	*	4
E.03	The building has appropriately durable finishes		*		*	2
E.04	The building will weather and age well					
BUILD QUALITY: Engineering						
F.01	The engineering systems are well designed, flexible and efficient in use	***	***		**	3
F.02	The engineering systems exploit any benefits from standardisation and prefabrication where relevant					
F.03	The engineering systems are energy efficient		**		*	2
F.04	There are emergency backup systems that are designed to minimise disruption					
F.05	During construction disruption to essential services is minimised					
BUILD QUALITY: Construction						
G.01	If phased planning and construction are necessary the various stages are well organised					

G.02	Temporary construction work is minimised					
Table cont'd from the previous page						
G.03	The impact of the building process on continuing healthcare provision is minimised					
G.04	The building can be readily maintained					
G.05	The construction is robust	***	*	*		3
G.06	The construction allows easy access to engineering systems for maintenance, replacement and expansion					
G.07	The construction exploits any benefits from standardisation and prefabrication where relevant	***	**		*	3
FUNCTIONALITY: Use						
H.01	The prime functional requirements of the brief are satisfied	*	*			2
H.02	The design facilitates the care model of the Trust					
H.03	Overall the building is capable of handling the projected throughput	*				1
H.04	Work flows and logistics are arranged optimally	**	*	*		3
H.05	The building is sufficiently adaptable to respond to change and to enable expansion		*			1
H.06	Where possible spaces are standardised and flexible in use patterns	*			*	2
H.07	The layout facilitates both security and supervision		*			1
FUNCTIONALITY: Access						
I.01	There is good access from available public transport including any on-site roads					
I.02	There is adequate parking for visitors and staff cars with appropriate provision for disabled people					
I.03	The approach and access for ambulances is appropriately provided					
I.04	Goods and waste disposal vehicle circulation is good and segregated from public and staff access where appropriate					
I.05	Pedestrian access routes are obvious, pleasant and suitable for wheelchair users and people with other disabilities / impaired sight					
I.06	Outdoor spaces are provided with appropriate and safe lighting indicating paths, ramps and steps					
I.07	The fire planning strategy allows for ready access and egress				*	1
FUNCTIONALITY: Space		***	***	***	*	4
J.01	The design achieves appropriate space standards	**			***	2
J.02	The ratio of usable space to the total area is good					
J.03	The circulation distances travelled by staff, patients and visitors are minimised by the layout			*		1
J.04	Any necessary isolation and segregation of spaces is achieved					
J.05	The design makes appropriate provision for gender segregation					
J.06	There is adequate storage space					
PROCESS: PROCUREMENT		**	***	**		3
SUSTAINABILITY		**		*	*	3

Appendix F: Case study data collection instrument

Case study instrument

Loughborough University

Standardised and bespoke/innovative approaches to evidence based design

Purpose: Exploration of evidence based design activities for selected four Standard/Traditional and four Bespoke/Innovative design components/elements/spaces

Table 1: Details of the design components/elements/spaces selected for the further study

Design approach	Selected components/elements/spaces for this study	
Innovative/Bespoke	1	Single bed room - On-suit bathroom - Bed head
	2	Communal spaces
	3	Ward layout -Clinical workstations
	4	Window design/ ventilation strategy
Standardised/Traditional	5	Finishes (Floor, wall and Ceiling)
	6	Water services
	7	Isolation room
	8	Doors

Methods: Interviews/discussions with representatives of the design team and representatives of the client/hospital (for 3 hospitals)

Document analysis (derogation (from standards) reports, post-occupancy evaluation results, etc..

Structure of the interviews/discussions (Semi – structured interviews)

1) Design strategy (for each element)

a) Why was the decision made to be Standard/Traditional or Bespoke/Innovative?
   - Were there any options? Or was it an iterative process?
   - What were the decision-making factors that need to be considered?

b) Who was involved in the decision making? – client, healthcare planner, architect, constructor

c) What evidence did you gather and how?
   - Internal evidence (including knowledge and expertise)
   - External evidence (including Standards, guidance and tools)

2) Design development and validation (for each element)

a) What were the main performance characteristics expected from the component X?

b) How they were expressed to the design team?

c) How was the performance assessed at design phase (e.g. theoretically, by testing or prototyping)?

3) Experience of the each element in use

a) Was the performance evaluated in use?

If yes
   - Who and when?
   - How was the performance evaluated?

b) Results of performance evaluation
   - Was it judged a success or failure, and why?
   - In what ways component 'X' is a success? And what evidence available to say so?

- What are the disappointments? Or what could have been improved? And what evidence available to say so?

c) Has the learning been captured for future design, and if so how?

d) In hindsight was the right decision made to adopt a standard or innovative solution (and why)?

4) Project-unique circumstances influencing the process

(Separately for Innovative/Bespoke and Standard/Traditional approaches to design of component/element/space)

a) Were there any contextual conditions that impacted on 1, 2 and 3 above?

b) Were there any skills, resources and stakeholder authority/responsibility required?

c) What could have been improved in terms of 1, 2 and 3 above?

Appendix G: Case study data analysis – Element stories

G.1 - Element stories for Case A

G.2 - Element stories for Case B

G.3 - Element stories for Case C

G.1 - Element stories for Case A

Index	Exemplar design element	No of design activities	Element story up to end of the design phase											
A.1	room layout - dimensions	4	Identify the design problem [A27D]	Devise a solution [A28C]	Evaluate the solution [A29D]	Adopt the solution [A30]								
			Trust requirements [A27D]	Site constraints [A28C]	Physical mock-up [A29D]	N/A-Decision [A30]								
A.2	Detail arragement inside the room	9	Brief to the design team [A46C]	Brief to the design team [A47C]	Brief to the design team [A48C]	Specify design in part [A49CD]	Devise a solution [A50]	Evaluate the solution [A51C]	Improve the solution - for mock-up results [A52C]	Improve the solution - for mock-up results [A53CD]	Post project learning - update GOSH standards [A54C]			
			Research - roger Ulrich [A46C]	Knowledge and experience - client [A47C]	Research - roger Ulrich [A48C]	Knowledge and experience - client - articulated into GOSH standards [A49CD]	Knowledge and experience - design team [A50]	Physical mock-up [A51C]	Physical mock-up [A52C]	Physical mock-up [A53CD]	Lessons learnt [A54C]			
A.3	Room layout - what goes in	4	Fix space requirements of standards and guidance [A34D]	Identify patients' preferences [A35D]	Identify other requirements [A36D]	Proceed with the solution [A37]								
			Standards and guidance [A34D]	Physical mock-up - small scale visits to childrens' destinations [A35D]	Knowledge and experience [A36D]	N/A-Decision [A37]								
A.4	Room layout - wardrobes	6	Identify user requirements [A38D]	Check what guidance says [A39D]	Guidance is silent - use knowledge and experience [A40D]	Identify a solution [A41D]	Evaluate the solution [A42D]	Proceed with the solution [A43]						
			Knowledge and experience [A38D]	Standards and guidance [A39D]	N/A-Decision [A40D]	Knowledge and experience [A41D]	Knowledge and experience [A42D]	N/A-Decision [A43]						
A.5	Location of on-suit	3	Devise several optional solutions [A31D]	Evaluate optional solutions [A32D]	Select the most suited solution [A33D]									
			Knolwedge and experience [A31D]	Knowledge and experience - design team and client [A32D]	N/A-Decision [A33D]									

Index	Exemplar design element	No of design activities	Element story up to end of the design phase											
A.6	Bed head service panel	10	Analyse existing system in use [A60CD]	Identify externally available solutions [A62D]	Identify externally available solutions [A63D]	Evaluate externally available solutions [A64D]	Reject all solutions [A65D]	Devise a (bsepoke) solution [A66CD]	Evaluate the solution [A67D]	Evaluate the solution [A68D]	Detail design of the solution [A69D]	Detail design of the solution [A70D]		
			Knowledge and experience - client - own other building [A60CD]	Evidence from supplier/ manufacturer [A62D]	Evidence from the industry [A63D]	User consultation [A64D]	Decision - all above [A65D]	Evidence from supplier/ manufacturer [A66CD]	User consultation [A67D]	Knowledge and experience - contractor [A68D]	Evidence from supplier/ manufacturer [A69D]	Knowledge and experience - design team and client [A70D]		
A.7	Control of environment	2	Identify problems of existing system [A72D]	Improve the design - mitigate problems [A73D]										
			User consultation [A72D]	Knowledge and experience [A73D]										
A.8	Ward layout	16	Identify space requirements [A88C]	Identify space requirements [A89C]	Identify space requirements [A90C]	Identify fucntional requirements [A91C]	Identify other requirements [A92D]	Collect other information - demographic details of hospital [A93C]	Prioritise space requirements [A94C]	Identify heirarchy of the spaces [A95CD]	Identify heirarchy of the spaces [A96D]	Devise a solution [A97C]	Model space use [A98D]	Develop the solution [A99D]
			Schedule of accomodation [A88C]	Trust requirements [A89C]	Schedule of accomodation [A90C]	Schedule of accomodation [A91C]	User consultation [A92D]	Operating principles and other details [A93C]	Knowledge and experience - design team and client [A94C]	Knowledge and experience - design team and client [A95CD]	Knowledge and experience - design team and client [A96D]	Knowledge and experience - design team standards and guidance [A97C]	User consultation [A98D]	Graphical model [A99D]
			Identify and mitigate problems [A100D]	Identify and mitigate problems [A101D]	Improve the solution - resulted from other changes [A102D]	Identify and mitigate problems [A103D]								
			Knowledge and experience - design team and client [A100D]	Knowledge and experience - design team and client [A101D]	Result of another solution [A102D]	Visits to other hospitals [A103D]								
A.9	% of single bed rooms	9	Identify a solution from standards and guidance [A17CD]	Evaluate the design [A18C]	Evaluate the design [A19D]	Evaluate the evidence [A20C]	Evaluate the evidence [A21C]	Evaluate the evidence [A22C]	Compare and contrast evidence with project objectives [A23C]	Devise a (bespoke)solution [A24C]	Evaluate the solution [A25C]			
			NHS papers [A17CD]	User consultation - staff [A18C]	Knowledge and experience [A19D]	Visits to international hospitals [A20C]	Visits to local hosptials [A21C]	Knowledge and experience - client - own other building [A22C]	Knowledge and experience - clienttrust requirements [A23C]	Knowledge and experience - clientstandards and guidance [A24C]	Knowledge and experience - client [A25C]			

Index	Exemplar design element	No of design activities	Element story up to end of the design phase											
A.10	Nurse base - decentralisation vs central	9	Identify an externally available solution [A104C], [A105C], [A106CD]	Compare solution with problems of existing system [A107CD]	Identify positive impacts [A108C]	Identify positive impacts [A109D]	Compare solution for other existing problems [A110D]	Identify positive impacts [A111D]	Identify negative impacts [A112D]	Identify negative impacts [A113D]	Adapt the solution [A114D]			
			Visits to international hospitals [A104C], [A105C], [A106CD]	User consultation - children and parents [A107CD]	Knowledge and experience [A108C]	Knowledge and experience [A109D]	Research [A110D]	Knowledge and experience [A111D]	Research [A112D]	Research [A113D]	Knowledge and experience [A114D]			
A.11	Nurse base - level of decentralisation	5	Decide the most suited design option [A115D]	Evaluate the solution [A116D]	Evaluate the solution [A117D]	Physical mock-up [A118D]	Improve the design - for mock-up results [A120D]							
			Knowledge and experience [A115D]	Knowledge and experience [A116D]	User consultation [A117D]	Physical mock-up [A118D]	Physical mock-up [A120D]							
A.12	Recessed PC	4	Identify design requirements [A121aC]	Identify an innovative solutions from the industry [A121bC]	Evaluate the solution [A122C]	Adapt solution for some areas [A123C]								
			Physical mock-up [A121aC]	Evidence from supplier/ manufacturer [A121bC]	Evidence from the supplier/ manufacturer user consulatation [A122C]	User consulatation [A123C]								
A.13	Play area	7	Start with traditional solution [A134D]	Identify problems of existing system [A135D]	Identify user requirements [A136D]	Devise a solution [A137D]	Identify additional funtions [A138D]	Improve the solution - support additional functions [A139D]	Improve the design - generic [A140D]					
			Knowledge and experience - design team and client [A134D]	Visits to local hospitals or Jo's experience?? [A135D]	User consultation - patients [A136D]	Knowledge and experience-client specialists [A137D]	User consultation - play specialist staff [A138D]	Knowledge and experience - client [A139D]	Knowledge and experience - design team and client [A140D]					
A.14	Parents waiting space	4	Identify user requirements [A141D]	Devise a solution [A142D]	Identify additional funtions [A143D]	Improve the solution - support additional functions [A144D]								

Index	Exemplar design element	No of design activities	Element story up to end of the design phase											
			Knowledge and experience - client user consultation - parents [A141D]	Knowledge and experience [A142D]	User consultation - parents knowledge and experience - client [A143D]	Knowledge and experience - design team [A144D]								
A.15	Staff rest	6	Identify user requirements [A145D]	Identify user requirements [A146D]	Collect and evaluate the evidence [A147D]	Devise a solution [A148D]	Devise a solution [A149D]	Evaluate the solution [A150D]						
			Knowledge and experience [A145D]	User consultation - staff [A146D]	Visits to local hospitals or Jo's experience?? [A147D]	Resource constraints [A148D]	Knowledge and experience [A149D]	Knowledge and experience [A150D]						
A.16	Isolation room	11	Analyse existing system in use [A218CE]	Identify a solution [A219D]	Evaluate the solution [A220D]	Evaluate the solution [A221C]	Evaluate the solution [A222D]	Identify positive impacts [A223D]	Adopt the soultion [A224CD]	Devise the engineering design [A226D]	Identify negative impacts [A227D]	Identify positive impacts [A228D]	Improve the design - support flexibility [A229D]	
			Knowledge and experience - client, engineer [A218CE]	Standards and guidance [A219D]	Expert opinion [A220D]	Research by DH and WSP [A221C]	Computational modelling [A222D]	Knowledge and experience [A223D]	Decision - all above [A224CD]	Knowledge and experience - Engineer [A226D]	Knowledge and experience [A227D]	Knowledge and experience [A228D]	Knowledge and experience [A229D]	
A.17	Finishes - generic	6	Identify project requirements [A178D]	Identify available products [A188D]	Evaluate products -by the designer [A189D]	Evaluate products for clients' criterions [A190D]	Select/shortlist products for different spaces [A191]	Evaluate products [A192DC]	Re-consider another option for failed products [A193D]					
			Trust requirements [A178D]	Knowledge and experience - design team, evidence from the industry [A188D]	Knowledge and experience - design teamstandards and guidanceevidence from supplier/manufacturer [A189D]	Knowledge and experience - clientuser consultation [A190D]	Decision - all above [A191]	Enabling works [A192DC]	Knowledge and experience - design team and clientstandards and guidanceevidence from supplier/ manufacturer [A193D]					
A.18	Finishes - on-suit floor	3	Identify a solution [A195]	Evaluate the solution [A196C]	Improve the design - mitigate problems [A197C]									

Index	Exemplar design element	No of design activities	Element story up to end of the design phase											
			Knowledge and experience - design team and client standards and guidance evidence from supplier/ manufacturer [A195]	Physical mock-up [A196C]	Knowledge and experience - client [A197C]									
A.19	Ceiling finishes	8	Identify a solution [A201D]	Evaluate products -by the designer [A202D]	Compare products for different requirements [A203D]	Select/shortlist products for different spaces [A204D]	Select/shortlist products for different spaces [A205D]	Evaluate products [A206D]	Select other products for rejected ones [A207D]	Improve the design - mitigate problems [A208D]				
			Knowledge and experience - design team evidence from supplier/ manufacturer [A201D]	Standards and guidance evidence from supplier/ manufacturer knowledge and experience [A202D]	Knowledge and experience - FM people space hierarchy details [A203D]	Decision [A204D]	Knowledge and experience - design team [A205D]	Physical mock-up [A206D]	Physical mock-up [A207D]	Knowledge and experience - Engineer [A208D]				
A.20	Doors - generic	4	Identify details of traffic for each door [A248D]	Categorise routes public,FM,staff,etc .. [A249D]	Identify design requirements for each type of door [A250D]	Identify solutions for each type of door [A251D]								
			User consultation [A248D]	User consultation [A249D]	Knowledge and experience [A250D]	Knowledge and experience [A251D]								
A.21	Finishes - doors	3	Start with traditional solution [A198C]	Identify problems of traditional system [A199C]	Improve the design - mitigate problems [A200C]									
			Knowledge and experience - design team and client [A198C]	Knowledge and experience - client - own other building [A199C]	Knowledge and experience - client - own other building [A200C]									
A.22	Doors - finger traping solutions	9	Identify a specific problems [A252D]	Identify externally available solutions [A253D]	Evaluate solutions [A254D]	Reject available solutions [A255D]	Devise a (bespoke) solution [A256D]	Evaluate the solution [A257D]	Mock-up [A258D]	Identify drawbacks [A259D]	Improve the design - for mock-up results [A260D]			
			User consultation [A252D]	Evidence from the industry [A253D]	User consultation K&E [A254D]	User consultation K&E [A255D]	Evidence from supplier/ manufacturer [A256D]	Physical mock-up [A257D]	Physical mock-up [A258D]	Physical mock-up [A259D]	Knowledge and experience [A260D]			

Index	Exemplar design element	No of design activities	Element story up to end of the design phase											
A.23	Single room door	3	Identify project requirements [A44aD]	Construct a solution [A44bD]	Technical detailing [A45D]									
			result of another solution [A44aD]	Result of another solution [A44bD]	Evidence from supplier/ manufacturer [A45D]									
A.24	Not having smart glass	5	Identify an innovative solutions [A55D]	Evaluate the solution [A56D]	compare negative and positive impacts [A57D]	Reject the solution [A58D]	Adopt the traditional solution [A59D]							
			Evidence from supplier/ manufacturer [A55D]	Knowledge and experience [A56D]	Physical mock-up knowledge and experience [A57D]	Physical mock-up knowledge and experience [A58D]	Knowledge and experience [A59D]							
A.25	Water services	8	Identify an innovative solution from the industry [A233CE]	Compare and contrast evidence with project objectives [A234E]	Evaluate the solution [A235D]	Generate evidence [A236E]	Evaluate the evidence [A237E]	Adopt solution [A238E]	Improve the design - support additional functions [A239C]	Improve the design - mitigate problems [A240C]				
			Evidence from the industry [A233CE]	Knowledge and experience - client client requirements [A234E]	Evidence from supplier/ manufacturer knowledge and experience - client and engineer [A235D]	Internal evidence generation through research [A236E]	Knowledge and experience - engineer [A237E]	Decision - all above [A238E]	Standards and guidance knowledge and experience - engineer [A239C]	Standards and guidance knowledge and experience - engineer [A240C]				
A.26	Ventilation strategy	3	Identify current trends [A159aD]	Evaluate options [A159bD]	Decide on ventilation strategy [A160]									
			Knowledge and experience [A159aD]	Knowledge and experience [A159bD]	Knowledge and experience trust requirements standards and guidance [A160]									
A.27	Window/ventilation design - room	12	Identify optional solutions [A161D]	Evaluate optional solutions [A162D]	Identify the design/constraints [A163D]	Select the most suited solution [A164D]	Evaluate the solution [A165D]	Improve the design - mitigate problems [A166D]	Evaluate the evidence [A167D]	Evaluate the solution [A168D]	Improve the design - support additional functions [A169D]	Evaluate the solution [A170D]	Physical mock-up [A171D]	Model performance [A172D]
			Knowledge and experience - engineer evidence from industry [A161D]	Knowledge and experience - design team and client [A162D]	Standards and guidance site constraints [A163D]	Decision - all above [A164D]	User consultation [A165D]	Evidence from the industry [A166D]	Visits to other facilities [A167D]	User consultation [A168D]	knowledge and experience [A169D]	Evidence from supplier/ manufacturer [A170D]	Physical mock-up [A171D]	Computational modelling [A172D]

G.2 - Element stories for Case B

Index	Exemplar design element	No of design activities	Element story up to end of the design phase										
B.1	Provision of single room	20	Identify an externally available solution [B1C]	Evaluate the solution [B2C]	Evaluate the solution [B3C]	Evaluate the solution [B4C]	Generate evidence [B5CD]	Collect evidence [B6CD]	Evaluate evidence [B7C]	Collect evidence [B8C]	Collect evidence [B9C]	Collect evidence [B10CD]	Collect evidence [B11C]
			Research [B1C]	Client's requirements - [B2C]	Client's requirements [B3C]	Expert opinion - community health council [B4C]	Internal evidence generation through research - NHS Wales [B5CD]	Visits to local hospitals [B6CD]	Visits to local hospitals [B7C]	Visits to international hospitals [B8C]	Web searches for international examples [B9C]	Expert opinion - Roger Ulrich [B10CD]	Published research evidence from the industry [B11C]
			Collect evidence [B12C]	Evaluate the solution [B13C]	Evaluate the solution [B14C]	Evaluate the solution [B15C]	Evaluate the solution - negative arguments [B16CD]	Evaluate the solution - positive impacts [B17C]	Evaluate the solution - positive impacts [B18C]	Evaluate the solution - positive impacts [B19C]	Evaluate the solution - positive impacts [B20C]		
			Internal evidence generation through research - clinical staff [B12C]	Expert opinion - present at conferences [B13C]	Expert opinion - patient safety agency [B14C]	Expert opinion - environmental isses [B15C]	User consultation [B16CD]	Client's requirements [B17C]	Knowledge and experience - client [B18C]	Knowledge and experience - client [B19C]	Knowledge and experience - client [B20C]		
B.2	Single room design	14	Identify a solution [B22aD]	Evaluate evidence (standards and guidance) [B22bD]	Formulate perfomance specification [B23CD]	Prioritise performance expectations [B24D]	Identify externally available solutions [B25C]	Evaluate evidence [B26C]	Devise several optional solutions [B27CD]	Evaluate solutions [B28CD]	Short list three optional solutions [B29D]	Evaluate solutions [B30CD]	Evaluate solutions [B31D]
			Standards and guidance [B22aD]	Knowledge and experience - design team and client client's requirements [B22bD]	Knowledge and experience - design team and client hospital operational policy client's requirements [B23CD]	Knowledge and experience - design team and client [B24D]	Visits to local hosptials [B25C]	User consultation - staff knowledge and experience - client [B26C]	Knowledge and experience - design team published research DH literature on single rooms expert lectures by Roger Ulrich Visits to local hospitals [B27CD]	Expert opinion - Welsh health of esteates, environmental authorities, patient safety agency, community health council knowledge and experience - stakeholders [B28CD]	Decision - above all [B29D]	Physical mock-up [B30CD]	Physical mock-up knowledge and experience - design team Individually by NA by health planners by board, by staff by puplic expert opinion - WHE, community health council environmental authority patient safety agency K&E - contractor [B31D]
			Select best suited option [B32D]	Detail design [B33D]	Evaluate the solution [B34D]								
			Decision - all above [B32D]	Standards and guidance HIS standards [B33D]	Physical mock-up - knowledge and experience - client [B34D]								

Index	Exemplar design element	No of design activities	Element story up to end of the design phase										
B.3	On-suit	8	Identify a solution [B37]	Evaluate the solution [B38aCD]	Identify optional solutions [B39C]	Evaluate optional solutions [B40C]	Select best suited option [B41C]	Improve the solution - mitigate negative aspects [B42C]	Devise a solution [B38bCD]	Evaluate the solution [B38cCD]			
			Standards and guidance [B37]	Knowledge and experience - design team and client [B38aCD]	Knowledge and experience - design team and client [B39C]	Stakeholder consultation [B40C]	Decision - all above [B41C]	Knowledge and experience - stakeholders standards and guidance [B42C]	Knowledge and experience - design team and client [B38bCD]	Physical mock-up [B38cCD]			
B.4	En-suit - size	5	Idenfity a solution [B173D]	Evaluate the solution [B174CD]	Evaluate evidence [B175D]	Devise a bespoke solution [B176D]	Evaluate the solution [B177]						
			Standards and guidance [B173D]	Knowledge and experience - design team and client [B174CD]	Visits to hospitals evidence from the industry [B175D]	Knowledge and experience - design team and client [B176D]	Physical mock-up [B177]						
B.5	Bed head service	5	Evaluate the existing system in use [B43CD]	Identify an innovative solution [B44CD]	Evaluate the solution [B45CD]	Adopt the solutions [B46D]	Detail design [B47C]						
			User consultation [B43CD]	Knowledge and experience - design team [B44CD]	Knowledge and experience - stakeholders expert opinion - PSA [B45CD]	Decision - all above [B46D]	Knowledge and experience - health planners expert opinion - Patient safety agency user consultation [B47C]						
B.6	Ward shape	4	Identify project requirements [B64C]	Evaluate evidence [B65C]	Identify several optional solutions [B66CD]	Evaluate optional solutions [B67CD]							
			Clients requirements [B64C]	Visits to hospitals [B65C]	Knowledge and experience - design team [B66CD]	Knowledge and experience - stakeholders [B67CD]							
B.7	Ward layout	6	Identify space requirements [B84D]	Evaluate evidence [B85D]	Devise a solution [B86D]	Evaluate the solution [B87D]	Reformulate space requirements [B88]	Improve the design [B89D]					

Index	Exemplar design element	No of design activities	Element story up to end of the design phase										
			Clients' requirements - schedule of accommodation [B84D]	Visits to hospitals [B85D]	Knowledge and experience - design team [B86D]	Knowledge and experience - stakeholders expert opinion [B87D]	Knowledge and experience - health planners [B88]	Knowledge and experience - design team [B89D]					
B.8	% single rooms	4	Check what guidance says [B208D]	Identify a solution [B209aD]	Evaluate the solution [B209bD]	Devise a bespoke solution [B210D]							
			Standards and guidance [B208D]	Client's requirements [B209aD]	Knowledge and experience - stakeholders [B209bD]	Knowledge and experience - stakeholders [B210D]							
B.9	Staff base	8	Identify a solution [B69D]	Evaluate the solution -identify positive impacts [B70CD]	Evaluate the solution -identify negative impacts [B71D]	Design a bespoke solution [B72CD]	Evaluate the solution [B73C]	Improve design - support negative impacts [B74C]	Evaluate the solution [B75CD]	Improve design - mock-up results [B76D]			
			Standards and guidance [B69D]	Knowledge and experience - director of nursing [B70CD]	Knowledge and experience - client [B71D]	Knowledge and experience - director of nursing and health planners [B72CD]	Knowledge and experience - client [B73C]	Knowledge and experience - client [B74C]	Physical mock-up [B75CD]	New evidence generated through mock-up [B76D]			
B.10	Computer at staff base	3	Identify a specific problems [B77C]	Formulate performance specification [B78]	Identify a solution [B79C]								
			Knowledge and experience - client [B77C]	Knowledge and experience - client [B78]	Evidence from supplier/ manufacturer knowledge and experience - IT people [B79C]								
B.11	Nurse call system - Sera	3	Identify a specific problems [B80]	Identify a solutions [B81C]	Evaluate the solutions [B82C]								
			Knowledge and experience - client [B80]	Evidence from the industry [B81C]	Knowledge and experience - IT people and client evidence from suppliers-manufacturers [B82C]								
B.12	Day space	5	Identify space requirements [B99C]	Identify a traditional solution [B100CD]	Evaluate evidence [B101CD]	Evaluate the solution [B102CD]	Adapt the solution [B103CD]						
			Standards and guidance [B99C]	Knowledge and experience [B100CD]	Visits to hospitals [B101CD]	Expert opinion - community health council [B102CD]	Knowledge and experience - client schedule of accommodation [B103CD]						

Index	Exemplar design element	No of design activities	Element story up to end of the design phase										
B.13	Isolaiton room - provision	6	Identify a solution [B186]	Evaluate the solution [B187DE]	Adapt the solution [B188CD]	Improve the design - support flexibility [B189C]	Improve the design - ensure architectural and construction details support the design [B189bE]	Improve the design - mitigate negative impacts [B190D]					
			Standards and guidance [B186]	K&E- design team and client, engineer [B187DE]	Decision - all above [B188CD]	Knowledge and experience - engineer [B189C]	Knowledge and experience - engineer [B189bE]	Knowledge and experience - design team and client [B190D]					
B.14	Isolaiton room - location	4	Identify a solution [B191D]	Identify a solution [B192D]	Devise a solution [B193D]	Evaluate the solution [B194D]							
			K&E- clinical staff [B191D]	Knowledge and experience - engineer [B192D]	Decision - all above [B193D]	K&E - stakeholders [B194D]							
B.15	Isolaiton room - Layout	4	Identify design requirements [B195D]	Devise a solution [B196D]	Design evaluation [B197C]	Evaluate performance of the design [B198CD]							
			Clients' requirements [B195D]	Standards and guidance knowledge and experience - design team [B196D]	Visits to international hospitals [B197C]	Knowledge and experience - engineer standards and guidance [B198CD]							
B.16	Floor finishes	9	Identify specification [B128D]	Collect evidence [B129D]	Evaluate evidence [B130D]	Short list finishes for different spaces [B131D]	Evaluate solutions [B132D]	Evaluate selected solutions [B133CD]	Select suitable finishes for different spaces [B134CD]	Improve the design [B135C]	Detail design [B136D]		
			Standars and guidance [B128D]	Evidence from the industry knowledge and experience - design team [B129D]	Knowledge and experience - design team [B130D]	Decision - all above [B131D]	Knowledge and experience - stakeholders [B132D]	Physical mock-up stage 1 - knowledge and experience client [B133CD]	Decision - all above [B134CD]	Knowledge and experience - client [B135C]	Knowledge and experience - design team - standard details [B136D]		
B.17	Wall finishes	6	Select traditional solutions [B137D]	Identify alternative innovative solution [B138C]	Evaluate the solution [B139CD]	Select most suited alternative [B140D]	Evaluate the solution [B141C]						
			Knowledge and experience - design team [B137D]	Evidence from the industry evidence from supplier/ manufacturer [B138C]	Evidence from supplier/ manufacturer factory visits [B139CD]	Decision - all above [B140D]	Physical mock-up? [B141C]						

Index	Exemplar design element	No of design activities	Element story up to end of the design phase										
B.18	Ceiling finishes	10	Identify project requirements [B143C]	Identify solutions [B144CD]	Evaluate alternative solutions [B145CD]	Evaluate evidence [B146CD]	Risk assessment [B147C]	Finalise different solutions for different spaces [B148CD]	Evaluate solutions [B149CD]	Improve the solution - for mock-up results [B150C]	Improve the solution - for mock-up results [B151C]	Improve the design - generic [B152C]	
			Knowledge and experience [B143C]	Knowledge and experience - design team [B144CD]	Knowledge and experience - stakeholders [B145CD]	Visits to local hospitals knowledge and experience - design team [B146CD]	Risk assessment [B147C]	Decision - all above [B148CD]	Physical mock-up stage 1 [B149CD]	New evidence generated through mock-up [B150C]	New evidence generated through mock-up [B151C]	Decision [B152C]	
B.19	Doors	9	Select traditional solutions [B156CD]	Evaluate the solutions [B157C]	Improve the solution - mitigate negative impacts [B158C]	Evaluate the solutions [B159C]	Improve the solution - mitigate negative impacts [B160CD]	Evaluate the solution [B161D]	Devise technical design [B162D]	Improve the solution- to support better outcomes [B163D]	Improve the design - mitigate negative impacts [B164D]		
			Standards and guidance knowledge and experience - design team [B156CD]	Knowledge and experience? [B157C]	Resulted from context [B158C]	Knowledge and experience - client [B159C]	Knowledge and experience - design team [B160CD]	Stakeholder consultation physical mock-up [B161D]	Knowledge and experience - design team [B162D]	Research knowledge and experience [B163D]	Knowledge and experience [B164D]		
B.20	Doors - finishes	4	Identify optional solutions [B166D]	Evaluate solutions [B167D]	Finalise solutions for each type of door [B168]	Improve design - mitigate problems [B169D]							
			Evidence from supplier/ manufacturer [B166D]	Standards and guidance knowledge and experience [B167D]	Decision - all above [B168]	Knowledge and experience - design team [B169D]							
B.21	Doors - ironmongeries	2	Identify optional solutions [B170D]	Evaluate solutions [B171D]									
			Evidence from supplier/ manufacturer [B170D]	K&E, Resource constraints [B171D]									
B.22	Vistamatic panels	4	Identify a solution [B178CD]	Evaluate the solution [B179D]	Evaluate evidence [B180CD]	Improve design - mitigate negative impacts [B181C]							
			Visits to local hospitals evidence from the industry client's requirements [B178CD]	Clients' requirements knowledge and experience - design team [B179D]	Evidence from the industry knowledge and experience - design team and client [B180CD]	Evidence from supplier/ manufacturer [B181C]							

Index	Exemplar design element	No of design activities	Element story up to end of the design phase										
B.23	Water services	3	Identify design requirements [B202CE]	Devise a solution [B203C]	Evaluate the soution [B204CE]								
			Statutory obligations [B202CE]	Knolwedge and experience standards and guidance [B203C]	Knolwedge and experience physical mock-up information from contractor, SGTs [B204CE]								
B.24	Ventilation strategy	3	Identify project requirements [B108D]	Evaluate evidence [B109D]	Decide on ventilation strategy [B110D]								
			Standards and guidance [B108D]	Knowledge and experience [B109D]	Knowledge and experience - engineer [B110D]								
B.25	Design of the window	11	Identify design requirements [B111D]	Devise several optional solutions [B112D]	Evaluate solutions [B113CD]	Select most suited solutions [B114D]	Evaluate the solution [B115CD]	Evaluate the solution [B116D doc]	Devise improved solutions [B117doc]	Evaluate solutions [B118D]	Select the best suited solution [B119D]	Improve the design [B120D]	Detail design - production information [B121D]

