Anaesthetic Rooms: A systems approach to improving design and practice in the United Kingdom

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Thesis submitted to the University of Nottingham
for the degree of Doctor of Philosophy

February 2017

Abstract

The use of anaesthetic rooms as the standard site of anaesthetic induction in the United Kingdom has been criticised and debated over several decades, and yet practice has remained largely unchanged. The impacts of the anaesthetic room on cost, efficiency, patient experience, and patient safety are either conflicting or unknown.

This research utilised a systems approach to evaluate the efficacy of anaesthetic rooms and make recommendations for the improvement of both the design and practice of surgical suites in the UK. The study incorporated mixed methods to investigate the qualitative and quantitative benefits of anaesthetic rooms for all stakeholders.

A survey of consultant anaesthetists investigated current practice and attitudes regarding the use of anaesthetic rooms and the importance of various types of 'evidence' for affecting change in practice. This study revealed the wide diversity of current anaesthetic practice and the factors that influence the selection of the site of induction.

A second study, which used interviews with anaesthetists and perioperative managers explored the decision making surrounding the continued use of anaesthetic rooms and the relationship between design and practice. Factors influencing the perpetuation of anaesthetic rooms were shown to exist systemically across individual, organisational, and external levels. Willingness to change and the relevance of evidence for decision making is discussed.

In a third study, a modified participatory design Delphi was used to investigate the decision making priorities of multiple anaesthetic room stakeholders to reach a consensus for the design of theatres in a new fictional hospital. The novel Delphi technique presented conflicting research findings to participants in order to require them to evaluate and come to agreement regarding the incorporation of anaesthetic rooms. A critique of this method is presented along with suggestions for future application.

A cost-benefit analysis of anaesthetic rooms was then conducted in one NHS Trust. This was supplemented by ethnographic observations of its surgical suites to provide context to the historical timing data gathered retrospectively for financial and

productive evaluations. The cost-benefit analysis revealed that there are missed opportunities associated with anaesthetic rooms, as downtime and delay mean that the potential financial gain and return on investment of anaesthetic rooms cannot be realised.

An investigation of patient experience with surgical anaesthesia was conducted through a multi-part questionnaire evaluating patients' expectations, anxiety, and satisfaction with their anaesthetic care. The study focused on the impact of the site of induction on patient experience and revealed that anaesthetic rooms do not appear to have a significant effect on patient anxiety and satisfaction. Opportunities for improving patient experience were identified, with the majority of these being unrelated to the site of induction of anaesthesia.

Through a number of separate studies, this research provides a complete evaluation of anaesthetic rooms. It has identified the contradictions between stated priorities for anaesthetic rooms that stakeholders report and the actual choices that they make for the use and design of surgical suites. The human factors methods and systems approach that has been taken to this thesis has shown that it is a valuable way of investigating deeply embedded practices in healthcare.

In addition, this research has set forth a novel method for integrating four dominant paradigms of healthcare improvement. The integration of participatory ergonomics and evidence-based practice may provide a useful method for reaching consensus of contentious issues, aligning systems design with individual and organisational priorities, and encouraging evidence evaluation as a part of the decision making process.

Acknowledgements

Firstly, I thank God for leading me to take this opportunity in the UK and sustaining me through it. I am ever grateful for the blessing that this journey has been in my life.

My deepest gratitude to my supervisors, Dr Sarah Atkinson, Dr Jennifer Martin, and Dr Emma Rowley, for their continual support and guidance throughout my PhD. Thank you for your encouragement through the most challenging and frustrating parts of this process, and graciously teaching this American the British way.

This research would not have been possible without the clinical guidance of Drs Bryn Baxendale and Iain Moppett. I am endlessly grateful for your involvement in this research and the many doors you opened, and connections you made on my behalf.

Many thanks to the healthcare professionals of Nottingham University Hospitals NHS Trust, who kindly assisted in this research as facilitators and participants. Additional thanks to all local collaborators and participants throughout the East Midlands who gave of their time and energy in the planning and completion of this work. A special thanks to Drs Anup Biswas, Perihan Ali, and Florence Apaloo -without you, our study would not have been possible.

Cheers to my colleagues and friends in the Human Factors Research Group for all of your smiles, cakes, and cups of tea. Thanks to Alex for being my office buddy and sharing in all of the ups and downs with good laughs and great beers.

Special shout out to my Lincoln Hall and University of Nottingham Volleyball Club families for bringing me encouragement, friendship, and distraction over the years!

To my family back home – although you still think I do Human Resources, your prayerful support, care packages, and endless love have been what I have needed to make it through. I love you always, no matter how far apart we are in the world.

And finally, to Jorge, you have inspired me to be courageous and unafraid to ask difficult questions. The many things you've taught me, the joy you've brought me, and the Mexican food you've fed me, have meant the world to me. Thank you for being my Player 1, my shoulder to cry on, and my best friend.

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Preface

Healthcare improvement became a passion of mine in 2010 when I began working in the surgical department of a large West Michigan hospital in the United States. Due to my degree in engineering and experience working for several years for a lean manufacturing company, I was entrusted to design and implement a total re-organisation of surgical equipment within the hospital. Little did I realise at the time that it would be my first healthcare experience seeking stakeholder involvement to improve practice and co-design a better system of working. It would also be my first experience confronting the resistance to and challenges of bringing about organisational change.

In 2011, I moved to the United Kingdom to pursue a master's degree in industrial engineering and operations management where I was able to research continuous improvement in the local National Health Service Trust. This doctoral research emerged from a visit to the Trust's operating theatres where I became aware of a noticeable difference between US operating rooms and UK operating theatres. The view from the corridors was not into theatres as expected, but into a separate room leading into the theatre called the anaesthetic room.

This room contained storage cabinets, counter tops, supply trolleys, and an anaesthetic machine. Although the equipment was familiar, the sight of a second anaesthetic machine located a few metres away in the operating theatre and the seemingly expansive store of anaesthetic drugs and supplies were curious. From a foreigner's perspective, a single anaesthetic drug trolley and machine located in the operating room, which was the norm in the US, was replaced with an entire room with storage and duplicated equipment. The topic came up in a later conversation with one anaesthetist who expressed his belief that the anaesthetic room is only used because of British tradition; however, in recent years its benefit has been contested within the anaesthetic community. It was this brief visit and conversation that led to the exploration of a very complex sociotechnical system, where I set out to discover the value of anaesthetic rooms from the eyes of an outsider.

Chapter 1 Introduction

1.1 Background

The anaesthetic room is a feature of most operating theatre suites across the United Kingdom (UK), but has largely been abandoned in countries such as the United States, Canada, and Australia (Broom *et al.*, 2006). This introduction identifies the origin of the anaesthetic room (AR) as the standard location for inducing anaesthesia in England, before moving on to discuss how the AR has become a requirement for practice in public sector healthcare in the UK, despite the change of direction abroad.

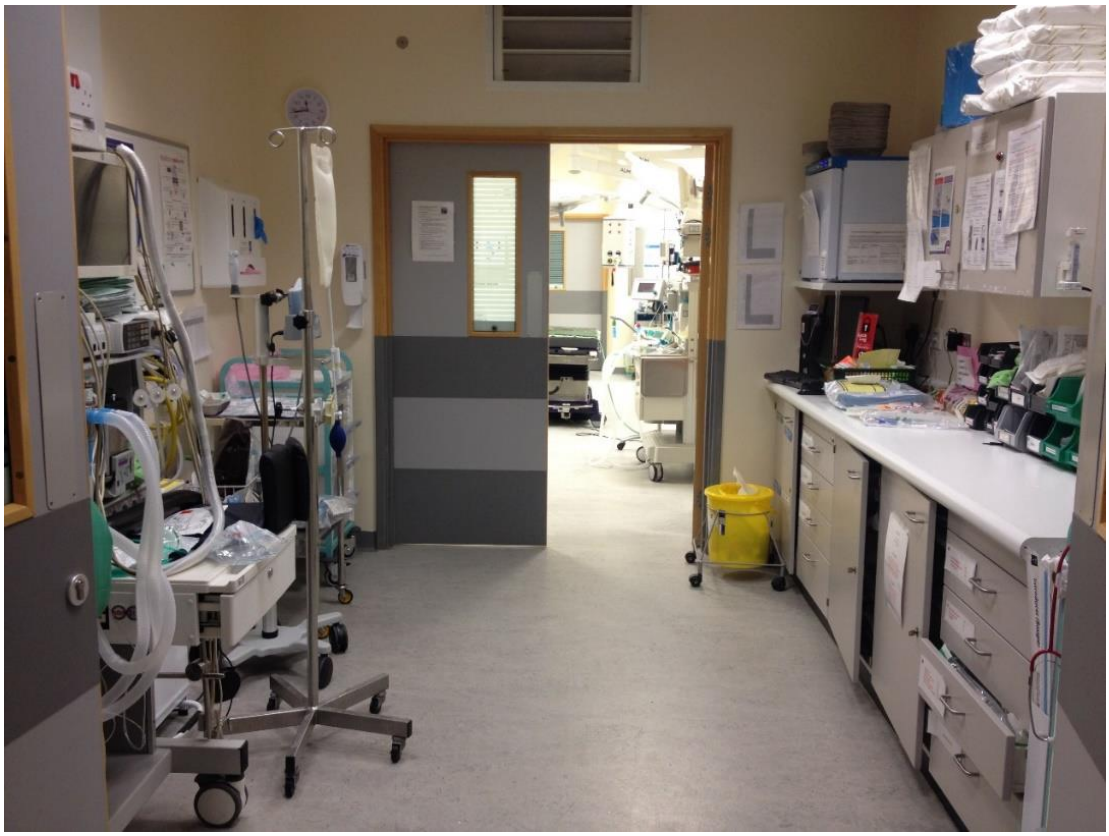


Figure 1.1 A view from the anaesthetic room looking into the operating theatre

There have been multiple accounts regarding the introduction and first mention of ARs (Zuck, 1995; Meyer-Witting & Wilkinson, 1992; Soni & Thomas, 1989a). The earliest account of a separate room for induction of anaesthesia is thought to be in 1860 (*British Journal of Anaesthesia*, 1963), where the image portrayed is of '… the patient… inhaling chloroform in an adjoining apartment… when the unconscious patient is brought in by a couple of sturdy porters, and laid upon the operating table' (p.332).

In 1873, Tomes shared an account of the use of a separate room for induction of anaesthesia in his witness of ether being administered in a surgical anaesthetic at Massachusetts General Hospital in Boston. Tomes (1873) stated:

> *'The patients are etherised in small anterooms adjoining the operating theatre…',* and *'…when anaesthesia is complete, the patient is picked up, and carried in the arms of a stout attendant into the theatre'* (p.297).

A few years later, in a reply to a *British Medical Journal* survey regarding provision of anaesthesia across the UK, Osborn, a surgical registrar at St. Thomas' Hospital in London and the only respondent to specifically mention the place of induction, wrote about his preference for anaesthetic induction, stating that:

> '*… chloroform should be always administered… in a small room adjoining the theatre, previously to the patient being brought in for the operation, as he does not then become excited and is more quickly brought under the influence*' (*Reports of Medical and Surgical Practice in the Hospitals and Asylums of Great Britain*, 1876, p.13).

Zuck (1995) discussed other responses from this nationwide questionnaire, stating that responses mentioned the administration of chloroform to patients on the wards, as an avoidance of inducing on the operating table. In Zuck's historical evaluation, he posited a correlation of the widespread introduction of ARs with the switch from chloroform to ether as an anaesthetic agent, as they occurred at the same time.

In 1875, during the planning stage of Johns Hopkins Hospital in Baltimore, a collection of essays was published with recommendations for the hospital design, suggesting a room adjacent to the operating theatres where induction of anaesthesia could take place (Billings *et al.*, 1875). Three of the five essays proposed the incorporation of a chloroform room; an etherizing room; and 'a private room in which anaesthetics are administered without exposure of the sick to the gaze and often ridicule of medical students' (Billings, *et al*., 1875, p.319). Some years later, a compilation of hospital plans by Burdett (1893) showed evidence of a room for the purpose of anaesthesia in 8 of nearly 70 hospitals across the world. These included four hospitals in the United Kingdom, including Derbyshire Royal Infirmary (in 1889), one in Australia, and three in the United States, including Johns Hopkins Hospital.

Several other examples of early ARs provide indications into the rationale surrounding their inclusion. Many of these factors have been considered and challenged in more contemporary studies surrounding the benefits or disadvantages of ARs in modern hospital design. Meyer-Witting & Wilkinson (1992) mention St. George's Hospital in London as an early example of a hospital that incorporated an induction room for each theatre, in order to prevent the patient from seeing things that might cause distress, such as the surgical equipment and instruments. A quiet place for induction of anaesthesia was also valued (Ferguson, 1914). Rawlings (1930) shed light into the psychological aspects of anaesthesia induction, and the design and ambiance requirements of the AR in relation to psychological well-being. He recommended a room that was 'peaceful, warm, light, not gaudy in decoration' (Rawlings, 1930, p.127). He even went so far as to suggest an avoidance of oak panelling in the AR, in case it was perceived as being reminiscent of a coffin! Wheeler and Cassels (1947), two anaesthesiologists from Chicago, suggested the trend toward anaesthetising patients in a separate room helped to alleviate the operating theatre from time spent on preparations outside of actual surgical tasks. They noted unnecessary delay when using the operating theatre for anaesthetising and even suggested a minimum of two ARs for three operating theatres.

Seventy-seven years after the first mention of an induction room in the UK, the Ministry of Health published recommendations for ARs to be built adjacent to each operating theatre (Ministry of Health, 1937 cited in Meyer-Witting & Wilkinson, 1992, p.1021). Although there were not many hospitals built between the World Wars in the UK, by the end of the Second World War, guidelines for hospital planning ensured the construction of ARs within surgical facilities (Zuck, 1995). In contrast, around the same time, the US Public Health Service (USPHS) did not include recommendations for the construction of ARs as a norm for general hospitals (USPHS, 1952). This seems to be when the UK and US diverged in philosophies regarding ARs. Whilst their use diminished in the US and eventually disappeared from building programmes, the UK was embracing the AR as a standard requirement within the National Health Service (Anon, 1965). As of 2002, 81% of operating theatres in Switzerland and 94% in the UK had separate induction rooms; however, in the US, Canada, Australia, and most Scandinavian countries, separate rooms were not built (Sieber & Leibundgut, 2002; Bromhead & Jones, 2002; Broom *et al.*, 2006).

Space in the hospital environment is a limited, and thus valuable, resource. Whether it is used for service provision, extra storage, or simply preserved for freer movement, space within the hospital setting must be wisely allocated to maximise its potential. In some cases, the AR has been referenced as a useful anteroom, disregarding its intended function as a place for induction.