G.3 - Element stories for Case C

Index	Exemplar design element	No of design activities	Element story up to end of the design phase								
C.1	Single room layout	9	Identify externally available solutions [C39DA]	Adapt a solution [C40CD]	Detail design [C41C]	Evaluate the solution [C42DA - CS]	Evaluate the solution [C43DA - CS]	Evaluate the solution [C44DA - CS]	Evaluate the solution [C45DA - CS]	Evaluate the solution [C46DA - FM]	Evaluate the solution [C47DA - CS/EC]
			PKL experience evidence from the industry [C39DA]	Standards and guidance knowledge and experience [C40CD]	Trust's standards [C41C]	User consultation - CS [C42DA - CS]	User consultation - CS [C43DA - CS]	User consultation - CS [C44DA - CS]	Evidence from the industry [C45DA - CS]	Knowledge and experience - FM [C46DA - FM]	Client's specialists' opinion - elderly care [C47DA - CS/EC]
C.2	On-suit	3	Identify a solution [C50C,D]	Evaluate the solution [C51DA - FM]	Evaluate the solution to improveC52DA - CS/EC]						
			Evidence from the supplier [C50C,D]	Knowledge and experience - FM [C51DA - FM]	Client's specialists' opinion - elderly care [C52DA - CS/EC]						
C.3	Bed head services	6	Identify optional solutions [C57D]	Evaluate solutions [C58D,C]	Select the best suited solution [C59C]	Detail design of the solution [C60C]	Technical design of the solution [C61C]	Evaluate the design [C62DA - FM]			
			Evidence from suppliers and manufacturers [C57D]	Knowledge and experience [C58D,C]	Decision - all [C59C]	Trust's standard equipment [C60C]	Knowledge and experience - engineer [C61C]	Knowledge and experience - FM [C62DA - FM]			
C.4	Size and shape o f the ward	4	Devise a schematic solution [C1D]	Identify externally available solutions [C2R, D]	Evaluate alternative solutions [C3D]	Select the best suited solution [C4DA]					
			Knowledge and experience - design team standards and guidance standards - client [C1D]	Evidence from the supplier [C2R, D]	Knowledge and experience - client and design team [C3D]	Knowledge and experience - client and design team evidence from manufacturer available sizes with manufacturer [C4DA]					
C.5	Layout - composition of single and shared bed bays	6	Analyse existing system in use [C7E]	Identify an innovative solution [C8C,E]	Evaluate the solution [C9C]	Adapt the solution [C10C DA - CS]	Improve the solution - support additional functions [C11C]	Evaluate the solution [C12C]			
			Knowledge and experience [C7E]	Evidence from the industry [C8C,E]	Knowledge and experience [C9C]	Knowledge and experience of client and design team [C10C DA - CS]	Knowledge and experience of client and design team [C11C]	Knowledge and experience of client [C12C]			
C.6	Layout - other	16	Devise a solution [C23DA - CS, DA]	Evaluate the solution [C24DA - CS]	Evaluate the solution [C25DA - CS]	Evaluate the solution [C26DA - CS]	Evaluate the solution [C27DA - CS]	Evaluate the solution [C28DA - CS]	Improve the solution [C29Res]	Evaluate the solution [C30DA - PM]	Evaluate the solution [C31DA - CS/EC]

Index	Exemplar design element	No of design activities	Element story up to end of the design phase								
			Knowledge and experience - client and design team Client's brief - ToR Client's brief - Room data sheets [C23DA - CS, DA]	User consultation - CS [C24DA - CS]	User consultation - CS [C25DA - CS]	User consultation - CS [C26DA - CS]	User consultation - CS [C27DA - CS]	User consultation - CS [C28DA - CS]	All above [C29Res]	Knowledge and experience - client and design team [C30DA - PM]	Client's specialists' opinion - elderly care [C31DA - CS/EC]
			Evaluate the solution [C32DA - CS/EC]	Evaluate the solution [C33DA - CS/EC]	Evaluate the solution [C34DA - CS/EC]	Evaluate the solution [C35DA - CS/EC]	Evaluate the solution [C36DA - CS/EC]	Evaluate the solution [C37DA - CS/EC]	Improve the solution [C38Res]		
			Client's specialists' opinion - elderly care [C32DA - CS/EC]	Client's specialists' opinion - elderly care [C33DA - CS/EC]	Client's specialists' opinion - elderly care [C34DA - CS/EC]	Client's specialists' opinion - elderly care [C35DA - CS/EC]	Client's specialists' opinion - elderly care [C36DA - CS/EC]	Client's specialists' opinion - elderly care [C37DA - CS/EC]	All above [C38Res]		
C.7	Layout - entrance to the ward	3	Identify the design problem [C20D]	Devise a solution [C21C]	Evaluate the solution [C22C]						
			Knowledge and experience - design team [C20D]	Knowledge and experience - design team [C21C]	Knowledge and experience - client [C22C]						
C.8	Layout - no of nurse bases	1	Adopt a solution [C13C]								
			Knowledge and experience [C13C]								
C.9	Layout - location of the nurse base	3	Devise a solution [C14C]	Evaluate the solution [C15DA - CS]	Improve the solution [C16DA - PM]						
			Knowledge and experience - FM team? [C14C]	User consultation - CS [C15DA - CS]	Knowledge and experience - client and design team [C16DA - PM]						
C.10	Day rooms	5	Analyse the existing system in use [C64C]	Identify a possible solution[C64bC]	Evaluate the solution [C65C]	Adopt the solution [C66C]	Evaluate the solution [C67C]				
			Knowledge and experience - client [C64C]	Knowledge and experience - client [C64C]	Knowledge and experience - client [C65C]	Decision - all [C66C]	User consultation [C67C]				
C.11	Corridors	2	Devise a solution [C68C, DA - FM]	Evaluate the solution [C69DA - CS/EC]							
			Knowledge and experience [C68C, DA - FM]	Client's specialists' opinion - elderly care [C69DA - CS/EC]							
C.12	Waiting space	2	Adopt a solution [C70Re]	Evaluate the solution [C71DA - CS]							
			Knowledge and experience [C70Re]	User consultation - CS [C71DA - CS]							

Index	Exemplar design element	No of design activities	Element story up to end of the design phase								
C.13	Stair ways	2	Devise a solution [C72Re]	Evaluate the solution [C73DA - FM]							
			knowledge and experience [C72Re]	Knowledge and experience - FM [C73DA - FM]							
C.14	Floor finishes	8	Specify solution - partly [C85C]	Specify performance - partly [C86DA]	Specify performance - partly [C87DA]	Identify available solutions [C88C, DA, D]	Select best suited solutions [C89C]	Evaluate the solution [C90DA - CS/EC]	Evaluate the solution [C91DA - FM]	Evaluate the solution [C92DA - FM]	
			Trust's standards [C85C]	Knowledge and experience standards and guidance? [C86DA]	Standards and guidance? [C87DA]	Knowledge and experience - designer, evidence from the manufacturer standards and guidance [C88C, DA, D]	Knowledge and experiencer [C89C]	Client's specialists' opinion - elderly care [C90DA - CS/EC]	Standards and guidance [C91DA - FM]	Knowledge and experience - FM [C92DA - FM]	
C.15	Wall finishes	5	Specify solution - partly [C95C]	Compare products for different requirements [C96D]	Select the most suited solutions [C97R]	Evaluate the solution [C98DA - FM]	Evaluate the solution [C99DA - CS/EC]				
			Trust's standards Standards and guidance [C95C]	Standards and guidance evidence from the industry [C96D]	Evidence from the manufacturer [C97R]	Knowledge and experience - FM [C98DA - FM]	Client's specialists' opinion - elderly care [C99DA - CS/EC]				
C.16	External walls	2	Identify available solutions [C100D]	Evaluate the solution [C101DA - FM]							
			Evidence from the industry [C100D]	Knowledge and experience [C101DA - FM]							
C.17	Worktop finishes	2	Adopt a solution [C103a]	Evaluate the solution [C103DA - FM]							
			Knowledge and experience - FM [C103a]	Knowledge and experience - FM [C103DA - FM]							
C.18	Doors - generic	8	Identify design requirements [C74C]	Specify performance [C75D]	Identify externally available solutions [C76C, D]	Select best suited solution [C77D]	Detail design of the solution [C78C]	Evaluate the design [C79C]	Improve the design - user comments [C80DA - CS]	Improve the design - user comments [C81C]	
			Trust's requirements [C74C]	Knowledge and experience [C75D]	Evidence from the suppliers and manufacturers [C76C, D]	Knowledge and experience standards and guidance [C77D]	Trust's standards [C78C]	User consultation [C79C]	User consultation - CS [C80DA - CS]	User consultation - CS [C81C]	
C.19	Glass panels/smart glass	2	Identify improvement opportunities [C82DA - CS/EC]	Improve the design - support additional functions [C83C]							

Index	Exemplar design element	No of design activities	Element story up to end of the design phase								
			Client's specialists' opinion - elderly care [C82DA - CS/EC]	Knowledge and experience - client evidence from the industry [C83C]							
C.20	Isolation room	4	Analyse existing system [C104aC]	Identify possible ado(a)ption [C104bC]	Design evaluation [C104cC]	Adopt the solution [C105D, C]					
			Knowledge and experience [C104aC]	Knowledge and experience [C104bC]	Knowledge and experience [C104cC]	Knowledge and experience [C105D, C]					
C.21	Water services design	5	Specify performance [C134E/a]	Devise a schematic solution [C134E]	Devise a schematic solution [C135DA - FM]	Develop the solution [C136E]	Evaluate the design [C137E]				
			Standards and guidance Trust's standards [C134E/a]	Knowledge and experience - client, engineer, [C134E]	Knowledge and experience - FM [C135DA - FM]	Knowledge and experience - Constructor [C136E]	Knowledge and experience - engineer [C137E]				
C.22	Fittings	5	Devise a schematic solution [C138E]	Evaluate the solution [C139E]	Evaluate the solution [C140E]	Improve the design - for user comments [C141E]	Improve the design - for user comments [C142C]				
			Knowledge and experience - client, engineer [C138E]	Knowledge and experience - client, engineer [C139E]	User consultation - clinical staff [C140E]	Knowledge and experience - client, engineer [C141E]	User consultation - clinical staff [C142C]				
C.23	Ventilation strategy	9	Brief to the design team [C106C]	Specify performance [C107E, D]	Specify performance [C108E]	Specify performance [C109E]	Evaluate the design [C110E]	Evaluate the design [C111DA - FM]	Evaluate the design [C112E]	Evaluate the design [C113E]	Evaluate the design [C114E]
			Client's briefing [C106C]	Knowledge and experience - client and engineer [C107E, D]	Standards and guidance Trust's standards [C108E]	Trust's standards [C109E]	Knowledge and experience - engineer [C110E]	Knowledge and experience - FM [C111DA - FM]	Visits to the factory - evidence from manufacturer [C112E]	Knowledge and experience - engineer [C113E]	Knowledge and experience - engineer [C114E]
C.24	Windows - generic	6	Specify solution - partly [C115E]	Specify solution - partly [C116E]	Specify solution - partly [C117E]	Devise a solution [C118C, E]	Evaluate the design [C119E]	Evaluate the design [C120DA - FM]			
			Knowledge and experience - engineer [C115E]	Knowledge and experience - engineer [C116E]	Standards and guidance [C117E]	Evidence from manufacturer [C118C, E]	Knowledge and experience - engineer [C119E]	Knowledge and experience - FM [C120DA - FM]			
C.25	Summer temperature control	6	Evaluate the design - identify a problem [C121DA - FM, E]	Evaluate the design - identify a problem [C122E]	Identify a solution [C123C]	Discard the solution [C124C]	Improve the design - to mitigate the problem [C125D]	Improve the design - to mitigate the problem [C126E]			
			Knowledge and experience - FM [C121DA - FM, E]	Standards and guidance - HTMs [C122E]	Knowledge and experience - FM [C123C]	Knowledge and experience - QS [C124C]	Knowledge and experience [C125D]	Knowledge and experience [C126E]			
C.26	Window blinds/ windows	2	Specify solution - partly [C129E]	Evaluate the solution [C130DA - CS/EC]							
			knowledge and experience - designer [C129E]	client's specialists' opinion - elderly care [C130DA - CS/EC]							

Appendix H: Case study data analysis – POE data

H.1 - POE data - Case A

H.2 - POE data - Case B

H.3 - POE data - Case C

Summary of the process

	Design component/ element/ space	Level of standardisation or innovation	Availability of evidence					Quality/ Integrity of existing evidence					Rate of success in operation					Would you recommend it next time
		-5 completely standard -3 mostly standard 3 mostly innovative 5 completely innovative	1–Poor 2–Fair 3–Good 4–Very good 5–Excellent					1–Poor 2–Fair 3–Good 4–Very good 5–Excellent					1–Poor 2–Fair 3–Good 4–Very good 5–Excellent					
1	Single bed room		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
	- On-suit bathroom		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
	- Bed head		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
2	Communal spaces		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
3	Ward layout		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
	- Clinical workstations		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
4	Window design/ ventilation strategy		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
5	Finishes (Floor, wall and Ceiling)		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
6	Water services		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
7	Isolation room		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
8	Doors		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	

H1: POE DATA – CASE STUDY A

Design element		**POE**
Single room	Single rooms	Increase bed head services to allow flexibility to provide high dependency care at single room
		Move celling beams away right above the bed
		Better light switches - current switches are not user friendly
		Positive feed back from parents about the rooms
		Better integral blinds, that don't break easily
		we already got many things we want -enough data points, & storage
		Bathrooms vs shower rooms- need to find out
Ward layout	Ward layout	Rooms at the end, feel isolated - We knew that would be an issue
		Rooms towards the end of staff room feels isolated due to less people movement
		Might change in the future with change in use of offices
		Nurses stations are used well
		Not enough space in the workstation, making nurse to keep a trolley aside - may not be an issue when the hospital go paperless
	Nurse base	Workstations are used well and patients being looked after as expected
		Location of notice boards and cupboards were changed
		Space of workstation is enough at intensive care bays because they get bigger space as well as less papers
Communal spaces	staff areas	Changes - cupboard over oven does not work Changed location of notice boards
		Part of me wonder whether they are little bit large for the staff I have not heard anything negative from staff
	seminar rooms	Seminar rooms get used very well
	office accommodation	The office accommodation is used very well, two specialities in particular, ICU probably don't use their offices as much as they could, so what they have done is they have created a couple of zones within the office so got a quite working area and a staff area we could have given them with a bigger staff room, and a smaller open plan office
	parents waiting space	Parents space less used - in some days there are no body there - an issue of staffing
Window/ventilation	Window	In four bed bays they don't like to open window, because it is a shared environment in four bed bays
		There are couple of examples where mechanical operation is noisy that they thought it would be, so in the nights it is annoying - changed the opening times through BMS
		Window blinds - better way of providing integral blinds, is there a device that don't beak easily,
	energy targets	The mixed mode ventilation to meet our energy targets, and it is too soon to know whether we actually saved energy in this building

H2: POE DATA – CASE STUDY B Cont'd from the previous page…		
	Thermal comfort	Quite a few complaints saying that rooms are too cold - in theory it may work with adult but we got children that ranging from few hours old to 18 I am not sure whether we are going to have mixed mode ventilation in 2B, it may be we have air conditioner but with the opportunity to open the window
	Thermostat	location of the thermostat digital display for the thermostat
	View	view - would be better when the court yard is done
Finishes	Floor finishes	Floor finishes seems standing up very well
		We do not like is the wood effect flooring at nurse bases, they don't like wood at all
		Need lazer cut lino
		Non-slip vynile floor - difficult to keep it looking clean, because of this slightly gritty surface
	Wall finishes	Wall finishes - lots of dirty finger marks > in PFI schemes they have a good cleaning regime added perspective wall protectors around door exit buttons
	Ceiling finishes	Ceiling tiles are not good in acoustic properties, this is problematic in corridors, but not in rooms
Isolation rooms	Isolation rooms	Because of the lobby, isolation room is isolated when it is used as a normal room and lobby is annoying
		The ICU has 3 rooms and those have been very well used- the question is whether it is right thing to do in every floor
Water services	Water services	New EU regulations might restrict the use of copper
		Cannot have different temperatures for different appliances, needs a cultural change
		Water quality - we get sample done at monthly basis and we have no problem at all
Doors	Doors	problems with door answering time - difficult for patients
		Better to have more automatic doors in those areas, entrances and exits.
	Finger guard	Finger guard mechanism– that worked very well
	Door finishes	Wood veneer seems to be standing up to most things quite well Users sometimes bang trolleys and other equipments which damage doors
		we needed more door protection particularly at the edges

H2: POE DATA – CASE STUDY B

Design element (YAB)	Sub-element	POE - Description in brief
Single patient rooms	Single room	There are major reductions in infection, MRSA
		Patients sleep better
		Patient falls - initially increased, steady later
		Single bed room design - feel as an overwhelming success
		Television on arm is better than television on wall with remote control
		Call system some times get overloaded in single room wards
	On-suit	Current elderly population does not like showers; Appliances needs to be flushed every three days if they are not used
	Bed head service	Need more new sockets for the bed head service panels
Wards	Ward layout	Did not look at dimentia evidence, has not been heard before
		It is better if we could mocked up a whole ward
	Store rooms	Not using store rooms properly
	Nurse base	Works well for observation
		Nurses have to walk more
		YYF - nurses cannot hear telephone ringing
		Good design
Communal spaces	Day rooms	Staff use the room for meetings
		Feel we need one
		Could have mocked up
		Day spaces are not well used
		Still got some value
	Corridors	There are complaints saying 'corridors too big' - I do not agree
Window and ventilation	Design of the window	Rooms are too warm in the summer
		Handle to open is not very good for elderly people > call nurse
		Mental health we had a problem, we cant have open gaps, so We had to put a mesh so people out side cannot come and put any drugs
		Visits did not provide any example
		Handles - knew the trouble
	Ventilation strategy	Capacity to support large windows
Finishes	Ceiling finishes	Happy with the plaster board ceiling
	Floor finishes	Kitchen floor tile retain food waste, had to change
		Wooden starecase finish dried out - cracks

H2: POE DATA – CASE STUDY B Cont'd from the previous page…		
Doors	Doors	More automatic doors will help trolleys to pass easily
		Doors work well, Critiques so as to corridors are too big
	Vistamatic panels	Works well at use
Isolation room	Isolation room	Not yet used for a proper isolation purpose
		Client group does not give regular isolation requirements
		Went well, standard
Water services	Water services	Shower heads changed
		Not any other problem
	Water services + wall finishes	Difficulties to take flexible horses out

H3: POE DATA – CASE STUDY C

Element	Sub-element	POE data
Ward	size and shape	Since the ward is 60ms long and nurse's base is in the middle, nurses have to walk a lot
	size and shape	Nurses spend time at patients so patients at corners does not feel they are not cared
	layout - location of the nurse base	Prefer decentralised nursing bases for future works
	layout - location of the nurse base	Need for a central base is a local choice, some types of wards may not need them
	layout - generic	We learned from that some of the ergonomic positioning could have been done better,
Single patient rooms	single room layout	Nurses prefer even more visualisation in the patients in the single rooms
	On-suit	Shower trays in the on-suit is not well supported into the floors, had to redo many of them
	bed head services	Happy with the bed head services design
Communal spaces	Corridors	Wider corridors help to prevent damages to wall finishes
Doors	Doors - generic	Bigger vision panels would be better
Finishes	Floor finishes	Joint of the new building to the existing did not work, had to redon the expansion joint
	Ceiling finishes	No issues with ceiling and ceiling finishes
Isolation rooms		
Windows and ventilation	Summer temperature control	There are problems of over heating during summer
Water services	fittings	Battery operated infarred taps need battery changes frequently
		Had few issues with sensor taps

Appendix I: Extended literature review – Research methods

EXTENDED LITERATURE REVIEW – RESEARCH METHODS

Research Design

Research design is the structure or framework that guides research method(s) (used in data collection) and the analysis of subsequent data (Bryman, 2004). Research design links together the elements of the methodology adopted for a study; relating the paradigm to the research strategy and then the strategy to the methods for collecting empirical data (Denzin and Lincoln, 2005). Literature reveals a variety of defined research designs: experiment; survey; case study; archival research; grounded theory; action research; history; phenomenology; and ethnography (Saunders et al., 2009; Bryman, 2004; Yin, 2009; Fellows and Liu, 2008; Creswell, 2007). A researcher should select an appropriate research design after careful consideration of intentions and capabilities of each design and comparison of designs with research aim, objectives and resources availability. The following is a brief discussion of intentions and capabilities of a few selected research designs applicable to this research.

a) Experiments

Experiments are controlled tests or investigations. In experiments, the researcher investigates the behaviour of dependent variable(s) while manipulating independent variable(s). Experimental research is rich in robustness and trustworthiness of casual findings (Bryman, 2004) and popular in the positivist domain and with the deductive approach. The involvement of humans in the process makes it difficult to arrive at a solution by manipulating the variables. Therefore, it was decided that the experimental approach would not be suitable for any of the research questions considered in this research.

b) Surveys

Surveys are used to collect data for a specific problem/phenomena regarding what, who, where, when, how much and how many questions (most of which have definite answers) from large populations using economical data collection methods, such as questionnaires (Saunders et al., 2009; Yin, 2009). The survey research approach is widely used in deductive research approaches to expand the understanding of existing theories and knowledge (Tan, 2002). Surveys are better at establishing relationships between variables and generate findings that could be generalisable to the population (Fowler, 2009). In addition, surveys are flexible to use in collecting a rich set of qualitative data using a small number of participants, and through the use of techniques other than questionnaire surveys. On the other hand, surveys possess some weaknesses, such as difficulties in capturing the thoughts of respondents (Fowler, 2013). An inability to identify the causes behind the particular answers of respondents (Tan, 2002), are weaknesses peculiar to some of the techniques used in surveys. For instance, questionnaire surveys might result in low respondent rates or incomplete answers due to various reasons, such as, respondent fatigue and overly long surveys. However, surveys offer a variety of data collection techniques which allow flexibility to overcome some of the weaknesses of surveys. For example, if accompanied by interviews surveys have the flexibility to capture the respondent's thoughts to a greater extent. It was apparent that surveys in the form of interviews may be useful to identify current practices of EBD in general. Surveys were not considered for the fourth and fifth objectives which required in-depth understanding of EBD practices at project level.

c) Case studies

A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and the context are not clearly evident (Yin, 2009). Further, it facilitates detailed and intensive analysis of a single case being investigated (Bryman, 2004). This is more appropriate to understanding 'how and why' questions within a particular phenomenon (Yin, 2009). Case study design is compatible with collecting data using various methods, such as (but not limited to) interviews, observations and documentary evidence which also allows triangulation (Yin, 2009). Therefore, case studies allow the researcher obtains a reliable, broad picture to continue with the study. Case study design is widely used in built environment and construction management research for in depth investigations. Amaratunga et al. (2002) stated that case studies are tailor-made for exploring new processes or behaviours, or those which are little understood. Case studies can also be used to theory build through an inductive approach to research (Eisenhardt and Graebner, 2007; Amarathunga et al., 2002) and can test

theory as well (Gibbert et al., 2008). Case studies also possess some weaknesses, such as the researcher not having control over the environment and or access to appropriate cases (Myers, 2008). Case study design was identified as a potential research design to achieve the fourth and fifth objectives of this research, since case studies allow collection of a rich set of data in its original context through intensive investigation.

d) Grounded theory

Grounded theory (GT) is a specific methodology developed by Glaser and Strauss in 1967 for the purpose of building theory from data (Corbin and Strauss, 2008). Today's grounded theory design has taken the major three variants from the original design, as described by prominent authors Glaser (Glaser and Strauss, 1967; Glaser, 2005 & 2007); Corbin and Strauss (1990, 1998 & 2008) and Charmaz (2003, 2006 & 2008).

The original procedure described by Glaser focuses on openness and creativity followed by the emergence of a theory. This approach is strictly adhering to 'emergence' of theory out of empirical data. Procedure entails 'theoretical coding' and 'coding families' using the technique of 'constant comparison' for concept emergence (Kelle, 2007). However, lack of clear procedures and reliance on researcher's 'theoretical sensitivity' to apply the technique of constant comparison has been seen as difficult. This has led to an alternative variant described by Strauss and Corbin (1998). This is identified as a 'forcing' (Richardson and Kramer, 2006; Kelle, 2007) variant, which stresses the 'deliberate development of theoretical insights by using explicit coding paradigms and procedures in which the role of theory seems to be clear' (Richardson and Kramer, 2006). This second variant entails the technique of the 'paradigm model' to develop and integrate categories from data. Authors pertaining to this third variant follow specific techniques such as writing storylines; moving from descriptive story to the theoretical explanation; use of integrative diagrams; reviewing and sorting through memos and are used to derive sub-categories and central categories. Even though this entails specific procedures being carried out, it is also gained a criticism that this variant as 'a shift from an open-ended to a deterministic positivistic stand that restrains GT researchers to be open-minded and receptive' (Richardson and Kramer, 2006). Therefore, a third major variant was introduced by scholars to take a step backward from 'forcing' variant towards 'emergence'. Responding to the weakness which was considered as a 'failure to explicitly conceptualise the role of previous theoretical knowledge in developing grounded categories', this third variant entails use of previous theoretical knowledge to build theories, using the GT approach. This approach uses abstract theoretical categories (with a general scope but with limited empirical content) as heuristic devices to later develop empirically grounded categories.

In addition to above three major variants some scholars also have taken various approaches under the name of GT and have often been criticised for misuse of GT approach. Thus, it is worth to identify the major unique feature of GT. Grounded theory approach's aim is to uncover and understand what lies behind phenomenon about which little is known (Richardson and Kramer, 2006). The approach intends to generate theories, and it entails an iterative process which involves data analysis as soon as the first data is collected (Strauss and Corbin, 2008). Parallel analysis guides the subsequent data collection process by determining new questions to add or eliminate. It also means collecting data until theoretical saturation is achieved (the status where new data does not enrich the analysis). Advantageously, the grounded theory design allows the researcher to capture all aspects of the phenomena by adding new questions of investigation and omitting irrelevant ones whilst the research continues in parallel with the analysis. Thus, it allows a collection of a rich set of data and the flexibility to alter data collection. Therefore, it was apparent that this was a suitable design to collect the most useful data to solve the research problem at hand. Hence, offering a good choice to achieve the fourth and fifth objectives of this research into EBD. If employed, grounded theory would have allowed the collection of a richer and broader set of data to uncover underlying structures and mechanisms of designing practices. Further, previous researchers have used grounded theory in combination with a critical realist perspective (Kempster and Parry, 2011).

e) Ethnography

Ethnography is a qualitative design in which the researcher describes and interprets the shared and learned patterns of values, behaviours, beliefs and languages of a culture sharing group (Creswell, 2007). It is an extended, involved observation of a group, most often through participant observation, in which the researcher is immersed in the day to day activities and lives of the group. It analyses processes, actions and interactions of a large single unit/place consisting of more than 20 participants in a unit (Creswell, 2007). Taking a critical realist perspective, this research believes in the three strata of empirical, actual and real events for the phenomena, and tries to understand the underlying reality as closely as possible. Thus, being immersed within the context of the research phenomenon would be the most suitable approach for a critical realist to achieve their aim. Prominent authors of critical realism (Sayer, 2000 & 2004; Bhaskar 2008; Archer et al., 1998) suggest ethnographic studies as the research design for research from a critical realist perspective. Without doubt, if resources permitted, the first choice for this PhD research would have been an ethnographic study with the retroductive reasoning, supported by several rounds of data collection to develop and test mechanisms that could improve EBD.

f) Action research

Action research is a participatory process concerned with developing practical knowledge in the pursuit of worthwhile human purposes and methods, to seek to bring action, reflection, practice and theory together (Reason and Bradbury, 2008). The main theme of action research is that research output results from an involvement with members of an organisation over a matter which is of genuine concern to them (Eden and Huxham, 1996). The primary purpose of action research is to produce practical knowledge that is useful to people in the everyday context of their lives. This method is more suitable for research driven by organisational motivation which, in turn, expects researchers to be actively involved in the organisational activities in order to produce something useful in a problem-solving situation.

Data collection

There are a few widely used data collection methods by researchers. These methods are suitable for different purposes. A research could be supported by a single data collection method or multiple data collection methods. Previous scholars (Creswell, 2003; Saunders et al., 2003;, Bryman, 2008) have acknowledged the importance of using multiple methods to collect data to ensure research is supported by a valid and reliable set of data that passes data triangulation principles. This research also used multiple data sources for each phase of the research to achieve these validity and reliability criteria. Below is a discussion of a few widely used data collection methods and how these methods were used in this research.

a) Questionnaire surveys

In a questionnaire survey, a series of questions (most of them are closed to a selected set of answers and a few open) prepared into a single questionnaire and sent to respondents through post, internet or by hand. Questions need to be developed carefully so that they can be easily followed and to avoid respondents' fatigue (Leones, 1998). Questions should be appropriate for self-completion by respondents without researchers help in most cases. Questionnaire surveys are suitable for researches which use a deductive form of reasoning. Diaries are also considered as one variance of self-completion questionnaire surveys, where respondents are asked to complete a diary to record answers for a set of pre-devised questions over a particular period of time. One of the advantages of the method is that it provides information about the time sequencing of events (Bryman, 2004). Diaries are often used as a supplementary method of data collection together with other methods. There are some advantages of questionnaires as a data collection method. They are cheaper and quicker to administer, absent of interviewer effects and interviewer variability, and convenient for the respondents. However, there are several weaknesses as well. Questionnaire surveys do not allow prompting or probing questions, or collect additional data. It is difficult to ask many questions

that are not salient to respondents. Questionnaire surveys are not suitable when the number of questions is large. Further, they are not appropriate for some kinds of respondents. There is also a risk of missing data and a low response rate.

b) Interviews

The most widely used qualitative method in built environment research is the interview (Amaratunga et al., 2002). It can be used to gather data to understand complex behaviours and processes (Patton, 2002). Interviews are flexible in nature and the interviewee can probe more into the main question until producing a thorough set of data about the questions asked.

Interviews could be un-structured, semi-structured or structured. The main differences between the three types of interview are the degree to which participants have control over the process and content of the interview (Fontana & Frey, 1998; Corbin and Morse, 2003). Unstructured interviews generate a large amount of data and are sometimes not useful in answering predetermined research questions. Semi-structured interviews allow the collection of data pertinent to pre-determined areas of questions and do not permit the interviewee to talk about aspects which are not interest to this research, hence more appropriate for this research intension. Totally structured interviews on the other hand do not allow the interviewer to collect data or probe respondents further to clarify emergent ideas or facts.

Table 0-1: Uses of three types of interviews (King, 1994)

Type of interview	Instances of suitability
Semi-structured interviews	1. Where a study focuses on the meaning of particular phenomena to the participants. 2. Where individual perceptions of processes within a social unit are to be studied prospectively, using a series of interviews. 3. Where individual historical accounts are required of how a particular phenomenon developed. 4. Where exploratory work is required before a quantitative study can be carried out. 5. Where a quantitative study has been carried out, and qualitative data is required to validate particular measures, or to clarify and illustrate the meaning of the findings.
Structured	1. Where testing of a formal hypothesis (-ses) is desired.

interviews	2. Where data gathered can be readily (and meaningfully) quantified. 3. Where factual information is to be collected and the researcher knows in advance the type of information the participants will be able to provide. 4. Where a postal survey would be likely to produce a very poor response rate. 5. Where the generalization of previously obtained qualitative findings is to be tested.
Un-structured interviews	1. Where a quick, descriptive account of a topic is required, without formal hypothesis-testing. 2. Where factual information is to be collected, but there is uncertainty about what and how much information participants will be able to provide. 3. Where the nature and range of participants' likely opinions about the research topic are not well known in advance, and cannot easily be quantified.

c) Focus groups

Focus group is a method of data generation through interaction between participants (Gibbs, 1997; Millward et al., 2012; Duggleby, 2005). According to Powel (1996; pp. 449) a focus group is *'a group of individuals selected and assembled by researchers to discuss and comment on, from personal experience, the topic that is the subject of the research*'. The focus group needs to be facilitated by a skilled moderator and an assistant, if possible, for recording purposes as well (Gibbs, 1997). Drawing from literature on the successful application of the focus group method, Millward et al. (1995) identified that focus groups are appropriate: 1) to develop and/or test constructs as a first step in developing a questionnaire; 2) to check the validity of conceptual models; 3) to supplement other more traditional methods; 4) to invite a uniquely different perspective on an issue; and 5) to generate conversation worthy of analysis in its own right. This method allows the researcher to gather a large amount of data in a limited time and to elicit people's understanding, opinion and views. Focus groups are synergistic, in that participants respond to each other and reveal insights on topics that would not be drawn out through an interview or questionnaire. Careful selection of respondents, questions and the skills of the moderator determine the success of the focus group as

a data collection method (Millward, 1995). Focus groups are mainly face to face discussion. This may act as a barrier hence, participants have to travel and meet in a single point. Millward et al. (2012) identified possibility and instances of using internet forums and telephone facilities to generate discussions between participants distributed in time and space.

d) Observation

Observational data collection involves the systematic, detailed observation of people and events to learn about behaviours and interactions in natural settings (Pope and Mays, 1995). Literature identifies several instances in which observation is appropriate (Powell and Steele, 1996; Curry et al., 2009). According to these authors, observations are appropriate if: 1) researcher wants direct information; 2) researcher is trying to understand an on-going behaviour, process, unfolding situation or event; 3) when there is a physical evidence, product or outcome that can be readily seen; 4) when written or other data collection methods seems inappropriate; 5) when the study goal is to understand cultural aspects of a setting or phenomenon; and 6) when the situation of interest is hidden from the public, or when those in the setting appear to have notably different views that do outsiders. When the observation involves examining people, it has been identified that participants may alter their talk or behaviour because they are being watched. Even though covert observation (participants are unaware of researcher's role) has been seen as a solution for this, this involves many ethical concerns which need to be considered. The researcher should collect field notes systematically and unobtrusively (Curry et al., 2009) for observational data to be useful in credible results.

e) Document analysis

A wide variety of written materials may serve as a valuable source of data for research. Documents may include written materials and other documents from organisation or programme records; memoranda and correspondence; official publications and reports; personal diaries, letters, artistic works, photographs, and memorabilia; and written responses to open-ended surveys (Patton, 2005). Particularly for construction management researches this may also include drawings, meetings, minutes and results of evaluation of buildings and operations as well. There are several advantages of document analysis as supporting source of data. It can assist in determining the history and other retrospective information about a program or event (Mathison, 2005), which may not be remembered with details by the people involved in those events. These can also be useful in collecting additional details about specific emergent issues identified during other methods of data collection.

The next sub-section discusses the data collection methods used in the each phase of the research.

Appendix J: Case studies – further details

7 CASE STUDY A (Detailed version)

7.1 INTRODUCTION

The main data collection method for this research is case studies. Three case studies (which are anonymously referred as Case study A, B and C) were conducted. This Chapter reports and discusses evidence-based design practices of Case Study A. A brief description of the case is provided followed by the report and discussion of the results of the case studies from three perspectives:

- Firstly, the data from Case study A was analysed to identify the sources of evidence used during case A, frequency and timing of evidence use and other selected dimensions of using evidence from different sources. Based on these results a bespoke version for the model of Evidence-based Design is generated for Case study A and presented in this section; also the changes that developed the generic model into the bespoke model are discussed.
- Secondly, the Chapter reports and discusses how performance specifications and prescriptive specifications were used during the problem definition and designing in Case study A.
- Finally, the impact of the project's unique circumstances on the Evidence-based Design process of Case Study A and how designers reflect on these circumstances are reported and discussed.

The Chapter is then concluded with a summary account of the Evidence-based Design practices for the Case study A.