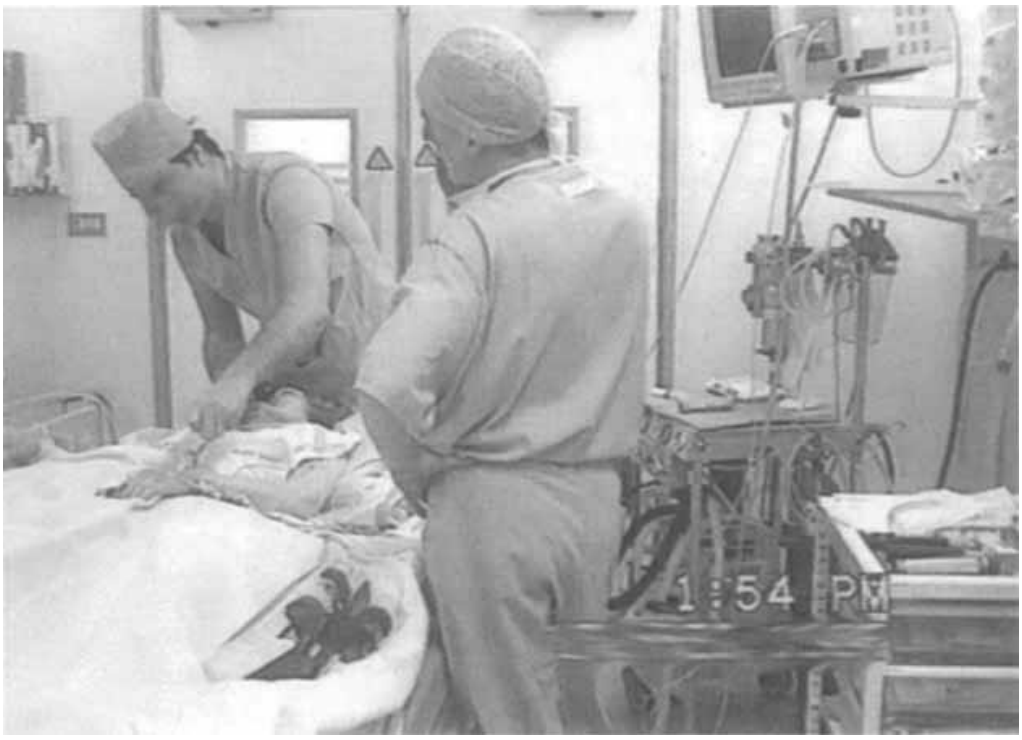


Figure 1.2 Anaesthetist and operating department practitioner in the anaesthetic room (Hindmarsh & Pilnick, 2002, p.143)

The AR can be used as the site for installation of venous cannulation and the connection of monitoring such as blood pressure cuffs and electrocardiogram electrodes (O'Connor *et al.,* 2003; Broadway *et al.,* 2001). **Figure 1.2** depicts typical activity in the anaesthetic room, as the anaesthetist injects a patient while the designated assistant, an operating department practitioner, stands by to assist. Meyer-Witting and Wilkinson (1992) refer to the AR as a space providing suitable working surfaces and close proximity to necessary drugs and equipment for provision of various anaesthetics. The space can also be utilised as a location for teaching junior doctors. The AR is seen as a benefit for the anaesthetist and patient, but was warned against becoming merely a passage for the theatre team, as Ostlere (1950, p.91) said, 'The anaesthetic room should be the anaesthetist's undisputed territory. It is not a store-room, nor a corridor, nor a convenient retiring-room for the operating team,' with the purpose of focusing on the 'bodily and mental comfort of the patient.'

The existence of ARs in the UK is well-established, nevertheless, further exploration is necessary to fully understand why they have continued to exist, despite their abandonment in other countries.

1.2 Research Questions

The main aims of this doctoral research are to understand the value of anaesthetic rooms and to determine if they should continue to exist within UK hospitals. The studies presented within this thesis are guided by the overall aims of investigating four research questions:

- What is the role of anaesthetic rooms in UK anaesthetic and surgical practice?
- How cost effective are anaesthetic rooms for mixed specialty providers?
- What are the clinical and management priorities for design and practice?
- To what extent are design and practice evidence-based?

1.2.1 What is the role of anaesthetic rooms in UK practice?

The main aim of this research question is to explore the purpose, functionality, and current use of anaesthetic rooms. The scope of this question includes the relevance of anaesthetic rooms within perioperative practice, and the beliefs and attitudes about the anaesthetic room from stakeholders including theatre personnel, managers, and patients. This question also explores the qualitative value of anaesthetic rooms to the people who are affected by their existence in UK surgical facilities.

1.2.2 How cost-effective are anaesthetic rooms?

The objective of this research question is to determine both the financial implications of utilising an anaesthetic room and the perceptions of benefit or detriment to cost efficiency of the organisation based on anaesthetic room use. This involved mixed research methods to capture the quantitative argument for anaesthetic rooms and the beliefs held by managers and staff members regarding the financial and productive effects of using the anaesthetic room.

1.2.3 What are the priorities for design and practice?

The rationale of both clinical team members and managers regarding anaesthetic room use and incorporation in the design of theatres is needed to understand the factors that are important to these decision leaders. In addition, the individual priority given to these factors may help to provide understanding of the requirements necessary to bring about improvement change. This question also allows for a comparison of what is said to be prioritised versus what appears to be prioritised in practice.

1.2.4 To what extent is design and practice evidence-based?

Finally, the last research question, and the most important, evaluates the degree to which the decisions made regarding anaesthetic rooms in British healthcare are evidence-based. The question enables the exploration of what is considered to be 'evidence' and how it affects the decision making regarding best practice and future planning of the healthcare environment. The pursuit of this question helps to shape recommendations for how best to translate research evidence into real change on the ground.

1.3 Thesis Outline

The progression of this research is presented in **Figure 1.3**, which depicts the individual studies here within, and the chapters where they will be presented. Literature informed the design and discussion of all chapters, and all conclusions and recommendations were a result of the development of knowledge through each stage of the research.

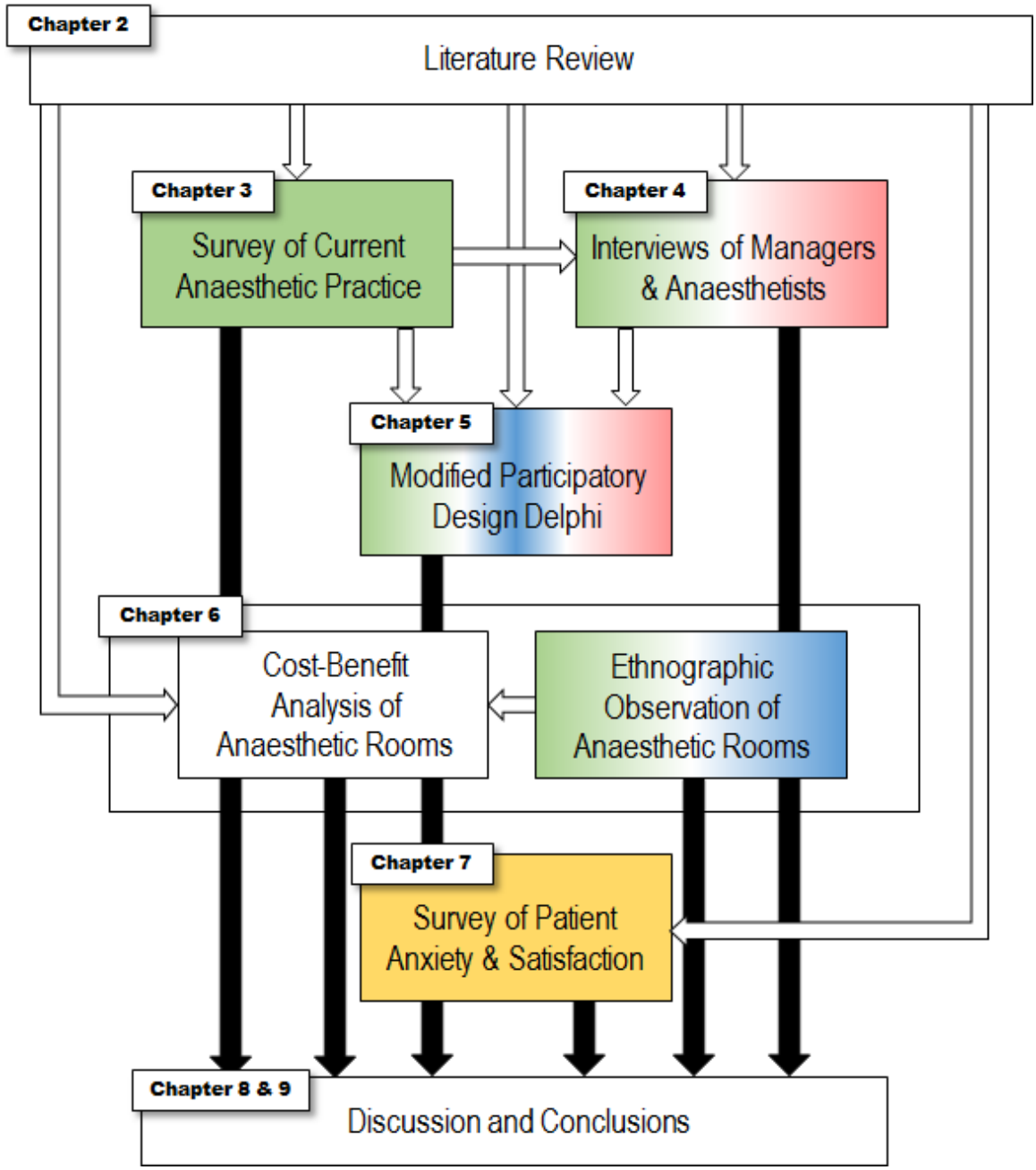


Figure 1.3 Outline of thesis chapters[1]

The research questions being investigated are shown in **Table 1.1** as they correspond to the chapters within this thesis.

[1] Colours are indicative of the stakeholder groups who were recruited for the corresponding studies. Green = anaesthetists; Red = managers; Blue = theatre staff / surgeons; Yellow = patients. White arrows depict the formative influences of the research studies.

Table 1.1 Research questions

Research Questions	Ch. 3 Survey of Current Practice	Ch. 4 Clinical & Management Interviews	Ch. 5 Participatory Design Delphi	Ch. 6 Cost-Efficiency Analysis	Ch. 7 Patient Experience Survey
What is the role of anaesthetic rooms in UK anaesthetic and surgical practice?	✖	✖	✖	✖	✖
How cost-effective are anaesthetic rooms for mixed specialty providers?		✖		✖	
What are the clinical and management priorities for design and practice?	✖	✖	✖		
To what extent are design and practice of anaesthetic rooms evidence-based?	✖	✖	✖		

Chapter 2 Literature Review

2.1 Chapter Overview

The literature presented in this chapter represents a wide range of topics relevant to this research. The context of this research will be explored beginning with the literature pertaining to the anaesthetic room and its use in clinical practice. Additionally, five key research areas are described which enhance understanding of the research questions in hand: patient safety research, quality improvement approaches, evidence-based practice, improvement science, and the human factors approach to healthcare improvement. While many of the theories, philosophies, and constructs discussed in this chapter originate from various disciplines and industries, those presented have specific applications to the healthcare setting.

This review excludes methodological literature relevant to the subsequent study chapters, as the literature for individual methods will be discussed within those chapters. The themes of research included are not exhaustive of all relevant subjects; however, they will provide the necessary foundation for understanding this thesis.

2.2 Anaesthetic Rooms

This section will summarise the range of literature available relating to the use of anaesthetic rooms; various clinical perspectives of the topic; studies pertaining to patient anxiety and safety; the available cost and efficiency research which considers the anaesthetic (induction) room contribution to operating theatre throughput and efficiency; and the national guidelines which address their use.

2.2.1 Standards of Practice

At the turn of the century, the prevalence of anaesthetic rooms in UK surgical suites was debated through several correspondences published in the *Anaesthesia* journal from British healthcare professionals both for and against anaesthetic rooms (Evans, 2004; O'Connor *et al.*, 2003; Sawyer, 2001; Newport, 2001; Broadway *et al.*, 2001).

An overwhelming preference for ARs remained seemingly unchanged throughout the 1990s and early turn of the century, when much of the debate came to light. Masters

and Harper (1990) conducted a survey which demonstrated a strong prevalence of ARs in UK hospitals and a majority opinion that anaesthetists find them necessary. A year later, at the Association of Anaesthetists of Great Britain and Ireland (AAGBI) annual meeting, a survey of 100 consultant anaesthetists showed similar results with 96% using ARs nearly all of the time on routine operating lists (Meyer-Witting & Wilkinson, 1992). Over a decade later, Bromhead and Jones (2002) surveyed 247 anaesthetic departments across the UK showing 96% of respondents used the AR as the standard site for induction, and 79% preferred to use them. Additionally, they determined that eight of ten departments that changed to in-theatre induction was for patient safety purposes, whilst the other two did so due to costs. Eighty-seven percent of respondents who used AR induction did not think clinical governance would lead to change in practice, despite safety risks. General perceptions from respondents showed that in-theatre induction seems to reduce efficiency, increased patient anxiety, provided for a worse teaching environment, and did not improve patient safety.

In contrast to the majority opinion of ARs, a postal survey of members of the Obstetric Anaesthetists' Association demonstrated an aversion to anaesthetic rooms in obstetric practice (Husain *et al.*, 2005). Of 252 respondents, regarding elective caesarean section procedures, 70% of clinicians never used ARs, and in emergency caesarean sections, 83% never did. Over 68% of 88 departments had departmental standards for practice or policies which required induction of all anaesthesia for caesarean sections in the operating theatre. As this study focused specifically on obstetric procedures, it raises questions of which specialties should have standard in-theatre inductions.

More recently, a poster was presented at the AAGBI Winter Scientific Meeting in 2013 showing that 83% of responding anaesthetists would be willing to anaesthetise their patients in the operating theatre if it were deemed safer, although it did not specify what criteria would be compelling enough. The same percent of respondents indicated they would anaesthetise more in the operating theatre if it were set-up to allow it. Overall, evaluation of patient opinion showed a majority was willing to be anaesthetised wherever the anaesthetist saw fit and where they would receive the best treatment (Erinle & Bourne, 2013).

2.2.2 Patient Anxiety

The pre-operative experience is an important consideration for clinicians as their patient's level of anxiety may have physiological effects, which could impact upon the ease of induction. The AR is seen as a quieter and calmer environment than the operating theatre, as it is perceived to have fewer distractions present. Newport (2001, p. 691) refers to inducing in the theatre as '… taking away the "quiet induction room environment" and placing the patient in the operating room with people "milling" about'. He emphasises the importance of retaining a space, which is free from noise, interruption, and distraction, and ranks this requirement above all other factors. Broadway *et al*. (2001) mention that staff members may be nervous to set up surgical equipment with the patient present in the room, and the patients may be distressed by the sights and sounds of the theatre.

Some of the earliest research on ARs pertains to the impact of the induction environment on patient experience and anxiety. During the 1950s, anaesthetists concerned themselves with the aesthetic of the induction room, proposing that attention to décor and ambiance could impact patient anxiety (Hewer, 1955; Steel, 1959). Lewis (1985) referred to an informal study of 50 patients induced in an AR with a mural or without a painting, but no difference in anxiety was determined.

These previous studies only considered the discomfort or worry of the patient with the assumption that they would be anaesthetised in the AR. Soni and Thomas (1989b) went further to question the use of the AR by conducting a study of 100 patients and concluded that there was no significant difference between the anxiety scores of patients induced in either the AR or the operating theatre. Looking at in-theatre induction alone, Kennedy *et al*. (1992) conducted a survey of mothers undergoing caesarean sections under regional anaesthesia and found that their anxiety was related to the procedure itself, the possibility of pain, and the welfare of their child, but not the theatre environment.

Whether the theatre environment alone induces anxiety in patients or not, the noise levels in the theatre are thought to be an added distress. Liu and Tan (2000) investigated this potential anxiety by measuring noise levels during the induction and maintenance of general anaesthesia in the operating theatre and interviewed patients. From a sample of 100 patients, 33 found the operating theatre to be a noisy environment, and 16 were

distressed by those noises. The continuous noise levels at the time of induction were a mean (standard deviation) of 70.3 (±16.8) decibels, which is higher than recommended levels for critical care, and higher than the threshold for physiological impacts. This study did not; however, address what behaviour change can be employed to minimise noise contributors.

Patient anxiety is a special consideration, particularly when the patient is of a young age. Paediatric patients and their guardians are a unique concern for clinicians as it has been generally understood that parents of adolescent patients must be permitted in the AR with their child to alleviate the worry of their child (and their own) throughout the induction process (Broadway *et al.*, 2001; Meyer-Witting & Wilkinson, 1992). In a questionnaire study of parents' perceptions of the benefit of their presence at induction, Ryder and Spargo (1991) found 99% of 139 respondents believed accompaniment was a benefit to their child and 95% thought it benefited the anaesthetist. The authors who mention the concern for parents who wish to accompany their children during the induction of anaesthesia do not acknowledge the possibility for the parents to enter the operating theatre, as an alternative to the AR. In 2003, a trial of in-theatre induction demonstrated a third of patients did not recall the room they were anaesthetised in, and those who did were not disturbed by the environment. Addressing the plight of paediatric patients, infection control representatives were consulted and determined that parents could enter the operating theatre with appropriate theatre footwear and sterile gowns over their clothes. In eight of the nine paediatric cases, parents commented that they were reassured to know exactly where their child was, opposed to leaving them in the AR (O'Connor *et al.*, 2003).

2.2.3 Patient Safety

The most commonly referenced disadvantage for using ARs for induction is the potential risk to patient safety. As is the norm, the patient is brought into the AR, connected to monitoring equipment, brought under anaesthesia, disconnected from monitoring, and transferred into the theatre where monitoring is re-established. This break in continuity of monitoring during the transfer of the patient from the anaesthetic room to the operating theatres is a patient safety risk (Broom *et al.*, 2006), and presents an opportunity for adverse incidents to occur, as the patient is unmonitored, unventilated, and anaesthetised. Husain *et al*. (2005) points out the theoretical risks of

transferring an anaesthetised patient, stating that the peri-induction period takes on risks such as anaphylaxis, severe hypotension and cardiac arrest. Brahams (1990, p. 333) is often quoted, in reference to an accidental anaesthetic death which was partially attributed to the transfer from the AR, regarding the concept of transferring a patient without monitoring or oxygen supply as 'clumsy and ill-conceived.' Besides breaking continuity of the anaesthetic record (Meyer-Witting & Wilkinson, 1992), which is essential for liability purposes, the anaesthetised patient's arterial oxygen saturation is reduced during the transfer, which takes on average 51 seconds (Riley *et al*., 1988).

The practice of transferring the anaesthetised patient between two rooms has safety risk implications not only for the patient, but for the medical professionals assisting in the surgical suite. There are several references to the potential hazards of transferring and positioning an unconscious patient (Broom *et al.*, 2006; Meyer-Witting & Wilkinson, 1992). Raising staff well-being to the conversation, Evans (2004) linked occupational-related injuries to the debate over induction location, pointing out the advantage of in-theatre induction as conscious patients can move themselves from the transfer trolley to the operating table and position themselves without risking the health and safety of the nurses and staff members involved.

There are specialties and circumstances in which ARs are abandoned for the security of anaesthetising in the theatre. A majority of consultants will anaesthetise a patient in the operating theatre occasionally, generally based on how ill the patient is (i.e. the patient's ASA grade -American Society of Anesthesiologists classification of the patient's physical status), if it is an emergency procedure, or if the patient requires continuous monitoring (Masters & Harper, 1990; Meyer-Witting & Wilkinson, 1992). Exceptions to the general rule of inducing in the AR include day surgery, minor operations, obstetric and dental procedures.

To focus on the exact safety risks that could occur due to the use of ARs for induction, Broom *et al.* (2006) conducted an observational study of 80 patients being transferred from the AR to the operating theatre and measured the duration of apnoea and time without monitoring during the process. The results showed a drop in arterial oxygen saturation and provided evidence that the transfer period may be a patient safety risk. The median time duration the patient was disconnected from breathing support in the AR to the first breath in the theatre was 54 seconds. It was observed that minor

distractions could accumulate during the transfer process and result in increased time of disconnection, risking the safety of the anaesthetised patient. To add to these considerations, in response to the publication, Herriman and Vernon (2007) highlighted the added risk and potentially longer times involved in transferring the morbidly obese.

The AR has been referenced as a 'safe haven' (Meyer-Witting & Wilkinson, 1992) where the patient and anaesthetist are separated from the noise and distraction of activities taking place in the operating theatre. Distraction during anaesthesia, particularly during induction, can significantly impact the anaesthetic team (Savoldelli *et al.*, 2010), due to stimuli such as alarms, conversations, workspace difficulties, teaching, and many others. Broom *et al.* (2011) studied noise and distraction during anaesthesia and found the loudest noise and interruption from entrance or exit of people was highest during emergence, opposed to induction, which could be due to the physical separation of the AR. The noise in operating theatre is acknowledged by a study by Hodge and Thompson (1990), which showed how noise can act as a barrier to clear communication.

In an observational study by Campbell *et al.* (2012), distractions were frequently noted during induction and transfer to the theatre, but most often during emergence. Following with interviews of consultant anaesthetists, they found that distraction is an integral part of anaesthetic work and can be managed through non-technical skills of experienced practitioners, gained through tacit knowledge (explored further in section 2.6.1); however, they identified a perception of increased distraction in the AR, despite higher frequency of distraction at emergence. It should also be acknowledged that distraction and interruption may also occur from the movement in and out of the AR, necessitated by the storage of supplies and equipment outside of the operating theatre.

2.2.4 Cost-Efficiency

The key claimed benefit of ARs is improved efficiency. Anaesthetic rooms were designed and constructed in a way so that a second patient can be brought into the room to commence anaesthesia, before the first patient has left the operating theatre. This 'anaesthetic overlap' or 'doubling up' can, therefore, provide quicker transitions between procedures, as initial preparations of patients can begin without waiting for the operating theatre to be vacated. It is also important to mention the time savings brought

from using ARs for providing local and regional anaesthetics. Harmer (2000) mentioned a trend towards the preference for using local and regional anaesthesia and analgesia. The AR can be used to initiate regional anaesthesia without delaying the operating list.

The debate surrounding ARs has also addressed the financial implications of their construction and use. Although ARs may already be a part of existing hospital infrastructure, the intentional construction of these spaces requires investment. In order to utilise these rooms, there is also an investment in purchasing duplicate monitoring equipment and paying to maintain it (Bromhead & Jones, 2002; Meyer-Witting & Wilkinson, 1992; Soni & Thomas, 1989b). To prevent the use of inadequate monitoring equipment for measuring vital functions during induction, the expensive duplication of equipment is necessitated (Anderson, 2000). There are obvious costs of housing an anaesthetic machine that is fully capable of ventilation and maintaining anaesthesia – yet only used for a few minutes to induce anaesthesia, that is situated only a few metres away from a duplicate machine within the operating theatre. Specialist registrars, Bromhead and Jones, conducted a survey in 2002, which estimated the cost of equipping ARs in the UK to be £30 million since 1994. In a different consideration of costs, Chakladar and White (2010) analysed the estimated power consumption of AR monitors when left on but not in use, and supposed that the contribution of 170 acute NHS Trusts consumes £36,615 per year, not including carbon emissions.

In 2000, Williams *et al*. compared the anaesthesia-controlled times (ACT) for various anaesthesia techniques and locations. The ACT time represented the time from entry into the operating theatre until surgical preparations began, with the addition of the time from the end of the surgical procedure to when the patient left the operating theatre. From the various combinations of anaesthetic provision, regional anaesthesia in the induction room provided the lowest ACT of 11.4 (±1.3 minutes), compared to general anaesthetic alone (20.3 ±1.2 minutes). Additionally, regional anaesthesia that was administered in a 'block room' helped to reduce pre-operative theatre time compared to those performed within the operating theatre.

In order to test the benefit, or detriment, of in-theatre induction, three clinicians in Ipswich conducted a trial and responded to an editorial in *Anaesthesia* with the results. Broadway *et al.* (2001) concluded that there was an insignificant delay in the operating

list, patients found it acceptable, theatre staff were able to set up instruments, and parents were able to come into the theatre with their children. Despite the positive results, there were minor problems in finding a quiet environment for teaching, although the researchers stated the importance of providing re-education for existing staff and teaching new surgical staff of the new way of working.

In 2003, O'Connor *et al.* conducted a 4-week trial inducing in the operating theatre and interviewed surgeons, scrub nurses, and anaesthetic assistants to determine their perceptions of productive timeliness. The AR was still used for initiation of monitoring and intravenous access. Neither the anaesthetic assistant nor the scrub nurse felt there was a delay in the list. Regarding list efficiency, the lead surgeon, anaesthetic assistant, and scrub nurse perceived an increase in efficiency of the running of the list in four, nine, and five occasions out of 21, respectively.

Torkki *et al*. (2005) conducted a comprehensive study analysing operating theatre times in Finland. They first used the 'traditional' in-theatre induction model for 5 weeks and continued for 4 weeks with a new model utilising a team of two nurses and an anaesthetist added to one operating theatre to provide parallel anaesthesia induction in an AR. Parallel working allowed for non-operative time to be reduced, and although time was saved between phases, this could have been attributed due to the time pressure of the concurrent anaesthesia provision. Taking place in an orthopaedic and trauma unit, the researchers found that an additional urgent orthopaedic case was possible during a 7-hour workday due to the time savings from parallel anaesthesia induction.

Published in the same issue of *Anesthesiology* as the Finnish study, Hanss *et al*. (2005) discussed the benefits and costs of overlapping induction of anaesthesia. The study evaluated 335 surgical cases with an additional team of one anaesthetist and one nurse for either two theatres or three, and measured turnover time, anaesthesia-controlled time, and nonsurgical time. Despite requiring additional staff, the model increased productivity and profit, as it made possible two more cases per day (for the model with an extra team for three operating theatres). There was, however, only indirect evidence that overlapping induction decreased the time in the operating theatre and increased the number of cases because the study could not be conducted double blinded.

In 2009, Saha *et al*. investigated causes for wasted time in the operating theatre by considering the time intervals between various points of the patient journey to and from

surgery in 55 elective gynaecological surgeries with general anaesthesia. The result showed significant wasted time in transferring the patient from the ward to the AR. The authors called for two anaesthetists at the end of surgery to reverse anaesthetic in one patient and begin induction of the next. The research study proposed parallel working to reduce surgeon and anaesthetist waits.

Much of the research evaluating the turnover times and efficiency of operating theatres has concluded that additional staffing and the use of overlapping induction will allow for an additional case to be fit into an operating list. These results vary based on the model employed, the types of procedures, required anaesthesia, and available staffing.

An additional consideration for efficient working is the task breakdown of anaesthetic activities. Using a human factors hierarchical task analysis method, Phipps *et al.* (2008) found induction of anaesthesia to be the most demanding phase of anaesthesia requiring the most tasks to be done, including multiple tasks required solely due to the transfer of the patient from the induction room to the operating theatre. The authors consider abandoning ARs if only considering task analysis.

2.2.5 National Guidance

The National Institute for Health and Care Excellence (NICE) produces evidence-based recommendations for health, public health, and social care practitioners in order to provide safe and quality care. Although there is an absence of NICE guidelines specific to AR use, the anaesthetic professional bodies such as the AAGBI and the Royal College of Anaesthetists (RCoA) have advice pertaining to their use, and the Department of Health (DOH) provides building requirements for healthcare facilities to ensure compliance with ventilation and infection control best practice through their Health Building Notes (HBN) and Health Technical Memoranda (HTM).

Health Technical Memorandum

The Health Technical Memorandum is aimed at estate managers, design engineers, and operations managers and it specifies the ventilation design and installation requirements relating to air-change rates, clean air-flow, and air pressure stabilisers in healthcare premises in order to prevent against medical gas exposure and healthcare-associated

infections. It would seem the ventilation design for UK surgical suites is based around the assumption of ARs, as it states:

> '*Separate scrub-up or disposal facilities are not necessary for air cleanliness, although operational policy may prefer such a provision. However, a separate anaesthetic room should be provided*' (DOH, 2007, p. 55).

The ventilation requirements stated in the HTM are based on various acts, regulations, British standards, and other publications. However, no published article was identified in the references explicitly comparing air cleanliness of the operating theatre with and without anaesthetic rooms.

The HTM suggests referral to first principles when designing non-standard rooms or theatre layouts. An example of a non-standard theatre configuration was that of cardiac theatres where the theatre is 50% larger than normal theatres and a perfusion laboratory is built, but no AR.

Although pressure stabilisers between the OT and AR are described, as well as recommended stabilisers between the AR and corridor, the air flow must not be so high as to cause a draught. The AR is also classed as a clean room, whereas the preparation room, scrub bay, and operating room are classed as sterile rooms which require different nominal pressures.

Health Building Notes

The Health Building Notes provide standards for the built environment and are intended for design teams, estates directors, private finance initiative (PFI) consortia, and private-sector contractors for the recommended design of healthcare buildings. The most recent HBN (26, Vol 1) for surgical procedure facilities presents an appendix weighing the advantages and disadvantages of the AR described by the lead anaesthetist of the NHS Modernisation Agency, yet no evidence is cited in the appendix nor throughout the guidance (DOH, 2004).

Recommendations are debatably biased in favour of ARs, for example:

- '… the inclusion of anaesthetic rooms will be necessary if the expected benefits are to be achieved.' (3.15)

- 'Once theatres are built without anaesthetic rooms, some anaesthetists maintain that efficiency can never be increased…' (3.17)
- '… the omission of an anaesthetic room will compromise the ability of a theatre suite ventilation system to maintain pressure.' (3.18)
- 'Where a preparation room is omitted, an anaesthetic room must be provided as the laying-up of instrument trolleys is not acceptable at the same time that the patient is being induced in the operating theatre.' (3.21)

The additional building requirements are as follows:

- The minimum size requirement for the AR is 19 m^2 (4.34).
- At least 4 people in addition to the patient, as well as appropriate equipment should fit within the space (4.36).
- ARs should be identical and not handed, and allow for access to the patient from all sides (4.37).
- Maintaining privacy and an undisturbed environment is emphasised (4.38).
- The AR should be sound insulated to maintain a calm and relaxing environment (4.39).

Royal College of Anaesthetists Guidelines

The Royal College of Anaesthetists' (RCoA) website provides a statement of intent for the guideline documents which are downloadable from the site. It states that:

> *'The documents below are for guidance only. They are not intended to replace the clinical judgement of the individual anaesthetist, and the freedom to determine the most appropriate treatment for individual patients in a particular place at a specific moment should not be constrained by a rigid application of this guidance.'* (RCoA, 2014).

RCoA guidelines for anaesthetic services do not explicitly recommend induction in the AR over theatre induction; however, they do acknowledge the room as somewhat of a standard for practice. Guidelines recommend building ARs according to the Department of Health building guidelines; informing patients of what to expect in the AR (RCoA, 2014); providing sufficient monitoring to similar specification and

condition as the equipment in the operating theatre (RCoA, 2015a); and enabling parents and carers to accompany children to the AR (RCoA, 2015b).

Association of Anaesthetists of Great Britain and Ireland Guidelines

The AAGBI also provides published guidelines available on their website. Some explicit statements are made regarding the AR. The guidance on 'The Anaesthesia Team' (AAGBI, 2010b) states that in some units the anaesthetist and trained assistant should be joined by a third member of staff in order to assist in the case of an untoward event, a morbidly obese patient, or the presence of carers within the AR. An additional member of staff should be in close proximity to the AR in any case, so as to be available for any arising problem. In collaboration with the Society for Obesity and Bariatric Anaesthesia (SOBA), specific guidance on care of the obese patient states that anaesthetising in the theatre should be considered for the obese patient because of possible problems in transporting an anaesthetised obese patient, whereby in-theatre induction allows for the patients to position themselves (AAGBI, 2015).