7.2 DESCRIPTION OF CASE

Case study A is a one phase of a redevelopment programme of a children's hospital located in London. The main purpose of the redevelopment is to improve the quality of the estate to avoid clinical quality being compromised. The project was mainly funded by a charity supporting the hospital and partly by the NHS. The hospital delivers speciality care for children from UK and around the world. The particular phase studied in this research is a nine storey building with 18,000m^2 floor area. The scope included procuring a new building to provide 92 beds, including 20 Cardiac Critical Care, two replacement theatres, two replacement interventional suites, a restaurant, kitchens and facilities management facilities (see Figure 7.1). This phase of the project was procured through the '*Develop and Construct'* procurement route where the client's consultants developed the design up to Stage C or D of RIBA plan of Work (RIBA, 2007) and handed over to a selected constructor to develop and construct. In this particular case, the designer who developed the design initially was novated to the project team as the designer for the selected constructor. The project (out-line design) started in February 2006 and the building became fully operational in July 2011. The construction cost was £88 million for this phase.

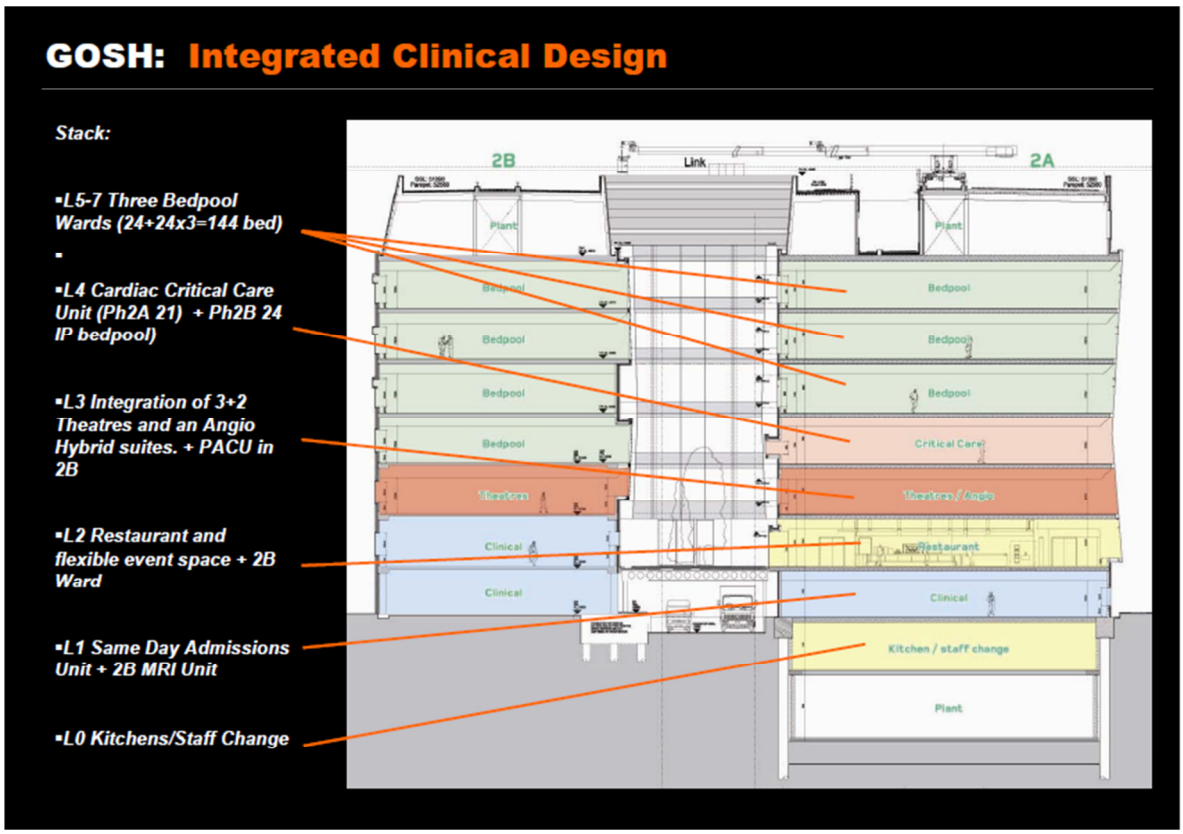


Figure 7-1: Cross sectional drawing of the Case study A

7.3 DATA

This case study investigated data in relation to the EBD process of 8 design elements as detailed in the Chapter 6. The hospital consists of Level 1 which was intended for use as a same day admissions unit; Level 2 for a restaurant; Level 3 for operating theatres; Level 4 for cardiac critical care; and Levels 5, 6 & 7 for typical bed pool wards. The scope studied within this research is approximately 42% of a typical bed pool floor within the hospital. The spaces considered in this case study do not cover the design of spaces within Levels 1, 2, 3 and 4. Table 7.1 shows the scope of design of spaces covered in this case study within a typical bed pool floor. However, data related to finishes, components and engineering services are generic to the whole hospital.

Table 7-1: Scope of the spaces considered within the Case study A

	Space type	Area occupied by the element (The typical floor GIFA of a floor is 1160m2)	Area occupied by the element as % of GIFA of a typical floor (1160m2)
1	Single bed room, en-suite	320m2	28%
2	Ward layout and nurse station	20m2	2%
3	Communal spaces	99m2	9%
4	Isolation room	51m2	4%
	Total	490m2	42%

Figure 7.2 illustrates the spaces explored in this study on a plan of a typical floor.

Data analysis revealed EBD process of 27 exemplar design elements associated with 166 design steps.

Figure 7-2: Scope of the spaces considered within the Case study A

7.4 EVIDENCE USE

7.4.1 An overview of evidence use

The main channels of evidence for Case study A were the members of the design team, their parent organisations, and supply chain partners (see Figure 7.3). Members of the design team have also gathered evidence from external evidence bases such as SGaTs from DH, general public consultation, other interested organisations, published research and by visiting existing facilities.

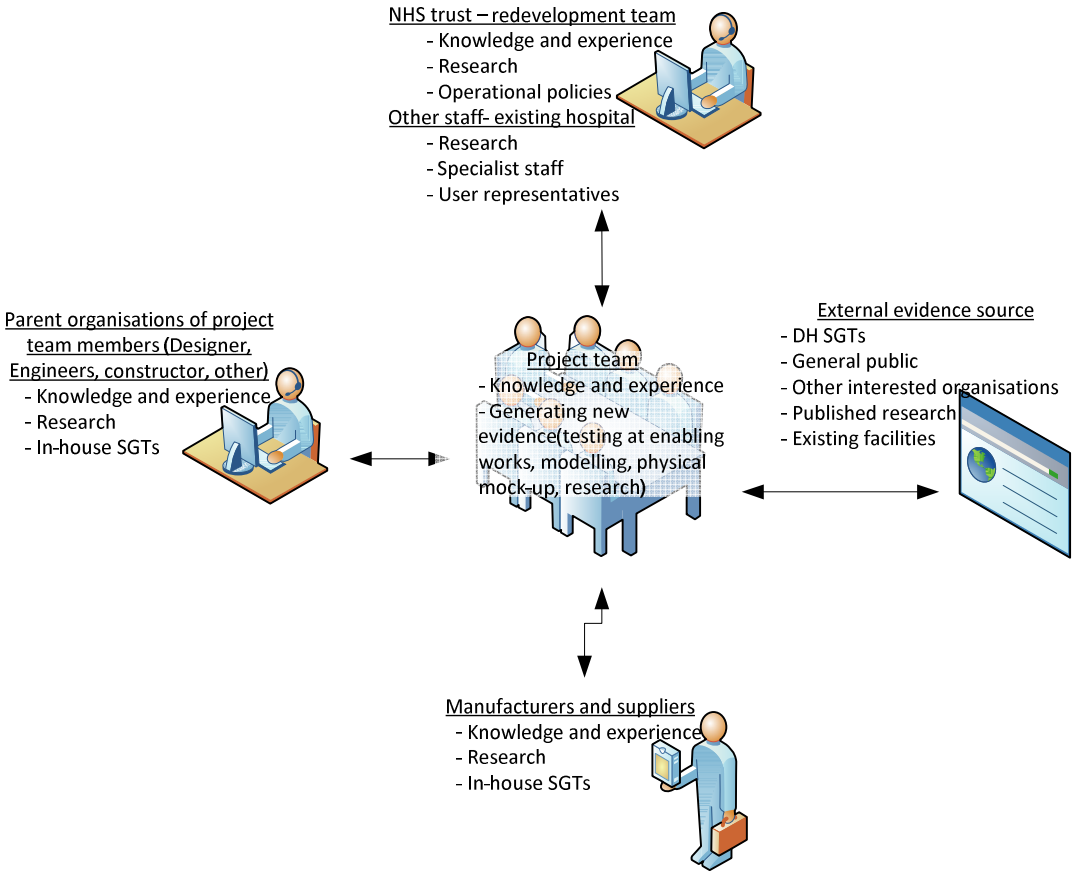


Figure 7-3: Evidence channels for Case Study A

The data analysis process that was explained in the Chapter 6 identified that designers have used the following nine sources of evidence to gather evidence for the design scope considered within this research.

1. Knowledge and experience
2. Internally generated evidence
3. Evidence from the industry
4. User consultation
5. Standards and guidance

6. Visits to facilities
7. Information from client
8. Research – external
9. Expert opinion

Data revealed details of evidence used for 166 design steps some of which include using evidence from more than one source. As described in Chapter 6, instances of using evidence were calculated to identify the frequency of using different evidence sources and the timing of their use. As a result 191 instances of evidence use could be identified for the Case study A.

The Table 7.2 provides details of the evidence sources used during the designing of 27 elements.

Table 7-2: Details of evidence sources used during the designing of 27 elements

	Main design units		Sub-design elements	No of design steps involved	Sources of evidence										Number of instances of evidence use	Total number of evidence sources used (& non used)
					Information from client	Evidence from the industry	Internally generated evidence	Knowledge & experience of stakeholders	User consultation	Expert opinion	Research - external	Standards and guidance	Facility visits	Constrained use of evidence		
1	Single bed room, en-suit & bed head service panel	1	Room dimensions	3	1		1							1	3	3
		2	Detail design inside the room	8			3	3			2				8	3
		3	Room layout - what goes in	3			1	1				1	1		4	4
		4	Room layout - wardrobes	4				3				1			4	2
		5	Location of en-suit	3				3							3	1
		6	Bed head service panel	10		4		3	2						9	3
		7	Control of environment	2				1	1						2	3
2	Ward layout and nurse station	8	Ward layout	16	5		1	6	2			1	1	1	17	7
		9	% of single bed rooms	9	1			5	1		1	1	2		11	6
		10	Nurse base-decentralisation vs central	9				4	1		3		1		9	4
		11	Nurse base - level of decentralisation	5			2	2	1						5	3
		12	Recessed PC	4		2	1		1						4	3
3	Communal spaces	13	Play area	7				3	1	2			1		7	4
		14	Parents waiting space	4				4	1						5	2
		15	Staff rest	6				3	1				1	1	6	4
4	Isolation room	16	Isolation room	11			1	6		1	1	1			10	5
5	Finishes	17	Finishes - generic	6	1	3	1	4	1			2			12	6
		18	Finishes - en-	3		1	1	2				1			5	4

			suit floor													
		19	Ceiling finishes	8		2	3	4				1			10	4
6	Doors	20	Doors - generic	4				2	2						4	2
		21	Finishes - doors	3				3							3	1
		22	Doors - finger trapping solutions	9		2	3	3	3						11	4
		23	Single room door	3		1								2	3	2
		24	Not having smart glass	5		1	2	4							7	3
7	Water services	25	Water services	8	1	2	1	5				2			11	4
8	Ventilation strategy and windows	26	Ventilation strategy	3	1			3				1			5	2
		27	Window design	12		3	2	3	2			1	1	1	13	7
				166	10	21	23	80	20	3	7	13	8	6	191	

The results in Table 7.2 reveal that the number of instances of using evidence and using a variety of evidence sources is different from element to element. For some elements, a considerable amount of evidence was sought from a considerable number of sources, whilst for some elements evidence was sought from a fewer number of sources. One reason for these differences could be the scope of the particular element. It is fair to assume that an element with a large scope is associated with a higher number of design steps resulting in accessing a larger amount of evidence from a variety of sources. For instance, elements of *detail design inside the room* and *ward layout* required a considerable amount of evidence to be sought. Secondly, the number of evidence sources which designers sought after when designing a particular element may imply the quality, availability and accessibility of the evidence used for that particular element. In this case study for 80% of instances evidence was sought from at least 3 sources. However, in the majority of the instances evidence was sought from 3 or 4 sources. Since, there were no specific problems reported relating to availability of evidence or accessibility to evidence, the most reasonable explanation for using a limited number of evidence sources could be that the evidence they gathered was of acceptable quality and did not necessitate more evidence being required.

The opinion of interviewees were inquired related to the availability of evidence, quality and integrity of existing evidence and rate of success of the design during operation (see Table 7.3). This reveals that the availability and quality of the existing evidence for designing the window was poor in comparison to the evidence used for other elements. This is further reflected in the designing process for '*bed-head services'*. Table 7.3 revealed designers' opinion relating to the poor quality and integrity of evidence available for this element. This was reflected within the evidence use during the design process. A higher number of design steps were taken during the designing of '*bed-head services';* nine instances of using evidence were reported.

Table 7-3: Designers' opinions of evidence used in Case A

	Design component/ element/ space	Availability of evidence	Quality/ Integrity of existing evidence	Rate of success in operation	Would you recommend the design next time
		1–Poor 2–Fair 3–Good 4–Very good 5–Excellent	1–Poor 2–Fair 3–Good 4–Very good 5–Excellent	1–Poor 2–Fair 3–Good 4–Very good 5–Excellent	
1	Single bed room	4	3.5	4	Yes
	- On-suit bathroom	3.5	3.5	4	Yes
	- Bed head	3	2.5	3	Yes
2	Communal spaces	4	4	4	Yes
3	Ward layout	3.5	3.5	4	Yes
	Clinical workstations	1.5	2	4	Yes
4	Window design/ ventilation strategy	2.5	2.5	2	Yes
5	Finishes (Floor, wall and Ceiling)	3	2.5	3	Yes
6	Water services	2	2	2	Yes + Yes with improvements
7	Isolation room	2	2.5	4	Yes
8	Doors	3	3.5	3	Yes

The data in Table 7.3 reveals that the design team have had 'good' or above level of access to evidence; except for design elements of clinical workstations, water services and isolation room. The quality of the available evidence for these elements was between 'fair' and 'very good'. The rate of success at operation was 'good' and above except for window & ventilation strategy and water services.

7.4.2 Frequency and timing of evidence use

Figure 7.4, shows the frequency of using evidence form the nine sources and none-use of evidence during the scope considered within Case study A. As stated in Chapter 6, for some design steps a combination of more than one source of evidence was used. Therefore, the frequency of use for a particular evidence source alone and frequency of using the source in combination with other sources were identified separately. Instances of constrained use of evidence were also reported.

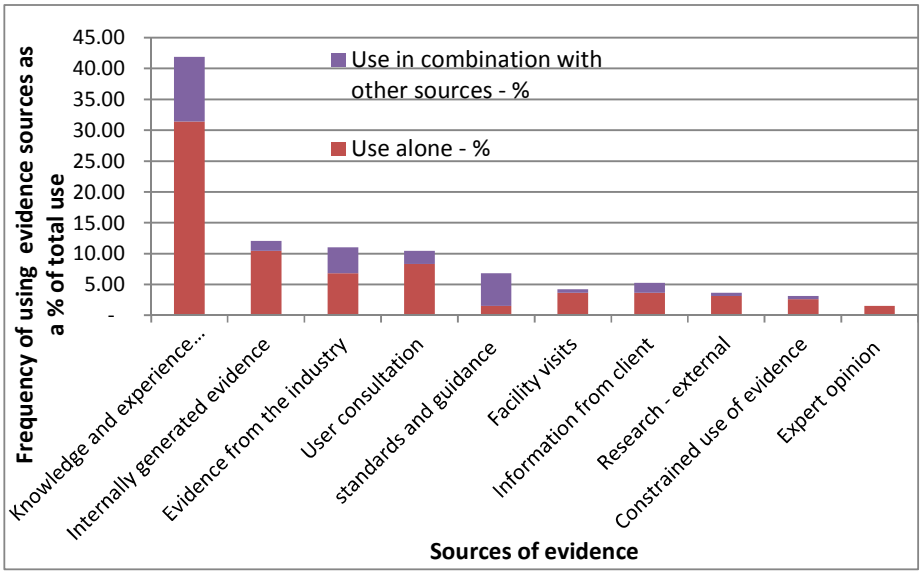


Figure 7-4 : Frequency of use for different evidence sources

Knowledge and experience was the most commonly used source of evidence for Case study A. The knowledge and experience of the design team members and their parent organisation were used extensively in all 27 design elements studied. There could be two reasons for the significant use of K&E during the design of Case study A. Firstly, as stated in the literature, knowledge and experience is an accumulated from learned evidence that was used during previous projects. Other than the client, parties engaged in the design team of Case study A had long established previous experience in designing healthcare buildings and other built environments. Therefore, it is possible that previously learned evidence from other sources is now reflected as K&E and not as its original source. Secondly, even though the client of Case study A does not have long standing experience in procuring healthcare buildings (compared to other parties), the project considered in Case study A was an intermediate phase of a major redevelopment, hence the client had experience in building design from the previous phases. The client's team on Case study A was specifically formed to engage full time for the redevelopment activities. Therefore, they have added a considerable input during the designing of Case study A. Furthermore, design elements such as single bed patient rooms are being used in the private wing of existing hospital and knowledge and experience gleaned

from them by the client was helpful in designing the new single patient rooms in this phase of the project.

Compared to K&E other sources of evidence were less used. For a better visual illustration of data related to other sources of evidence, this graph was re-plotted without K&E (Figure 7.5).

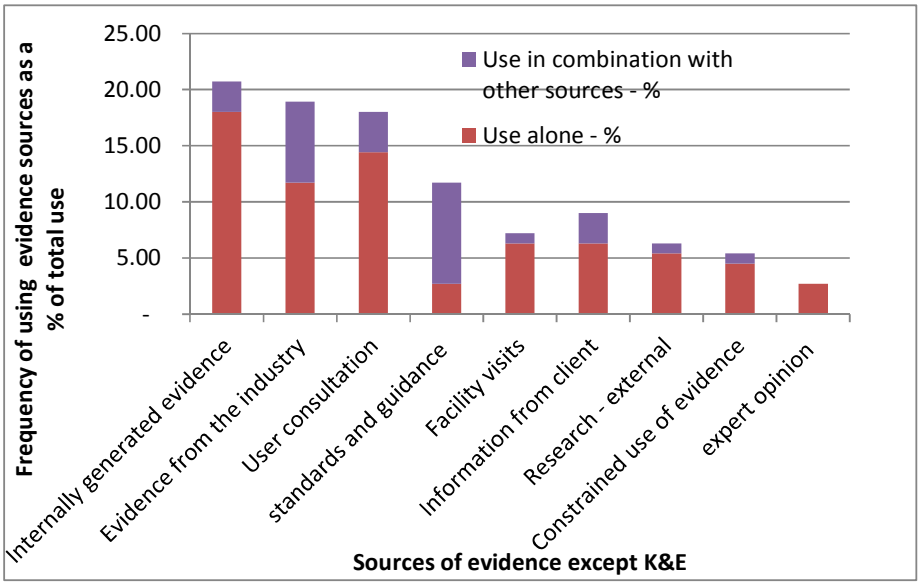


Figure 7-5 : Frequency of using different evidence sources except K&E

The next most frequently sources were 'internally generated evidence', 'evidence from the industry' and 'user consultation' at approximately 15-20% of the design activities. Standards and guidance, facility visits, information from the client, and external research were cited at 3-7%. Another interesting observation is that, during the use, internally generated evidence is less supported by evidence from other sources, whilst evidence from the industry and evidence from SGaTs are used in combination with other sources of evidence in a considerable proportion of situations.

Table 7.4 illustrates the timing of use for nine sources of evidence during the designing of Case study A. For the purpose of illustration, the total instances of using evidence for design evaluation were combined into one column in Table 7.4. However, design evaluation was an iterative process throughout the design stages. For instance, Figure 7.6 illustrates the process of procuring bed head service panels.

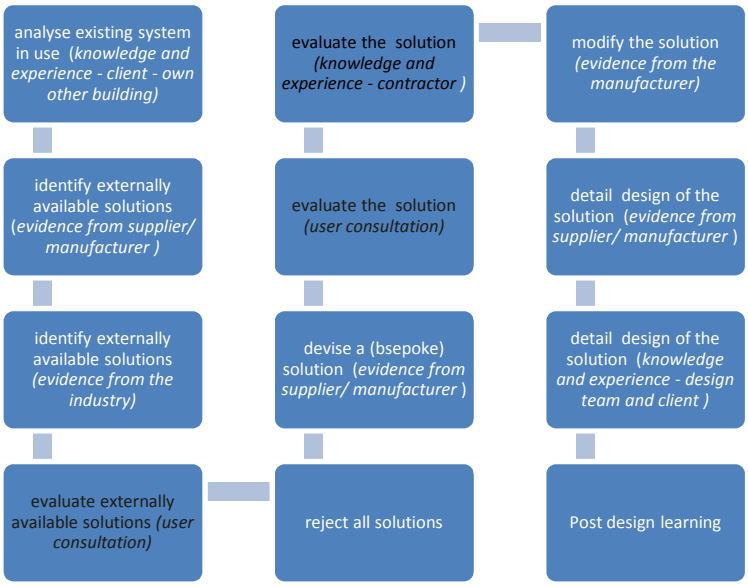


Figure 7-6 : Design process of bed head service panel

In this specific example, an initial design evaluation was undertaken for externally available solutions. All the solutions which were available from the industry were rejected and the design team then devised a bespoke solution with support from a selected supplier of bed-head service panels. This bespoke solution was then followed by another step of evaluation.

Table 7-4 : Timing of evidence use for Case A (Total number of instances - 191)

	Pre-design phase (Problem defining)					Design phase (Designing and design evaluation)									Total
	Analyse existing system	Identify & process strategic requirements	Identify project specific requirements	Specify performance specification	Specify prescriptive specification	Identify possible ado(a)ption	Evaluate evidence	Adopt the solution	Adapt a solution	Reject the solution	Devise a solution	Construct a solution	Detail design	Improve the solution	Design evaluation	
Information from client	-	1	6	-	-	-	1	-	1	-	-	-	-	-	1	10
Evidence from the industry	-	-	-	-	2	9	-	-	-	-	2	-	2	-	6	21
Internally generated evidence	-	-	2	-	-	1	-	-	-	1	1	-	-	-	18	23
Knowledge and experience stakeholders	2	-	5	2	1	11	2	2	2	2	10	-	2	9	30	80
User consultation	2	-	4	-	-	-	1	-	1	1	1	-	-	-	10	20
Expert opinion	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	3
Research (external)	-	-	-	2	1	-	-	-	-	-	-	-	-	-	4	7
Standards and guidance	-	-	-	-	1	4	-	-	1	-	2	-	-	2	3	13
Facility visits	-	-	1	-	-	1	4	-	-	-	-	-	-	1	1	8
Constrained use of evidence	-	-	1	-	-	-	-	-	-	-	1	2	-	1	1	6
Total count	4	1	15	8	5	26	8	2	5	4	18	2	4	14	75	191

According to the results in Table 7.4, K&E was used during almost all design activities. Internally generated evidence and evidence from user consultation were mainly used for design evaluation activities. Information from the client, evidence from visits to facilities and evidence from the industry were mainly used to identify design solutions and activities associated with early stages of designing. Evidence from SGaTs was used in both the early stages of designing but less frequently. These results imply that evidence sources may have their own particular ways of supporting the design process. This was analysed by a cross case comparison and presented in Chapter 10 of this thesis.

7.4.3 Other dimensions of evidence

Table 7.5 summarises the findings of Case study A relating to the use of nine sources of evidence.

7.4.3.1 Knowledge and experience (K&E)

As discussed previously, K&E was the most frequently used source of evidence, and was evidently an informed source of research-based evidence. In many instances, research-based evidence was used as design principles during designing. For instance, the following interview conversation reveals how the design team tried to minimise nurses' walking distance during the laying out of single patient rooms.

> *".....If you say you got single bedrooms like that (illustrating one layout), if you have en-suite bathrooms like that, and your nurse if you got a nurse serving three four bedroom, ... the travel distance is greater, so actually making things tighter helps on travel distance of nurses....."(a representative from designer)*

It could be assumed that individuals learn research-based evidence by reading published evidence, other educational modes (such as conferences, communities of practices) or by previous experience.

In addition, there were instances where members of the design team have learned evidence from the private wing of the existing hospital which has single-bed patient rooms and POE's of previously engaged similar hospitals. Therefore, it is fair to assume that evidence gathered through K&E in this case study is rich in credibility since it is supported by facts of actual use in previous designs.

Table 7-5 : Uses of nine sources of evidence during the designing of Case study A

	Means of gathering evidence	Purpose of evidence	User Channel of evidence	Availability of evidence	Suitability /Relevance of evidence	Quality of evidence	Success of application
Information from client	* Client's brief * Trust's operating principles * Schedule of accommodation	* To identify project requirements * To identify demographic details of the prospective hospital	Client	Yes	No flaws were reported	No flaws were reported	No failures were reported due to evidence from this source.
Evidence from the industry	* Trade shows * Client's working collaborations with local and international hospitals	* To identify externally available solutions * To identify innovative solutions * To identify detail and technical detailing * To evaluate solutions	* Designer (for architectural solutions) * Client (clinical service solutions) * Engineer (for technical solutions)	(+) This was the second most used source of evidence (+) Due to the reputation of the project some suppliers and manufacturers themselves have approached the project	(-) modifications were made to solutions in few instances (-) one solution (Philips green light system) was rejected due to inapplicability	No flaws were reported	(-) Few snags related to some solutions identified from the industry were reported.
Internally generated evidence	* Research * Modelling * Physical mock-up * Testing through enabling work * POE of client own other facilities	* To evaluate products and solutions * To evaluate options * To aid detail design (using in-house standards)	* Members of the design team * Clinicians of the existing hospital * Facility management team of existing hospital (e.g. – infection control team)	(+) Internal research was considerably used (+) Had a dedicated redevelopment team and funding allocation for EBD	(-) These were purposely done for project specific problems	(-) Physical mock-ups : some of the weaknesses of the design were left due to testing conditions different from operational conditions (e.g. floor finishes of on-suit)	(-) Few snags were identified due to evidence from this source.
Knowledge and experience stakeholders	* In-house standards compiled from previous phase of the development * engage in designing and design evaluation activities	*Used during almost all types of activities of designing, but extensively to identify solutions, devise solutions and evaluate solutions	Members of the design team	(+) This was the second phase of the project – a good level of knowledge and experience was available	(+) In-house standards from recent and previous phase of same development (+) Private wing of the hospital has had few single bed patient rooms to learn from	No flaws were reported	No failures were reported due to evidence from this source.
User consultation	* User groups were formed to involve in design evaluation process (eg: single-room group; finishes group; art group) * A tool was developed to capture patient and family requirements (using existing patients and families at that time) * Comment on physical mock-up	* To evaluate the design * To identify user requirements, * To identify additional functions/ improvement opportunities * To analyse existing systems in use, * To identify current use of facility or parts of the facility, and * To collect data for new evidence generation	* Clinical staff, * Infection control team * Facilities management staff * Patients and families of existing hospital	(+) A considerably well user involvement was made (+) Building physical-mock up on the existing hospital site has positively impacted user consultation	(+) These were purposely done for the project	No flaws were reported	No failures were reported due to evidence from this source.
Expert opinion	* Direct consultation * invited presentations/guest lectures (eg DH presentation on Isolation room design) * Engage in designing and design evaluation	* To identify the design problem * To evaluate the design * To identify improvement opportunities	* Specialist staff within the hospital * Experts from DH	(+)In-house expertise was available within the existing hospital	No flaws were reported	No flaws were reported	No failures were reported due to evidence from this source.
Research – external	* Pebble project evidence * Roger Ulrich's evidence reviews * Research published by DH * Research published In peer reviewed journals and professional journals * Other	* To evaluate the design * To identify solutions * To guide design	* Clinical staff (peer reviewed journals) * Other members of the design team (other published research)	(+)Project team has had good access to this form of evidence – due to research culture of client and funding allocated for EBD	No flaws were reported	No flaws were reported	No failures were reported due to evidence from this source.
Standards and guidance	* DH standards and guidance * Industry standards and guidance	* To identify solutions * To improve innovative solutions * To evaluate solutions * To use as a starting point	Not Applicable	Yes	(-) Due to the project-unique circumstances, evidence from SGaTs was frequently used with improvements	(-) Was used in conjunction with other sources of evidence	No failures were reported due to evidence from this source.
Facility visits	* Visits to local hospitals and other places that are interest to children * Clinicians visits to American hospitals * International visits were video recorded to share with other members of the design team	* To identify up to date design solutions - To evaluate application of solutions learned from other evidence * To evaluate evidence * To identify children's preferences.	* International visits were done mainly by clinicians * Local visits (hospitals and other places) by other members of the design team	(+) Visits specific to this project (+) Clinicians invited by other hospitals around the world for clinical purposes	(-) Evidence adopted from facility visits was not suitable in some instances due to differences in operational conditions and care models of visited hospitals	(-) visits to PFI hospitals : operating regime of PFI hospitals are better than a non PFI hospital, therefore some of the characteristics of the finishes were not identified (eg: white wall finishes easily get dirty)	(-) Instances of minor failures in adapting evidence from other facilities were reported. These were mainly caused due to differences in contextual circumstance of different facilities.

7.4.3.2 Evidence from the industry

Evidence from the industry was used extensively during Case study A, and was used to identify solutions for single room door, smart glass on the single room door, bed-head service panel, recessed PC at the nurse base, window and ventilation design, floor finishes, ceiling finishes, water services design and finger trapping solution for the doors.

In addition to the aspects mentioned in Table 7.5, there are two notable facts about using evidence from the industry: evaluation process and performance of the design during use. A series of steps were then made to evaluate solutions identified from industry. Some of the solutions were adopted or adapted after evaluation, while some were abandoned. The design of the bed-head service panel and finger trapping solution for the door edges are two major examples which have gone through a series of iterative processes until reaching the best suited bespoke solution for Case A. Intelligent drug storage system, recessed PC to be used in the nurse bases and some finishes are a few of the other solutions that were considered and adopted. On the other hand, rubber floor finish, 'vistamatic' door panels and Phillips green light system were considered and abandoned after evaluation for different reasons. Minor failures for some solutions identified from industry, were identified during the operational phase. For instance, a recessed PC, used in other industries, was proposed by the Architect for incorporation into the nurse station; it was later found that the capacity of this type of PCs could not cope with healthcare information systems. Therefore, a thorough examination is required before adopting solutions used in other industries.

7.4.3.3 Internally generated evidence

There was the second most used source of evidence in Case A, which was used in 10 design examples among 27 design examples examined in the study (refer Table 7.2). Clinical staff from the existing hospital, infection control staff, and facilities management staffs were also involved in generating new evidence to be used in Case A.

There are a few instances which the design team has designed novel solutions based on internally generated evidence. For instance, the water services strategy of Case A is a completely bespoke novel solution which they have not seen in any other UK hospital before. This design was devised by applying internal research undertaken by the client's staff (infection control team and clinicians) in collaboration with engineers. Modelling was used to predict the thermal comfort of the facility in use, user traffic flows in circulation areas and performance of single-bed patient rooms and nurses' stations. Case study A has had the advantage of enabling ideas from facilities used as temporary patient accommodation until the old building was replaced with a new building. Designers have used

this opportunity to test products and components before integrating them into the main development.

However, it was difficult to determine the credibility of the internally generated evidence other than the research evidence. The main weakness of this type of evidence is that it had to be generated based on simulated operating conditions. For instance, thermal performance and comfort of the single rooms was modelled using computer aided simulation techniques. Single bed room design was physically mocked-up to evaluate how the design would perform during actual operation. Yet, during the POE's it was identified that in a few instances actual operating conditions were different to the operating conditions predicted or modelled during the modelling process, resulting in some minor failures. For instance, during the mock-up evaluation, floor finishes were evaluated giving consideration to colour of finish, performance of grits and time to dry the floor after use. However, during the actual use of the building, performance of the en-suite floor finish was poor, because the floor is more frequently and heavily used than the model predicted during the evaluation process. Therefore, evidence generated during a physical mock up needs to be improved.

7.4.3.4 Standards and guidance

SGaTs were the fourth most used source of evidence. This result should be interpreted with caution. During the interviews with representatives from all three parties mention that they used evidence from HBNs, HTMs and other SGaTs. It was mentioned that SGaTs were used for design of single bed rooms, % of single bed rooms, detail arrangements inside the room, ward layout, window and ventilation design, ceiling finishes, isolation room and water services. But data analysis resulted in a low count for SGaTs use, because they did not frequently mentioned specific examples or design activities related to use of SGaTs (see quotes below).

"……..(during the designing of single bed patient room) they (Designer) started working based on what they knew and based on what we knew and from HBN 23…." (a representative from Client)

*"……..we listed products out there in the market and then there were certain things we knew that don't work, we had categories from HTMs for ex: type two category: that is humidity we had several products that fit into that category……"(*a representative from Designer)

Furthermore, one of the three engineering services considered in this case study (water service strategy) was a novel solution which is not supported by existing HTMs. This has resulted in a low count for frequency of using evidence from SGaTs.

A detailed appraisal of how SGaTs were used during Case A was identified previously during a workshop (Phiri et al., 2012).

7.4.3.5 Visits to facilities

Case study A benefited from evidence gathered through visits to national and international facilities. Using evidence from facility visits was interesting for few reasons. Firstly, clinicians of the hospital were invited, for clinical purposes, by local and international hospitals. They have used these opportunities to bring built environment related evidence to the new development. Secondly, the hospital concerned in Case study A was a member of a group consisting best international paediatric hospitals. Due to these reasons, a considerable number of international visits were made by clinicians to hospitals in the US and around Europe. Design solutions identified through these visits, were video recorded to share with the rest of the design team. Interviews with the designer's representatives identified this as an effective mechanism for sharing evidence. Finally, not limiting to the hospitals, the design team visited other facilities interesting to children (see quote below).

"…….we did not just go to the hospitals, we also looked anywhere that children go to, so we went to national history museum, some thing story telling one in Stratford, we went to several places that were really good destinations for children, ……. it was all about trying to make hospital not feel like an institution but trying to make it a place where children like….." (a representative from the Designer)

Furthermore, purposeful follow up visits were made to gather further evidence for some of the solutions identified.