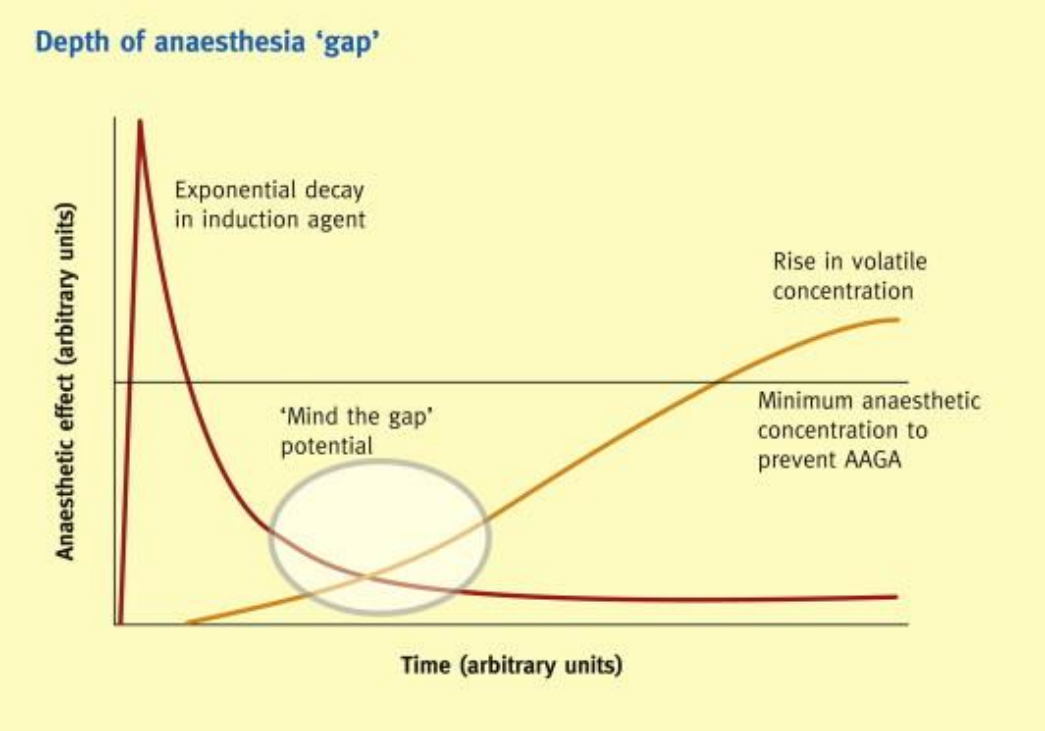


Figure 2.1 Diagram of the depth of anaesthesia 'gap' (Chapman & O'Connor, 2015, p.369)

The AAGBI's acknowledgement of possible risk of arterial desaturation during transfer was cited from the observational study of patients during transfer by Broom *et al*. (2006), as described earlier. In addition, the AAGBI references the 5th National Audit

Project (NAP5) which was a joint project of the RCoA and the AAGBI focusing on accidental awareness during general anaesthesia (AAGA). The transfer between the AR and operating theatre was determined to be a period of risk for AAGA at 1:19,600 (Pandit *et al.*, 2014). Chapman & O'Connor (2015) highlight the 'gap' in anaesthesia that puts patients at risk for AAGA during the initiation of maintenance of anaesthesia. As shown in **Figure 2.1**, following the induction of anaesthesia, the transition to maintenance results in a decline of intravenous anaesthetic while volatile agents are increasing in concentration, resulting in a gap in the depth of anaesthesia. This gap often coincides with the disconnection of breathing circuits and interruption of volatile agents while the patient is physically moved between the AR and the operating theatre. Accidental awareness is also of greatest risk for obese, emergency, obstetric, cardiac, thoracic, neurosurgery, and difficult airway patients (Chapman & O'Connor, 2015).

2.3 Patient Safety

In 2000, the Institute of Medicine in the United States brought patient safety to the forefront of healthcare quality management with their report (call to action), 'To Err Is Human', in which it was estimated that nearly 100,000 Americans die each year in hospitals due to medical errors (Kohn *et al*., 2000). Improving patient safety became a national priority with gained support from government agencies. Similarly, in the UK, the Department of Health's (2000) report, 'An organisation with a memory,' addressed many organisational failures of the NHS and called for a national reporting system to measure and analyse adverse events. The patient safety movement is now established and is widely promoted through clinical training, guidelines, organisational structures, industry regulations, and research.

Patient safety research frequently overlaps with the pursuit of the evidence-based medicine agenda (discussed later). The Agency for Healthcare Research and Quality (AHRQ) in the US, compiled a report which critically examined the existing research literature on treatments and technologies in order to make evidence-based recommendations for patient safety best practice (Shojania *et al*., 2001). However, Leape *et al.* (2002) critiqued their report by identifying the absence of review of not only efficacious treatments/technologies, but also methods for ensuring patients receive the preferred treatment, and eliminating errors from the system delivering care.

It is understood that patient safety is complex and must be tackled from multiple levels (i.e. individuals, teams, management, organisations, etc.), however it is argued that a shift from the dominant (and sometimes overly simplistic) patient safety paradigm to an understanding of the rich socio-cultural elements and complexities which influence the organisations striving for improved patient safety is warranted (Rowley & Waring, 2011). The human factors systems approach to patient safety is discussed in section 2.7.1.

2.3.1 Risk and Error Management

Many lessons in enhancing safety can be learned from high reliability industries such as aviation, nuclear power, and petro-chemicals, where accidents can result in significant harm. A large proportion of the patient safety initiative has focused on failure reduction and prevention. This can be undertaken using an individual or systems approach. While placing individual blame for unsafe behaviour can be gratifying, a systems approach recognises the inherent fallibility of human nature and strives to install safeguards within the systems level in order to improve the conditions in which the human works (Reason, 2000).

Cook *et al.* (2000) offer an alternative from the conventional view of accidents, that assumes safety is designed into a system which is compromised by its human components. This perspective emphasises the use of rules, guidelines, and technology to minimise human interference, whereas Cook *et al.* emphasise the 'gaps' which naturally occur in the continuity of care which are naturally bridged by practitioners modifying their technical work and coping with new demands. Valuing the robustness of 'sharp end' practitioners' ability to manage these gaps may be a beneficial way to approach patient safety improvements.

James Reason's (2000) Swiss cheese model, shown in **Figure 2.2**, is famously used to depict the combination of active errors and latent factors (holes within defences) aligning to result in failure. Active errors (i.e. human errors) can be done both of commission or omission (e.g. slips, lapses, fumbles, neglecting protocol, etc.), whereas latent conditions are inherent to the system and can combine with active failures resulting in accidents. Examples of latent conditions include increased time pressure, fatigue, or understaffing.

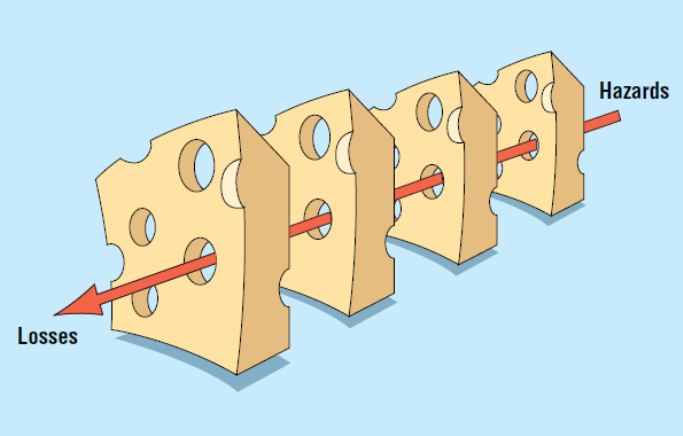


Figure 2.2 Swiss cheese model of system accidents (Reason, 2000, p.769)

Incident reporting and documentation of near-misses or adverse events is a common retrospective approach to error management. In healthcare, sometimes errors are not easily detected until adverse events take place. Errors of treatment can be more easily identified compared to diagnostic or prevention errors due to the often rapid appearance of adverse events (Hoff *et al*., 2004). Spontaneous active event reporting or the self-reporting of an incidence by the 'sharp end practitioner' is beneficial, but tends to under report (Bates *et al*., 1995). It is also more likely to recall an error of commission than an error of omission (Øvretveit, 2009).

There are several methods for identifying risks besides incidence reporting including reviewing archival records, process mapping, and probabilistic risk assessment (Battles & Lilford, 2003). Root cause analysis (RCA) and Failure Mode and Effect Analysis (FMEA) are commonly used process analysis methods. RCA is a formalised and structured way of analysing the circumstances which resulted in an error -identifying the latent conditions linked to the unsafe behaviour. While useful, the analyses are retrospective, speculative in nature, and should not be considered representative of clinical outcomes (Shojania *et al*., 2001). In addition, hindsight bias is an issue as knowledge of the outcome can influence retrospective studies (Cook *et al.*, 2000). The Veterans Affairs National Center for Patient Safety developed a simplified FMEA for healthcare (HFMEA) which is preventative and considers the likelihood and severity of outcomes resulting from failure (DeRosier *et al*., 2002). It is seen as a gold standard for proactive analysis and is required for all Joint Commission on Accreditation of Healthcare Organizations (JCAHO) accredited organisations in the US to be conducted annually (La Pietra *et al*., 2005).

2.3.2 Safety Culture

Safety culture is a patient safety strategy that takes an organisational culture view, aiming to promote an employee ethos which prioritises safety. In contrast to a safety culture is a 'blame culture' or 'pathological culture', which is punitive to failure and is more inclined to deny the existence of problems and may attempt to hide them (Westrum, 1993). Additionally, non-compliance can become normalised within the prevailing culture of an organisation, which requires adjustment (Vaughan, 1999). Several challenges to safety culture in healthcare include organisational priorities of efficiency and cost controls, the inability of medical staff to acknowledge fallibility, and the 'professional norms of perfectionism' (Nieva & Sorra, 2003).

An example of a poor safety culture is the very public case of the Bristol Children's Heart Surgery scandal where mortality rates twice that of the national average were reported for paediatric cardiac surgery patients between 1984 and 1995. After internally auditing and identifying questionable outcomes from particular surgeons, the 'whistleblower' who raised these concerns to upper management eventually resigned due to feelings of threat from a 'blame and shame' culture (BBC News, 2001). In review of the case, Smith (1998) reiterated the fact that collected performance data should not be used for judgement, but for improvement.

Safety culture and safety climate are sometimes used interchangeably but can be distinguished from one another. Safety culture is a combination of the underlying beliefs and values of the organisation, which may not be directly associated to safety (Guldenmund, 2000). Safety climate, in contrast, is most visible and can be understood as the 'surface' of the underlying culture (Arfanis *et al.*, 2011). Denison (1996) argued that while quantitative surveys can measure organisational climate, qualitative methods are necessary to fully understand the context of the organisational culture.

Colla *et al*.'s (2005) systematic review of patient safety climate surveys revealed five common dimensions: leadership, policies and procedures, staffing, communication, and reporting. These cultural evaluation tools were used for both internal and external benchmarking (between departments or wards and hospitals), but rarely was organisational safety climate linked to patient outcomes. These tools can also be used to compare safety climate or culture between professions (i.e. doctors, nurses, ancillary staff, etc.), to identify areas for improvement, to evaluate change after a patient safety

programme is implemented, and as a way of abiding by regulatory requirements (Nieva & Sorra, 2003).

Specifically addressing the safety culture within anaesthesiology, Arfanis *et al.* (2011) present the concept of a safety 'microcultures' which can exist within a larger organisation. The safety microculture reflects the shared understanding of a group, i.e. anaesthetists, of what should be regarded as safe practice, what risks are regularly encountered, and what methods are accepted for managing risk. Group knowledge about safety can be shared both formally (i.e. training, peer-reviewed publication) or informally (i.e. observation, gossip). The individual personalities, membership to professional groups, and shared tacit knowledge are all influencing factors to safety culture in anaesthesia (Arfanis *et al.*, 2011).

2.4 Quality Improvement in Healthcare

In healthcare, patient safety falls under the wide umbrella of quality improvement (QI). This section will briefly overview a few popular quality improvement approaches including total quality management, lean healthcare, benchmarking, and evidence-based medicine/practice, which will be discussed more in section 2.5.

There are many valid approaches to healthcare quality improvement, with varying degree of evidence to support them, including accreditation and accountability, professional development and revalidation, business process re-engineering, Six Sigma, continuous quality improvement, ISO 9000, risk management and error prevention, organisational development and leadership enhancement, disease management and managed care, or patient empowerment. With a plethora of strategies for improving quality and safety in healthcare, a scientific approach is essential in order to prevent implementation which are unproven, may be wasteful of scarce resources, may not result in positive change, and could cause harm (Auerbach *et al.*, 2007). Some reviews of QI literature have shown study design flaws (i.e. short duration, selection bias, and low external validity) (Alexander & Hearld, 2009), which calls for higher quality and robust evaluations of the effectiveness of various QI interventions.

2.4.1 Total Quality Management

Total Quality Management (TQM) is a management philosophy and management method which encourages and empowers all staff to improve quality within the

organisation. TQM originated from industry with influence from notable authorities such as Edwards Deming, Joseph Juran, Philip Crosby, and Armand Feigenbaum, among others (Parsley & Corrigan, 1999). Examples of TQM implementation, in and outside of healthcare, has been carried out to varying degrees. Key components of TQM include (Øvretveit, 2000):

- Customer focus (both internal and external)
- Process analysis; statistical control
- Quality project teams
- Systematically implemented methods which analyse problems, make change, and evaluate the results of quality improvement (e.g. Plan-Do-Check-Act cycle)
- Data collection for identification of problems and assessment
- Implementation of change.

An important consideration in healthcare applications of TQM is the understood definition of quality. Deming (1986) addresses the difficulty in defining quality in medical care provision as quality is determined by managers, providers, and patients. Considerations must be made for patient quality, professional quality, and management quality (Øvretveit, 1992).

Research evaluating TQM programme implementation across European healthcare has shown little evidence of benefit, although it has been successful in some individual projects. Several difficulties can arise with this type of organisation wide approach due to the cost of investment (without guaranteed return on investment), internal resistance to cultural changes and teamwork (across professional boundaries) required for sustained change, as well as the time constraints, and promoting continuous improvement with low market incentives (Øvretveit, 2000).

2.4.2 Lean Healthcare

Lean Thinking (a.k.a. Lean) is another management philosophy which originates from the Toyota Production System in manufacturing. The primary principles of lean are the reduction of ‘waste’ or non-value adding activities in order to satisfy the customer and improve productivity. This assumes the organisation is comprised of processes where waste can be removed, value can be added, and the process can be incrementally and continuously improved (Ohno, 1988).