Similar to the evidence identified from the industry, solutions encountered through these visits were carefully evaluated before adopting, adapting or rejecting. For instance, adopting some of the designs available in US hospitals was difficult in the UK due to the differences in healthcare service funding in the two countries. It was mentioned that in US hospitals they use single rooms and decentralised nurse stations for intensive care units are supported by constant CCTV monitoring of patients. Since, Case A did not consider CCTV monitoring of patients, they adapted this US model only for non-critical patient accommodations. The high-dependency unit is designed as shared bed bays where nurses can constantly monitor patients.

Instances of minor failures in adapting evidence from facility visits were reported. These were mainly caused due to differences in contextual circumstance of different facilities. For instance, walls were painted white following evidence that it is used in many hospitals visited. However, it was realised that white walls easily get dirty. The facilities vested were operated under PFI schemes which have

different and extensive maintenance regimes to maintain wall finishes. This was not noticed during facility visits.

7.4.3.6 User consultation

User consultation was considerably used to gather evidence for Case study A. Evidence gathered from this source was notable in relation to its procedure. Several user groups were formed to consult on different aspects of the design. Some of them include bed pool groups for single room design; finishes group for finishes; and art group for art works. Throughout the process of designing, these groups were consulted iteratively to evaluate the design. In addition, a generic user consultation was carried out to evaluate the single-bed patient room design via a physical mock-up. Public consultation was not a good way to capture insights from patients and families because the hospital serves patients from all over the UK and around the world in speciality care. Therefore, the redevelopment team developed a tool to capture patient and family requirements (using existing patients and families at that time) to use throughout the redevelopment. Children in the existing hospital were asked to model their dream bedroom with shoe boxes and insights from this exercise were used to design the bedrooms. Specialist staff consulted during the design process (play specialists) are categorised as expert opinion.

7.4.3.7 Research - external

It was identified that external research evidence was used during 7 design examples. There were two favourable conditions for using published evidence during the designing of Case study A. Firstly, a sum of money was allocated Evidence-based design within the project budget, allowing the Case study to be a part of the Pebble project and to conduct internal research. Secondly, the client group consisting of clinicians had access to published research for medical purposes.

Even though the Interviews with the Designer's representatives did not reveal that they subscribe to any research journal, there were specific examples where they have used published research. For instance, the conversation below reveals the Designer's awareness of research into the design of nurses' stations.

> *"……..is it good to have a complete disposed workstation or is it good to have a mix? Somebody had done a study somewhere and they looked at old fashion nurse station and 100% disposed workstations, and came up with the finding that either of them is not good alone and better to have a mix……." (a representative from Designer)*

Interviews with representatives from the Client and the Designer revealed that a considerable amount of published research was considered during the designing of the single bed patient room.

Yet, specific design activities performed, based on published research, were less revealed within data, which eventually reflected on the low frequency of use of published evidence (see below quotes from interviews).

> *"……single bed room is a solution to nurses walking issue - the biggest issue in the single bedroom is nurses have to walk a lot……." (a representative from the Designer)*

> *"……we told architect we don't need any fixed furniture so either they got to be built into the structure, or we got to move them in and out……." (a representative from the Client)*

After examining the quotes above and case study data, it is apparent that these published researches were primarily used to identify design rules to guide the design. Specifically, the need to reduce nurses' walking distance; increase patient observation by nurses and staff, patient and family satisfaction were used as design rules during the design phase.

Previous literature suggests that published research is seldom used by designers during the design phase. In contrast to these claims, the results from Case study A revealed that published research was significantly considered during the designing of Case study A.

7.4.3.8 Information from client

Information from the client was mainly used to identify project requirements. These were mainly conveyed in the form of the client's initial brief, trust's operating principles and schedule of accommodation. Considering the content of these inputs, these can be better termed as information not evidence.

7.4.3.9 Constrained use of evidence

Constrained use of evidence is reported in a few instances. The size and layout of bedrooms were influenced by the available restricted site area. A single room door was designed to suit a ceiling hoist mechanism.

7.4.3.10 Expert opinion

For Case A, expert opinion was the least used source of evidence. But, it is important to mention at this point that the Client organisation (hospital) has many specialist staff within the organisation and they were consulted when appropriate. Design of play area is a good example which designers used evidence from clinical specialists. The reason for the low count for instances of using evidence from expert opinion is that all the instances of consulting experts were not included in the case study scope. Therefore, this result should be interpreted with caution.

7.4.4 Reflections on the model

A bespoke version of the SaFE model for Case A was produced using the Case study data (Figure 7.7) based on the methodology explained in Chapter 6. The following discussion compares and contrasts the bespoke model of EBD for Case A with the generic SaFE model discussed in Chapter five.

1. Some of the data sources in the generic model were not used for Case A.

Data did not revealed instances where the design team used evidence that was derived from knowledge and experience in the public domain, knowledge and experience of peers, evidence from industry and professional journals, and any other written evidence of industry best practices; which are obtained from conferences, and peer generated evidence.

2. Specific data sources from published evidence.

The generic model was not explicit with regards to specific details about data sources which contain research evidence. Specific details regarding these sources were revealed during the case study and they were included in the bespoke model. These are published research evidence accessed through research institutions with whom the project team is collaborating; well-known research evidence reviews (systematic review done by Professor Roger Ulrich and his team); research published by external organisations such as DH, NICE (National Institution for Clinical Excellence); and research published in journals.

3. Invalidated evidence flows

The data collected was not adequate enough to validate evidence flows going into the phases of construction including products and systems supply and commissioning and testing. Due to the restricted time available for the research there was no opportunity to interview the constructor. Details of Post Occupancy Evaluation procedure were not accessible at the time of data collection.

4. Details of evidence flowing into the sub-processes could be identified.

For instance, several sub-processes for the main process of designing were identified. They are adopting a solution, adapting a solution, rejecting a solution, devising a solution, constructing a solution, detailed design and improving the solution. However, at this stage in the modelling process evidence flows into the sub-processes were not included.

Sources and flows of evidence model (Case study A)

Conceptual SaFE model SaFE A → Verified SaFE model SaFE B1-B4 → Validated SaFE model SaFE C1-C4 → **Case specific SaFE models SaFE D/E/F** → SaFE model with (RIBA plan of work 2013 overlay) SaFE G1 – G4

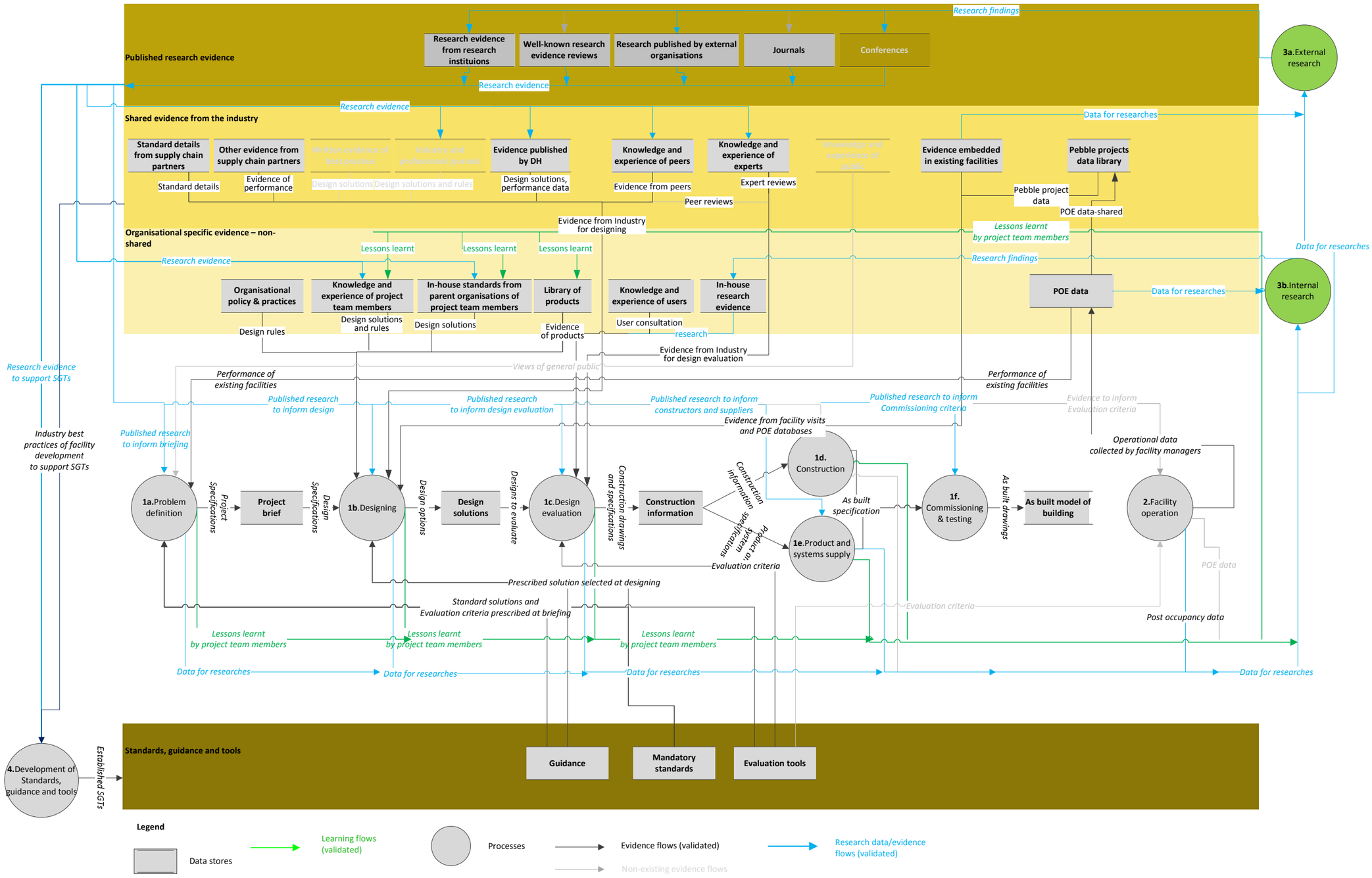


Figure 7-7 : The SaFE Model - Case study A

7.5 USE OF PERFORMANCE AND PRESCRIPTIVE SPECIFICATIONS

Data revealed that evidence expressed in the form of performance and prescriptive specifications are used during problem definition, designing and design evaluation.

Stories of the 27 design elements identified within Case A, was deductively analysed to identify how designers used performance specifications and prescriptive specifications during problem definition and design.

Specifically, case study data were analysed to identify designers' use of two approaches to problem definition:

- problem definition based on evidence from SGaTs; and
- problem definition based on specifications devised based on other evidence.

And their use of four approaches to designing:

- designing based on guided solutions;
- designing based on de facto and innovative solutions;
- devising solutions; and
- constructing solutions.

Further details of the analysis are presented in Chapter 6. Distinct approaches for design evaluation could not be identified at element level. Designers used almost all sources of evidence to evaluate the design throughout the designing. These were presented and discussed in Section 7.4.

Based on the deductive analysis, it was identified that designers in the Case A have adopted 5 variant approaches to problem definition and 9 variant approaches to designing. Table 7.6 summarises the approaches taken by designers of Case A for problem definition and design for each of the 27 element.

Table 7-6: Details of approaches to problem definition and approaches to designing in Case study A

		Design element	**category**	**Approach to problem definition**	**Approach to designing**	**Solution origin**	**Nature of output design**
A	1	Ward layout-other	Space/layout	DP	DS		Bespoke
A	2	Location of en-suit	Location	DP	DS		Bespoke
A	3	Nurse base - level of decentralisation	Composition	-	DS		Bespoke
A	4	Play area	Space/layout	->DP	DS		Bespoke
Continue to next page.							

Table 7-6: cont'd from the previous page

A	5	Parents waiting space	Space/layout	DP	DS		Bespoke
A	6	Staff rest	Space/layout	DP	DS		Bespoke
A	7	Water services	E/Services	-	DS		Bespoke
A	8	Room dimensions	Shape and size	DP	DS(C)		Bespoke
A	9	Single room door	Component	DP	DS(C)		Bespoke
A	10	Isolation room	Space/layout	DP+GP	GS	DH SGaTs	Standard
A	11	Room layout - what goes in	Space/layout	DP+GP	GS+DS	SGaTs	
A	12	% of single bed rooms	Composition	-	GS+SS > DS	SGaTs + **iSS** (Evidence from the industry) solution abandoned	Bespoke
A	13	Room layout - wardrobes	Component	DP	SS	**dfSS** (in-house K&E)	Bespoke
A	14	Control of environment	Facilities	DP	SS	**dfSS** (in-house K&E)	
A	15	Finishes - generic	Finishes	DP	SS	**iSS** (Evidence from the industry)	Standard
A	16	Finishes - en-suit floor	Finishes	-	SS	**iSS** (Evidence from the industry)	Standard
A	17	Ceiling finishes	Finishes	-	SS	**iSS** (Evidence from the industry)	Standard
A	18	Doors - generic	Component	DP	SS	**iSS** (Evidence from the industry)	Bespoke
A	19	Not having smart glass	Provision	-	SS	**iSS** (Evidence from the industry)	Standard
A	20	Finishes - doors	Finishes	-	SS	**iSS** (Evidence from the industry)	Standard
A	21	Bed head service panel	Component	DP	SS > DS	**dfSS** (in-house K&E) failed	Bespoke
A	22	Doors - finger trapping solutions	Component	DP	SS > DS	**iSS** (Evidence from the industry)	Bespoke
A	23	Nurse base-decentralisation vs central	Option appraisal	-	SS+	**iSS** (Evidence from the industry)	Bespoke
A	24	Recessed PC	Component	DP	SS+	**iSS** (Evidence from the industry)	Bespoke
A	25	Ventilation strategy	E/Services	-	SS+	**dfSS** (Traditional solution)	Standard
A	26	Window design	Component	-	SS+	**dfSS** (in-house K&E) + **iSS** (Evidence from the industry)	Standard
A	27	Detail design inside the room	Space/layout	DP	SS+DS	**dfSS** (in-house K&E)	

Key : GP – Problem definition based on *guided specifications*, **DP**- Problem definition based on devised *specifications*, '**-**' - No pre-determined approach to problem definition, **DS** – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Adopt or adapt a selected de facto or innovative solution , '**+**' - Significant moderations made, **>** - transition of approach, **iSS –**

innovative solution**, dfSS –** de facto solution

7.5.1 Prescriptive and performance specifications for problem definition

Pre-design activities conducted by the project team were considered as activities of problem defining (refer Table 7.4). The project team in Case A involved in the following activities for defining design problem.

- analyse existing system;
- identify and process strategic requirements;
- identify project specific requirements; and
- specify performance and prescriptive specifications to guide consequent designing.

Examining Table 7.4 it is evident that approximately 17% (33 out of total of 191) of the project team's activities are related to problem definition. Identifying project specific requirements is the most frequent (50% of activities concerned in this phase) activity within this phase. Evidence from internally identifiable sources (information from client, knowledge and experience of stakeholders, user consultation and internally generated evidence) was used significantly (approximately 78% of instances). Evidence from the industry, externally published research, SGaTs and from facility visits were marginally used during problem definition activities.

Evidence for analysis of existing systems was gathered mainly by user consultation carried out by the client, and the client's knowledge and experience (example, existing bed-head service panels, availability of control of comfort for patients). These were then passed on to the other members of the design team. Involvement by other members of the design team in this activity was limited. Project specific requirements were used mainly to identify space requirements, user requirements and other requirements to support operation of the facility. Involvement by members from the Client, the Architect and the Engineer was apparent during this activity. Performance specifications were set based on evidence from published research and knowledge and experience of the Client, whilst, prescriptive specifications were set based on evidence from knowledge and experience, evidence from the industry, published research, SGaTs and visits to other facilities.

In summary, the results from Case A show that problem definition activities were mainly used to identify details of the design problem and design requirements. These activities were then used to specify design requirements expected within the subsequent design. These design requirements were primarily related to design output. In 24% of the instances (8 out of 33) prescriptive solutions were specified as a result of problem definition activities.

Another important finding was that health outcome related evidence was considered during problem definition activities. For instance, improved end user satisfaction by providing overnight accommodation for family, problems of having different types of bed-head service panels in different locations of the hospital and trust, importance of giving end users some control of their environment, reducing infection control, improving security, reducing nurses' walking distances and errors in reporting and improving patient observation were some of the health outcome related consideration made during problem definition activities.

Table 7-8 shows a summary of how problem definition approaches were used within Case A.

Table 7-8: Approaches to problem definition and approaches to designing for Case A

Base for problem definition		Approach to design								
		DS	DS ©	GS+DS	GS	GS+SS> DS	SS>DS	SS	SS+	SS+DS
GP	-									
DP	14	4	2				2	4	1	1
-	10	2				1		4	3	
GP+DP	2			1	1					
->DP	1	1								

Key :
GP – Problem definition based on g*uided specifications*, **DP**- Problem definition based on devised *specifications*, '**-**' - No pre-determined approach to problem definition, '**-**' - No pre-determined approach to problem definition,
DS – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Adopt or adapt a selected de facto or innovative solution, '**+**' - Significant moderations made, **>** - transition of approach

Examining the results in Table 7.8, it is evident that in the majority of instances, designers devised specifications (DP) to define design problems. In a considerable number of instances no pre-determined approach to problem definition was made (-). Surprisingly, designers marginally used SGaTs alone or in combination with other sources of evidence during problem definition. Furthermore, any association between the approach to problem definition and the approach to designing is not obvious at this juncture.

7.5.1.1 Problem definition based on devised specifications (DP)

For a significant number of design elements designers devised design requirements. Some of these criteria were supplementary to the specifications stated in the SGaTs (see quote below)

> *"……we first look at the room we go the space around the bed from HBN……then we thought with extra area we could have some space for family or carerers and then we thought to have some storage as well…… Storage area is not covered by the single room space (in the HBN)……."(a representative from the designer)*

Specific reasons for devising new design requirements could be identified. Firstly, unique circumstances associated with children's care settings and other project-unique circumstances resulted new design requirements. A representative from the Designer explained how the design problem in a children's care setting is different to other hospitals.

> *"……..there are lots of private hospitals, …… people want to feel like they are in a hotel room, they need their privacy, ……. paediatric is completely opposite, parents wants to feel like their child is being looked after……."*

In addition to circumstances associated with children's care settings, other circumstances of the project such as location, shape of the site were considered during problem definition. A representative from the Designer mentioned one such driver.

> *"……But other places may have their own drives, for an example in the lake district, they want the window that facilitate vision of lake at the outside of the building……."*

Secondly, some new design requirements were devised to respond to the client's and the user's requirements. Finally new design problems identified during design evaluations were also resulted in devising some new design requirements.

These design requirements were mainly devised based on the evidence identified from knowledge and experience; the client's requirements; visits to other facilities; user consultation; and internal and external research. For instance, a representative from the Client explained how the evidence from research used during problem definition of the Case study A.

> *"……all those research coming out of Roger Ulrich, we knew we want infection control, we knew we need to provide privacy, and we knew we did not want curtains because of washing them storing them and infection control……" (Research) (a representative from the Client)*

7.5.1.2 Problem definition based on guided specifications (GP)

There are no instances where problem definition was solely based on SGaTs. The reason for this is not very clear within the data. However, this should not be interpreted as designers derogate from the specifications stated in the SGaTs. Informants for the case study data mentioned that they used SGaTs at the early of the process (see quotes below), but specific activities or examples of using these were hardly expressed within data. This eventually resulted in a low count for frequency of use of SGaTs during problem definition. This was evident from the interviews with the representatives from the Client and the Designer.

"….they started working based on what they knew and based on what we knew and from HBN 23 and all those sort of things, between us was a good collaborative process…." (a representative from the Client)

"…..HBNs and all the design standards, ……. there was a book that came out about a year before we start which particularly looking at children's hospitals, we looked at that,….." (a representative from the Designer)

As stated before, the main focus of problem definition phase was to identify Case A's specific project requirements based on the evidence gathered from internal sources which were then transformed into performance specifications. Therefore, it could be assumed that designers prefer bespoke specifications devised on the basis of the analysis of project specific issues as opposed to using generic specifications contained in the SGaTs.

7.5.1.3 No pre-determined approach to problem definition **(-)**

In 37% of elements (10 out of 27) any activity related to problem definition could not be identified prior to the designing of those elements.

For these elements, in majority of instances, design solutions were identified externally and were subsequently adopted or adapted. Specifically, these solutions were identified through the evidence from industry (in 5 instances); traditional solutions known to the design team (in 1 instance); and a combination of both (in 2 instances). It was evident that solutions identified externally from industry, were significantly evaluated and resulted in improvements (SS^{+}) and rejection (SS>). Further details about solutions identified externally through these sources are discussed in Section 7.4. In two instances, subsequent solutions were devised based on evidence from knowledge and experience. They are; *level of decentralisation of nurse station* and *water service strategy*. For decentralisation of the nurses' station, few options for decentralised nurse bases were devised based on the clients and designer's knowledge and experience. After evaluating the negative and positive impact of the options they reached a bespoke solution. During the design of water services strategy, the engineer, together with the client, designed water services with a low temperature system based on their technical knowledge and research evidence. SGaTs published by DH for water services cover only water service system with high temperatures. Therefore, designers of Case A designed the water services based on evidence from K&E and later evaluated the output water temperature measurements. Internal research evidence was also supportive of this later design.

7.5.2 Prescriptive and performance specifications for designing

Nine variant approaches for designing could be identified within Case A. Table 7.9 shows a summary of approaches to designing used within Case study A. Further details related to this deductive analysis are discussed in Chapter 6.

Table 7-9 : Design approaches used during the design of Case A

		Design elements in the pre and conceptual design phase						Design elements in the detail and technical design phase				
		Space/layout	Composition	Location	Shape and size	Provision	Option appraisal	E/services	Facilities	Finishes	Components	
DS	DS	4	1	1				1				7
	DS ©				1						1	2
	GS+SS>DS		1									1
	SS>DS										2	2
GS	GS	1										1
SS	SS					1			1	4	2	8
	SS+						1	1			2	4
A combination	GS+DS	1										1
	SS+DS	1										1

Notes : DS – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Adopt or adapt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach

According to the results in Table 7.9 the design elements that fall into the conceptual design phase are based on the approach of 'devising a solutions' while the design elements of the detail/technical design phase primarily based on the 'selecting a solution' approach (SS and its variants).

7.5.2.1 *Designing based on prescriptive specifications*

In approximately half of the elements (13 out of 27) designers used prescriptive solutions selected from the de facto standards or from the industry (SS and variants - 99%) and from SGaTs (GS and variants – 1%).

Rejections and modifications

Instances of rejecting prescribed solutions identified within de facto standards (SS > DS) and instances of modifying prescribed solutions identified within de facto standards (SS +) could be identified. These imply that the design team has made a comprehensive effort during the adaption/adoption of prescribed solutions gleaned through de facto standards. In four instances de

facto solutions were used after improvements (SS+). The reasons for these improvements were associated with:

1. improving the design to suit new design/ requirements identified during the design evaluation (for instance, recessed PC, window design);
2. Improving the design based on research evidence (for instance, nurse base decentralisation vs central nurse base); and
3. tailoring the design to project-unique circumstances (for instance, ventilation strategy).

In three instances initially considered de facto solutions were abandoned to devise better solutions (SS > DS approach). In two of the three instances, solutions were abandoned due to differences in project-unique circumstances. The solution of 100% single-bed patient rooms were abandoned due to differences in the care model and staffing model used in US hospitals, from where the solution was identified. Bed-head service panels previously used were abandoned because of poor integration with some of the child's bed types and set performance criteria. The third instance was devising a solution to prevent finger trapping in doors. The design team has looked at the solutions available on the market but none of them were up to the expected criteria.

> *"….we looked at every single thing in the market, they all looked like post rationalised applied plastic things when the door opens it is a plastic nib……" (a representative from the Designer)*

Therefore, the design team devised performance criteria and ask a door manufacturer to devise a solution to suit the specified criteria.

A closer look into data from the element stories (refer Appendix G) reveals that designing based on prescriptive solutions has followed a thorough evaluation. This careful evaluation has prevented difficulties that could have arisen during operation had those solutions been adopted. Irrespective of the comprehensive evaluation step, minor concerns about adopted or adapted solutions were reported during the operational phase. For instance, it was realised that the wall finishes used in Case A required a heavy cleaning regime to maintain cleanliness, however, as most of hospitals they visited were PFI hospitals, which also have a heavy cleaning regime, it was clear that they have not identified this concern during facility visits.

Origins of prescriptive solutions

Solutions were originated mostly from industry and few from in-house (partner organisations of project) and SGaTs. The reason for seeking solutions from industry so frequently could be that the

design team wanted to use the best solutions that industry could provide. This reflected by the approach they adopted in selecting finishes. Both the Client and the Design organisation have experience of procuring building materials and yet they still conducted a comprehensive evaluation of all the finishes available on the market. The quote below explains this further.

> *"…….for each of the element, we looked what products were available in the market, we looked at all the options for finishes……we made a matrix to compare every type of finishes from floor, walls and ceiling tiles, right down to the level of plasterboards, different types of plaster board……." (a representative from the Designer)*

The reason for the limited use of prescribed solutions contained in the SGaTs (GS) could be the specific nature of hospital buildings and specific nature of patient services required.

For the elements of the pre and conceptual design phase, SGaTs were used as a starting point. Prescriptive solutions identified from SGaTs were then modified and developed further to suit specific project requirements. The rationale behind these prescriptive solutions were elicited and preserved as design rules to support these modifications. For instance, designing *the percentage of single bedrooms, patient rooms* and *nurse station* were started with the SGaTs solutions. For instance, exemplar room layout given in DH guidance was used with modifications. Changes were made to the bed position and to the position of the bath room in order to improve the nurse's observation of patients and to reduce the length of passage from bedroom to bathroom. Furthermore, even though it is not included in the exemplar layout, extra storage (wardrobes) was added into the room design as the hospital serves patients from remote locations in the UK and around the world which creates extra demand for storage. It is also worth noting that the majority of the solutions identified externally for pre and conceptual design phases were eventually resulted in bespoke solutions, after modification. Surprisingly, the solution identified with SGaTs (GS) for technical design and detail design was followed with no or minor modifications. The design of the isolation room was primarily based on SGaTs.

7.5.2.2 *Devising solutions (DS)*

For more than half of the elements (14 out of 26) designers have devised solutions (DS). Only, in a few of these instances, the solutions were partly identified from the prescriptive solutions contained in SGaTs and in some instances solutions were devised when initially selected solutions failed (SS > DS).

Examining the results in Table 7.8, it is apparent that this approach was mainly (10 out of 14) used for the elements in conceptual design phase, specifically for space/layout, shape and size, location

and composition. Only in two instances this approach was used to devise solutions in the detail design phase when initially selected solutions were failed (SS > DS).

Even though this approach is not primarily used for elements in the detail and technical design phases, design of *the water service strategy* was devised based on internal research, K&E and evidence from other sources. Initiated within the client's research, the design team in Case A, has devised a bespoke strategy for water service to reduce legionella growth and for energy savings.

7.5.3 Approach to design evaluation

Examining the results of the case studies it was realised that there are no distinguishable approaches for design evaluation, but activities of design evaluation were frequently conducted during the design and end of design using all available sources of evidence. The results shown in Table 7.5 show that design evaluation was supported by evidence from almost all sources. The primary focuses of these evaluations were:

- to support option appraisal;
- to assess whether the design complies with performance and prescriptive specifications set during problem definition and designing; and
- to identify further improvement opportunities.

POE evaluation of Case A was carried out by an independent organisation with the support of the client's redevelopment team. Results from the formal POE were not available to the public at the time of data collection for this study. Instead, the interview with the client representative revealed her views on the performance of the design during the operational phase. In summary, her interview revealed that the design is well used as expected; supporting health outcomes and the client's redevelopment team is pleased with the design. Specific points identified by the client's representative regarding the effectiveness of the design at the operational phase are summarised in Appendix H.1.

7.6 IMPACT OF PROJECT-UNIQUE CIRCUMSTANCES ON THE EBD PROCESS

This section provides a detailed account of how the evidence-based design process of Case Study A was influenced by project-unique circumstances and how design team reflected on these circumstances.

Interview contents was analysed based on the principles of inductive thematic analysis (refer Chapter 2) to identify the project's unique circumstances impacted on the EBD process. This analysis revealed eight circumstances unique to Case A that have impacted Case A's EBD process and how design team reflected on these circumstances.

1. Nature of the hospital and its care model
2. Patients' characteristics
3. Local departmental needs
4. Funding
5. Shape of the site
6. Operating conditions different to testing conditions
7. Culture of users
8. International evidence coming from different contexts
9. Other

7.6.1 Nature of the hospital and its care model

As stated earlier, this hospital is a world leading hospital providing specialist care for children. They are engaged in associations with other hospitals of a similar nature to share knowledge and experience for clinical purposes. These associations were helpful in the process of redevelopment of estates. Clinical staffs were able to use these associations to identify evidence of built environments, during the time of Case A's redevelopment, without any extra cost to the redevelopment.

In addition to formal collaboration, it was also mentioned that clinicians in the hospital regularly travel around the world for clinical purposes. This was also taken as an opportunity to identify evidence of the built environment during the redevelopment programme. It is also worth repeating that some of the visits made by clinicians were video recorded and evidence was effectively passed onto the rest of the design team.

7.6.2 Patients' characteristics

Patients' characteristics have a considerable impact on the EBD process of Case A. The patient group in Case A is children. The hospital is one of the very few dedicated to child specialist care and they treat patients from all over the UK and around the world. Children's ages could vary from a few months old through toddlers to children under 18 years old, and they have different interests. Interviewees revealed the impact of the patients' characteristics on the process and how they tackled related concerns.

Some evidence did not work well in a children's hospital. For an instance, a Phillips green light system which helps patients to sleep properly does not work well for children's sleeping patterns.

The interests of different age groups were considered during the design of the play areas. The design team, in consultation with play specialists, designed two separate play rooms for children and adolescents taking into consideration the differences in their activities and needs. Furthermore, the design team have used child-friendly artwork throughout the hospital building. Specific examples are a rainbow ceiling in the large restaurant and art and music on the way to operation theatres.

The design team considered several other concerns specific to children during the design process. One such specific issue is of children's fingers being trapped between door and door frame. With the evidence from the suppliers and manufacturers the design team devised a solution to avoid fingers being trapped at door edges. In another instance, the bed-head service panel was designed , a consideration was made to avoid obstructing children's cots or being obstructed by children's cots.

Since the hospital serves patients from remote areas of the UK and around the world, overnight accommodation and storage was considered as an important element of single room design.

7.6.3 Local departmental needs

Local departmental needs were considered throughout the design phase. For instance, following the NHS guidance to maximise the number of single-bed patient rooms, the initial design consisted of 100% single-bed patient rooms. However, after considering the need for closer and constant observation for the high-dependency care patients, the design was changed to incorporate some shared-bed bays for high dependency care patients.

This was also reflected in the design for the ventilation strategy. Initially it was expected to be designed as a naturally ventilated building, but later in consideration of the differing needs of different departments, the design team adopted a mixed mode ventilation strategy. The areas for single- patient bedrooms and the restaurant was designed to support natural ventilation, the shared-bed bays are designed to support natural ventilation with windows that can be opened, however, difficulties associated with opening windows in shared spaces were identified during the operational phase. Operating theatres were designed as sealed spaces for clinical purposes.

A similarly strategy was considered for the ceiling materials and the design.

> *"in the corridors and public areas they are a slotted ceiling which contain panels to have access, in the rooms they are grid, ……. we used acoustic tiles in public areas……"*

Few problems were identified during the operational phase due to not effectively reflecting on local departmental needs. For instance, offices of a similar design were adopted for all the departments, but it was later found that some of the departments in the hospital have modified their office to suit their own local needs. The representative from the Client identified this as below.

> *"……The office accommodation is used very well, by two specialities in particular, ICU probably don't use their offices as much as they could, so what they have done is they have created a couple of zones within the office……."*

7.6.4 Funding

The project was funded mainly by the charity that supports the hospital and partly by the NHS.

The project had a specifically allocated sum of funding for Evidence-based design. This was an opportunity for the Case A to reflect on the EBD principles. Case A did visits to international hospitals and become a part of the Pebble project.

Furthermore, the project had the funds to build enabling works for the temporary accommodation of patients during the redevelopment. The design team have used these enabling works as an opportunity to test evidence and generate new evidence for various design solutions.

One of the main examples that explain the opportunity provided by the enabling works was testing of the floor finishes. During the initial evaluation of the different floor finishes, a rubber floor material had satisfied and scored most for performance requirements expected of a floor finish. This was then tested during the enabling works and found to be problematic to lay, and left an unpleasant finish. The manufacturers and suppliers of the materials were invited to the site to look at the problem, but the situation could not be improved. Finally, this product was disregarded and a traditional floor finish was used.

7.6.5 Shape of the site

The shape of the site for Case A has impacted the design of some elements by restricting the options available. The size and shape of the single patient room was partly influenced by the size and shape of the site; this was because the design had to accommodate a set number of bedrooms within the available site. Gardens and buildings were impacted due to the shape of the site. This in turn has impacted on the configuration of different departments within the building and user traffic flows. Taking these traffic flows into account, the building design has incorporated three different entrances to be used by patients and families, clinical staff and other support staff.

7.6.6 Operating conditions different to testing conditions

In some instances early design evaluation (prior to construction) was not very effective. The reason for this was the difficulty of simulating operational conditions during design evaluations. Designs of floor finish of the en-suite, mechanical window opening system, ventilation beams for the ceiling and wall finishes were resulted in minor failures due to this issue. For example, during the mock-up evaluation, floor finishes were evaluated with regard to colour of finish, performance of grits, and time taken to dry. However, it was reported that performance of the en-suite floor finish was different to the time of evaluation because during the operational phase the floor was frequently and heavily used as opposed to the use during the evaluation process.

The other example is the colour of wall finish. The design team had selected white paint as a wall finish after visiting several newly built healthcare buildings. Later, during the operational phase, it was understood that a heavy cleaning regime is required to maintain cleanliness in the building and leave the wall finish in good condition. The hospital that provided evidence of using white paint was built under a PFI scheme which maintains a good cleaning regime for PFI interests.

7.6.7 Culture of users

It was also mentioned that the performance of some solutions could have been better if the building is considerately used. For instance, wood veneer was used as a door finish in Case A. Interviews with the client representative revealed that damage to the door finish could have been reduced if users operated doors cautiously, especially when passing through with trolleys and other equipment. The other example is the temperature of water outlets. Since the water service design is based on a low temperature water supply strategy, the water runs at a set temperature and there are no local temperature controls at outlets. Therefore the temperature of the water distributed to both wash basin and shower/bath is set at a same set temperature. The interview with the client revealed that some users perceive the lack of local temperature control to be a negative issue and they consider that the design is faulty and she also mentioned that a cultural change would be required to adapt users to the new system.

7.6.8 International evidence come from different contexts

Difficulties in applying international evidence were identified for Case A. These were caused by the different way in which health services are funded in different countries and differences in cost of providing health service in different countries. For instance, it was mentioned that the US has 100% single patient room hospitals supported by CCTV monitoring which UK public hospital would not adopt due to the comparatively higher cost associated with that type of care model.