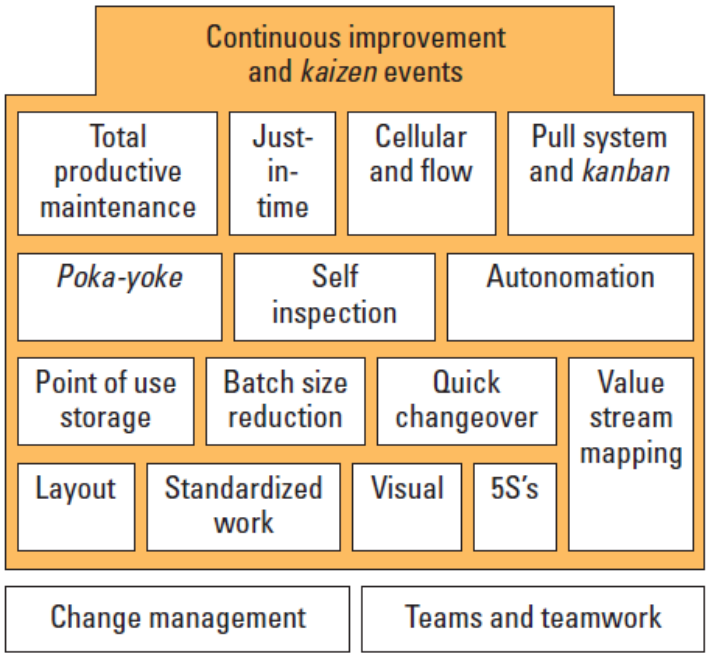


Figure 2.3 The 18 building blocks of lean healthcare (Manos *et al.*, 2006, p.26)

The application of lean to healthcare (Lean Healthcare) requires some adaptation to suit the particular setting, while the building blocks of lean remain the same (see **Figure 2.3**). For example, most hospitals are not-for-profit and value adding for patients is different than for customers in manufacturing. Defining what the customer values in the product/service can be difficult in healthcare as the customer may be considered the patient or commissioners (Radnor *et al*., 2012). Eliminating waste is a key principle of lean and TPS identifies seven forms of waste: waiting, defects, motion, inventory, overproduction, transportation, and processing. Manos *et al.* (2006) include an eighth form of waste –underutilising staff or failing to utilise the knowledge and creativity that employees can bring.

The Institute for Innovation and Improvement launched the 'Productive Series' in the NHS (including the 'Productive Theatre' programme), which was a large scale implementation of Lean and applied various tools and a 5S (sort, set, shine, standardise, sustain) approach for workplace organisation. Like TQM, implementation of Lean, which calls for whole organisational change and involvement, has varied between organisations. Many managers have tended to implement only a collection of Lean tools, such as PDCA cycles, process mapping, and waste audits (Womack & Jones, 2003) instead of a system-wide culture of improvement (Waring & Bishop, 2010). This type of tool-based Lean approach can be detrimental as understanding across the system

may be limited. As well in the NHS, the organisation as a publically owned and controlled institution presents strong forces of organisational and professional cultures (Radnor *et al*., 2012). Additional resistance can be found from staff being wary of management priorities for reducing costs and potentially staff numbers. There may also be lack of trust in expert credibility, available time to participate in lean activities, and a perception of overly standardised procedures (Waring & Bishop, 2010).

2.4.3 Benchmarking

Benchmarking was introduced by the Xerox Corporation in the 1980s when it sought to reduce production costs in order to stand up against competitors. Camp (1989) describes benchmarking as the superior and more efficient performance of one organisation being defined and transferred to another organisation as 'best practice'. This type of performance measurement and comparison has gained traction in the healthcare sector due to the need to control costs, to manage risk and quality of care, and to satisfy patients' expectations (Ettorchi-Tardy *et al*., 2012). Benchmarking is beneficial across competing organisations, within an organisation (internal benchmarking), and between organisations from different spheres whose business processes are relevant to one another (Mayle *et al*., 2002).

In 1997, the Department of Health's White Paper, 'The New NHS: Modern, Dependable' made a call for benchmarking and sharing good practice to improve the NHS, which would be beneficial on an intra-organisational level due to the sheer size of the NHS (Newell *et al*., 2003). Comparative benchmarking of performance metrics or indicators is an important part of government policy in the UK. These indicators are used to rank hospitals in competitive league tables, which are used for governance and consumer knowledge (Northcott & Llewellyn, 2005). It is important to note, however, the difference between 'indicator-benchmarking' and 'ideas-benchmarking', where the former can overlook the organisational learning (to be discussed later) possible from broader knowledge outside of performance metrics, and the latter transfers that valuable knowledge of how to improve the organisational process (Mayle *et al*., 2002).

Benchmarking does not guarantee improvement. Pollitt (1996) points out several problems which can arise including the selection of a process to benchmark which is unimportant; ignoring measured data showing an area that could be improved; and a lack of investment of time or resources to the benchmarking process.

In addition to benchmarking as a method for improving practice, important consideration must be taken for the translation of 'best practice' knowledge. Newell *et al*. (2003) argues that process knowledge, or knowledge of current practice within an organisation, is essential for successful translation of product knowledge (i.e. knowledge of the 'best practice'). As current practice is only known partially by individual actors, emphasis should be placed on the importance of communicating and interacting with those actors to establish process knowledge.

2.5 Evidence-Based Practice

This section will discuss the evidence-based practice broadly and what is considered 'evidence'. The integration of evidence in management and design decisions will also be discussed.

Evidence-based medicine/practice (EBM/EBP) emerged as a way to improve the decision making of physicians in providing patients with the most effective treatments. EBP is inherently an improvement method which overlaps with other quality improvement initiatives of sharing 'best practice' knowledge to learn and implement change. Sackett *et al*. (1996) famously defines EBM as:

> *'... the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients. The practice of evidence-based medicine means integrating individual clinical expertise with the best available external clinical evidence from systematic research'* (p.71).

Sackett's definition of EBM reveals the traditional view of 'evidence' as research evidence, and specifically quantitative research where randomised controlled trials (RCTs), systematic reviews, and meta-analyses are upheld as the gold standards for evidence as they control for bias. **Table 2.1** presents the hierarchy of evidence as used by NICE in the development of public health guidance, which is consistent with this view of RCTs, systematic reviews, and meta-analyses as the highest quality evidence, Type 1. Cohort studies, controlled before and after (CBA) studies, interrupted time series (ITS) studies, and correlation studies are Type 2. Non-analytical studies are Type 3, followed by expert opinion and formal consensus as the lowest form of evidence at Type 4.

Table 2.1 NICE hierarchy of evidence for efficacy of intervention studies (NICE, 2006, p.35)

Type and quality of evidence	
1^{++}	High quality meta-analyses, systematic reviews of RCTs, or RCTs (including cluster RCTs) with a very low risk of bias
1^{+}	Well conducted meta-analyses, systematic reviews of RCTs, or RCTs (including cluster RCTs) with a low risk of bias
1^{-}	Meta-analyses, systematic reviews of RCTs, or RCTs (including cluster RCTs) with a high risk of bias
2^{++}	High quality systematic reviews of these types of studies, or individual, non-RCTs, case-control studies, cohort studies, CBA studies, ITS, and correlation studies with a very low risk of confounding, bias or chance and a high probability that the relationship is causal
2^{+}	Well conducted non-RCTs, case-control studies, cohort studies, CBA studies, ITS and correlation studies with a low risk of confounding, bias or chance and a moderate probability that the relationship is causal
2^{-}	Non-RCTs, case-control studies, cohort studies, CBA studies, ITS and correlation studies with a high risk – or chance – of confounding bias, and a significant risk that the relationship is not causal
3	Non-analytic studies (for example, case reports, case series)
4	Expert opinion, formal consensus
NB: for policy interventions, then CBA can be awarded level 1 evidence.	

Many voices within the EBP discourse are recognising the importance of additional considerations when integrating 'best evidence' into practice. While practitioners must be able to search research literature, and critically appraise the findings by evaluating their strengths and weaknesses, they must also synthesise best evidence combining clinical judgment with data (Rosswurm & Larrabee, 1999). Haynes (1999) explains in a BMJ editorial the need to include more effectiveness and efficiency studies to ensure interventions are appropriate for context and that they are cost-effective.

The relationship between the practitioner and patient necessitates additional sources of evidence besides research evidence, including clinical experience, patient experience, values, circumstances, and contextual information (Rycroft-Malone *et al*., 2004; Hoffmann *et al.*, 2013). This dynamic relationship does not allow decisions to be made on evidence alone. Oxman and Flottorp (2001) state that:

> *'Empathy and compassion are necessary in establishing a good relationship between providers and recipients of care and to ensure that patients' needs and anxieties are recognised and addressed'* (p.102).

The cost of prioritising RCTs and quantitative research methods is the undervaluing of qualitative research, which is essential for gathering insights and nuances of the

individual stakeholders or communities affected by EBP (Hoffmann *et al*., 2013). Qualitative research is useful for decision making as it informs the practitioner or manager of the 'feasibility, appropriateness or meaningfulness of a certain intervention or activity' (Hoffmann *et al*., 2013, p.222). Further research is required to make explicit the craft knowledge and clinical experience of practitioners so it can be critiqued (Rycroft-Malone *et al*., 2004). Collecting this information is beneficial as evidence has more power when research matches the clinical experience (Ferlie *et al*., 1999).

Much of the 'best practice' and 'best evidence' discussed in this section relates to knowledge generation and its validation. Nutley and Davies (2000) consider these components of EBP as well as its dissemination and adoption. The gaps between the creation of research and its implementation are explored further under the topic of improvement science.

2.5.1 Evidence-based Management

Despite the advancement of the EBP movement, the concept of evidence-based management has not progressed with equal success (Kovner *et al*., 2000). It has been questioned why managerial and policy innovations are not held to the same standards of a quality evidence-base which clinical innovations are (Walshe & Rundall, 2001), particularly considering the tendency in managerial practice to rush into adopting the newest quality improvement fads (such as those listed previously) –implemented to varying degrees with equally variable success (Staw & Epstein, 2000). Developing evidence-based management research could provide a wider body of shared knowledge in areas such as cost control, productivity, quality of care, and health outcomes (Finkler & Ward, 2003).

The implementation of EBP within management has its own challenges in contrast to EBP within the clinical domain. Walshe & Rundall (2001) explain several of the differences, as opposed to being highly professionalised and unified, healthcare managers come from diverse backgrounds and do not share a common language. Healthcare managers may not be trained in researching evidence and critically appraising that evidence. Decision making on the management level relies more on personal experience and beliefs than a shared body of knowledge such as in the medical profession. This decision making process is not easily defined, happens on a longer time scale, and may require decisions of greater magnitude. These decisions are

typically made with the input of others, in order to gather support for a decision. Wider system constraints such as organisational policies and procedures, resource availability, and the interests of varying stakeholders may contradict research or restrict the total incorporation of evidence into management decisions. A competitive environment may also limit the open sharing of information (Finkler & Ward, 2003).

Learmonth and Harding (2006) present the difficulties of utilising evidence for organisational management decisions as the definitions of what counts as evidence and the highly debatable nature of the questions to be answered can be morally and politically driven. While evidence-based management may grant credibility to the otherwise presumed lack of scientific knowledge of managers, it may also undermine management desire for power and influence, which may be a difficult pill to swallow. Pfeffer and Sutton (2006) overheard a former Netscape CEO who stated:

> *'If the decision is going to be made by the facts, then everyone's facts, as long as they are relevant, are equal. If the decision is going to be made on the basis of people's opinions, then mine count for a lot more'* (p.73).

2.5.2 Evidence-based Design

The literature on evidence-based medicine has more recently extended toward evidence-based design decision making, which draws on scientific research for guidance on the physical environment in the healthcare setting (Hamilton, 2003). The physical environment can be a major component affecting the provision of care. Although verifying causality is unachievable, correlations have been studied between the built environment and health outcomes, including environmental considerations of noise, lighting, air handling, layout, art, and way-finding (Codinhoto *et al.*, 2008).

In 2008, researchers from Texas A&M University and Georgia Institute of Technology expanded on an earlier literature review, which sought to evaluate research on healthcare design and implications for patient safety, and outcomes for both patients and staff. The body of literature regarding hospital design contained few RCTs, showing recognition of the complexity of altering the physical environment, which can have many simultaneous effects that are not easily controlled (Ulrich *et al.*, 2008). Some early findings of their work indicated that single-bed rooms improve quality of

care and satisfaction of patients, and increased exposure to daylight and artwork can help to reduce depression and pain (Ulrich, 2006).

Codinhoto *et al.* (2009) acknowledge the role of national guidance as a resource for UK hospitals to bridge the gap between research and design of healthcare facilities, as they affirm the evidential base for NHS Health Building Notes and Health Technical Memoranda. However, the design of the built environment requires input from architects, budget holders, contractors, managers, and (ideally) users. Further research is required to investigate the theory, methods, tools, and guidelines, which these decision-makers can use to incorporate best evidence into the design process (Codinhoto *et al.*, 2009).

2.6 Improvement Science

The term 'improvement science' is a relatively new one, which lacks consensus on how it should be used and applied. Improvement science is an emergent area of research focusing on the improvement of healthcare. Other names include implementation science, science of improvement, translational research, quality improvement science, evidence-based practice, knowledge translation, and research utilisation (The Health Foundation, 2011). Schackman (2010) used the following definition for implementation science:

> '*Implementation science is the scientific study of methods to promote the integration of research findings and evidence-based interventions into healthcare policy and practice and hence to improve the quality and effectiveness of health services and care*' (p.S28).

The goal of improvement/implementation science is not equivalent to that of quality improvement initiatives. Bauer *et al*. (2015) contrast implementation science with quality improvement by stating how QI is often driven by a specific problem that needs addressing, whereas improvement science originates from underutilised EBP. It aims for the spread of generalizable knowledge. Bauer *et al.* (2015) goes on to explain that:

> '*The emerging science of implementation provides a systematized approach to identifying and addressing barriers and facilitators to system change, and thus represents a critical component of any learning healthcare system*' (p.10).

Improvement science focuses on the process of implementing EBP and fostering partnerships between academics (experts of research methodologies) and practitioners (frontline workers understanding the work context) to oppose prevailing culture and develop new ways of thinking and acting (Marshall *et al*., 2013). These main themes of improvement science, behaviour change (for improvement) and strategies for implementation of EBP, will be explored in more depth to consider varying theories and frameworks which have added to the body of improvement science knowledge.

2.6.1 Behaviour Change Theory

Research in the field of implementation science must theorise about the predictors for health professional behaviour change in order to formulate strategic implementation. Even with full awareness of evidence and clinical willingness to change, health practitioners may have difficulty countering the 'well established patterns of care', particularly when the broader contextual environment is not conducive to change (Grol & Grimshaw, 2003, p.1225).

Nutley and Davies (2000) discuss macro and micro approaches to change or combinations of the two. The macro, or whole systems change, approach is usually top-down systems redesign. The micro approach, bottom-up, is targeted at modifying the attitudes and behaviours of individuals.

Gaps between clinical best practice and actual practice are not a result of ill intent. Numerous factors can act as incentives or barriers to change. Oxman and Flottorp (2001) noted that often knowledge is insufficient to ensure behaviour change. They consider three main areas affecting behaviour change: the practice environment, prevailing opinion, and knowledge and attitudes. Implementation strategies should be tailored specifically to the local context by collecting data on potential barriers and incentives for change using methods such as interviews, surveys, focus groups, Delphi methods, observations, auditing routinely collected data, and analysis of documents (Grol & Wensing, 2004).

Consistent with and adding to the areas identified by Oxman and Flottorp, Grol and Wensing (2004) propose consideration of barriers and incentives with a multi-level approach, primarily considering six levels:

1. Innovation
2. Patient
3. Individual professional
4. Social context / healthcare team
5. Organisational context
6. Economic and political context / wider environment.

It is essential to apply theories for behaviour change to the relevant level, as interventions may apply best to the individual, the team, the organisation, or the wider system (Eccles *et al*., 2005). Numerous theories coming from various disciplinary perspectives can be used to understand behaviour change including: cognitive theories, adult-learning approaches, behavioural theories, social influence theories, marketing theories, organisational theories and others (Grol & Grimshaw, 2003). The following sections will briefly mention some relevant theories from the individual, social, and organisational levels.