7.6.9 Other

Following are the other local circumstances that have impacted the design for Case A.

1. Capacity related circumstances;
2. Delays in planned working practice (operational) changes;
3. Contractual clauses in relation to changes to the design;
4. Staffing circumstances; and
5. Changes in to legislations.

Firstly, finding a recessed PC to support the capacity of data of Case A was a difficulty. Secondly, the hospital was designed as a paperless place of the future, however, until the hospital becomes paperless there are difficulties for staff to store and place paper notes. Thirdly, the impact on the project cost and contract from improvement opportunities identified during the later stages of the design was considered. Fourthly, the ward was designed with a parents waiting area at the beginning of the ward, but it was said that the space is not well used because the area is not always staffed. Fifthly, the water service design has incorporated copper silver ionisation technology. It is suspected that a recent law regarding the use of copper EU/UK countries would result in some difficulties.

In summary, Case study A was in a very favourable position in terms of ability to access evidence and resources to access evidence. By being a world leading paediatric hospital, Case study A has had a considerable level of access to international and local evidence. The project has had a specifically allocated sum of money for Evidence-based Design which in turn obliges teams to reflect on EBD aspects in order to give an account of how the money was used. Furthermore, there was an in-house redevelopment team working on behalf of the client. They have had experience of designing built environments from previous phases of redevelopment. All these have influenced EBD practices in Case Study A.

7.7 CHAPTER SUMMARY

This Chapter reported and discussed EBD practices in Case study A related to three main aspects:

- details of using evidence from nine sources during the process of designing;
- details of using performance and prescriptive specifications during problem definition and designing ; and
- impact of project-unique circumstances on EBD practices and how designers reflect on these circumstances.

K&E was the most frequently used source of evidence in Case A, and evidence from K&E was used during almost all of the 15 design activities identified in this research. The second most used source of evidence was internally generated evidence followed by the evidence acquired from the industry. It was also observed that internally generated evidence was frequently used alone whereas evidence from the industry and SGaTs was supported by evidence from other sources during use. This may imply applicability of evidence in project-unique circumstances. Results suggested that evidence sources may have a particular way of supporting during the design process. K&E was used during almost all design activities. Internally generated evidence and evidence from user consultation were mainly used for design evaluation activities. Information from the client, evidence from visits to other facilities and evidence from the industry were mainly used to identify design solutions and activities associated with early stages of designing. Evidence from SGaTs was less frequently used but they were used in both the early stages of designing as well as design evaluation activities. Other dimensions of evidence related to means of gathering, user channels for accessing, purposes of using, availability, suitability, quality and success of using that evidence were also identified to make sure this case study design provides a rich picture of Case A. This analysis supplemented the above results by providing further details of particular ways of using evidence sources and their applicability to the project's unique circumstances. A bespoke version of the SaFE model was generated for Case A. Some of the evidence sources identified within the generic model were not used in Case A, whilst case study data were useful in identifying specific details behind the evidence use practices. Furthermore, details of evidence flowing into sub-processes of designing which were not included in the original model could be identified.

Practices of using performance and prescriptive specifications were identified for problem definition and designing. For more than half of the elements (51%) the design team have devised specifications to define the problems. These activities were primarily based on evidence that could be sourced internally (K&E, user consultation, internally generated evidence). Within a considerable number of elements (37%) there was no pre-determined approach for problem definition. During the problem definition, both output specifications of the subsequent design as well as service outcomes that need to be achieved through the design, were considered. However, in later cases, the outcomes that needed to be achieved through the design were transformed into possible design interventions. Specifications from SGaTs were not much used during the problem definition in Case A.

A balance of using prescriptive solutions and devising solutions could be identified for designing Case A. The former approach was more prominent during the elements designed in pre and conceptual design phases, whilst the later approach was more prominent during the designing of elements in

the details and technical design phases. Prescriptive solutions contained in SGaTs were marginally used, and for some instances they were used in combination with other approaches. From the results, it is apparent that evidence in SGaTs is more often used for identifying performance specification as opposed to identifying prescriptive solutions.

Practices of evidence use were reflected by the project's unique circumstances associated with Case A. Case A was special because of the type of the patient served within the hospital and the demographics of the patients. Case A was in a beneficial position related to funding and a specific allowance for EBD activities were included in the Case A's budget, which has given designers of Case A, opportunities to access and use research-based evidence. Other circumstances related to the shape of the site, less applicability to international evidence, culture of users, inability of simulating precise operating conditions during the testing phase have impacted EBD practices and the success of the resultant design.

8 CASE STUDY B (Detailed version)

8.1 INTRODUCTION

This Chapter reports and discuss evidence-based design practices of Case Study B.

A brief description of the case is provided at the beginning. The middle sections are structured to report and discuss the results from Case study B from three perspectives:

- Firstly, the data revealed in Case study B was analysed to identify the sources of evidence used during Case B, the frequency and timing of use and other selected dimensions of using evidence from different sources. Based on these results a bespoke version of the model of Evidence-based design was generated for Case study B and is presented in this section along with an explanation of the changes made to the generic model.
- Secondly, the Chapter reports and discusses how performance specifications and prescriptive specifications were used during the problem definition phase and designing phase in Case study B.
- Finally, the impact of the project's unique circumstances on the Evidence-based design process and how designers reflected on these circumstances are reported and discussed.

The Chapter is then concluded by giving a summary account of the Evidence-based design practices for the Case study B.

8.2 DESCRIPTION OF THE CASE STUDY B

Case study B is a newly built hospital in Wales. It is a 'pathfinder' project which was delivered through the 'Designed for Life: Building for Wales' scheme. The project was funded by the Government and the hospital was built to support a new health service strategy. The previous strategy of the health board was to provide care in several district hospitals where both critical and non-critical care was provided under one roof. When the existing building stock became too old and began to incur considerable maintenance costs, the Health Board decided to invest money in new facilities. Having decided to replace a number of old buildings they have also used this opportunity to change the care model of the Health Board. Based on a new strategy, the Health Board procured three new non-critical care hospitals and one specialist and critical care hospital to replace several existing district hospitals. The hospital selected for Case B (see Figure 8.1) is one of three non-critical care hospitals provides care for mental health patients and elderly patients. The hospital is a 100% single-bed room hospital and the scope of the project includes 96 beds, an integrated mental health unit, a 15 room out-patient department, x-ray department, urgent care centre, therapies unit and birthing centre. The project cost was £60 million and work began in July 2008 and opened for operation in December 2010.

Figure 8-1: A graphical and actual view of Case study B

8.3 DATA

The hospital in Case study B comprises two floors. The ground floor consists of out-patient departments, diagnostic and therapeutic services and restaurants. The first floor consists of in-patient single bedroom accommodation and associated spaces. During the data collection process, data related to the 8 main elements of evidence-based design were sought. The scope of this study mainly covered spaces within the first floor which are used for in-patient accommodation. Table 8.1 shows the scope of spaces considered within this case study as a % of the floor area (first floor only). Data related to finishes, components and engineering services are generic to the whole hospital.

Table 8-1: Scope of the spaces considered within Case study B

	Space type	Area occupied by the element (The typical floor GIFA of a floor is 3512m^2)	Area occupied by the element as % of GIFA of a typical floor (3512m^2)
1	Single bedroom, en-suite	2372 m2	68%
2	Ward layout and nurse station	120m2	3%
3	Communal spaces	135m2	4%
4	Isolation room	81m2	2%
	Total	2289m2	77%

Figure 8.1 illustrates the spaces covered by this study on the plan of a typical floor.

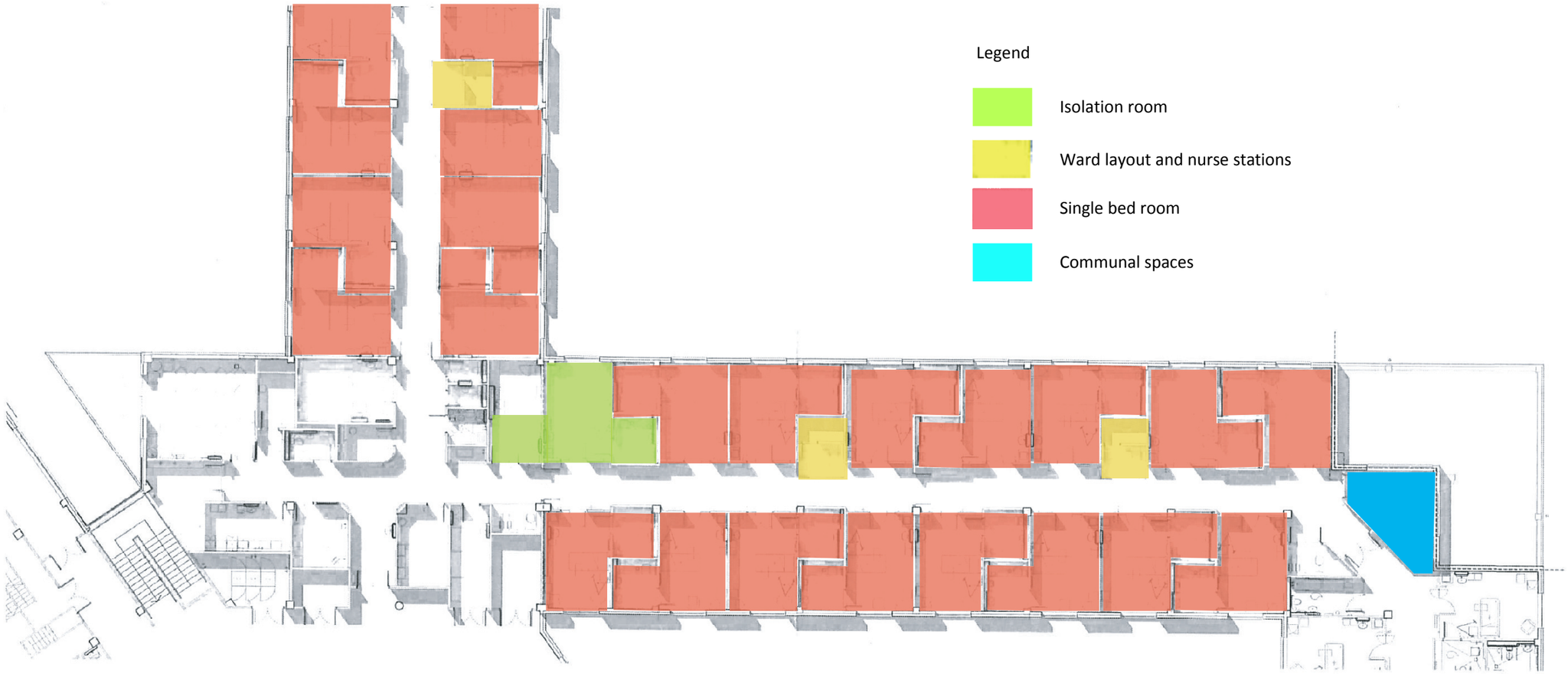
The data analysis revealed details of EBD process in 25 exemplar design elements associated with 147 design steps and 184 instances of evidence use.

8.4 EVIDENCE USE

8.4.1 An overview of evidence use

Evidence was gathered from several channels as illustrated in Figure 8.2. The main channels of evidence were members of the design team, their parent organisation and supply chain partners and external evidence sources such as SGaTs from DH, general public consultation, other interested organisations, published research and existing facilities.

Figure 8-2: Scope of the spaces considered within Case study B



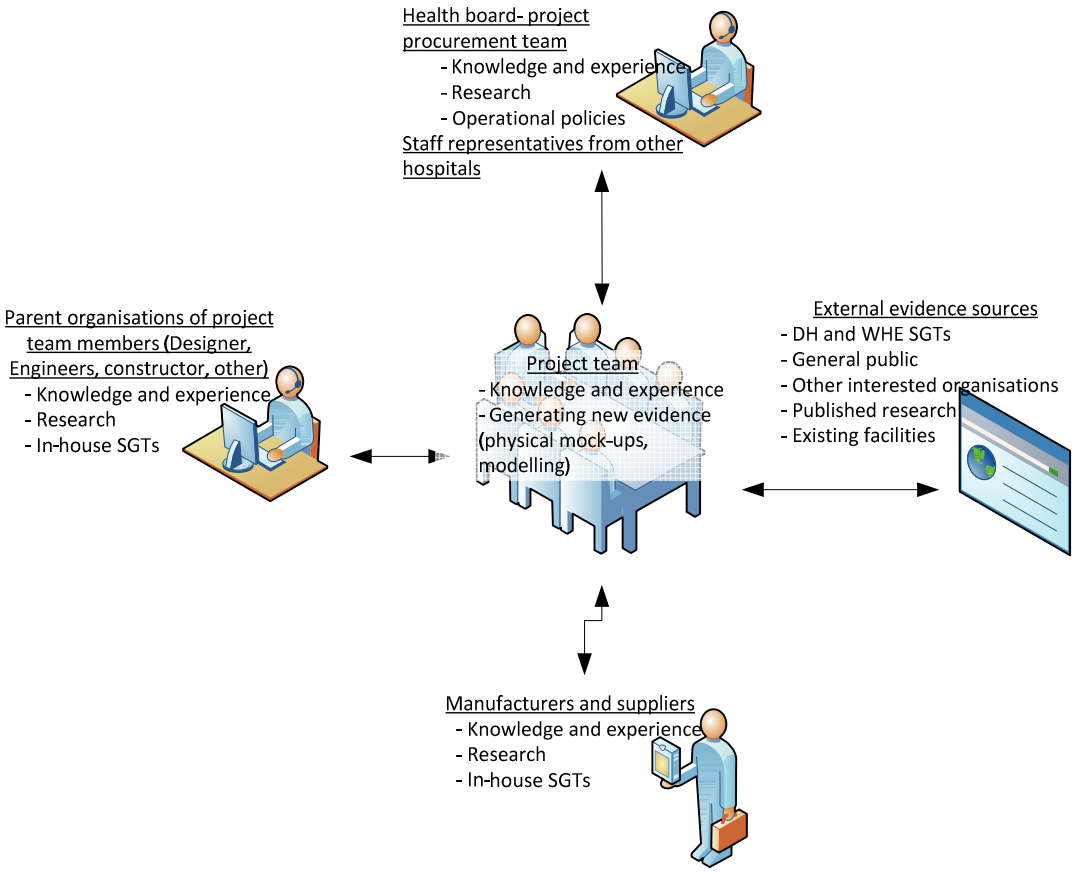


Figure 8-3: Evidence channels for Case Study B

There are two unique aspects about the evidence channels for this case study. Firstly, the project was a pilot project for the 'design for life' scheme started by the Welsh Health of Estates (WHE), and the first 100% single bedroom hospital in the UK. Therefore, the design team had access to research activities conducted by WHE (Welsh Health Estates) regarding single bed room hospitals. Secondly, the hospital was built to support a new care model for the Health Board to treat non-critical elderly patients and mental health patients. Hospital staffs were not fixed at the time of development and the staffs of the Health Board had no previous experience of this nature of hospital. In addition, the Health Board has not procured a new build hospital on this scale in recent years. The impact these circumstances were evidence during the design process.

Data gathered for Case study B revealed evidence use for 25 exemplar design elements associated with 147 design steps. Similarly to Case study A, some of the design steps have used evidence from more than one source. These instances were separately counted and 184 instances of evidence use were identified for Case study B (see Table 8.2).

Through the data analysis process, which was explained in the Chapter 6, it was identified that designers used the following nine sources to gather evidence for designing the scope considered within this case study.

1. Knowledge and experience
2. Internally generated evidence
3. Evidence from the industry
4. User consultation
5. Standards and guidance
6. Visits to facilities
7. Information from client
8. Research – external
9. Expert opinion

Table 8.2 provides details of the evidence sources used to design the 25 elements.

Table 8-2: Details of evidence sources used during the designing of 25 elements

Major design element		Sub-design element	Number of design steps involved	Sources of evidence										Number of instances of evidence use	No of evidence sources used (& non used)
				Information from client	Evidence from the industry	Internally generated evidence	Knowledge and experience stakeholders	User consultation	expert opinion	Research - external	standards and guidance	Facility visits	Constrained use of evidence		
1	1	Provision of single room	20	1			2				0	1		4	3
	2	% single rooms	4	1			4		1			1		7	4
	3	Single room design	14	3	1	2	3	1	5	3		3		21	8
	4	On-suit vs Central	8	1			2				1			4	3
	5	En-suit - size	5	3		3	8	1	2	1	2	1		21	8
	6	Bed head service	5			1	6				2			9	3
2	7	Ward shape	4		1	1	2				1	1		6	5
	8	Ward layout	6			1	3	2	2					8	4
	9	Staff base	8			2	5				1			8	3
	10	Computer at staff base	3		1		3							4	2
	11	Nurse call system - Sera	3		2		2							4	2
3	12	Day space	5				2		1		1	1		5	4
4	13	Isolation room - provision	6				4				1			5	2
	14	Isolation room - location	3				3							3	1
	15	Isolation room - Layout	4	1			2				2	1		6	4
5	16	Floor finishes	9		1	1	6				1			9	4

	17	Wall finishes- EN-SUIT	6		2	1	1						4	3
	18	Ceiling finishes	10			3	5					1	9	3
6	19	Doors	9			1	8			1	1		12	5
	20	Doors - finishes	4		1		2				1		4	3
	21	Doors-ironmongeries	2		1		1					1	3	3
	22	Vistamatic panels	4	2	3		2					1	8	4
7	23	Water services	3			1	2				3		6	3
8	24	Ventilation strategy	3				2				1		3	2
	25	Design of the window	11	1		3	6				1		11	3
Total			147	13	13	20	86	4	11	5	19	11	2	13	184

According to the results of Table 8.2 it is evident that a considerable number of evidence uses were sought from more than 3 sources for the majority of the design elements. In five instances designers sought evidence from more than 4 sources. As suggested in the Chapter 6, when the scope of a particular element is greater, (for instance doors and windows) the instance of gathering evidence could be higher. One example was design of doors. It was identified that the design of doors and windows was a comprehensive task due to the fact that the overall design of the hospital incorporated bespoke spaces which has eventually necessitated bespoke doors.

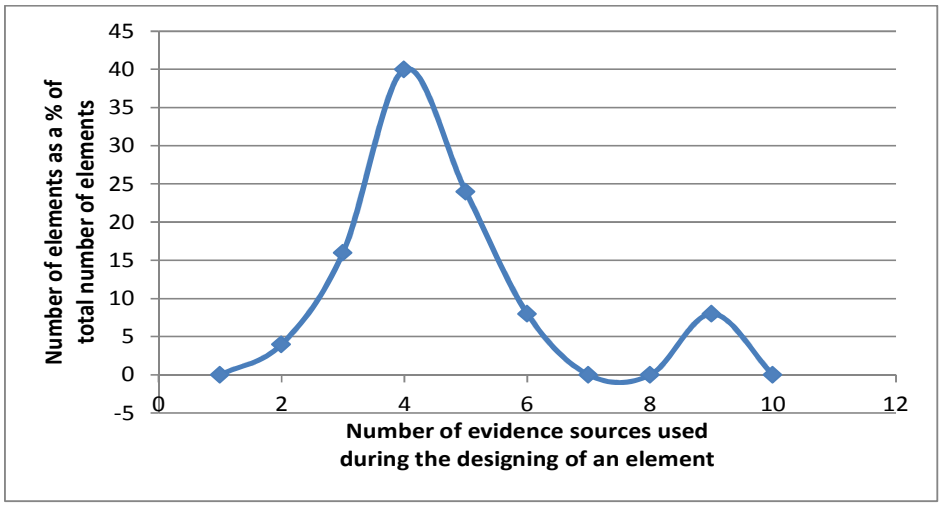


Figure 8-4: Number of evidence sources used during the designing of an element

The number of evidence sources used to design an element was plotted (see Figure 8.4) and according to the results, in the majority of instances, evidence was gathered from more than three sources. In approximately 70% of instances, evidence was gathered from 3 to 5 number sources. As suggested in Chapter 6, when there is reasonable access to nine sources of evidence the reason for seeking evidence from a limited number of sources could be related to the acceptable quality of the evidence available. During the designs of single bedrooms and the en-suite evidence was gathered from 8 sources. The reasons for this could be that these two items were major elements within the design which occupied nearly 2/3 of in-patient floor area.

The opinion of interviewees were inquired related to the availability of evidence, quality and integrity of existing evidence and rate of success of the design during operation (see Table 8.3). The results shown in Table 8.3 reveal that the availability of evidence was *fair* or above, for all elements except communal spaces whilst the quality and integrity of used evidence was *fair* or above for all elements except the en-suite bathrooms.

Table 8-3: Summary of evidence used in Case B as expressed by interviewees

	Design component/ element/ space	Availability of evidence	Quality/ Integrity of existing evidence	Rate of success in operation	Would you recommend it next time
		1–Poor 2–Fair 3–Good 4–Very good 5–Excellent	1–Poor 2–Fair 3–Good 4–Very good 5–Excellent	1–Poor 2–Fair 3–Good 4–Very good 5–Excellent	
1	Single bed room	2.5	3	5	Yes
	- En-suit bathroom	2	1.5	4	Yes
	- Bed head service panel	2.5	3	3	Yes
2	Communal spaces	1.5	2.5	2	Yes
3	Ward layout	2	2	4	Yes
	Clinical workstations	2.5	2	5	Yes
4	Window design/ ventilation strategy	3.5	3	1	Yes (with improvements)
5	Finishes (Floor, wall and Ceiling)	3.5	3.5	4	Yes
6	Water services	3	3	3	Yes
7	Isolation room	4.5	4.5	4	Yes
8	Doors	3.5	3.5	4	Yes

8.4.2 Frequency and timing of evidence use

Figure 8.5, shows the frequency of using evidence from the nine sources and the constrained use of evidence within Case study B. The frequency of using a particular evidence source alone and the frequency of using the source in combination with other sources were identified separately.

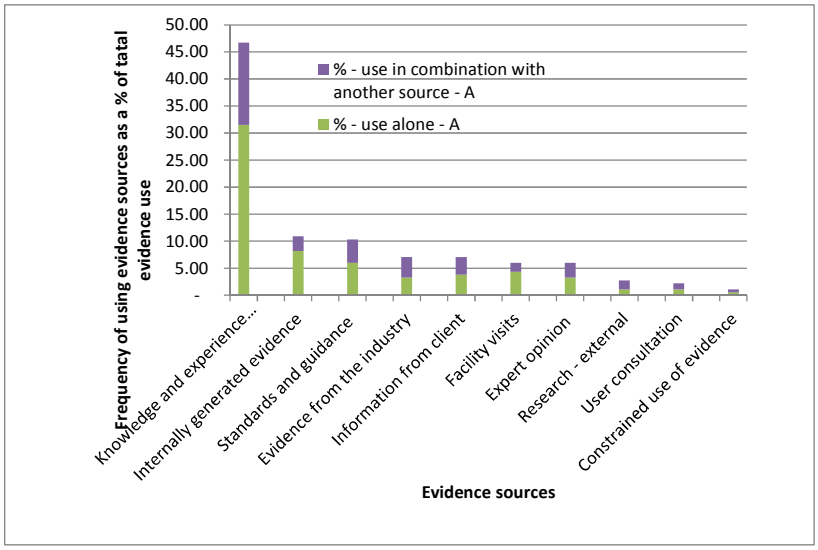


Figure 8-5: Frequency of use for different evidence sources for Case study B

The most and least used sources of evidence for Case B are K&E and user consultation respectively. For a better visual illustration of the details for other sources of evidence, the same data were re-plotted without K&E (See Figure 8.6 below).

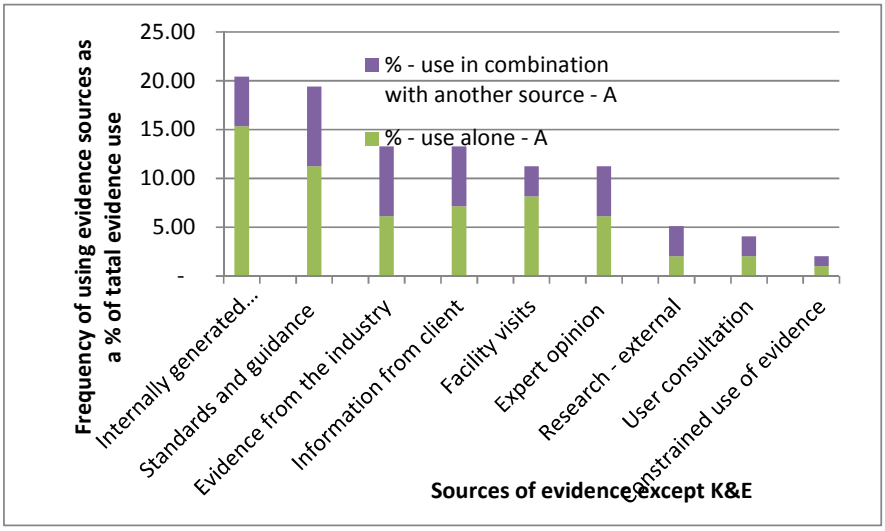


Figure 8-6: Frequency of use for different evidence sources without K&E

Examining Figure 8.6, it is obvious that evidence from six sources was fairly used in Case B and evidence from externally published research and user consultation were used less frequently. It can also be observed that internally generated evidence alone was used during designing whilst, evidence from all other sources were used extensively in combination with other sources.

Table 8.4 illustrates the timing of evidence use for Case B. Evidence use is highest during design evaluation. Almost all the sources of evidence are used during design evaluation with knowledge and experience being the highest and internal research second highest. Instances of using externally published research during design evaluation are not reported within the considered scoped of this case study. A fair use of evidence was noticeable for the activities of identifying

solutions, evaluating evidence and devising solutions. It is worth repeating here that design evaluation was an iterative activity throughout the design process. For the purpose of easy illustration, the total instances of using evidence for design evaluation were combined into one column of Table 8.4. An individual account of the different evidence sources' use in Case B is discussed next.

Table 8-4: Timing of evidence use for Case Study B

	Pre-design phase (Problem definition)			Design phase (Designing and design evaluation)										Total
	Analyse existing system	Identify project specific requirements	Specify performance specification	Identify possible ado(a)ption	Evaluate evidence	Adopt a solution	Adapt a solution	Reject the solution	Devise a solution	Construct a solution	Detail design	Improve the solution	Design evaluation	
Information from client	-	3	3	2	-	-	-	-	-	-	-	-	5	13
Constrained use of evidence	-	-	-	-	-	-	-	-	1	-	-	-	1	2
Evidence from the industry	-	-	-	6	3	-	-	-	-	-	-	-	4	13
Research – internal	-	-	-	-	2	-	-	-	1	-	-	-	17	20
Knowledge and experience stakeholders	-	3	4	12	4	-	1	1	10	-	3	10	38	86
User consultation	1	-	-	-	-	-	-	-	-	-	1	-	2	4
Expert opinion	-	-	-	-	1	-	-	-	-	-	1	-	9	11
Research – external	-	-	-	1	2	-	-	-	1	-	-	1	-	5
Standards and guidance	-	4	2	6	-	-	-	-	2	-	1	-	4	19
Facility visits	-	-	-	2	8	-	-	-	-	-	-	-	1	11
Total count	1	10	9	29	20	-	1	1	15	-	6	11	81	184

8.4.3 Other dimensions of evidence

In addition to the frequency and timing of evident use the data revealed information related to other dimensions of using nine evidence sources (see Table 8.5 below).

Table 8-5: Uses of nine sources of evidence during the designing of Case study B

	Means of gathering evidence	Purposes of evidence	User channel of evidence	Availability of evidence	Suitability/Relevance of evidence	Quality of evidence	Success of application
Information from client	* Client's brief * Hospital operational policy documents * Schedule of accommodation * Board papers	* To identify project requirements * To evaluate solutions	* Client	Evidence from this source was available and no flaws were reported	No flaws were reported	No flaws were reported	No failures were reported due to evidence from this source.
Evidence from the industry	* Discussions with peers and colleagues of parent organisations	* To identify solutions * To evaluate evidence identified through other sources * To evaluate the design	* Clinicians * Health board * Other members of the design team	Evidence from this source was available and no flaws were reported	No flaws were reported	No flaws were reported	(-) Some of the solutions adopted were failed due to lack of evaluation before use
Internally generated evidence	* Research undertaken by Welsh Health Estates (WHE) * Clinical staff engage in research * physical mock-up * Performance modelling for * Engagement with research institutions	* To evaluate solutions	* WHE * Members of the design team and their parent organisations * Clinical staff	(+) Since this was the first single-bed patient room hospital in the Wales, the project team has involved in the parallel research activities conducted by WHE	(+) Physical mock-up : the evaluation of physical mock-up was structured, based on an initially identified set of performance criteria	(-)Physical-mock-up was built up in a non-hospital site, free transportation was provided for visits (-) Phase II mock-up for detail design was not evaluated by the comments of project team only	No failures were reported due to evidence from this source.
Knowledge and experience stakeholders	* Engagement in designing and design evaluation	Used during almost all types of activities of designing, but extensively to identify solutions, devise solutions and evaluate solutions and evidence	*WHE * Members of the design team and their parent organisations	(-)knowledge and experience from the clinical and other hospital staff was not available	(-) This was the first new-built single bed room hospital. (+) Architect was previously engaged in converted single bed room hospital projects	No flaws were reported	No failures were reported due to evidence from this source.
User consultation	* Phase I mock-up evaluation for the single room design	* To evaluate single room design * To evaluate existing system in use * To evaluate external evidence	* General public * Representative staffs from other hospitals within the health board	(-) User consultation was limited to evaluation of phase I of the physical mock-up of the single rom design. (-) By the time of design development hospital staff was not fixed.	(-) Any consultation of facility management staff was not revealed	(-) User consultation was conducted to evaluate Phase I mock-up of single room design only. (+) User consultation was conducted based on a structured evaluation method	No failures were reported due to evidence from this source.
Expert opinion	* Inviting expert organisations to evaluate design * Presenting the design at conferences	* To collect evidence * To evaluate solutions * To devise optional solutions * To guide detail design	* Community health council * National Patient Safety Agency * Environmental authorities * Experts from the conferences	(+) A significant consultation of experts for the design process could be identified (-) Opinion from clinical specialists was not sought	(-) No in-house clinical specialists were available since a new hospital	(-) the previous structure of care provision of health board was different to new proposed hospital which means to be specialised in non-critical elderly care and mental health. (-) Experts for these two types were not consulted externally	(-) Specific design features related to dementia was missed out of design (-) Window design was later modified to suit specific requirements of the mental health unit
Research - external	* Access to medical journals by clinical staff * Professor Roger Ulrich's visit funded by WHE * Healthcare related conferences * Research reports by DH and WHE	* To guide designing * To gather evidence	* WHE * Clinical staff * Members of the design team	(+) A good access to research was available due to the reason that this was the first single-bed patient room hospital in the Wales and WHE has conducted parallel research work/literature reviews	(+) These researches were project specific	(-) Published research related to design for dementia was missed out.	(-) Specific design features related to dementia was missed out of design
Standards and guidance	* Standards and guidance from DH * Standards and guidance from WHE	* To identify design requirements * To set performance and prescriptive specifications * To identify solutions, * To guide designing * To detail the design * To evaluate design * To use as a starting point to design.	DH WHE	Yes	(-) Some solutions identified within SGaTs were rejected either due to weaknesses of the solutions or due to their unsuitability for project-unique requirements.	(-) half of the instances, SGTs were used with combination of other evidence sources	No failures were reported due to evidence from this source.
Facility visits	* Physical visits * Internet searches for best practice hospitals	* To evaluate evidence obtained through other sources * To collect evidence * To identify solutions	* Client's representatives * Other members of the design team	(-) Visits to international facilities were limited due to funding constraints	(-) most of the single-bed patient rooms visited were multi-bed wards adapted to single rooms - this has made application of evidence difficult	(-) Critical applications was necessary	No failures were reported due to evidence from this source.

8.4.3.1 Knowledge and experience (K&E)

According to the results K&E was the most extensively used source of evidence and was used during almost all types of activities in the design process. As stated earlier, the client had limited experience of procuring or operating a facility of this nature, yet any specific difficulties encountered due to the limited K&E of the client was not mentioned.

K&E is used in two ways during the design process. Firstly, in some instances, solutions were devised based on the K&E and other evidence from sources of evidence were used to evaluate the solution. For instance, the design team was not satisfied with the exemplar layouts given in the standards and guidance. Therefore the Architect devised several design solutions for the single bedroom layout. Based on a set evaluation criteria (developed through other sources of evidence) three of them were initially selected. The three selected solutions were then mocked up physically to identify the best suited solution for the project based on other evidence. Secondly, K&E was used to support evidence acquired from other sources. Design of ceiling finishes provides a good example for this second use. Several types of ceiling finishes were considered and they were evaluated based on K&E of members of the design team. After considering the positive and negative impacts of two types of ceiling, plaster board ceilings were used in some spaces while grid ceilings were used for other spaces. A representative from the Designer explained the rationale of this process as:

> *"…….client wanted to have a solid ceiling because it gives a more domestic feeling and none clinical environment, infection control preferred it because grid ceiling collect dusts, we designers liked solid ceiling because of appearance, …….we wanted plasterboard ceiling initially because estate teams thought it is much better, the tiles once you got them down couple of times it never get back properly, …….there are minor weaknesses of grid ceilings, tiles may fragile while removing, but it is easy to replace….on the other hand contractors liked grid ceiling because it is cheaper and easy to construct……."(a representative from Designer)*

8.4.3.2 Internally generated evidence

Internally generated evidence was the second highest evidence source used in Case B. Evidence from this source was used during the design of *provision of single room, single room design, staff base, design of the window, floor finishes, wall finishes, celling finishes, doors, en-suite and water service design.*

As stated before, Case study B involves construction of a new hospital, on a new site to deliver a new care model. The staffs that are going to serve the new hospital was not set at the time of designing

and as they had worked only with the previous care model of the Health Board and consequently would have little evidence to add to the project. Therefore, research and other investigations into internally generated evidence were conducted by the Health Board and other stakeholders engaged in Case study B. The project has also had the opportunity to engage in the research activities conducted by WHE related to single patient room design.

In a similar way to Case study A, it was difficult to verify the credibility of the internally generated evidence used in Case study B because they are not linked to the POE results of the project.

8.4.3.3 Evidence from the industry

Evidence from the industry was the fourth most frequently used source for evidence. A considerable effort was made to evaluate these solutions before implementation, yet some of the solutions adopted failed during the building operational phase due to lack of evaluation prior to adoption. For instance, a new tile which was used in other sectors was used for the kitchen area floor in Case study B, but it was found, during the operational phase, that food waste collected in the tile grooves. The whole area was replaced with a type of new tile. In addition, the nurse call system adopted has caused some difficulties.