Individual Professionals

The task of the individual to translate EBP knowledge into action requires an understanding of human cognition and knowledge management. From the psychology literature, the nature of memory reveals different types of knowledge/memory which are created: 'declarative' and 'procedural' knowledge (Nutley & Davies, 2000). Declarative (also codified) knowledge is explicit and is able to be stated. Procedural (or personal) knowledge is sometimes referred to as 'tacit knowledge' or 'craft expertise' and it is inherent to being a professional because of the deep embeddedness of this knowledge, which is not readily articulated. Tacit knowledge is the most influential in development of practitioner routines and is developed from practical problem solving within the socio-technical system (Nutley & Davies, 2000; Eraut, 2000). In a survey of 330 clinical nurses, Gerrish and Clayton (2004) found that most nurses relied less on formal knowledge acquired from research literature than from experiential knowledge, gained from interaction with patients and colleagues. Tacit knowledge is built around custom and practices, which may be ineffective, yet it can be deeply embedded and therefore pose as a potential barrier to change and EBP implantation (Nutley *et al*., 2003).

Cabana *et al.* (1999) conducted a review of 76 studies investigating barriers to clinical adherence to practice guidelines and identified salient barriers including: awareness, absence of external barriers, agreement, familiarity, self-efficacy, overcoming inertia of previous practice, and outcome expectancy. Many of these factors and how they affect the individual have been theorised in different ways. Drawing from health psychology, Eccles *et al.* (2005) reference various theories which are relevant to behaviour change of the individual including:

- Motivational theories: seek to explain how individuals come to wish to change;
- Action theories: seek to explain how individuals move from intention to behaviour change;
- Stage theories: proposes a methodical advance through stages of behaviour change.

Eccles *et al*. (2005) emphasise the importance of making explicit the theoretical underpinnings and rationale for interventions, as theory is not always systematically used in implementations science.

Social Context

Socio-cultural theories of learning posit that health professionals learn their professional practices and ways of thinking from 'communities of practice' (COP) (Lave & Wenger, 1991). Even with continued professional development, experiential learning is also important for health professionals to undertake EBP (Hoffmann *et al*., 2013). Communities of practice theory unites COPs, which are formed by people sharing a common concern, and engages them in collective learning. This can be across professional, organisational, and geographical boundaries.

Social cognitive theories can provide insight into the cognitive mechanisms underpinning behaviour (Godin *et al*., 2008). Examples of these theories include the Theory of Reasoned Action, the Theory of Planned Behaviour, Bandura's social cognitive theory, and Triandis' theory of interpersonal behaviour. Godin *et al.* (2008) conducted a systematic review of 78 social cognitive theory studies and identified variables explaining intention and predicting behaviour: beliefs about consequences, moral norm, role & identity, characteristics of healthcare professional, beliefs about capabilities, habit / past behaviour, and social influences. Oxman and Flottorp (2001)

reference the social influences model of behaviour change, which emphasises the importance of opinion leaders in communicating what is appropriate behaviour.

The successful implementation of change is highly affected by the social arrangements of professional and occupational groups and their boundaries. Some professionals may be resistant to EBP due to a lack of trust of experts and an effort to retain authority of their profession in the face of increasing managerialism (Traynor, 2002). Clinical autonomy is very valuable to doctors –even if sometimes that means providing care which conflicts with best evidence (Oxman & Flottorp, 2001).

The social distinctions of professional groups and inherent hierarchies are important. Newman *et al*. (1998) found from an organisational appraisal of an acute hospital NHS trust that barriers to change presented themselves through strong professional distinctions and the sense of powerlessness from nurses in decision making. This lack of authority was apparent again in a survey of nurses undergoing EBP implementation, as well as time constraints and a resistant ward culture (Gerrish & Clayton, 2004).

Organisational Context

More traditional explanations of the gap in theory and practice has tended to emphasise the attitudes and behaviour of the individual, without proper consideration of the social, economic, political, and organisational influences (Rafferty *et al*., 1996). As Nutley and Davies (2000) stated:

> *'The interventions to achieve change may begin by targeting individuals, but if change is to endure it needs to move beyond the individual and become embedded within… structures, systems and resources'* (p.322).

The influences on individual practice from Nutley & Davies (2000) is shown below in **Figure 2.4**. The aspects of research evidence (EBP), craft knowledge (individual), and social factors such as peer values and pressures and service user demands have been covered. The remaining broader influences include organisational structures and cultural norms or organisational culture, as well as organisational resources.

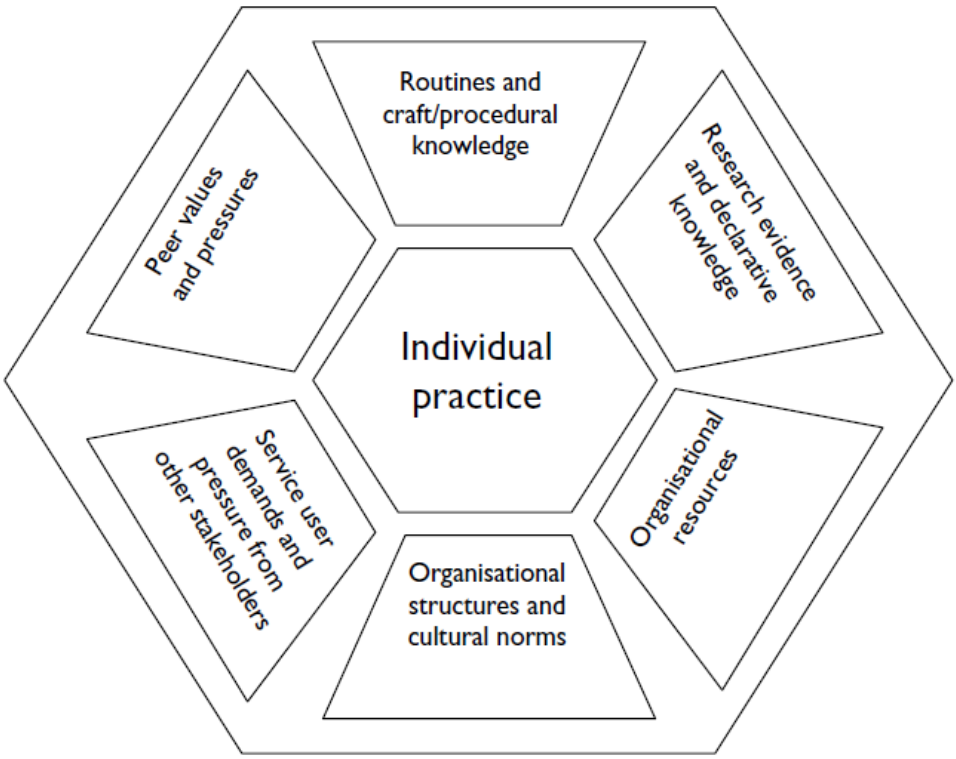


Figure 2.4 Broader influences on individual practice (Nutley & Davies, 2000, p.337)

Organisational culture has the power to enable or disable particularities of individual practice. In the effort to increase the value of EBP within an organisation, it should also be reflected in evidence-based management. Additional organisational influences include resource availability, i.e. people, property/equipment, budgets, etc. These resources can be fixed and limited and may therefore reinforce the status quo (Nutley & Davies, 2000).

The concept of organisational learning (Argyris & Schön, 1996) helps to explain the generation of knowledge through 'double-loop learning'. This double loop connects the observed effects of any action with strategies and values, to inform and allow the organisation to learn. This cannot be done with an overly restrictive management. Management should place broad constraints to allow for new learning (avoid inhibitory loops) (Morgan, 1986). Senge (1990) describes the five disciplines to become a learning organisation: open systems thinking; improving individual capabilities; updating mental models; a shared vision; and team learning. Similarly, learning from communities of practice can take place at an organisational level, in 'communities-of-communities' (Brown & Duguid, 1991).

2.6.2 Implementation Strategies

Valuable insight can be found from the research utilisation and knowledge translation literature with respect to the best strategies for implementing safety, quality, or evidence into healthcare practice. Everett Rogers' Diffusion of Innovations Theory has been used to understand the dissemination of an innovation through the participants of a social system. Within his theory, the process of diffusion ranges on a continuum from highly centralised to highly decentralised, where power and control of innovation diffusion is shared (Rogers, 1995). Nutley & Davies (2000) describe EBP implementation as the diffusion of an ideology, technical innovation, and organisational innovation. Literature tends to emphasise the uptake of new innovations, but brings less attention to calls for discontinuance of ineffective practices. Evidence may not always promote a new practice/innovation.

Traditionally, the model for the dissemination of research evidence into practice is depicted as a linear process from the distinct domains of the university researchers as (objective) knowledge creators to frontline practitioners (actors in the subjective practice). This has alluded to a natural hierarchy of university-centred knowledge creation. Green (2008) refers to the inaccuracy of assuming a linear transfer of research into practice as the 'pipeline' fallacy. An alternative model depicts knowledge at local levels from centres of expertise as well as expert centres, and the two domains are collaborative in generating and utilising knowledge (Nutley & Davies, 2000).

Despite the differences in the interests, language, and time scales of researchers and practitioners, greater collaboration is required between the two groups. Nutley *et al*. (2003) suggest the importance of understanding how practitioners conceptualise the problem with their existing knowledge, which may vary from the researcher's understanding. Successful implementation should, therefore, focus on the attitudes and local practices of recipients of research. Green (2008) proposes production of research closer to local practice such as through action research, participatory research, and practice-based research. External validity should also be promoted, opposed to a focus on internal validity only.

Due to the substantial amount of published research that health professionals would need to be aware of, guidelines are a useful tool for presenting new evidence in concise recommendations for practice. Guidelines 'aim to reduce variations in practice across

health professionals for the same condition and improve patient outcomes' (Hoffmann *et al*., 2013, p.314). This brings into question the development of these guidelines and the translation and use of the guidelines. The development of such guidelines (such as those from national or professional bodies) should be done using systematic reviews of evidence (Oxman & Flottorp, 2001). Dissemination of guidelines should be strategic in order to achieve successful implementation. Both written and personal approaches (i.e. scientific journals, outreach visits, local consensus discussions, etc.) should be used to explain guidelines (Grol, 2001).

The Cochrane Collaboration's Effective Practice and Organisation of Care (EPOC) group is responsible for undertaking systematic reviews of intervention effectiveness. Based on a review of 41 systematic reviews considering interventions for behaviour change, they found that no single intervention was effective all of the time (Grimshaw *et al*., 2001). Interventions which had variable successes included audit and feedback; use of local opinion leaders; local consensus-generating procedures; and patient-mediated interventions. The most consistently effective interventions were interactive education meetings; education outreach visits; and reminders. Multifaceted interventions (combining more than one) was seemingly more effective than any single intervention alone. Similarly, Oxman *et al*. (1995) reviewed 102 systematic reviews of educational interventions in healthcare and found there were no 'magic bullets' for improving healthcare. Additionally, the EPOC members have found that targeting interventions for change at specified barriers to change and at different levels are more effective than non-specific interventions (Grol & Grimshaw, 2003), and that there is a dearth of economic evaluations and cost analyses that accompany intervention implementation (Grimshaw *et al*., 2004).

While there are several theories, concepts, and frameworks for the successful implementation of EBP, one of particular interest is the Promoting Action on Research Implementation in Health Services (PARIHS) framework. Harvey & Kitson (2015) consider the variables for successful implementation (SI) to be a function of evidence, context, and facilitation with an assumption of equal importance –expressed as SI = *f*(E,C,F). Evidence (strength of evidence), context (culture, leadership, and measurement), and facilitation (characteristics, role, style) are each scored on a continuum from low to high. Taking for example evidence on the continuum,

- Unsystematic and anecdotal evidence = low
- Lack of professional consensus = low
- Patients' opinions overlooked = low

Harvey & Kitson do suggest that '…if clinical experience and patient preferences come out in favour of a particular intervention, even though the research evidence is low, then there may be more likelihood of it being adopted or continued' (2015, p.150).

2.7 Human Factors in Healthcare

Human factors and ergonomics (HFE) can be defined as the 'scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance' (International Ergonomics Association, 2016). The three primary domains of HFE include:

- Physical ergonomics (i.e. physical space redesign, safety and health);
- Cognitive ergonomics (i.e. decision making, work stress, training); and
- Organisational/social (macro) ergonomics (i.e. teamwork, work design, participatory design, safety culture).

Crossing all of these domains, HFE aims to systematically address human interactions with the system(s) in which they operate and optimise both the social and technical aspects of the system. In the realm of healthcare, Gurses *et al.* (2011, p.1-5) describe the effort of HFE specialists in studying and designing all parts within a system as 'an integrated whole (e.g. hospital) to maximise the system's overall performance, including patient safety, efficiency, and clinicians' quality of working life.'

Knowledge and use of HFE principles, theory, concepts, and methods have grown in healthcare, with applications in medical devices, equipment, and information systems (Norris, 2012). Although clinical familiarity with HFE was lacking only a decade ago, the field has grown and many healthcare providers have come to value human-centred systems thinking (Catchpole, 2013). Anaesthesiology has been a leading medical specialty in the adoption of HFE techniques, drawing from high reliability industries such as aviation, in the effort to improve patient safety (Gaba, 2000).

With the uptake of HFE in healthcare, a false equivalency of 'human factors' with 'human error' has emerged, blaming the behaviour of people as the cause for failure resulting in adverse events or patient harm. This misunderstanding of HFE incorrectly concentrates effort on the individual instead of the system, allows the perpetuation of underlying problems, and attempts to modify behaviour by training instead of system redesign to support performance (Russ *et al.*, 2013; Catchpole, 2013). The HFE approach to healthcare improvement is explored further in the following sections, which will discuss specifically a systems approach to improving healthcare quality and patient safety, and literature surrounding the (re)design of healthcare.

2.7.1 Systems Approach to Quality and Safety

HFE is by nature a systems discipline and should acknowledge the existence and interactions of the broader context on any individual component (Wilson, 2014). Healthcare, among other domains, consists of multiple, tightly coupled, sub-systems with work practices crossing numerous boundaries and interacting with one another, thus increasing complexity significantly. Additional complexity arises from the role of the healthcare practitioner and patient ('customers') in the design of products and services (Carayon, 2006). Complexity science supplements this understanding of healthcare by recognising the interconnected individual units within the system will act in ways that are relatively unpredictable, non-linear, self-organising, and adaptive (Plsek & Greenhalgh, 2001).

The sociotechnical system (STS) considers multiple levels of interactions between people and elements of the work system such as organisational structures and processes. Rasmussen (1997) and Moray (2000) depicted the STS within vertical models, with interactions taking place between system levels. A simplified depiction of Moray's 'onion' model is shown in **Figure 2.5**. The complexity of some systems may not be easily depicted in a linear fashion as many systems exist as nested, 'systems of systems', with systems and sub-systems, parent-child systems, or sibling-sibling systems (Wilson, 2014). In the healthcare delivery system, Karsh and Brown (2010) describe the hierarchical and nested nature of systems, as a hospital contains multiple units consisting of doctors and nurses. The patient is nested under the supervision of a nurse, but may be under the responsibility of multiple nurses across different shifts, and the charge nurses, nurse manager, and supervisor. An additional hierarchy exists for the

more junior physicians caring for the patient under supervision of more senior physicians. Karsh and Brown (2010) suggest the macro-ergonomics is the way forward in patient safety research, by investigating the influence of multiple levels.