8.4.3.4 Published Research (External)

According to the results, use of externally published research in Case study B is lower when compared to other sources of evidence. This result should be interpreted with caution. Due to parallel research activities existing at WHE, Case study B had a good opportunity to access published research. An interview with a representative from the Client explained the details of the research use (see quote below).

> *"……..there were couple of visits (by Professor Roger Ulrich), the original one is for 'clinical futures' …… X (the Architect organisation) gave us lots of information…… we got construction news and things like that…… one of the ladies, who is nursing in charge in YAB now she has done her dissertation on single bed room…….. we went to a conference and presented on what we were doing…….. a discussion document produced by the NHS about Single bed room……"(a representative from the Client)*

Since, this activity is counted once during the data analysis (as collect evidence) a low count for frequency of use of externally published evidence is shown in this quantitative analysis.

Specifically, externally published research was extensively used during the design of a single bedroom, but Case study B did not utilise the published evidence to its full potential. Even though

research evidence related to single-bed patient room designs was widely referred to, published evidence relating to elderly care facilities or mental health facilities was hardly considered. The following quote from the client's interview explains this further.

> *"……what we did not do is, obviously in elderly there is dementia and we did not really looked at the design evidence for dementia patients, that is one thing we picked up in the POE, Kings fund has done some really good work with patient group for dementia design, and it is very simple, we just missed it, ……it is until we went to a second conference a lady who is a carer for dementia she has done lots of work on design for dementia……"(a representative from the Client)*

This conversation implies the importance of using effective ways to disseminate externally conducted research.

8.4.3.5 Standards and guidance

Standards and guidance was the third most used source of evidence for Case B. Solutions prescribed in standards and guidance was used as a starting point for the design. After evaluation some of the solutions were used with modifications and some of the solutions were rejected. These modifications were mainly made to adapt the design to particular project requirements.

Rejections were made either due to weaknesses in the solutions or due to their unsuitability for project's unique requirements. The single patient bedroom is a good example where the solutions prescribed in SGaTs was rejected due to weaknesses. Both client and the Architect were not satisfied with the exemplar layout given in the single bed patient room guidance, due to the fact that they do not reflect research evidence which confirms the benefits of single patient rooms. Similarly, they have rejected an exemplar en-suite layout prescribed by guidance to design a better en-suite layout to suit project-unique requirements.

For half of these instances, SGaTs were used in combination with other evidence sources. In some instances it was used to support evidence from other sources. For instance, the doors used in Case B were devised as bespoke solutions and the support of standards and guidance for this process is mentioned in the following way;

> *"…….so doors are very much bespoke designs, but criterions are based on certain guidance, other than the size of the opening they are very much bespoke design really…" (a representative from the Designer)*

However, irrespective of the weaknesses of SGaTs, they were considered and evaluated to consider adoption, adaption or rejection.

8.4.3.6 User consultation

User consultation was limited for Case B but was used during *provision of single rooms, single room design and bed head services*. The main reason for this limit is that at the time of the design phase the appointment of hospital staffs were not fixed. The general public and staff representatives from other hospitals were invited to view the Phase I mock-up evaluation for the single room design and yet they were not invited to view the Phase II mock-up evaluation. Phase II mock-up evaluation was mainly based on the comments made by stakeholder representatives of the design team.

Even though this is an unavoidable project circumstance for any new hospital, this was a drawback in the process. During the operational stage the Engineer mentioned that some of the mechanical systems are misused by the hospital staff operating them because they were not involved in the design consultation.

8.4.3.7 Expert opinion

Expert opinion was used during the design processes for provision of single room, single room design, bed head services, and ward layout and day space.

Experts consulted were:

- Community health council;
- National Patient Safety Agency;
- Environmental authorities; and
- Experts from conferences (by attending and presenting at conferences).

Expert opinion was mainly used for the design evaluation. Their opinion and knowledge were extensively used to evaluate the single patient room design. There were also instance of using evidence from expert opinion during the detail design phases. For instance, the expert opinion of health planners and patient safety agencies were used during the detail design phase to decide the most suitable side to locate vertical bed head service panels.

8.4.3.8 Visits to other facilities

Evidence from facility visits were used in the design of single room, provision of single room, ward shape, day space, ceiling finishes, en-suite, ‘vistamatic’ door vision panels, and isolation room.

The Client's representatives visited mainly local hospitals and hospitals in Ireland. Other members of the design team also visited local hospitals. It was also mentioned that, visits to local hospitals were not especially useful, since most of them were adapted to single patient rooms and were not new constructions (see the quote below).

> *"…….they are not new build they have taken existing buildings and adapt it, so that is how we benchmark, we could not go and find that is exactly what we wanted, we had to visit couple of places and to see what clinicians say……"(a representative from the Client)*

In addition, they have used web searches to identify details of international examples.

8.4.3.9 Information from client

The information from the Client was communicated through the initial client's brief, hospital operational policy documents, and schedules of accommodation. Information from the Client was mainly used to identify project requirements and to evaluate the design. They were seldom used to identify solutions or to articulate performance specifications.

8.4.3.10 Limited use of evidence due to constraints

None-use of evidence due to constraints was rare on the project and only two instances were reported; the design of the doors for the single rooms.

> *"……. since all equipment going to the patients as all hoists and X ray machines going to the patient so traditional doors were not tall enough and we had to make the doors bigger, …."(a representative from the Designer)*

It was also mentioned that during the selection of ironmongeries, the budge available was a consideration.

8.4.4 Reflections on the model

A bespoke version of the SaFE model for Case B was produced using the Case study data (Figure 8.5) based on the methodology explained in the Chapter 6. The following discussion compares and contrasts the bespoke model of EBD for case B with the original generic SaFE model.

From this bespoke SaFE model it is evident that some of the data sources in the generic model were not used for Case B. Data did not reveal any instances where the design team have used in-house standards from their parent organisations. Using POE data from previous projects, from any shared database or any instances of using written industry best practices was not evident. This could be attributable to two reasons. Firstly, the client organisation had no experience of procuring buildings

of a similar nature, and secondly, since the hospital design is heavily innovative in terms having 100% single bedrooms, standard details for generic hospital may be less relevant. The design team have collaborated with WHE research on single-patient room, but any collaboration with any other research institution could not be found within the available data. Similarly, details of accessing evidence published in academic journals were not evident; the reason for this could be that the design team had adequate access to related research evidence through WHE research projects. However, failing to refer to evidence related to facility design for dementia and mental health patients was identified. There are discussed in the previous section of this Chapter.

As apparent in this model, the design team relied heavily on evidence from experts in several aspects of the design. Specifically, they have consulted community The Health Council, National Patient Safety Agency (NPSA), Design Council and Environmental Authority to gather evidence to design and evaluate the design.

There are few evidence flows which could not be validated. Collected data was not adequate enough to validate evidence flows into the phases of construction including products and systems supply and commissioning and testing. Due to the restricted time available for the research, there was no opportunity to interview the Constructor. Details of Post Occupancy Evaluation procedure were not accessible at the time of data collection.

During the case study, details of evidence flowing into the sub-processes could be identified. For instance, several sub-processes within the main process of designing were identified. They are; adopting a solution, adapting a solution, rejecting a solution, devising a solution, constructing a solution, detail design and improving the solution. These details are described in Table 8.1. However, at this level of the model, the flow of evidence into sub-processes was not included.

Sources and flows of evidence model (Case study B)

Conceptual SaFE model SaFE A → Verified SaFE model SaFE B1-B4 → Validated SaFE model SaFE C1-C4 → **Case specific SaFE models SaFE D/E/F** → SaFE model with (RIBA plan of work 2013 overlay) SaFE G1 – G4

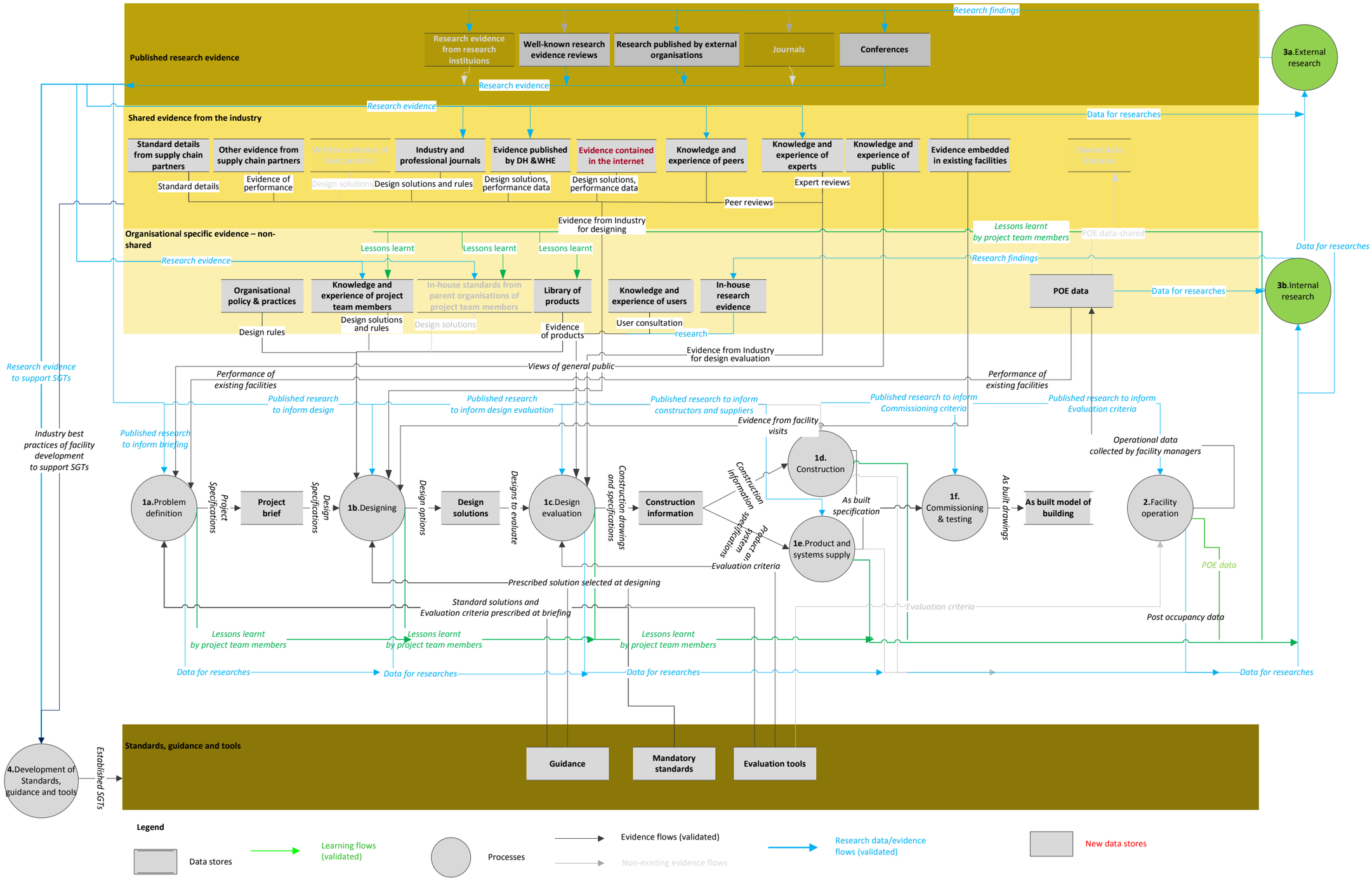


Figure 8-7: The SaFE model - Case study B

8.5 USE OF PERFORMANCE AND PRESCRIPTIVE SPECIFICATIONS

The data revealed that evidence expressed in the forms of performance specifications and prescriptive specifications are used during problem definition, designing and design evaluation.

Stories of the 25 design elements identified within Case B, were deductively analysed to identify how designers used performance and prescriptive specifications during problem definition and designing.

Specifically, case study data were analysed to identify designers' use of two approaches to problem definition:

- problem definition based on specifications identified within SGaTs; and
- problem definition based on specifications devised based on other evidence.

And their use of four approaches to designing:

- designing based on guided solutions;
- designing based on de facto and innovative solutions;
- devising solutions; and
- constructing solutions.

Further details of the analysis are presented in Chapter 6. Distinct approaches to design evaluation could not be identified at element level. Designers used almost all sources of evidence to evaluate the design throughout the designing phase and these were presented and discussed in Section 8.4.

Based on the deductive analysis, it was identified that designers in Case B have adopted 5 variant approaches to problem definition and 7 variant approaches to designing. Table 8.6 summarises the approaches taken by designers in Case B for problem definition and designing for each of the 25 element.

Table 8-6: Approaches to designing for exemplar design elements studied in Case B

	Design element	Category	Approach to problem definition	Approach to designing	Solution origin	Nature of output design
B1	Ward layout- other	Space/layout	DP	DS		Bespoke
B2	% single rooms	Composition	-	GS > DS		Bespoke
B3	Single room design	Space/layout	->DP+GP	GS > DS	**SGaTs** solution abandoned	Bespoke
B4	En-suit - size	Shape and size	-	GS > DS	**SGaTs** solution abandoned	Bespoke
B5	Doors	Component	->DP	GS > DS	**SGaTs** + **dfSS** (in-house K&E)	Bespoke
B6	Isolation room - provision	Provision	-	GS+	SGaTs	Standard
B7	Staff base	Space/layout	GP	GS+	SGaTs	Bespoke
B8	Isolation room - Layout	Space/layout	DP	GS+	SGaTs	Bespoke
B9	On-suit vs Central	Option appraisal	-	GS+SS	**SGaTs** + **dfSS** (Traditional solution)	Bespoke
B10	Ward shape	Shape and size	DP	SS	**dfSS** (in-house K&E) + **iSS** (Evidence from the industry)	Standard
B11	Provision of single room	Provision	-	SS	**iSS** (Research evidence)	Standard
B12	Day space	Provision	GP	SS	**dfSS** (Traditional solution)	Standard
B13	Isolation room - location	Location	-	SS	**dfSS** (in-house K&E)	Bespoke
B14	Bed head service	Component	-	SS	K&E > **iSS** (Evidence from the industry)	Standard
B15	Computer at staff base	Component	DP	SS	**iSS** (Evidence from the industry)	Standard
B16	Nurse call system - Sera	Component	DP	SS	**iSS** (Evidence from the industry)	Standard
B17	Floor finishes	Finishes	GP	SS	**iSS** (Evidence from the industry)	Standard
B18	Wall finishes- EN-SUIT	Finishes	-	SS	**iSS** (Evidence from the industry)	Standard
B19	Ceiling finishes	Finishes	DP	SS	**iSS** (Evidence from the industry)	Standard
B20	Doors - finishes	Finishes	-	SS	**iSS** (Evidence from the industry)	Standard
B21	Doors- ironmongeries	Component	-	SS	**iSS** (Evidence from the industry)	Standard
B22	Ventilation strategy	E/services	GP	SS	**dfSS** (in-house K&E)	Standard
B23	Vistamatic panels	Component	-	SS+	**iSS** (Evidence from the industry)	Standard
B24	Design of the window	Component	GP	SS^{+}	K&E + **iSS** (Evidence from the industry)	Standard
B25	Water services	E/services	GP	$SS+GS^{+}$	**dfSS** (in-house K&E) + **SGaTs**	Standard

Key : GP – Problem definition based on g*uided specifications*, **DP**- Problem definition based on devised *specifications*, '**-**' - No pre-determined approach to problem definition, '**-**' - No pre-determined approach to problem definition, **DS** – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Adopt or adapt a selected de facto or innovative solution, '$^{+}$' - Significant moderations made, **>** - transition of approach, **iSS –** innovative solution**, dfSS –** de facto solution

8.5.1 Prescriptive and performance specifications for problem definition

Pre-design activities conducted by the project team were considered to be activities of problem definition (refer to Table 8.4). Examining Table 8.4 it is evident that approximately 11% (20 out of total of 184) of the project team's activities are related to problem definition. The project team in Case B was involved in the following activities for defining the design problem.

- Analyse existing system;
- Identify project specific requirements; and / or
- Specify performance specifications to guide consequent designing .

Analysis of the existing system was performed for one element only. Activities related to identifying performance specific project requirements and specifying performance specifications have equally dominated this phase. In 70% of the instances (14 out of 20) problem definition activities were based on evidence gathered from internal sources (K&E, user consultation, and information from the Client), whilst in 30% of instances problem definition was supported by evidence gathered from SGaTs. Surprisingly, evidence from user consultation was used in only one instance. The reason for this could be non-existence of project specific users at the time of designing.

Two main focuses were prominent during problem defining activities in Case B. Firstly, a considerable effort was made to identify the operational outcomes that needed to be achieved through subsequent design changes. Reducing infection control and improving patient satisfaction were the two main operational outcomes expected from the design. Specifically, a considerable effort was made to identify design requirements for the single-bed patient room design. These were expressed into 'Terms of Reference' (ToR) to guide subsequent design of single-bed patient room. 26 design requirements related to aspects of functionality, infection control, patient observation, patient environment, and other were included in the ToR.

One other interesting observation was that, health outcomes that could be achieved through building elements were considered during problem definition activities. In a few instances, these were transformed into specific prescriptive specifications. For instance, storage areas and finishes are articulated into the ToR as below.

> *"*Storage areas – storage of clean supplies in single rooms."
>
> *"Finishes – floors, walls and ceilings. Consideration of types, contrasts, non-slip coverings and required floor levels"*

Table 8.7 shows a summary of how problem definition approaches were used within Case study B.

Table 8-7: Approaches of performance setting and approaches of designing - Case study B

Base for problem definition	Total	Approach to designing						
		DS	GS+	GS>DS	SS	SS+	GS+SS	SS+GS^{+}
GP	6				3	2		1
DP	6	1	1		4			
-	11		1	2	6	1	1	
->DP	1			1				
->DP+GP	1			1				

Key :
GP – Problem definition based on g*uided specifications*, **DP**- Problem definition based on devised *specifications*, '**-**' - No pre-determined approach to problem definition, '**-**' - No pre-determined approach to problem definition, **DS** – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '$^{+}$' - Significant moderations made, **>** - transition of approach

Results from Table 8.7 reveal that in majority of instances, no pre-determined approach to problem definition (-) was made. Defining problems based on performance criterion gathered from SGaTs (GP) and defining problems based on devised performance criterions (DP) were used in a similar number of instances. Similarly to Case A, any association between the approach to problem definition and the approach to designing is not obvious at this juncture.

8.5.1.1 Problem definition based on guided specifications (GP)

For six elements, design requirements were set exclusively on the evidence from SGaTs published by DH and WHE. These were mainly articulated into performance specifications for design output (see Quotes below).

> *"……Maximise extent of openable area, within the guidelines set out in HTM55 to limit….."(a representative of from the Designer)*

> *"….the building notes say you need some kind of a communal space…"(a representative of from the Designer)*

8.5.1.2 Problem definition based on devised specifications (DP)

For seven elements, design team has devised design requirements based on evidence from various other sources. As stated early in this sub-section, information from the Client and K&E were the main sources of evidence used during problem definition other than SGaTs.

Devised design requirements contained both performances requirements that need to be reflected within the output design and the performance requirements that need to be achieved at service outcomes (see Quotes below).

"bed head to be viewed from screen / observation window" *(a quote from ToR of the single bed room design)*

"Orientation, aspect and views; from bed and chair positions" (a quote from ToR of the single bed room design)

New design requirements were devised for several reasons. Firstly, they were devised for the new design element encounters during the journey of innovative design elements. When the parent design element is an innovative/novel bespoke design or an adapted solution from some other context, new design problems emerge during the subsequent journey. For instance, during the designing of decentralised nurse stations, the design team found new design requirements regarding the equipment used at nurse stations. An interview with client representative revealed these as below:

"…..because we can't have computers at the desk you are at out and not in a locked room, so all the technology had to be designed as secured…."(a representative of the Client)

"……need some way to facilitate nurses' communication….."(a representative of the Client)

The design team have devised design requirements by analysing these new design problems/requirements. Secondly, new design requirements were devised to guide designing of new solutions when the design team is not satisfied with the existing solutions. For instance, during the single-bed patient room design, the Client and the Architect was not satisfied with the single bedroom layouts prescribed in the HBN 04 (see the quote below).

"…..guidance available and I don't think and trust doesn't think most of them are appropriate, ……. the board did not like the guidance because that did not meet their criteria of single bed rooms …….one of those guidance note is bathroom is almost at the opposite side of the bed room……."(a representative of the Designer)

Therefore, they decided to deviate from the guided solutions and devise a knowledge based solution. The first step was to decide on the specifications, which they have articulated into a 'Terms of Reference' (ToR). Based on the knowledge and experience of the design team and internal and external research evidence, the design team identified 26 main criteria before devising a solution. A weightage was given to criteria for use during option appraisal. This ToR and evaluation system was used throughout the design process of the single-bed patient room.

Thirdly, new design requirements were devised to support project-unique design requirements. For instance, the ward layout was developed based on the room data sheets developed by healthcare

planners to support the service model and capacities of the hospital. The shape of the ward is another project-unique design element. For Case B, the project had a site/location with hardly had any restriction on the design. Therefore, the design team was able to consider and devise new design requirements to guide the design of the ward.

Finally, new design requirements were devised when the guided specifications are not adequate. For instance, during the designing of doors, the design team found the doors shown in the SGaTs are not well suited for single-bed patient room hospital design. Consequently, they have identified new design requirements for the doors and have devised the doors accordingly. The project team has acknowledged the importance of the existing standards and guidance provided by the DH and WHE. The purposes of deviating from the endorsed guidance were:

- to supplement endorsed SGaTs;
- for elements that is not covered by the existing SGaTs; and
- for elements with exiting solutions where SGaTs are no longer appropriate.

Problem definition activities for the designing of the isolation room revealed deviating from SGaTs for two of these reasons. An interview with a representative from the Architect revealed that they deviated from SGaTs related to isolation room lobby to add extra requirements to the design based on the client's requirements and other staff requirement (see the Quote below).

> *"……being able to bed be in the lobby with both set of doors closed, engineers kept saying we don't have to do that but clients wanted it …….some of nursing staff wanted the isolation room at the beginning of the ward so that infected patient is not taken right through the ward, but then other nursing staff wanted them closer to staff base……." (to supplement endorsed SGaTs - Source: a representative from the Designer)*

The quote below explains a situation where the design team deviated from SGaTs during the designing of single bedroom doors since existing guidance for door is not appropriate for single bed room doors.

> *"……but we identified as a problem, since all equipment going to the patients as all hoists and X ray machines going to the patient so traditional doors were not tall enough ……" (a representative from the Designer)*

These design requirements were mainly devised based on the evidence identified from knowledge and experience, the Client's requirements, and external research evidence and the following quotes explain these further.

8.5.1.3 No pre-determined approach to problem definition (-)

This approach was the most prominent approach for problem definition in Case B. Examining the data related to the subsequent design of the elements, it was evident that subsequent solutions were identified from previously known solutions and from the industry. Furthermore, according to the results in Table 8.6, this approach was mainly used for elements of the detail design phase.

8.5.2 Prescriptive and performance specifications for designing

Seven variant approaches for designing could be identified within Case B. Table 8.8 shows a summary of the approaches to designing used within Case study B.

Table 8-8: Approach to designing for different types design elements

Approach to the solution		Design elements in the pre and conceptual design phase						Design elements in the detail and technical design phase				Total instances of
		Space/layout	Composition	Location	Shape and size	Provision	Option appraisal	E/services	Facilities	Finishes	Components	
DS	DS	1										1
	GS>DS	1	1		1						1	4
GS	GS+	2				1						3
SS	SS	1		1		2		1		4	4	13
	SS+										2	2
A combination	GS+SS						1					1
	SS+GS+							1				1
Notes : DS – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach												25

8.5.2.1 *Devising solutions (DS)*

This approach was less frequently used in Case B., the reasons for this limited use could be associated with:

- need to incorporate innovation emerged into the market,
- design process lead by the architect,
- design team's style of designing, and
- weaknesses of SGaTs.

Interviews with representatives from the Client and the Architect mentioned that they had the intention of incorporating innovative solutions into the design. Both the Designer and the Client

have introduced innovative solutions to Case B, based on the evidence from the industry. Since the Client in Case B is less experienced at procuring buildings of this scale, the rest of the design team have taken a leading role during the design development. The Architect who is well established and experienced has introduced several innovative solutions to the design based on the experience gained on other projects and other sectors. Kruger and Cross (2006), claimed that some designers because of their style of designing spend more time identifying solutions. This could be applicable to the above result though no evidence to confirm this claim could be found. In four instances (% of single rooms, single room design, size of en-suit, doors) design solutions were devised when guided solutions that were considered were failed (GS>DS).

For only one element, this approach was used at detail and conceptual design phases (*design of doors*), in all other instances this approach was used for design elements in the pre and conceptual design phases.

8.5.2.2 Designing based on prescriptive solutions (GS, SS)

This was the most prominent (80% of elements) approach within Case B. The majority of the prescriptive solutions (for 83% the elements) were identified based on de facto standards and from innovative solutions emerging onto the market. Examining the results in Table 8.6, it is evident that a considerable number of prescriptive solutions were identified from innovative solutions that emerged from industry. Some of them were introduced by the Architect (bed head service panel, 'whiterock' wall finish for instance) whilst some introduced by the Client (nurse call system, 'vistamatic' door vision panels for instance). In a few instances prescriptive solutions were identified within de facto standards. These solutions were evaluated for their suitability before being incorporated into the design. However, instances of rejection of any of such considered solutions could not be identified.

Guided solutions were considered for nine elements. Solutions for three elements were identified from SGaTs and in other two instances solutions were partly identified within SGaTs and partly based on other evidence. For another four elements, prescriptive solutions selected from SGaTs were abandoned due to reasons associated with:

- economical and spatial efficiency (for instance, % of single rooms);
- guided solutions do not support all the specifications expected by design team (for instance, single room layouts);
- project-unique uses are different to the rationale behind the solutions stated in the guidance (for instance, en-suite size); and

- guidance being outdated or silent (for instance, doors).

Due to the following causes, some of the guided solutions were significantly improved; resulting in bespoke solutions (GS^{+}).

- Changes in local capacity requirements (for instance, provision of isolation rooms)
- Adjustments made to support an affordable staffing model (for instance, staff base decentralisation)
- Client's extra requirements (for instance, Isolation room layout)
- Improvements made to responds to issues identified during design evaluation (for instance, water services – fittings)

In Case B, prescriptive solutions were used fairly for all types of design elements within pre and conceptual design phases and detail and technical design phases. Yet, prescriptive solutions adopted for the design elements in the pre and conceptual design phase have eventually resulted in bespoke designs after improvements; while solutions adopted during the detail design phase were subjected to limited or no improvements.

Two prescriptive solutions were identified from published research. They are *single bedroom design* and *decentralised nurse station decision*. These two solutions were also supported by the evidence from SGaTs.

8.5.3 Approach to design evaluation

Examining the results from the case studies it was realised that there are no distinguishable approach to design evaluation, but activities in design evaluation were conducted frequently during the designing and end of designing phase using all available sources of evidence. Results in Table 8.4 shows that design evaluation was supported by evidence from almost all sources. Primary focuses for these evaluations were:

- to support option appraisal;
- to assess whether the designs comply with performance and prescriptive specifications set during problem definition and designing; and / or
- to identify further improvement opportunities.

A formal Post Occupancy Evaluation for Case B was conducted by an external organisation. The results are considered to be significantly successful. Some of the major performance achievements are greater reduction in infection and MRSA, increased patient and staff satisfaction, greater privacy and dignity, patients sleeping better. A few minor snags were also reported. One example is floor

finishes in the kitchen area. The Architect had proposed an innovative floor tile and sent samples of the tile for inspection and approval. During the operation phase, it was observe that food waste collected in tile groves. Eventually the whole area was re-laid with traditional tiles. It was also reported that some rooms become over heated during the summer days. The Client identified the reason for this was that the building was commissioned during the winter; but the Engineer believes it to be a result of incorrect use of the heating and ventilation system. A detailed account of the positive and negative performance related to studied elements is included in Appendix H.2.

8.6 IMPACT OF PROJECT-UNIQUE CIRCUMSTANCES ON THE EBD PROCESS

This section provides a detailed account of how the evidence-based design process of Case Study B was influenced by project-unique circumstances and how designers reflect on these circumstances. The interview content of Case B was analysed based on the principles of inductive thematic analysis (refer Chapter 2) to identify project-unique circumstances impacted on the EBD process. This analysis revealed ten circumstances unique to Case B that has impacted Case B's EBD process.

1. Funding
2. Being the first project of its nature and non-availability of similar projects
3. Local departmental needs
4. Being part of a pilot project
5. Age group of patients
6. Culture of staff and other users
7. Issues while integrating with other technical systems
8. Operational conditions different from testing conditions
9. International evidence comes from different contexts
10. Other

8.6.1 Funding (including funding for testing and more time during design phase)

Availability of funds, amount of funds and timing of funding have impacted the EBD process at all stages.

Impact of funding to access evidence

The design team did not undertake many visits to other facilities due to funding restrictions. Clinicians (client) visited three local hospitals and single bed hospitals in Ireland. During the design

process, one of the client representatives visited hospitals in France for medical purposes. This opportunity was used to look at built environmental design as well.

This hospital had no specifically allocated sum of money for Evidence-based design; though luckily they had access to evidence via other means. In the same time frame as the strategy development of Case study B, the Welsh Health Estates (WHE) was conducting research on single-bed patient rooms. The design team from Case B had the opportunity to use some of the resources of WHE research team. In particular, WHE invited Professor Roger Ulrich, who has done systematic reviews of the available therapeutic evidence base and the design team from Case B had the opportunity to gather evidence from that event. In addition, the Architect of the Case B was part of the WHE research, and this eventually helpful during development of the design for Case B.

Application of evidence and availability of funds to afford better solutions

There were instances of missed opportunities due to lack of funding and earned opportunities due to availability of extra funding. The interview with one of the Client's representatives revealed that, it would have been better if they had had the chance to mock up a whole single bedroom ward at an existing hospital, run it for a year, and generate evidence. However, as the Welsh Government had allocated the funding for Case B over the period of 2008-2011 and the Health Board were unwilling to defer funding for a further year this suggestion could not be put into practice.

In another instance, the design team managed to obtain approval for extra funds deliver a better solution for the en-suite bathrooms. The layout of the en-suite presented in the DH guidance is based on the idea that the en-suite door will be open into the patient room and the patient and carer could use the space in the bedroom to locate a wheelchair or any other assistance equipment. The design team from Case B thought that this arrangement was inconvenient and an un-suitable option for the targeted patient group (elderly patients). They were able to apply and gain some additional funding from the WHE to increase the size of the en-suite bathrooms.

Post project learning - Funding for POE

The POE was conducted by an external (to the original design team) third party on behalf of the Client. Other members of the design team did not have an opportunity to engage in the process or post discussions officially but informal communication with the Client. The Architect applied for funding from an independent research funding body to conduct a detailed POE for the project, but was not successful. However, the Architect's interview revealed that as a practice, a member of the Architect's organisation visits the site during the operational phase and gather evidence on the design by talking to users (staff and patients) and by physical observation.

8.6.2 Being the first project of its nature and non-availability of similar projects

The project was the first newly constructed, 100% single bed hospital in the UK. Other hospital facilities the project team visited, to gather evidence on single bed patient rooms, were not newly constructed but adapted from shared bed bays to single patient rooms. Almost all the interviewees mentioned this as a concern in extracting and applying evidence.

> *"……..they are not new build they have taken existing buildings and adapt it, so that is how we benchmark, we could not go and find that is exactly what we wanted, we had to visit couple of places and to see what clinicians say……"(a representative from the Client)*

Some of the design elements considered in Case B's design was not available in the adapted hospitals. For instance, the windows in hospitals they visited hospitals were of an older style designed to support shared bed bays.

But interviewees acknowledged that the visits were still useful. The following quote from an interview with a representative from the Client explains this further.

> *"…….these hospitals have not originally got single- bed rooms they have adapted, but it gave us an idea how do they work for infection control or whatever, but it had a different service model, because you got nurses caring six beds and single bed rooms, but what we were doing is all single bed rooms……."*

8.6.3 Local departmental needs

Local departmental needs had an impact on the design. Examples of successfully reflecting local departmental needs, as well as disappointments for not reflecting on departmental needs were identified within Case B.

En-suite bathrooms were designed to be larger as opposed to the size prescribed by guidance, to reflect the needs and activities associated with elderly patients. This was received positively at the operational phase. Similarly, nurses' station decentralised design took into consideration the staffing model and observation required for the targeted patient group. This too was received positively during the operational phase.

The design did not consider the needs of patients suffering with dementia (which constitutes a major target patient group in the hospital). The client representative interviewed mentioned that performance would have been better if they looked at dementia design evidence. Surprisingly, it was

mentioned that they were not aware of specific design considerations for dementia patients until they heard about these evidence later during a conference. This confirms the literature claim that designers are not aware of what they do not know (Hamilton and Watkins, 2009).

Similarly, specific design requirements for a mental health patient unit were not well considered during the design of the windows. A representative from the Client explains this as,

> *"……for mental health we had a problem, we can't have open gaps, so we had to put a mesh so people outside cannot come and put any drugs in so we had to put this mesh at the end which is ugly, so windows are our problem to get the ventilation right, we can't have smaller windows because patient need to see out while sitting……".(a representative from the Client)*

8.6.4 Being a part of a pilot project

Case B was a 'pathfinder' project to be delivered through the 'Designed for Life: Building for Wales' scheme, and this allowed the design team to access to extra resources, such as access to research evidence gathered by WHE, and the opportunity to learn from Professor Roger Ulrich's evidence reviews. More importantly, WHE attended project meetings and commented on the design because it was the first project to be delivered. These were identified as favourable for the design of Case B.

8.6.5 Age group of patients - (elderly)

Since the current elderly population prefer a bath to a shower, the design has incorporated one bathroom for each ward, but there were other problems associated with this such as nurses having to flush the bath every three days for infection control reasons.

The bedroom was designed with windows that could be opened to support natural ventilation and energy savings. But, during the operational phase it was understood that opening windows manually is difficult for elderly people. It was mentioned that they were aware of the possibility of this problem during the design phase and from the patients' point of view this has caused patient dissatisfaction. Further, patients had to contact nurses through the nurse call system to get help to open and shut the window. This overloaded the nurse call system and resulted in nurses having difficulty in identifying which calls are urgent and which are not. Any consideration regarding mechanically opening windows was not revealed during interviews. It may well be they did not consider this option due to cost.

8.6.6 Culture of staff and other users

This new facility was designed with new amenities to be used by both patients and staff but it was mentioned that previous working culture had not changed and the new facilities were not used to their optimum efficiency. The quote below from the Client explains one of such instances.

> *"….we are happy about X(Case Study B) but they still putting things in corridors like mobile hoists, not using store rooms properly…."(a representative from the Client)*

Interviews revealed that the decentralised nurses' station design was positively received in Case Study B. The Health Board adopted a similar design for a similar hospital within the Health Board and it was mentioned that the staff in the other hospital found it difficult to adapt to the new system. The reason was considered to be the culture and attitude of senior management staff leading the clinical staff.

> *"…… the design is good and it worked well in the XX hospital, and the other thing nurses in the X hospital (the similar hospital) says they cannot hear the telephone ringing at the desk while they are in patient rooms, but we don't get that problem in XX hospital[Case B], ……. it is interesting because you got the same design but two different staffing groups, I think system in the YAB was better they were prepared for it, but in YYF they did not like it from the start……, so you need all of these to work, it is not just down to design….." (a representative from the Client)*

8.6.7 Issues while integrating with other technical systems

The requirements of the engineering systems or technical systems have constrained the number of options to could be used in some design elements. For an example, ceilings in some areas have to support access to the services above the ceiling. The design team was constrained by this requirement when selecting appropriate ceiling materials for different areas.

They found a similar difficulty when introducing and using a new wall tile ('whiterock') for en-suite walls. Whiterock, which consists of large panels made it challenging to contend with pipe work therefore, the design team had to design walls with access panels at particular locations to enable pipes and fittings to be installed.

8.6.8 Operational conditions different from testing conditions

During the design evaluations, conditions of testing were not exactly similar to the conditions in the operation phase. Unforeseen and different conditions during the operation have resulted the building not performing as expected during design evaluations. For an instance, the building was

commissioned during the winter season and found to be thermally comfortable. It was later found that in the summer months some spaces become over heated.

8.6.9 International evidence come from different contexts

There were difficulties associated with application of international evidence. Interviewees revealed that tiles were a common floor finish used in European hospitals; however, the use of tiles to finish non-clinical areas in UK hospitals was difficult due to cost.

Similarly, sliding doors used in American hospitals were identified as inappropriate for Case B.

> *"…….. in America they use quite a lot of sliding doors, and that is something we cannot do here, infection control people don't like sliding doors, maintenance don't like sliding doors, but I am not sure that sliding doors can meet current guidance……." (a representative from the Client)*

A nurse call system was incorporated to the design based on the evidence of its use in US. This has faced unexpected issues, since the staffing model in the UK is different to that in America. The staffing model used in Case B is, one nurse for every eight rooms. It was mentioned that patients use the call system for all urgent and non-urgent needs. This overloads the call system and means that nurses are unable to distinguish between urgent needs and those with which neighbouring patients would normally help. The interviews also revealed that when a nurse attended to a patient's call she needed to switch the call light off in the patient's room to signal that the call has received attention, but as the system was new to staff they may have forgotten to switch the light off which then resulted in system overload.

8.6.10 Other

Even though there is specific guidance on hospital isolation rooms, single bedrooms are better for isolating patients than shared wards. Therefore, the requirement for isolation rooms in a single bed room hospital was minimal. The patient group served by Case B does not bring extremely high isolation demands as opposed to a big city where people arrive from aboard. Considering the project-unique circumstances, the design team has incorporated only one isolation room per ward.

HBN guidance suggests one touchdown base per two rooms for hospitals incorporating single-bed patient rooms. However, this was derogated since such a design requires more staff to run the service which Case B cannot afford.

Security related issues have also impacted the project: for instance, leaving computers on the nurses' desk in an unlocked room was identified as a concern and the computer network had to be designed to tackle this issue.

8.7 CHAPTER SUMMARY

This Chapter reported and discussed EBD practices of Case study B related to three main perspectives:

- practices of using nine sources of evidence during the process of designing;
- practices of using performance and prescriptive specifications during the process of designing ; and
- impact of project-unique circumstances on EBD practices and how practitioners reflected on these circumstances.

K&E was the most frequently used source of evidence in Case B and evidence from K&E was used during almost all 14 design activities identified within Case B. The second most used source of evidence was internally generated evidence followed by the evidence from SGaTs. It was also observed that internally generated evidence was frequently used alone whereas evidence gathered externally was extensively supported by evidence from other sources. This may imply applicability of evidence in project-unique circumstances as well as designers' opinion related (lack of) credibility of the evidence gathered externally. Results suggested that evidence sources may have particular ways of support during the design process. K&E and information from the Client was used during almost all types of design activities. Internally generated evidence and evidence from expert opinion were primarily used for design evaluation activities. Evidence from visits to facilities and evidence from the industry were mainly used to identify design solutions and activities associated with the early stages of designing. In Case B, evidence from SGaTs was used mainly in the early stages of designing to identify solutions and they were fairly often used during design evaluation activities. Other dimensions of evidence related to means of gathering, user channels of access, purposes for use, availability, suitability, quality and success of using that evidence were also identified. This analysis supplemented the above results by providing further details of particular ways of using evidence sources and their applicability in project-unique circumstances. A bespoke version of the SaFE model was generated for Case B. Some of the evidence sources identified within generic model were not used in Case B, whilst case study data were useful in identifying specific details behind the means of generating and disseminating evidence from some sources. Furthermore, details of evidence flowing into sub-process of designing could be identified.

Practices of using performance and prescriptive specifications were identified for problem definition and designing. No pre-determined approach for problem definition was prominent for the majority of the elements (44%) in Case B. Defining design problems based on specifications contained in SGaTs and by devising specifications based on evidence from other sources were equally (24% each) used. During the problem definition, both the output specifications of the subsequent design as well as service outcomes that need to be achieved through the design were considered. Therapeutic aspects of the building were considered during problem definition activities.

The most prominent approach (for 80% of the elements) for designing in Case B was designing based on prescriptive solutions. For nearly half of these instances, prescriptive solutions gathered through SGaTs were considered. However, in four instances, due to project-unique requirements and weakness of the solutions gathered from SGaTs, these solutions were rejected and the design team eventually devised solutions. However, the rationale behind these prescriptive solutions was identified and applied during subsequent designing. Designing based on prescriptive solutions was equally used for elements in the pre and conceptual design phases and detail and technical design phases. During pre and conceptual design phases prescriptive solutions gathered mainly from SGaTs, whilst during detail and technical design phases prescriptive solutions gathered mainly from de facto standards and innovative solutions emerging from industry.

EBD practices of using evidence from nine sources and using evidence during problem definition and designing reflected project-unique circumstances that were associated with Case B. Case B was special due to the fact that it was new-build to support a new care model of the Health Board, hence there were no specific staffs allocated for the proposed hospital at the time of designing. Practices of evidence use reflected circumstances associated with: non-availability of some of the evidence sources and mitigatory measures taken by the project team. Furthermore, the hospital was designed to serve non critical care for elderly and mental health patients. These circumstances had an impact on the EBD practices of Case B. Not reflecting on these circumstance has left the design with a few failures that could have been avoided. Case B was in a beneficial position relating to access to external research since it was a pilot project of WHE to establish single-bed patient rooms in Wales. Therefore, Case B had access to research resources used by WHE for this initiative. Funds were identified as reasonable, but the timing of funding has impacted the EBD process of Case B. Other circumstances related to the shape of the site, culture of users, inability to create precise operating conditions during the testing have impacted EBD practices and the success of the resultant design in Case B.

9 CASE STUDY C (Detailed version)

9.1 INTRODUCTION

This Chapter reports and discusses evidence-based design practices of Case Study C. A brief description of the case is provided at the beginning. The middle sections are structured to report and discuss the results of case studies from three perspectives:

- Firstly, data used in Case study C was analysed to identify sources of evidence used during Case C, the frequency and timing of evidence sources used and other selected dimensions of using evidence from different sources. Based on these results a bespoke version of the model for Evidence-based design was generated for Case study C and presented in this section and the changes made to the generic model that helped to develop the bespoke model, are discussed.
- Secondly, the Chapter reports and discusses how performance specifications and prescriptive specifications were used during problem definition and designing in Case study C.
- Finally, the impact of the project-unique circumstances on the Evidence-based design process and how designers reflect on these circumstances are reported and discussed.

The Chapter is then concluded by giving a summary account of Evidence-based design practices for Case study C.

9.2 DESCRIPTION OF THE CASE

Case study C is a modular building. The building was procured through fast track for time in order to cater for forecasted winter pressure. The duration of the project was six months from inception to completion. One of the main objectives of the project was to ensure that patients can be treated in

newly constructed wards in six months. However, the focus on a better patient and staff environment was not rationalised. It was mentioned that:

"The quality of the patient spaces and staff working environment has been critical to the design – with generous ward accommodation and large windows to maximise natural daylight and ventilation." (Estates director)

The building was procured as a modular construction to suit the tight schedule. The scope of the project is 3,000 m^2, comprising ground floor clinical and non-clinical general accommodation, with the first floor incorporating two 28-bed wards. The ward comprises shared four bed bays, single-bed patient rooms, store rooms, kitchens, reception area and waiting areas. The total project cost £10million. The project was started in July 2008 and completed in December 2008.

9.3 DATA

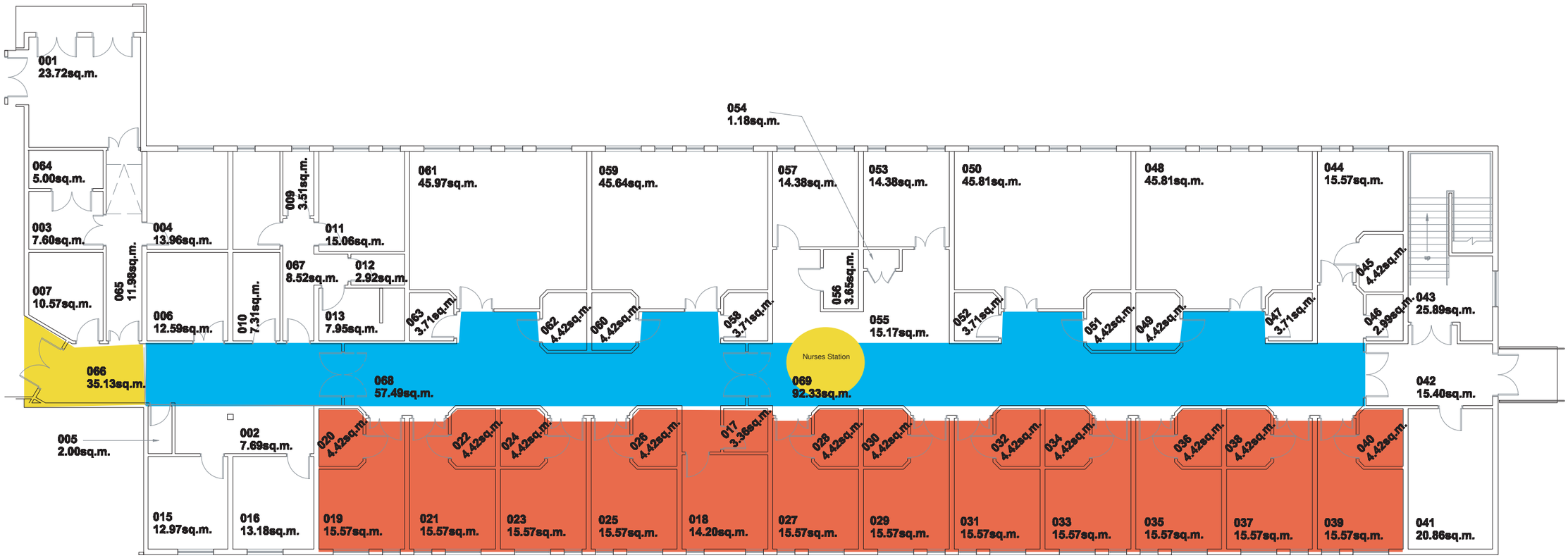
The hospital building considered in Case study C consists of an inpatient ward with a gross internal area of 895m2. Table 9.1 shows the scope of the spaces studied during this case study.

Table 9-1: Scope of the spaces considered within Case study C

	Space type	Area occupied by the element (total floor area 895m2)	Area occupied by the element as % (total floor area 895m2)
1	Single bed room, en-suite	239m2	28%
2	Ward layout and nurse station	66m2	8%
3	Communal spaces	120m2	14%
4	Isolation room	0m2	0%
	Total	424m2	50%

Figure 9.1 illustrates the spaces covered in this study on a plan of a typical floor.

Figure 9-1: Scope of the spaces considered within Case study C



Legend

- Isolation room
- Ward layout and nurse stations
- Single bed room
- Communal spaces

9.4 EVIDENCE USE

9.4.1 An overview of evidence use

During the designing of Case study C, evidence was obtained from several sources as illustrated in Figure 9.2. The main channels of evidence were members of the design team, their parent organisations and supply chain partners and external evidence sources such as SGaTs from DH.

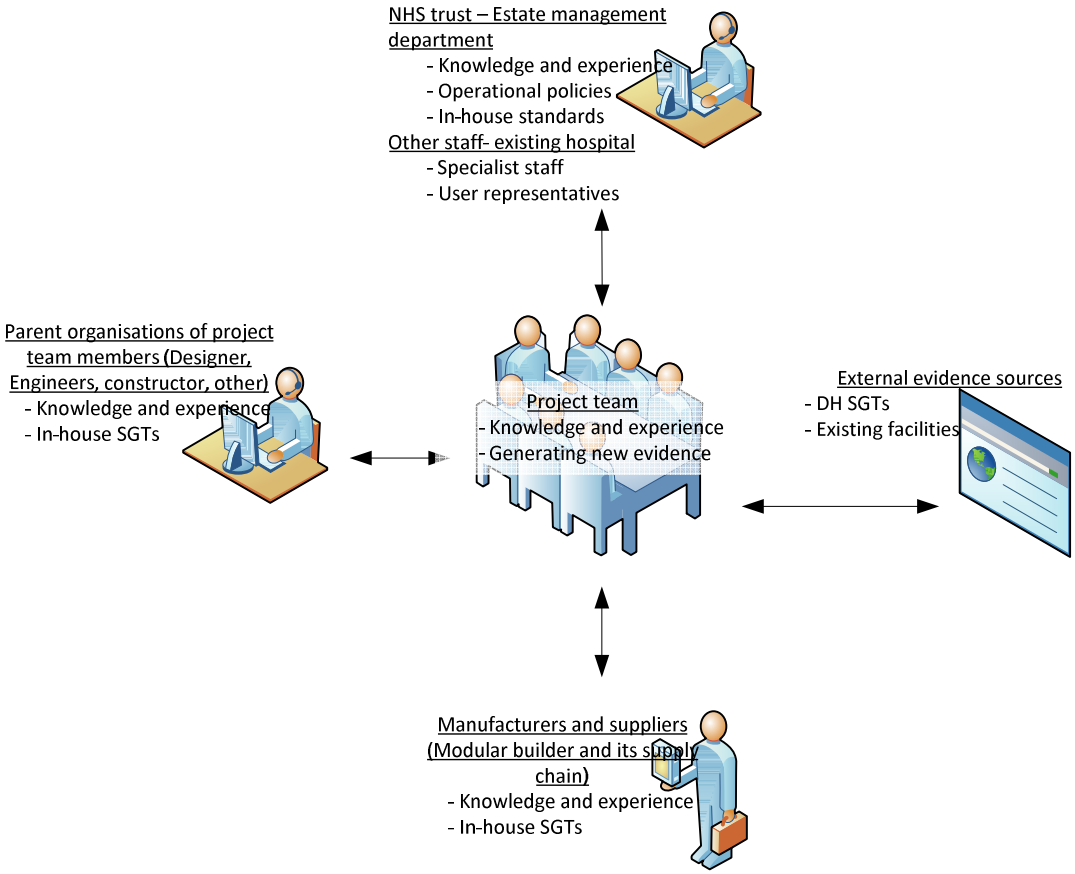


Figure 9-2: Evidence channels for Case Study C

These channels had strengths and weaknesses. As explained earlier, Case study C is unique because of its duration; which was six months from inception to completion. The trust had experience of procuring a modular building previously and had experience in building work as the in-house team for facilities maintenance of the existing hospital. The client team consisted of construction professionals such as engineers and architects. The impact of these circumstances was evident during the design process. The input from the Designer and Engineer was limited to conceptual design and design evaluation, since the design was then developed and fabricated by the modular contractor and his supply chain.

Table 9.2 provides details of the evidence sources used during the design of 26 elements.

Table 9-2: Details of evidence sources used during design of 26 elements

	Initial unit of analysis		Design elements identified within data	Number of design steps involved	Sources of evidence										Number of instances of evidence use	Total number of evidence sources
					Information from client	Evidence from the industry	Internally generated	Knowledge and experience	User consultation	Expert opinion	Research - external	standards and guidance	Facility visits	None use of evidence		
1	Single bed room , en-suit & bed head service panel	1	single room layout	9		2		3	3	1		2			11	5
		2	On-suit	3		1		1		1					3	3
		3	bed head services	6		1		4							5	2
2	Ward layout and nurse station	4	size and shape of the ward	4		2		3				1			6	3
		5	layout - composition of single and shared bed bays	6		1		5							6	2
		6	layout - other	16	1			2	5	7					15	4
		7	layout - entrance to the ward	3				3							3	1
		8	layout - no of nurse bases	1				1							1	1
		9	layout - location of the nurse base	3				2	1						3	2
3	Communal spaces	10	day rooms	5				3	1						4	2
		11	corridors	2				1		1					2	2
		12	waiting space	2				1	1						2	2
		13	stair ways	2				2							2	1
4	Isolation room	14	isolation room	4				4							4	1
5	Finishes	15	floor finishes	8		1		5		1		4			11	4
		16	wall finishes	5		2		2		1		1			6	4
		17	External walls	2		1		1							2	2
		18	worktop finishes	2				2							2	1
6	Doors	19	doors - generic	8	1	1		3	3			1			9	4
		20	glass panels/smart glass	2		1		1		1					3	3
7	Water services	21	water services design	5				5				1			6	2
		22	fittings - water services	5				3	2						5	2
8	Ventilation strategy and windows	23	ventilation strategy	9	1	1		7				1			10	4
		24	windows - generic	6		1		4				1			6	3
		25	summer temperature control	6				5				1			6	2
		26	window blinds/ windows	2				1		1					2	2
Total				122	3	15	0	74	16	14	0	13	0	0	135	

Evidence use for 26 exemplar design elements was associated with 122 design steps identified during the data analysis for Case study C. Similar to Cases A and B, some of the design steps were supported by evidence from more than one source. These instances were separately counted and 135 instances of evidence use were identified for Case study C.

Through the data analysis process that was explained in the Chapter 6, it was identified that designers used the following six evidence source to gather evidence for designing for the scope considered within this Case study.

1. Knowledge and experience
2. Evidence from the industry
3. User consultation
4. Standards and guidance
5. Information from client
6. Expert opinion

As stated above, only 6 sources of evidence were available for Case study C. Even though the project had access to a limited number of evidence sources, according to Table 9.2, it is evident that the number of instances of searching for evidence for each element is not low compared to the results from Cases A and B.

In the majority of instances evidence was gathered from two sources. The reason for accessing evidence from two sources in the majority of instances could be the limited time available for the designers to gather and evaluate external evidence.

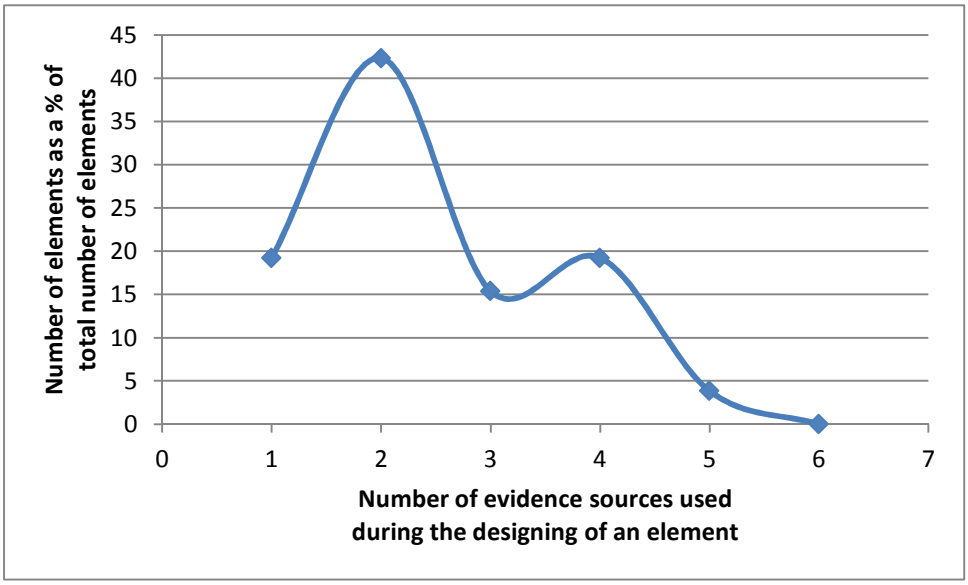


Figure 9-3: Number of evidence sources used during the designing of an element

The opinion of interviewed were inquired related to the availability of evidence, quality and integrity of existing evidence and rate of success of the design during operation (see Table 9.3).

Table 9-3: Summary of evidence used in Case C expressed by interviewees

	Design component/ element/ space	Availability of evidence	Quality/ Integrity of existing evidence	Rate of success in operation	Would you recommend it next time
		1–Poor 2–Fair 3–Good 4–Very good 5–Excellent	1–Poor 2–Fair 3–Good 4–Very good 5–Excellent	1–Poor 2–Fair 3–Good 4–Very good 5–Excellent	
1	Single bed room	4	4	4	Yes
	- On-suit bathroom	3	2	2	With improvements
	- Bed head	4	4	4	Yes
2	Communal spaces	N/A	N/A	N/A	N/A
3	Ward layout	3	3	3	Yes
	Clinical workstations	3	3	3	No
4	Window design/ ventilation strategy	3	3	2	With improvements
5	Finishes (Floor, wall and Ceiling)	2	3	3	Yes
6	Water services	3	2	3	With improvements
7	Isolation room	N/A	N/A	N/A	N/A
8	Doors	2	3	3	Yes

The data in the table above (Table 9.3) reveals that the design team have had access to evidence at levels from 'Fair' to 'Very good'. The quality of the available evidence was also between 'Fair' and 'Very good'. The rate of success at operation was 'Good' and above except for window & ventilation strategy and en-suite bathrooms.

9.4.2 Frequency and timing of evidence use

Figure 9.4 shows the frequency of using evidence from six sources and the constrained use of evidence during the scope under consideration within Case study C. The frequency of using a particular evidence source alone and the frequency of using the source in combination with other sources were identified separately. Instances of constrained use of evidence were also reported. The use of evidence from six sources is calculated as a % of the total number of instances of evidence use (135) studied within Case B.

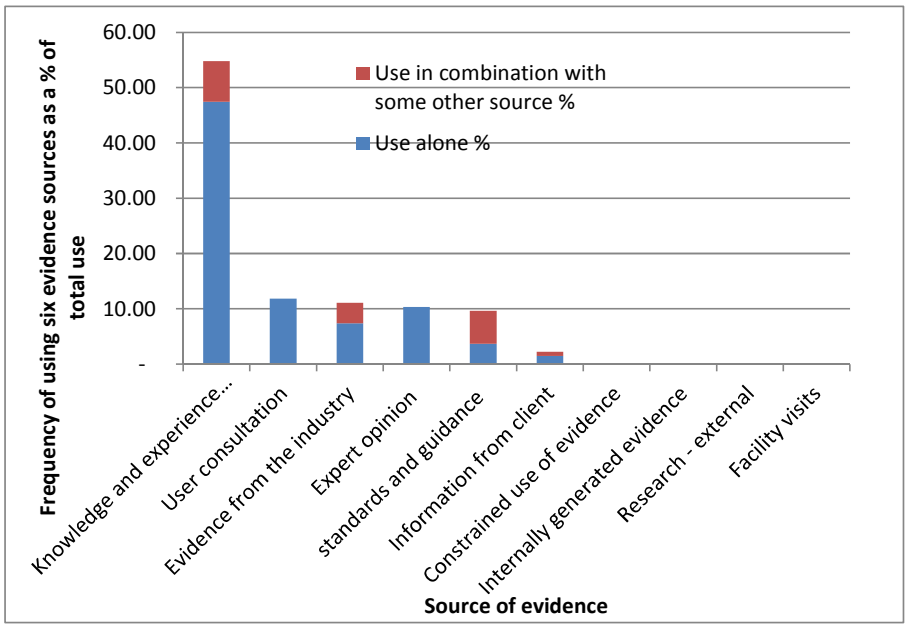


Figure 9-4: Frequency of use for different evidence sources for Case study C

Knowledge and experience was the most frequently used evidence source compared to other sources of evidence. For better visual illustration of details for other sources of evidence the same data were re-plotted without K&E (See Figure 9.5).

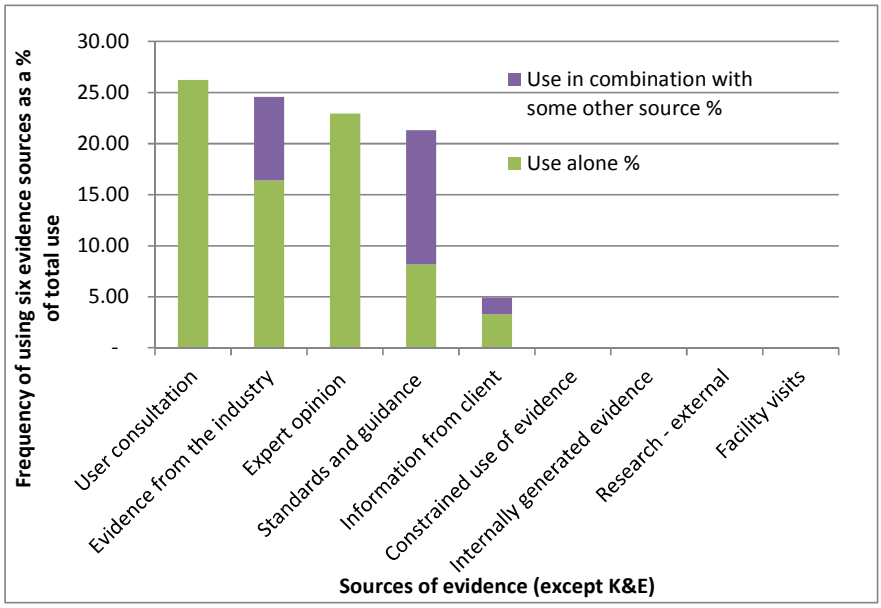


Figure 9-5: Frequency of use for different evidence sources without K&E for Case study C

According to the results in Figure 9.5, evidence from user consultation, evidence from the industry, expert opinion, and standards and guidance were used almost equally. Data did not reveal any instances of using internally generated evidence, externally published research and evidence from facility visits. The Client for Case C had in-house standards and they were categorised under knowledge and experience in this analysis. It is also apparent that evidence gathered internally (from user consultation and expert opinion) was used alone, whilst evidence gathered externally was supported by evidence from other sources.

Table 9.4 illustrates the timing of use of six source of evidence during the designing of Case study C.

Table 9-4: Timing of evidence use for Case Study C

	Pre-design phase (Problem				Design phase (Designing and design evaluation)										
	Analyse existing system	Identify project specific requirements	Specify performance specification	Specify prescriptive specification	Evaluate evidence	Identify possible ado(a)ption	Adopt the solution	Adapt a solution	Reject the solution	Devise a solution	Construct a solution	Detail design	Improve the solution	Design evaluation	Total
Information from client	-	2	-	-	-	-	-	-	-	1	-	-	-	-	3
Constrained use of evidence	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Evidence from the industry	-	-	-	-	-	8	3	-	-	-	-	-	1	3	15
Internally generated evidence	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Knowledge and experience	3	1	7	6	-	7	6	2	1	9	-	5	6	21	74
User consultation	-	-	-	-	-	-	-	-	-	-	-	-	3	13	16
Expert opinion	-	-	-	1	-	-	-	-	-	-	-	-	-	13	14
Research - external	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Standards and guidance	-	-	5	2	-	1	2	1	-	-	-	-	-	2	13
Facility visits	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3	3	12	9	-	16	11	3	1	10	-	5	10	52	135

9.4.3 Other dimensions of evidence

In addition to the frequency and timing of using six evidence sources, data revealed answers to 'how and why' questions in terms of following aspects.

Table 9-5: Uses of nine sources of evidence during the designing of Case study C

	Means of gathering evidence	**Purposes of evidence**	**User Channel of evidence**	**Availability of evidence**	**Suitability/ Relevance of evidence**	**Quality of evidence**	**Success of application**
Information from client	* Schedule of accommodation * Room data sheets	* To identify design requirements	Client and clinical staff	Evidence from this source was available	No flaws were reported	N/A	No failures were reported due to evidence from this source.
Evidence from the industry	* Involvement in designing * Visiting the pre-fabrication factories * Visiting facilities done by same modular builder	* To identify a suitable modular builder * To evaluate different products available with the selected modular builder and their supply chain partners. * To identify solutions * To evaluate solutions	Modular contractor and their supply chain partners	Evidence from this source was available	(+) Evidence from similar hospitals build by selected modular contractor was available.		(-) Shower tray used in the single rooms was well supported with the floor, and was damaged in use
Internally generated evidence	Instances of generating evidence specific to this project was not mentioned or identified through data. Yet evidence of therapeutic built environments (which generally originated within research) was considered during the design process.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Knowledge and experience stakeholders	* engage in concept development and design evaluation * Standard equipment and product list to be used as specifications	*To devise conceptual design * To devise project specifications *To evaluate solutions *To evaluate evidence acquired from the industry *To specify standards equipment	* In-house facility management team * Other members of the framework agreement	Yes	(+) The client has had previous experience on procurement of a modular building	(+) Client as the in-house facility management team was knowledgeable on operational phase of building as well	No failures were reported due to evidence from this source.
User consultation	* Design evaluation meetings	* To evaluate the design * To identify improvement to the design * To identify patient needs	* Clinical staff * Nursing staff	(+) This hospital was built on existing hospital site as a part of an expansion, the project was within the same site	No flaws were reported	(-) Any instance of consulting existing patients or general public could not be identified.	No failures were reported due to evidence from this source.
Expert opinion	* Design evaluation meetings	* To evaluate the design * To identify design requirements	* Elderly care specialist of the existing hospital	(+) Experts were available within existing hospital	(+) Hospital was designed for elderly care, elderly care specialists were available within existing hospital	No flaws were reported	No failures were reported due to evidence from this source.
Research - external	Instances of generating evidence specific to this project was not mentioned or identified through data. Yet evidence of therapeutic built environments (which generally originated within research) was considered during the design process.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Standards and guidance	* Standards and guidance from DH guidance	* To set performance and prescriptive specifications * To guide conceptual design	Not applicable	Yes	(+)Prescriptive solutions contained in the SGaTs were used as a starting points, and modifications were made	(-) Standards and guidance were used in combination with other sources of evidence	No failures were reported due to evidence from this source.
Facility visits	Not done due to time constraints – yet, previously completed buildings by the same modular builder ware known before	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

9.4.3.1 Knowledge and experience (K&E)

According to the results K&E was the most extensively used sources of evidence. The apparent reason for this is that the project had only 6 months from inception to completion which makes it impractical to gather evidence from external sources. Secondly, the Client has an in-house facility management team comprised of building professionals, and thirdly, the Client had previous experience of procuring a modular building for the same hospital.

K&E was used in almost all activities but it was predominantly used during design evaluation. K&E is the only source of evidence used to devise solutions. The reason for this is most of the elements of the design were undertaken by the modular contractor and their supply chain partners. However, the conceptual design was initially completed by the design team (see the quote below).

> *"……as a team we worked out the layout based on the users' brief in isolation without what is the modular solution would be…."(a representative from the Designer)*

K&E was used as a supporting source of evidence to evaluate evidence acquired from industry.

9.4.3.2 Standards and guidance

Case C used in-house standards and guidance as well as published SGaTs from the Department of Health during the design process. In the previous table and two Figures, in-house standards and guidance were counted as K&E. Table 9.6 below illustrates two types of SGaTs use in Case study C.

Table 9-6: Use of internal and external standards and guidance in Case study C

	Analyse existing system	Identify project specific user needs	Specify performance specification	Specify prescriptive specification	Evaluate evidence	Identify possible ado(a)ption	Adopt the solution	Adapt a solution	Reject the solution	Devise a solution	Construct a solution	Detail design	Improve the solution	Design evaluation
In-house standards	-	1	2	1	-	-	-	-	-	-	-	3	-	-
standards and guidance	1	-	4	2	-	1	2	1	-	-	-	-	-	2

Since, the Client had an in-house facilities management team they have maintained a standard equipment and product list to be used as specifications during the procurement of new buildings and maintenance works. Similarly, the Engineer's organisation had standard in-house specifications which they used regularly as engineering specifications. These in-house standards were mainly used

during detail designing and marginally during the early design stages. Engineering consultants have produced engineering service specifications to guide the engineering design based on in-house and DH standards. These were then used as specifications for the contract by the modular builder and their supply chain partners.

Evidence from SGaTs is used in combination with other sources of evidence, mainly knowledge and experience of the members of the design team and evidence from industry. Evidence from industry, user consultation and expert opinion were also used as supporting sources of evidence.

9.4.3.3 Expert opinion

The hospital was built to accommodate elderly care patients. Elderly care specialists were available in the existing hospital was consulted as a source of evidence. A representative from the Client explains how the specialist staffs were consulted simultaneously during the pre-design stages to identify design requirements.

> *"……quite often in early part I sat down with the clinicians, clinical team to make sure what we get is right……"(a representative from the Client)*

Minutes of meetings revealed several improvement opportunities identified through consultation with elderly care specialists during the design evaluation phase. They included concerns aspects such as adjacencies, spaciousness, extra space required, and finishes; and concerns regarding health outcomes; infection control, patient observation and patient safety (see quotes below).

> *"……concern re-main staff base being at top end of ward, need to be much more central in order to observe elderly patients…." (Minutes of meeting)*

> *"…….please use vertical washable blinds……" (Minutes of meeting)*

Availability of in-house expertise can be considered to be an advantage in a situation where the project lasted only 6 months from inception to completion.

9.4.3.4 *Evidence from industry*

Even though the Client had previous experience of procuring a modular building, a considerable amount of evidence was collected from industry within the limited time available. Evidence from industry was used during the design of the *size and shape of the ward, ward layout, single room layout, on-suite bathrooms, bed-head services panel, doors, door vision panel, floor and wall finishes ventilation strategy and windows*.

Evidence from industry was mainly channelled from the modular constructors and the supply chain partners of the preferred modular builder. Evidence from industry was collected for following two main reasons.

- To identify a suitable modular builder.
- To obtain appraisals for different products available at the selected modular builder and their supply chain partners.

Initially several modular constructors were visited and the preferred constructor was selected after considering cost, quality and time performance. It was also mentioned that the design team visited the factories of several modular builders to gather evidence on their processes and the performance of the finished buildings. The quote below from a representative from the designer explains specific aspects they concerned about during these visits.