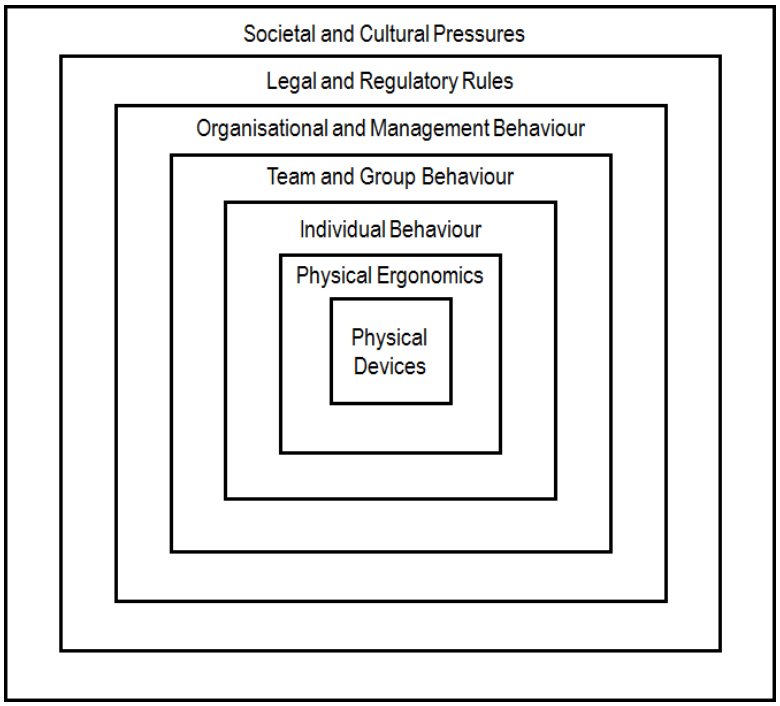


Figure 2.5 Simplified version of Moray's (2000) model of a sociotechnical system

The systems perspective of risk management has been fostered by the works of Charles Perrow (1984) and James Reason (1995) who have considered the interactions of failures resulting in a cascade of more serious failures and organisational contributions to 'latent conditions' which permit errors to occur, respectively. In an example of HFE systems thinking, Vincente (2003) utilised Rasmussen's (1997) framework to show the relationships between different levels affecting the decision making within a medical device manufacturer. The systems approach in risk management should not, however, strictly focus on error identification and minimisation, but on enhancing human performance on all levels (Cook & Woods, 1994). Holden (2011) reviewed the implementation of Lean thinking in emergency departments, showing the impact on organisational change, such as work structures and processes, that indirectly affect healthcare quality and outcomes. He suggested a HFE approach could supplement such organisational change by understanding better the needs of people (e.g. patients and employees) and their contributions in the change process.

Dul *et al.* (2012) differentiate HFE from other disciplines such as engineering, medicine, and psychology, based on its two-fold focus on the outcomes of any system: performance and well-being. Performance relates to outcomes of the work system such as productivity, efficiency, quality, flexibility, and reliability. Well-being is also a product of the system, including factors such as health, safety, satisfaction, learning, and personal development. Specialists in HFE are equipped to manage the practical trade-offs of complex systems to help solve problems of improving performance and safety (Wilson *et al.*, 2009).

Originally funded by the AHRQ, the Systems Engineering Initiative for Patient Safety (SEIPS) was developed as a work systems model which incorporates a systems approach to improve patient safety and performance (Carayon *et al.*, 2006) and was updated to SEIPS 2.0, in 2013 (Holden *et al.*, 2013). The model, shown in **Figure 2.6**, draws on Donabedian's (1988) structure-process-outcome (SPO) framework for the assessment of quality in healthcare.

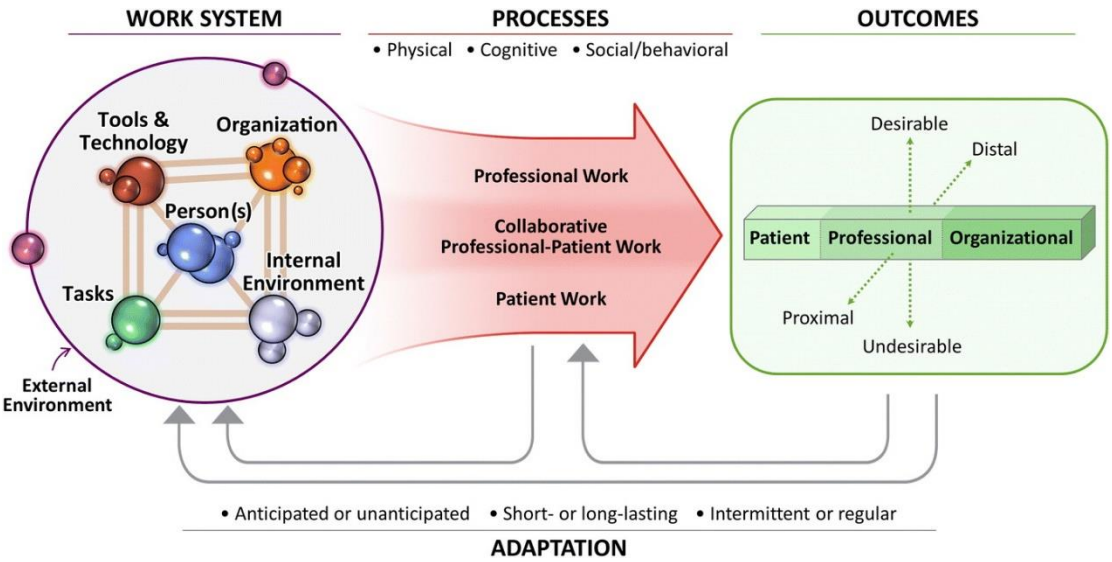


Figure 2.6 The SEIPS 2.0 model (Holden *et al.*, 2013, p.1672)

The SEIPS model places focus on the work system, or structure in the traditional SPO framework, which will affect the clinical processes and eventual outcomes of patients, employees, and organisations. Carayon *et al.* (2006) models the various interactions between five key components of the work system:

- Person (e.g. experience, motivation, physical and psychological characteristics)
- Tasks (e.g. work load, autonomy, control, time pressure, attention needs)

- Tools and technologies (e.g. information technology, medical devices)
- Physical environment (e.g. physical layout, noise, lighting, temperature)
- Organisation (e.g. teamwork, (safety) culture, scheduling, management style).

In 2013, the updated version of the model (SEIPS 2.0) proposed several changes to the work system model including the following:

- Patient includes both patients and healthcare professionals simultaneously.
- Differentiation of the internal and external environments to address macro-level factors including influences from society and policy, etc.
- Incorporation of a hierarchical arrangement between factors on an individual, organisational, internal, and external environment levels.

The work processes were changed in SEIPS 2.0 to represent physical, cognitive, and social or behavioural performance processes. Additionally, the work outcomes relating to the patients, professionals, and organisations were reframed to encompass outcomes which may become evident through time (i.e. proximal and distal) and may be desirable or undesirable. SEIPS 2.0 also developed the model further to incorporate three additional concepts of configuration, engagement, and adaptation.

The concept of configuration focuses on the interactions taking place between various system components, sometimes simultaneously. In **Figure 2.6**, the work system model depicts the numerous possibilities of networked system elements with spheres relevant to each work system component. Holden *et al.* (2013) describe "relevant" interactions to be those that strongly influence the performance of the work process. Akin to different properties being exhibited based on molecular configuration, the dynamic work system will have changing configurations that are relevant to certain processes at specific points in time.

Engagement in work activities was defined by Holden *et al.* (2013), considering both agents and co-agents involved in work activity. The main categories for engagement were differentiated as professional, patient, and collaborative work. Professional centred on the professional or team of professionals providing care to the patient, whereas patient work considered engagement from patients, family members, and non-professionals. Collaborative work captured the active involvement of a combination of agents along the continuum of engagement.

Finally, the concept of adaptation was incorporated into SEIPS 2.0 with the addition of feedback loops showing adaptations, both intended and unintended. Wilson (2014) discussed the inevitability of adaptations to complex sociotechnical systems, and Holden *et al.* (2013) described the variability of adaptations as being anticipated or unanticipated, short or long-lasting, intermittent or regularly occurring.

This conceptualisation of work systems has been applied to identify both obstacles and facilitators to performance. The SEIPS model was used after identifying major performance obstacles to intensive care unit nurses in order to test the impact on nursing workload, quality of care, and quality of nurse work life (Gurses & Carayon, 2009; Gurses *et al.*, 2009). Through this exercise, areas within the work system were identified which could be changed in order to improve quality and performance. The decision making involved in redesigning the work system is discussed in the next section. The SEIPS model can also be combined with root cause analyses in order to systematically consider possible contributing factors to adverse events (Carayon *et al.*, 2014). In practice, Carayon *et al.* (2006) warned of possible misalignment of what the work system model identifies and the individual professional autonomy expected from healthcare providers within their work system. This resistance to management of work processes using this approach could result in difficulty implementing the SEIPS model.

2.7.2 Design and Change of Healthcare Systems

The HFE systems approach can be taken to identify areas for improvement, and incorporate that knowledge in change initiatives or systems (re)design. In the effort of improving patient safety, several paradigms have been proposed, mainly focusing on reducing injury, reducing error, or improving evidence-based practice. Karsh *et al.* (2006) argue the mechanisms for such paradigms are unexplained in their effect on injury, error, and quality, and therefore suggest a HFE paradigm aiming to improve healthcare practitioner (HCP) performance and reduce hazards. Building on the SEIPS model, previously discussed, Karsh *et al.* (2006) described the system inputs (work system) similarly; however, they emphasised the three transformations/processes which patients and HCPs undergo -physically, cognitively, and socially, which was later added to the SEIPS model. Although as the authors stated, ‘all human activities are essentially ‘cognitive’ to the extent that the brain is involved in everything we do’

(p.i62). Designing systems to enhance performance (and therefore eliminating hazards), is proactive, encourages positive thinking, and identifies the needs of HCPs.

The Balance Theory was developed by Smith and Carayon in the 1980's as an integration of literature surrounding job design, worker well-being, and performance (Smith & Sainfort, 1989). The core principles of the Balance Theory are (1) to eliminate any negative aspects within the work system model, and (2) to balance the work system. As it may not always be possible to eliminate all negative aspects of the work system, a balance of the system can be achieved by compensatory balance, where positive elements can compensate for any negative elements, or overall system balance can be achieved where there are more overall benefits compared to problems. The Balance Theory can be used for job design and even organisational design to reduce work stress and health and safety problems while improving motivation and performance (Carayon & Smith, 2000). Smith & Sainfort (1989) describe the stress load on the individual as a physical demand of the individual resulting in a psychological response which is affected by the perception of the demand. Drawing from several job stress theories, the Balance Theory recognises the influence of perception of load, based on factors such as individual personality, past experiences, and social situations. This theory utilises the work system model to identify stressful elements in all areas of the work system, to balance overall those elements. Although the Balance Theory integrates system thinking and provides a holistic conceptualisation of work stress and design in order to improve the system, the theory lacks in recommending how organisations can reconcile individual perceptions of stress and reasonable workloads, and the resulting conflicts which may exist. Additionally, the theory requires judgements to be made as to what is good or bad (or tolerable), and who should be making such judgements. This idea will be explored throughout this thesis.

A key feature of HFE is involvement of end users as participants in the design and development process (Noro & Imada, 1991). In order to match the needs of 'customers' to products or services, user-centred design has become more prevalent; however, the 'user as subject' design approach relies on a researcher as an expert to gather input from users. Participatory design or co-design treats the 'user as partner' and involves the collaboration of multiple users in the design process (Sanders & Stappers, 2008). In healthcare, participatory design has been used in design of healthcare facility (Caixeta *et al.*, 2013) and information systems (Sjöberg, & Timpka, 1998).

In a similar vein, participatory ergonomics (PE) emphasises the involvement of workers to improve the productivity and quality of their job. PE has been applied in industries including manufacturing, military, construction, transport, healthcare and others (Hignett *et al.*, 2005). Early work by Haines *et al.* (2002) provided practical guidance for PE initiatives by framing multiple dimensions relevant to PE, shown in **Table 2.2** in ranked order of importance (as in Hignett *et al.*, 2005). The most important dimensions for PE related to who is given decision making power and ensuring involvement of participants at all levels.

Table 2.2 Framework for participatory ergonomics (Hignett *et al.*, 2005)

Rank	Dimension	Extent of dimension
1	Decision making	Group delegation; Group consultation; Individual consultation
2	Mix of participants	Operators; Supervisors; Middle management; Union personnel; Specialist/technical staff; Senior management
3	Remit	Process development; Problem identification; Solution generation; Solution evaluation; Solution implementation; Process maintenance
4	Role of ergonomics specialist	Initiates and guides process; Acts as a team member; Trains participants; Available for consultation
5	Involvement	Full direct; Partial direct; Representative
6	Focus	Designing equipment or tasks; Designing jobs, teams or work organisation; Formulating policies or strategies
7	Level of influence	Entire organisation; Department/work group
8	Requirement	Compulsory; Voluntary
9	Permanence	Ongoing; Temporary

Wilson & Haines (1997) recommend early involvement of those who would be affected by an innovation to ensure successful implementation and sustainability of the innovation. In healthcare, HCPs and patients are system users and must be involved in

design in order to meet their needs. Dul *et al.* (2012) present the four main groups of stakeholders who can value from being involved in system design:

- System actors (i.e. employees, patients)
- System experts (i.e. professionals, including engineers and HFE specialists)
- System decision makers (i.e. managers, purchasesrs)
- System influencers (i.e. government, regulators, media, general public)

The challenges of change have been previously discussed with regards to individual, social, and organisational change theories; however, the challenge of systems design must continue after undergoing organisational or technological change -beyond the implementation (Clegg, 2000). Carayon (2006) integrated the model and principles for learning, development, and continuous change (Engestrom, 2000; Weick & Quinn, 1999) to compile an initial set of principles for macroergonomic continuous system adaptation and improvement including the following:

- Participate – active participation of customers (e.g. participatory ergonomics);
- Interact – continuous interactions between customers and the organisation;
- Design – continuous system design and redesign;
- Adapt – adaptive product/service and long-run system adaptability;
- Learn – supporting individual and organisational learning;
- Make Sense – sense-making of on-going changes and their impact.

While the literature included in this review is non-exhaustive, it has provided sufficient background into complex system design, with a focus on the goals of system (re)design, those who should participate in the design process, and the need to continually learn and adapt following change implementation.

2.8 Chapter Summary

The literature surrounding anaesthetic rooms, specifically, and strategies for improvement change, more broadly, have been discussed in this chapter. The studies pertinent to aspects of anaesthetic room use are conflicting and do not entirely align regarding a support or challenge to this practice. The wider goals of improved patient safety and healthcare quality have been explored, and the unique strategies and challenges of achieving them presented. While tools and approaches for understanding

organisational culture and change are prevalent in the literature, a gap exists as to the mechanism by which conflicting research evidence, individual goals, and organisational priorities can be balanced in devising solutions for healthcare practice and systems design.

Chapter 3 Evaluation of Current Anaesthetic Room Practice

3.1 Chapter Overview

This chapter explores current practice and preferences of consultant anaesthetists for the use of anaesthetic rooms. Considering the outcomes from previously published surveys investigating anaesthetic room use, this chapter presents the findings of a questionnaire study examining the most current opinions and preferences of consultant anaesthetists within the East Midlands region of the UK.

3.2 Introduction

The professional discourse surrounding anaesthetic rooms has been published in the form of editorials, correspondences, ad-hoc audits, and some peer-reviewed studies aiming to either justify or disprove their necessity (Evans, 2004; O'Connor *et al.*, 2003; Sawyer, 2001; Newport, 2001; Broadway *et al.*, 2001). Standards of practice and personal preferences for the use of anaesthetic rooms in the UK have been investigated using surveys in the past (e.g. Husain *et al.*, 2005; Bromhead & Jones, 2002; Masters & Harper, 1990). Considering the known contention on the subject and claims of seemingly little change within the anaesthetic community (Harmer, 2000), a current view of practice was needed to identify where individual anaesthetists have chosen to align themselves in this disagreement.

This questionnaire study was developed in order to explore current anaesthetic practice and general perspectives of anaesthetists on anaesthetic room use. The aims of the study were to:

- explore the role of anaesthetic rooms across multiple organisations;
- identify the ways in which anaesthetic rooms are used;
- gather the reasons for preference of in-theatre or anaesthetic room induction;
- investigate the willingness of anaesthetists to change anaesthetic room practice;
- and find which types of evidence would be most influential in changing practice.