> *"…….it was scored on the details of the quality, quality was the key of the finished product, modular have different finishes, how do they strip, flooring, and exterior finish, the interior finish is probably more focused……."(a representative from the Designer)*

An initial layout design for a ward was undertaken, irrespective of the solutions available from the modular constructors. This was then compared with the solutions available with the selected modular builder and after some minor compromises the design was finalised. Evidence from the modular builder and their supply chain partner was considered during the detail design phase to evaluate products and components. Some of the examples included different types of finishes, doors, bed head services and en-suite pre-fabricated units.

9.4.3.5 *User consultation*

In addition to consulting elderly care specialist consultants, representatives from other clinical staff (mainly matrons) were consulted to evaluate the design, and these evidence was useful for identifying improvement opportunities in relation to:

- spaces within the ward (for instance, adjacencies to other spaces, location of nurses' station);
- facilities for patients and staff (for instance, patient hoist store, access and security); and
- concerns regarding health outcomes (for instance, infection control, patient observation).

Instances of consultations with existing patients or the general public could not be identified.

During the analysis for Case C, evidence from the infection control team and other facilities management staff were not considered but were counted as 'knowledge and experience of the Client'. This was due to the fact that they were a part of the Client's team and continuously involved during the design process.

9.4.3.6 Published research evidence and internally generated evidence

Instances of using published research evidence or internally generated evidence could not be found within the explored scope of Case C. The reason was the limited time available to procure Case C.

However, evidence of therapeutic built environments (which generally originated from within research studies) was considered during the design process. These were channelled through the knowledge and experience of members of the design team. Some of these instances are reflected in the quotes below.

The importance of single rooms for infection control was reflected as;

> "……at the moment there is a tendency to have single bed rooms instead of shared bed bays ……..whether we take it from infection control point of view, and from patients point of view privacy and dignity……." *(a representative from the Designer)*

The importance of appropriate nurses' observation zones was reflected as;

> "…….we changed the bed position, the on-suite, the entry door for corridor, what you got in the HBNs for bed position is there(illustrating the location as in SGaTs), you cannot see the patient, so we decided to have that patient in that (illustrating the new location) position, so could actually see them without going into the room….." *(a representative from the Client)*

The importance of noise reduction was reflected as;

> *"…….the attention be paid to acoustics and that thought will need to be given sound transmission……..." (minutes of meeting)*

Therefore, it is apparent that even though there are no details of accessing research evidence directly, the research evidence was embedded in the other sources of evidence. It could be expected that research is informed into K&E of individuals through previous experience of using research evidence and/or through educational modes such as self-reading, CPD, attending conferences and any other mode of education. Case C maintained in-house standards which were derived through previous experience of procuring building works. The in-house standards may contain evidence that

could be categorised as research, but this could not be verified due to the time restrictions of this research.

9.4.4 Reflections on the model

A bespoke version of the SaFE model for Case C was produced using the Case study data (Figure 9.6). The following discussion compares and contrasts the bespoke SaFE model for case C with the original generic SaFE model.

1. Some of the data sources in the generic model were not used for Case C.

Possibly, due to the time restrictions in Case C, the design team did not access external evidence sources frequently. The Data did not reveal any specific instances of gathering evidence from public knowledge and experience, written evidence of best practice, industry and professional journals, knowledge and experience of peers and shared data libraries.

Case C did not use internally generated evidence or externally published evidence. However, the Client had in-house standards and technical details that were compiled through previous experience which may have comprised some research-based evidence.

2. Invalidated evidence flows

The data collected was not adequate to validate the evidence flowing into the phases of construction including; products and systems supply and commissioning and testing. Due to the restrictions on the time available for the research, there was no opportunity to interview the modular builder.

3. Evidence accessed excessively from knowledge and experience and specialist consultation

Even though the project team had limited access to external evidence, due to time restrictions, they relied on a considerable amount of evidence gathered from the knowledge and experience and through consultation with internal specialist staff. According to the results of the POE, the project was considered to be a success except for few snags. Thus, it is apparent that the evidence collection had not been compromised by the lack of evidence from external sources. Furthermore, the Client had previous experience of procuring a modular building, for the same hospital. Therefore, the inability to demonstrate the strength of evidence flowing into the design process and not being able to relate the process to the output and outcome performance could be considered as a drawback in this graphical model.

Sources and flows of evidence model (Case study C)

Conceptual SaFE model SaFE A → Verified SaFE model SaFE B1-B4 → Validated SaFE model SaFE C1-C4 → **Case specific SaFE models SaFE D/E/F** → SaFE model with (RIBA plan of work 2013 overlay) SaFE G1 – G4

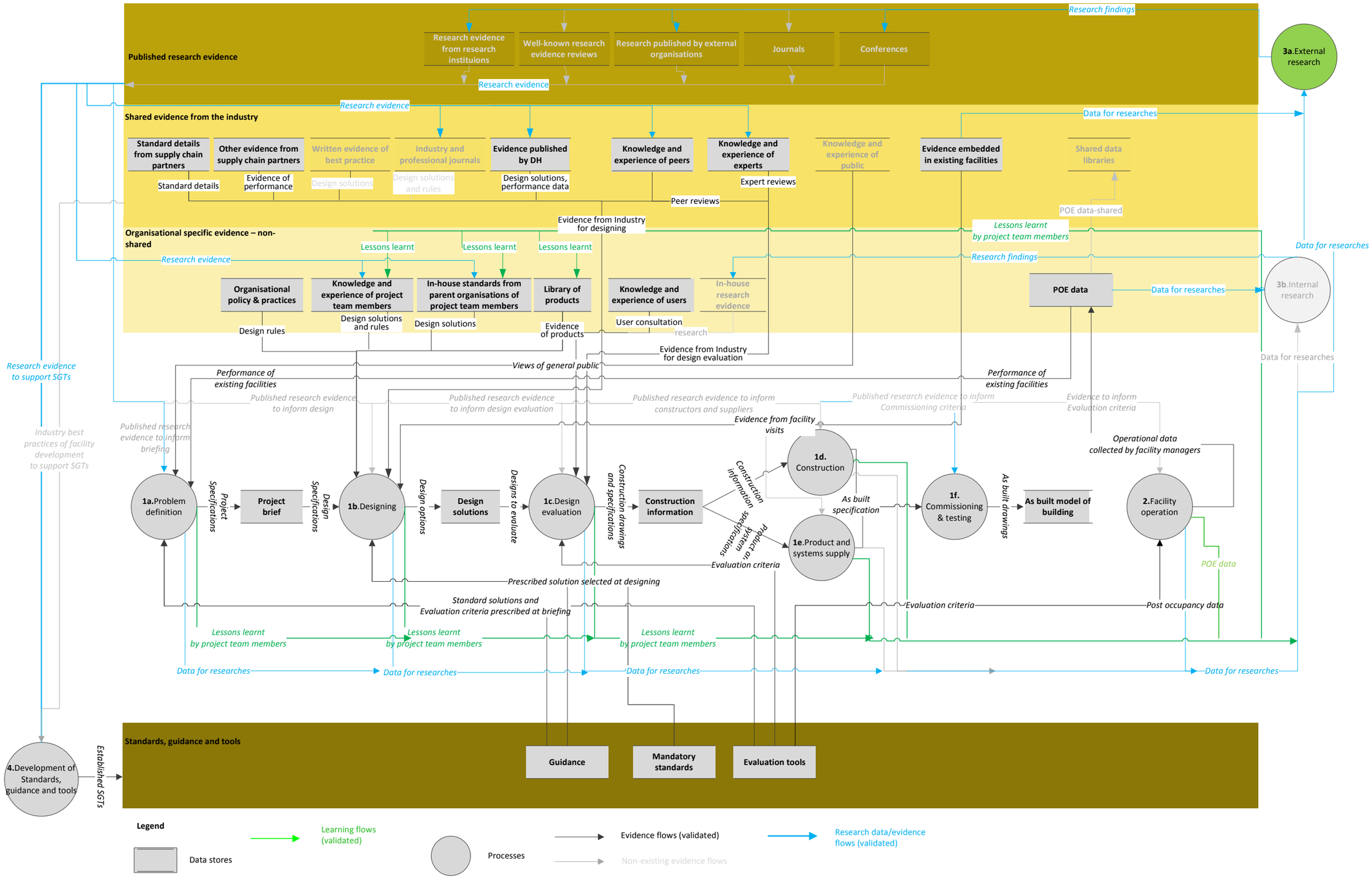


Figure 9-6: The SaFE model - Case study C

9.5 USE OF PERFORMANCE AND PRESCRIPTIVE SPECIFICATIONS

Data revealed that evidence expressed in the forms of performance specifications and prescriptive specifications are used during problem definition, designing and design evaluation.

The stories of the 26 design elements identified within Case C, was deductively analysed to identify how designers used performance specifications and prescriptive specifications during problem definition and designing.

Specifically, the case study data were analysed to identify designers' use of two approaches to problem definition:

- problem definition based on specifications identified within SGaTs; and
- problem definition based on specifications devised and based on other evidence.

and their use of four approaches to designing:

- designing based on guided solutions;
- designing based on de facto and innovative solutions;
- devising solutions; and
- constructing solutions.

Further details of the analysis are presented in the Chapter 6. Distinct approaches to design evaluation could not be identified at element level. Designers used almost all sources of evidence to evaluate the design throughout the designing phase. These were presented and discussed in Section 9.4.

Based on the deductive analysis, it was identified that designers in Case C adopted 3 variant approaches to problem definition and 5 variant approaches to designing. Table 9.7 summarises the approaches taken by designers in Case C for problem definition and designing for each of the 26 element.

Table 9-7: Details of approaches to problem definition and designing in Case study C

Case index	Design element	Category	Approach to problem definition	Approach to designing	Solution origin	Nature of output design
C1	Corridors	Space/layout	-	DS		Bespoke
C2	Waiting space	Provision	-	DS		Bespoke
C3	Stair ways	Space/layout	-	DS		Bespoke
C4	Layout - other	Space/layout	-	DS		Bespoke
C5	Layout - entrance to the ward	Space/layout	-	DS		Bespoke
C6	Location of the nurse base	Location	-	DS		Bespoke
C7	Summer temperature control	E/services	GP+DP	DS		Bespoke

Table cont'd in the next page…

Table 9-7 cont'd ….

C8	Single room layout	Space/layout	-	GS+DS+SS	**SGaTs** + **iSS** (Evidence from the industry) + **dfSS** (in-house K&E)	Bespoke
C9	Wall finishes	Finishes	-	GS+SS	**iSS** (Evidence from the industry)	Standard
C10	Layout - no of nurse bases	Provision	-	SS	**dfSS** (Traditional solution)	Traditional
C11	Day rooms	Provision	-	SS	**SGaTs** + **dfSS** (Traditional solution)	No day rooms
C12	Isolation room - provision	Provision	-	SS	**dfSS** (Traditional solution)	No isolation rooms
C13	On-suit	Space/layout	-	SS	**iSS** (Evidence from the industry)	Standard
C14	Bed head services	Component	-	SS	**iSS** (Evidence from the industry)	Standard
C15	Floor finishes	Finishes	DP+GP	SS	**iSS** (Evidence from the industry)	Standard
C16	External walls	Finishes	-	SS	**iSS** (Evidence from the industry)	Standard
C17	Worktop finishes	Finishes	-	SS	**iSS** (Evidence from the industry)	Standard
C18	Doors - generic	Component	DP	SS	**iSS** (Evidence from the industry)	Standard
C19	Glass panels/smart glass	Component	DP	SS	**iSS** (Evidence from the industry)	Standard
C20	Water services design	E/services	GP+DP	SS	**dfSS** (Traditional solution)	
C21	Fittings - water services	Component	-	SS	**dfSS** (in-house K&E)	Standard
C22	Ventilation strategy	E/services	GP+DP	SS	**dfSS** (Traditional solution)	
C23	Windows - generic	Component	-	SS	**dfSS** (in-house K&E)	Bespoke
C24	Window blinds/ windows	Component	-	SS	**dfSS** (in-house K&E)	
C25	Size and shape of the ward	Shape and size	DP+GP	SS+	**dfSS** (in-house K&E) + **iSS** (Evidence from the industry)	Standard
C26	Composition of single and shared bed bays	Composition	-	SS+	**dfSS** (in-house K&E)	Bespoke

Key : GP – Problem definition based on g*uided specifications*, **DP**- Problem definition based on devised *specifications*, '**-**' - No pre-determined approach to problem definition, '**-**' - No pre-determined approach to problem definition, **DS** – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach, **iSS –** innovative solution**, dfSS –** de facto solution

9.5.1 Prescriptive and performance specifications for problem definition

Pre-design activities conducted by the project team were considered to be activities of problem defining (refer Table 9.4). Examining Table 9.4 it is evident that approximately 20% (27 out of total of 135) of the project team's activities are related to problem definition. A considerably amount of effort was exerted for problem definition activities, irrespective of the limited time the project had from inception to completion. There were two main reasons for this; firstly, since the Client team was the in-house facility management team of the existing hospital, they were well aware of the problems in existing facilities. Identifying problems associated with the elements concerned in the newly proposed project was, therefore, less time consuming. Furthermore, they had an up to date list of standard products and equipment based on the knowledge they had acquired during maintenance of existing facilities. Evidence from these in-house standards was used to express prescriptive solutions. Secondly, the project team devised the concept design for Case C, which was then passed on to the modular contractor to develop and fabricate. Therefore, a considerable effort was made to guide the modular contractor through performance and prescriptive specifications.

The project team from Case C were involved in following activities for defining the design problem.

- To analyse existing system.
- To identify project specific requirements.
- To identify performance and prescriptive specifications to guide consequent designing.

Activities related to analysing the existing system and identifying project specific requirements were marginally used, whilst 78% of problem defining activities are related identifying performance and prescriptive specifications. In more than half of the instances (63%) these activities were based on evidence from K&E of stakeholders. Evidence from SGaTs was fairly (26% of the instances) used during problem definition activities and evidence of information from the Client and expert opinion were marginally used.

It was observed that design requirements set during the problem definition phase were primarily focused on defining the output specifications of the design and the outcome of the health outcomes was a marginal concern. There were two reasons for this; firstly, designers considered improvements to service outcomes (e.g. patient observation, view outside, patient safety) when they devised the conceptual design for the single-bed rooms. Since, this represents only one activity of the process, it was counted as a marginal concern during the quantitative analysis. Secondly, aspects related to service outcome improvements were incorporated into the design during design evaluation activities, based on the evidence from clinical users and expert opinion.

Table 9.8 shows a summary of how problem definition approaches were used within Case study C.

Table 9-8: Approaches to performance setting and approaches to designing for Case C

Base for problem definition	Total	DS	SS	SS+	GS+SS	SS+DS+GS
DP	2		2			
GP+DP	5	1	3	1		
-	19	6	10	1	1	1
Key : GP – Problem definition based on g*uided specifications*, **DP**- Problem definition based on devised *specifications*, '**-**' - No pre-determined approach to problem definition, '**-**' - No pre-determined approach to problem definition, **DS** – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '**+**' - Significant moderations made, **>** - transition of approach						

According to the results shown in Table 9.8, the most prominent approach (in 73% of the instances) to problem definition within Case C is, *No pre-determined approach to problem definition* (**-**). Defining the problem based on devised and guided specifications (GP+DP) were fairly used. Defining the problem based only on devised specifications (DP) was marginally used.

9.5.1.1 Problem definition based on guided specifications (GP)

In Case C, instances of basing problem definition solely on the evidence from SGaTs could not be identified. However, evidence from SGaTs was used in combination with evidence from K&E (GP+DP) in four instances. Three out of these four instances are related to engineering design elements. As stated before, the reason for using evidence from SGaTs to define the performance of engineering services is that this part was designed by the modular contractor. Engineering consultants from Case C specified performance and prescriptive specifications ('M*&E PERFORMANCE SPECIFICATION FOR THE NEW ADDITIONAL MODULAR WARDS* AT XXX (the hospital)' to guide the modular contractor. The specifications state performance criteria for each of the engineering services. Based on these specifications, the modular builder and his supply chain partners designed the engineering services for Case C, which were then evaluated by the Engineer. This specification manual was formulated based on evidence from HTM guidance; K&E of the Engineer and in-house standards of the Engineer, and the Client.

9.5.1.2 Problem definition based on devised specifications (DP)

Only in two instances designers used this approach within Case C. They are 'vistamatic' panels in the doors and the design of the doors. Design requirements related to 'vistamatic' panels were identified based on user consultation and were incorporated into the design via the devised specifications. The reason for devising door specifications could be that there was no comprehensive guidance available within published SGaTs for single-bed room doors. The quote below taken from HBN related to single bed room evident the ill-supported nature of this guidance for designing of doors.

> *"……Materials used for doors and frames should be able to withstand frequent impact from mobile equipment and should be easily cleanable. All double-swing doors should incorporate*

appropriate glass vision panels; however, privacy, safety and other considerations may require the panels on bedroom doors to be capable of being obscured, possibly with integral blinds……"(HBN 04-01, pp.12)

Furthermore, 'HBN 00-04 – Circulation and communication spaces' provides guidance on types of doors, door width, vision panels for doors, glazing, privacy and several other aspects that should be considered. However, this guidance is generic and specifications for single room doors are not mentioned separately.

9.5.1.3 No pre-determined approach to problem definition (-)

No pre-determined approach to problem definition (-) could be identified for 73% of the instances. There are two apparent explanations for this result. Firstly, as the project was severely restricted by duration, it could be assumed that that the project team had less time to spend in the early phases of designing. The analysis revealed that the design team has used more evidence for design evaluation, from expert opinion and user consultation, than for activities related to problem definition. Secondly, because the building was procured as a modular building, to a certain extent, they have had to limit their design to what is available from the modular builder and his supply chain partners. In a situation like this, it could be assumed that, evaluating the design solutions is preferable to proceeding with a comprehensive set of prescriptive specifications. It is also worth noting here that in order to mitigate negative impacts associated with this procurement process the project team devised a conceptual design which was passed on to the modular contractor.

9.5.2 Prescriptive and performance specifications for designing

Five variant approaches to designing could be identified within Case C. Table 9.9 shows a summary of the approaches to designing used within the Case study C.

Table 9-9: Design approaches of different design element types

		Design elements in the pre and conceptual design phase						Design elements in the detail and technical design phase				
		Space/layout	Composition	Location	Shape and size	Provision	Option appraisal	E/services	Facilities	Finishes	Components	
DS	DS	4		1		1		1				7
SS	SS	1				3		2		3	6	15
	SS+		1		1							2
A combination	GS+SS									1		1
	SS+DS+GS	1										1
Key : **DS** – Devise a solution, **GS** – Ad(o)apt a guided solution, **SS** – Ad(o)apt a selected de facto or innovative solution, '+' - Significant moderations made, **>** - transition of approach												26

9.5.2.1 Devise solutions (DS)

This approach was used marginally (27% of the elements) during the designing of Case C. There were two reasons for this result. Firstly, Case C had to limit their design to solutions available from the modular contractor and his supply chain partners. Based on the requirements of the project the design team prepared an initial conceptual design and some compromises were made based on the choices available from the modular constructor. For the elements in the detail design phase such as components and finishes were procured through the supply chain partners of the modular builder. It could be assumed that evaluating the solutions available through the supply chain partners easier than devising bespoke solutions for these elements. Secondly*, the Engineer of the Case C acted as a consultant on behalf of the Client. The modular contractor devised solutions for the engineering services based on specifications issued by the Engineer.*

Irrespective of the limited opportunity to devise bespoke solutions, devising a solution approach was triggered in following instances.

1. Analysis of the performance of existing solutions revealed drawbacks in existing solutions and new facets of problems.

For instance, during the design of corridors drawbacks were identified in the solutions prescribed in the standards and better solutions was required (refer below quote).

> *"….Corridors, 2000 is the HBN standards and we got 2500, it is general and in some places it is wider than that, even 3000, because we do have trolleys going and out, so to pass them by we have 3000 but in other areas minimum 2500, and that was our decision, quite early on, 2000 we found we get lots of damages on the walls even if there is a protection on wall, they don't do it at skirting level, you still get damage, so we decided another 500 would ease that problem and it has!...."*. *(a representative from the Client)*

2. New problems identified through user and specialist consultation during design evaluation.

New design problems were identified by clinical staff during user consultations (waiting space location), facility management staff during design evaluation (lighting levels on staircases), internal specialist consultation (new spaces within the ward – extra stores, reduced kitchen space), knowledge and experience of the design team during design evaluation (location of nurse base). Design team devised bespoke solutions to suit these new design problems.

3. For new and project specific design problems.

The modular ward had to be connected by a corridor into the existing hospital building (none-modular) at the entrance to the ward. A bespoke ward entrance was designed to respond to design

requirements (not disturbing user flows in existing corridor, a technical solution to connect a modular building to a concrete frame structure) that were unique to those instances.

This approach was used mainly for elements in the pre and conceptual design phases (6 out of 7 elements).

9.5.2.2 Designing based on prescriptive specifications

These results reveal that designing based on prescriptive solutions is the most prominent (for 73% of the elements) approach in Case C. Examining the results in Table 9.4 it is evident that a majority of these solutions originated from evidence from industry and in few instances de facto solutions were used based on in-house knowledge and experience. As stated above, the apparent reason for the increased use of prescriptive solutions is that the design team often had to select solutions available from the supply chain partners of the modular builder. Modifications to prescriptive solution (SS+) were done only two elements out of 25 elements considered in this study (size and shape of the ward, and composition between single patient rooms and shared bed bays). The reasons for this could be time restrictions in Case C and limited opportunity to use bespoke solutions when procuring a modular building. However, it is worth noting again, that minor improvements to the design were always made during the design evaluation activities. Use of prescriptive solutions from SGaTs (GS) were limited, but single room design was informed by the exemplar solutions given in the SGaTs.

According to the data from the Client, most of these elements were successful during the operational phase and only few failures were identified. For instance, en-suite bath trays selected from the previous experience was found to be failed during the operational phase, causing a considerable amount of maintenance and rework. Infra-red taps is another example. The particular infra-red-taps which were used for this project were battery operated, and it was mentioned that the batteries need to be replaced very often. These issues are discussed further in section 8.5.

9.5.3 Approach to design evaluation

Examining the results of the case study it was realised that there are no distinguishable approaches to design evaluation; but the activities of design evaluation were frequently conducted during the design and end of design phases using all available sources of evidence. Results in Table 9.5 show that design evaluation was supported by evidence from almost all sources used in Case C. The extensive of evidence from expert opinion and user consultation was apparent. The primary focus of these evaluations was:

- to support option appraisal;
- to assess whether the designs comply with performance and prescriptive specifications set during problem definition and designing; and

- to identify further improvement opportunities.

Results from the post occupancy evaluation phase in Case C were notably positive with only a small number of minor issues being reported. A detailed account of the positive and negative performance related to studied elements is included in Appendix H.3.

9.6 IMPACT OF PROJECT-UNIQUE CIRCUMSTANCES ON THE EBD PROCESS

This section provides a detailed account of how the evidence-based design process in Case Study C was influenced by project specific project-unique circumstances and how designers reflected on these circumstances.

Interview contents from Case C were analysed based on the principles of inductive thematic analysis (refer Chapter 2) to identify how project-unique circumstances impacted on the EBD process. This analysis revealed six circumstances unique to Case C that have impacted Case C's EBD process.

1. Restrictions on bespoke designs due to modular systems
2. Local departmental needs
3. Incomplete previous knowledge
4. Previous experience
5. Enthusiasm and teamwork
6. Other

These well be discussed further in the rest of this section.

9.6.1 Restrictions on bespoke designs through modular systems

Procuring a modular building has restricted the design team's freedom to a certain extent. Even though the design team initially designed the layout of the ward and single-bed room in isolation of the modular solutions available, slight compromises were made later based on the choices available with the modular builder. The below quote from a representative from the client explained the nature of choices,

> *".....so that was pass it to the designers and contractors, so they are free to select which variety of poly floor, and it is varying standards for wearing of course, 2mm, 2.5mm, different looks with flooring……." (a representative from the Client)*

The selected modular contractor used his own supply chain partners for sub-contracting works. Therefore, the choices available for design elements, such as finishes, doors and windows, and ironmongery were limited to a small number of options available with these supply chain partners (refer to quote below).

"…….number of choices in terms of finishes were quite limited, they are supply chain partners of modular contractors, they say this is the range, comply with the HBNs and HTMs but these are the colours you got to choose, it is not the what I can do with a traditional way….." (a representative from the Designer)

However, interviewees acknowledge that the choices available were increased with time. For instance, a representative from the Designer mentioned that,

"…….we still had a choice, it was limited" (a representative from the Designer)

9.6.2 Local departmental needs

Case C was a part of an existing hospital which already had consulting and examination rooms and other clinical rooms. This allowed the design team to design shared bed-bay wards without worrying about other clinical spaces. Furthermore, the targeted patient group (elderly patient care) did not require specific clinical spaces. Shared bed bays would have necessitated separate clinical spaces if it was a different patient group such as a paediatric ward. The following interview quote explains this further.

"……it is a local choice, because we have medical wards, we have surgical wards, depends what it is. No wards are same, we got 30 wards they are all different, people want different service at different wards……but specialities needs special things,……"(a representative from the Client)

For the same reason, design did not incorporate isolation rooms (refer quote below).

"…… this was a normal elderly ward, if it is a high dependency unit or an intensive care unit or even a near-natel ward you would have that, but in this kind of a ward, on-suit room is enough for isolation from infection……"(a representative from the Client)

9.6.3 Incomplete previous knowledge

Few failures were reported due to basing designs on incomplete previous knowledge. One example is the shower tray used in the en-suite bathrooms. The shower tray design used in the Case C was adapted (an increase in size) from a previous project. Later, during the operation phase, it was found that the shower tray was not well supported to the structure and drops downward to the structural floor resulting water leaks. The estate team have had to restore many of the installed shower trays. The reason for this is that the design team has considered structural details of the design (see the quote below).

"…It was a different modular contractor, and different shower tray, the shower trays we had in this last modular build is quite a lot large, and that is part of the issue and that structure needs to be right to support that amount of space…." (a representative from the Client)

Another example is infra-red taps used in the water services design. For reasons associated with infection control the designers used infra-red taps for the wards. Later, it was realised that the type of tap installed by the subcontractor is battery operated and requires frequent replacement of batteries. Eventually, the estate team have replaced all existing taps with taps that could be connected to mains electricity. This could have been avoided if the evidence that was collected had included the details of associated systems and sub-systems.

9.6.4 Previous experience

Previous experience was a major advantage to the success of Case C. The trust had standard equipment specifications based on previous experience and these were used for many design elements such as sanitary fittings, bed head services fittings and other engineering services plant and fittings. In addition, the trust also had previous experience of procuring a modular building for the same hospital. One example to explain this is the bed head services panel used in Case study C. The design team decided to use vertical bed head service panels based on the evidence from the previous projects and the standard equipment and specification they used in the trust (see quote below).

"…….. In York we did it vertical, …… lot of older ones are horizontal and they were quite antiquating type trunking, when you get it in vertical you get the sockets and gasses in the right position, close to the bed, if you have them horizontally and you have lot of sockets and lots of gasses it ends up in a long way from the bed, cables and connections, that is not good for safety…." (a representative from the Client)

9.6.5 Enthusiasm and teamwork

The main objective of Case C was to procure the building and within six months be ready to cater to the expected service commitments during the winter season. The design team believe the reason for the success was due to many different aspects related to enthusiasm and team work including effective communication. The project team engaged in morale-building activities such as bowling events. All these have resulted in procuring the building within the time intended.

9.6.6 Other

Few other circumstances have impacted the design process and its performance. One example is the issue of overheating during the summer. The external wall finish used in Case C was designed with a light weight composite material with the intention that during phase II it will over clad with another

layer which would act as a thermal control. However, phase II was not progressed as expected and the building is experiencing over heating problems during the summer months.

The evidence-based design process of Case C was a responsive process to project-specific circumstances. Specifically, the very limited time available for design and other circumstances associated with modular buildings have influenced the process. Due to these circumstances access and application of external evidence was limited. Externally published research or internal generation of evidence was not used in this project. Therapeutic building evidence was considered based on knowledge and experience. The knowledge and experience of the design team and the Client's in-house team supported the achievement of a better environment for patients and staff. The availability of in-house clinical specialists was advantageous and a number of improvements to the design were made following these consultations. The project is considered to be a success, despite the lack of resources available. The success should be attributed to the reflective activities taken by the design team in practicing EBD to mitigate the negative impacts or failures that could have resulted.

9.7 CHAPTER SUMMARY

This Chapter has reported and discussed the EBD practices of Case study C related to three main aspects:

- practices of using evidence from six sources;
- practices of using performance and prescriptive specifications during the problem definition and designing ; and
- impact of project-unique circumstances on EBD practices and how designers reflected on these circumstances.

Case C gathered evidence from six sources. K&E was the most frequently (approximately in 55% instances) used source of evidence in Case C. The second most used source of evidence was evidence from user consultation, followed by the evidence from industry, expert opinion and SGaTs. Evidence from all these four sources were used almost equally (approximately 10% each). It was also observed that internal evidence sources (K&E, user consultation, expert opinion) were frequently used alone whereas evidence from industry and evidence from SGaTs were supported by evidence from other sources. Specific examples of using internally generated evidence or using externally published research could not be identified in Case C. Other dimensions of evidence related to the means by which evidence was gathered, user channels for accessing evidence, purposes for using, availability, suitability, quality and success of using that evidence were also identified and the findings provides a rich picture of evidence use practices in Case C. A bespoke version of SaFE model was generated for Case C. Several of the evidence sources identified within the generic model were

not used in Case C, access to evidence through internally available sources and through stakeholders of the design team were noticeable in the bespoke model of EBD for Case C.

Practices for using performance and prescriptive specifications were identified for problem definition and designing. No pre-determined approach for problem definition was seen for majority of the elements (73%). Problem definition was based on the specifications from SGaTs and devised specifications in approximately 20% of instances. Performance and prescriptive specifications identified during the problem definition phase primarily focused in defining output of the design and the health outcomes was seen as a marginal concern.

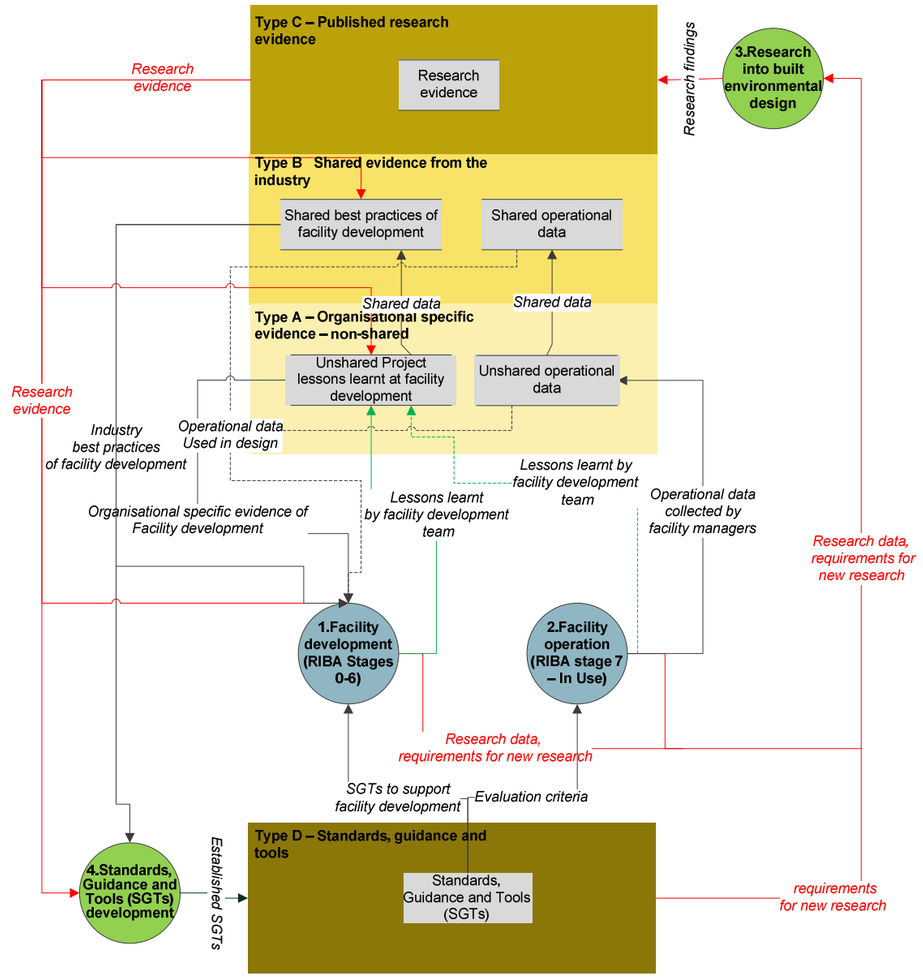
Using prescriptive solutions was the most prominent (69%) approach to designing in Case C. Devising solutions based were identified in only 7 elements out of 26 elements studied in Case C.

Designers devised solutions primarily for elements in the pre and conceptual design phases and they have adopted prescriptive solutions mainly for the elements in the technical and detail design phases, and fairly for elements in pre and conceptual design phases. Using prescriptive solutions from SGaTs was subtle in Case C and the majority of prescriptive solutions were identified based on evidence from K&E and other evidence sources.

EBD practices of gathering evidence from six sources and using evidence during problem definition and designing reflected project-unique circumstances that were associated with Case C. Case C was special for the type of construction and the project duration. Case C was procured as a modular building and the total duration from inception to completion was 6 months. Results revealed how EBD activities in Case C reflected on these two major circumstances throughout the process. Furthermore, the Client in Case C was the in-house facilities management team of the existing hospital and they had experience of procuring a modular building before, and the existing hospital had specialist consultants who engaged with the targeted patient group of Case C. These circumstances favourably impacted in the EBD process and mitigated many of the negative impacts associated with limited time duration. Any difficulty associated with the amount of funding was not reported, but the timing of the funding has impacted on EBD activities in Case C. In addition, enthusiasm and team work approach has contributed to the success of Case C.

Appendix K: RIBA plan of work 2013 overlay on the SaFE model

RIBA Plan of Work 2013 overlay for Sources and flows of evidence model (Parent model)



Legend

- Data stores
- Learning flows
- Learning flows (optional)
- Processes in the facility life cycle
- Information flows (validated)
- Information flows (optional)
- Processes external to facility lifecycle
- Research data and evidence flows
- Research data and evidence flows (optional)

Conceptual SaFE model SaFE A → Verified SaFE model SaFE B1-B4 → Validated SaFE model SaFE C1-C4 → Case specific SaFE models SaFE D/E/F → **SaFE model with (RIBA plan of work 2013 overlay) SaFE G1,G2 – G4**

RIBA Plan of Work 2013 overlay for Sources and flows of evidence model (In detail)