In order to understand current anaesthetic practice and the range of opinions surrounding anaesthetic rooms, consultant anaesthetists were selected as the key

stakeholders that would best be able to describe both their own practice and the rationale behind it.

3.3 Methods

3.3.1 Participants

Consultant anaesthetists were identified as the ideal participants for this study aiming to explore current practice and gauging individual willingness to change anaesthetic room practice. Eligibility criteria for this study was limited to consultant grade anaesthetists, as was suggested by two anaesthetists involved in the design of this questionnaire. They advised that experienced anaesthetists at consultant level would be able to decide the site of induction for patients without repudiation of their choice from more senior anaesthetists, which could be the case for registrars or other trainee grade anaesthetists.

Based on membership data from the AAGBI, the entire population of anaesthetists within the UK is well over 10,500, with 55% being domestic practising non-trainee anaesthetists (AAGBI, 2014). The sampling frame for this study was limited to the East Midlands region of the UK, because although data collection across the UK was pursued by contacting a membership officer of the AAGBI, it was not possible due to lack of membership of the researcher to the association. Based on correspondence with the AAGBI officer, a postcode search of membership within the East Midlands showed 761 AAGBI members of varying statuses (J. Gallagher 2014, personal communication, 15 May).

A random sampling method (Gray, 2014) was used to recruit from all consultant anaesthetists working within the East Midlands NHS Trusts which granted study approval. Clinical local collaborators were identified in each Trust in order to facilitate recruitment in each site. The anaesthetic advisors of this research initiated connections with local hospitals to involve local collaborators. All local collaborators were members of the anaesthetic or surgical directorates within their Trusts and distributed a study invitation email (and two reminders at one week and three weeks) to all consultant anaesthetists within their Trusts. Collaborators were identified in ten NHS Trusts within the East Midlands, of which nine approved the study to take place in the desired time frame for the research.

3.3.2 Ethics

The questionnaire study of this chapter was part of a larger study protocol including studies from Chapter 3-6. The protocol (version 3) was approved by the University of Nottingham Faculty of Engineering Research Ethics Committee on 22nd May, 2014. Due to the self-completing nature of this questionnaire study, consent of participants was assumed upon completion of the survey. No written consent was required; however, a participant information sheet was sent to all participants within the email invitation distributed to them by the local collaborator of their site.

All data collected maintained confidentiality of the participants; however, participants were able to provide an email address at the end of the survey so that a summary of the study results could be sent to them and recruitment for future studies could take place. These email addresses were stored separately from survey data to prevent identification of individual participant responses.

3.3.3 Data Collection

As a cross-sectional study, a self-completed online survey was chosen as the method of data collection, gathering both quantitative and qualitative data regarding attitudes and behaviour of respondents. This method was selected as the most economical and timely option (Bowling, 2014) for distributing and collecting completed questionnaires from participants across an entire region of the country. A web-based survey is also argued as superior to traditional paper-and-pencil surveys in ensuring better completeness of data (Kongsved *et al.*, 2007). Setting the requirement or optionality of each question in a web-based survey automatically prompts the participant to complete unanswered required questions, if they attempt to proceed to the next page without completing the questions. The University of Nottingham provided a free license for use of the Bristol Online Surveys (BOS) tool in developing the survey.

A criticism of survey methodology is that it assumes a common language and understanding of statement wording between the researcher and respondents (Bowling 2014). In order to prevent miscommunication of an American researcher to British-practising anaesthetists, the initial survey design and questions were content validated by two consultant anaesthetist collaborators. Some terminology was changed which differed between the USA and UK, such as the abbreviations EKG versus ECG for

electrocardiogram. Certain activities were clarified in terms which would be better understood by using professionally accepted acronyms (e.g. World Health Organisation (WHO) checklist, arterial (ART) and central venous pressure (CVP) lines, National Confidential Enquiry Into Patient Outcome and Death (NCEPOD) lists). The survey was reviewed in its final form by two experienced healthcare researchers at The University of Nottingham.

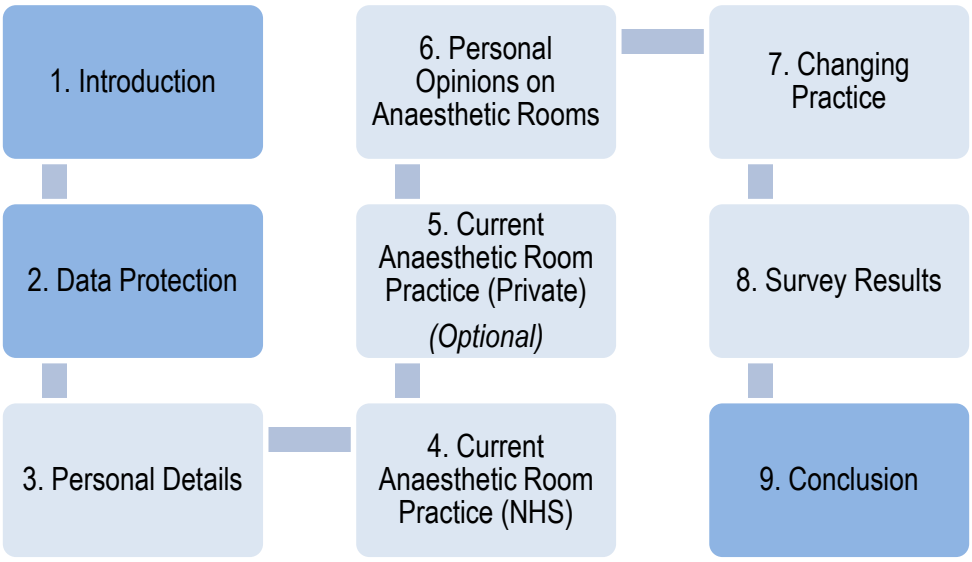


Figure 3.1 Anaesthetic room questionnaire sections

The survey design consisted of nine sections, as shown in **Figure 3.1**, which included six data entry sections. Questions included multiple choice (single and multiple answers), rating scales (e.g. Never to Always, or 'Not At All Important' to 'Very Important'), and open responses. Rattray & Jones (2007) suggest that closed questions can limit the depth of responses provided by respondents, which may be inappropriate if little is known regarding a subject area, open response questions were used to further explore rationale and decision making, which would not be made evident through multiple choice responses alone.

The survey took approximately 10 minutes to complete and consisted of 22 questions. It was launched on 22nd July, 2014 and closed on 31st December, 2014, with a total duration of 5 months. The portions of the survey, Parts 3-4 and 6-7, are shown in **Appendix A**[2].

[2] Part 5 is excluded from the appendix as the questions are identical to Part 4, but oriented toward experience in the private sector, which was optional depending on individual experience.

3.3.4 Data Analysis

Quantitative data analysis of the questionnaire responses required descriptive, bivariate, and multivariate statistics. The statistical analysis was conducted using version 22 of the Statistical Package for Social Sciences (SPSS). Descriptive statistics were used to define the demographics of respondents and the frequency of use of anaesthetic rooms. Bivariate analysis was used to determine the relationship between individual characteristics of the participants versus preference and opinions, using contingency tables of Pearson's Chi-square analysis. Multivariate analysis of the importance of various factors for choosing the site of induction was done using the Wilcoxon Signed Rank Test, as the rating scales used for factors of importance (anchored from 0 = 'Not at all Important' to 4 = 'Very Important') on a Likert scale should be considered ordinal data, thereby requiring nonparametric testing. Although this rule of thumb is commonly disregarded, as Jamieson (2004, p. 1218) states 'the average of 'fair' and 'good' is not 'fair-and-a-half'; this is true even when one assigns integers to represent 'fair' and 'good'!' In addition to quantitative analysis of the survey data, open response questions were categorised using Microsoft Excel® to identify frequently referenced topics.

3.4 Hypotheses

The survey was designed to explore the role and importance of anaesthetic rooms, while also testing the relationships of variables referenced in literature. The following section presents the hypotheses which were formulated from anaesthetic room literature and collaborative input from local anaesthetists.

3.4.1 Experience & Training

Previous surveys of anaesthetic practice have shown that younger anaesthetists are less adamant in terms of whether they will induce in the anaesthetic room or the theatre (Husain *et al.*, 2005; Masters & Harper, 1990). Therefore, it is possible that more senior anaesthetists would be less willing to alter their practice.

Hypothesis 1. More experienced anaesthetists will prefer to use the anaesthetic room more often.

Hypothesis 2. More experienced anaesthetists will be less willing to change their practice in regard to the site of induction.

Working abroad may also have an influence on anaesthetic preferences as consultants who worked in countries where anaesthetic rooms are not the norm were less likely to feel anaesthetic rooms are always desirable (Masters & Harper, 1990).

Hypothesis 3. Anaesthetists with experience training or working outside of the UK will not prefer to anaesthetise in the anaesthetic room as frequently as those who do not have international experience.

Hypothesis 4. Anaesthetists with experience training or working outside of the UK will be more willing to change their practice in regard to the site of induction.

A final aspect of individual experience, which may have an impact on adaptability and therefore willingness to change practice, is work within the independent sector in addition to NHS practice. This theory was developed from knowledge of a local private treatment centre which did not have any anaesthetic rooms built as part of the relatively new theatre complex. The ability to practise in both organisations and both models of working may be evident in the willingness to change of anaesthetists who practise between the public and private sectors.

Hypothesis 5. Anaesthetists that practise in the private sector will be more willing to change anaesthetic practice than those who only work in the NHS.

3.4.2 Infrastructure & Organisational Policy

Based on literature, the existence of anaesthetic rooms is the norm in UK hospitals, and although the Department of Health's requirements for anaesthetic rooms mention both the advantages and disadvantages of building such a room, they are still strongly supported in the Health Building Note on facilities for surgical procedures (DOH, 2004).

Hypothesis 6. The majority of hospitals will have anaesthetic rooms built adjacent to most operating theatres.

During the development stage of the study, local collaborators informed the research team of the private treatment centre which chose not to include anaesthetic rooms when the facility was constructed. As construction of new hospitals is infrequent in the NHS,

it is possible that more private hospitals, which were built more recently, may have chosen not to build anaesthetic rooms. This could suggest that there is a relationship between the healthcare sector and the prevalence of anaesthetic rooms.

Hypothesis 7. There will be a relationship between the healthcare sector and presence of anaesthetic rooms in the hospital.

3.4.3 Surgical Specialties

The specialty of surgery has been relevant to the debate on anaesthetic rooms as the benefit of the room differs depending on the type of surgical procedure. While the use of anaesthetic rooms can increase the number of cases done on an orthopaedic list (Torkki *et al.*, 2005), the majority of obstetric anaesthetists have abandoned anaesthetic room induction for patient safety reasons (Husain *et al.*, 2005). This suggests that the preferred site of induction may vary significantly between specialties, and also with respect to the type of patient being anaesthetised:

Hypothesis 8. Preference for anaesthetic rooms will vary significantly based on specialty of surgery.

Hypothesis 9. Preference for anaesthetic rooms will vary significantly based on type of patient.

3.4.4 Changing Practice

Based on previously mentioned surveys, there appears to be a lack of change over decades of debate on anaesthetic rooms, therefore, it is a likely assumption that the majority of anaesthetists are unwilling to change accepted practice.

Hypothesis 10. The majority of anaesthetists will be unwilling to change anaesthetic practice in regards to the site of induction.

Additional factors that may affect willingness to change include professional experience, international experience, and experience working in the private sector (see Hypotheses 2, 4, and 5, respectively).

3.5 Results

A brief summary of results was compiled in the form of a newsletter for respondents that wished to receive the results of the study. The results summary that was shared with participants can be seen in **Appendix B**.

3.5.1 Demographics

A total of 202 consultant anaesthetists completed the questionnaire, with an estimated overall response rate of 42% for the nine NHS Trusts that distributed the survey. As the link to the web-based survey was distributed by local collaborators within each NHS Trust, all respondents were practising clinicians within the NHS. Ninety-one (45%) of those anaesthetists also practised in the private sector. The distribution of responses between Trusts is shown below in **Table 3.1**.

Table 3.1 Distribution of responses based on study site

Site	NHS Trusts	Participants (% of total)	Estimated Response Rate
1	University Hospitals of Leicester	50 (25%)	45%
2	Nottingham University Hospitals	32 (16%)	33%
3	Northampton General Hospital	27 (13%)	79%
4	Derby Teaching Hospital	23 (11%)	41%
5	Peterborough and Stamford Hospitals	19 (9%)	46%
6	Doncaster and Bassetlaw Hospitals	17 (8%)	43%
7	Sherwood Forest Hospitals	13 (6%)	45%
8	United Lincolnshire Hospitals	12 (6%)	26%
9	Chesterfield Royal Hospitals	9 (4%)	41%

The majority of respondents had practised as consultant grade anaesthetists for between 5 to 14 years (40%), with most others qualifying either 15-24 years before (27%) or within the last 5 years (25%). The remaining respondents were consultants for over 25 years (7%).

In terms of training and experience working outside of the British healthcare system, 53.5% of respondents (n = 108) had only trained and worked within the UK, whereas the remaining 46.5% (n = 94) had either trained or worked abroad. **Figure 3.2** shows

the breakdown of training and work experience of all of the respondents. Of the 94 anaesthetists who had international experience, 54 had undertaken their medical training outside of the UK and 76 had practised anaesthetics internationally. The differentiation between anaesthetists with international experience and those without was used for testing the significance on clinical preference and attitudes toward changing practice (hypotheses 3 and 4).

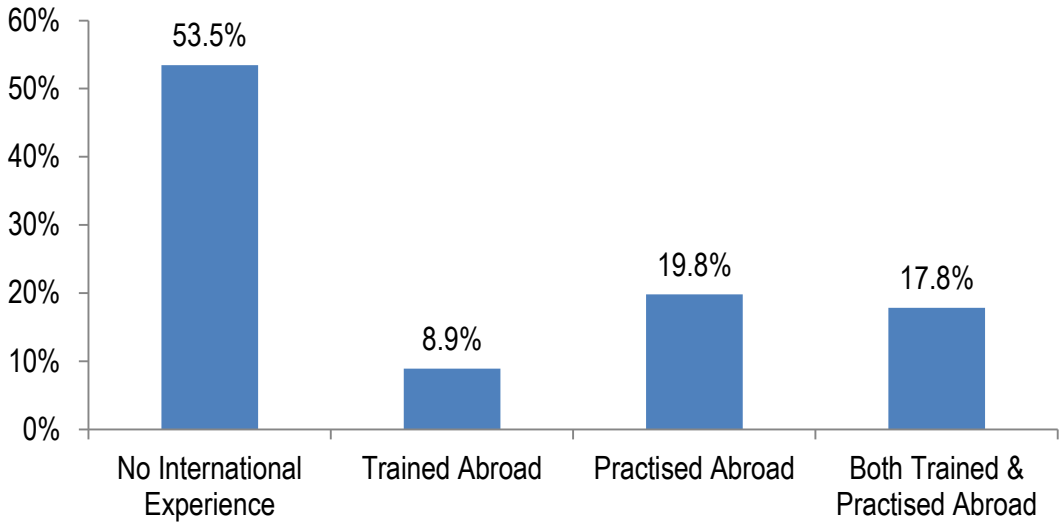


Figure 3.2 International training and work experience

The most frequently reported countries where consultants had trained or worked were Australia, India, the USA, South Africa, and the Netherlands. For those who worked or trained internationally, the typical site of induction for the last country where the consultant worked was the operating theatre for 73% of respondents, the anaesthetic room for 22%, and 4% had no typical site of induction. This demonstrates that for the majority of consultants with international experience, they have had practice or training with in-theatre induction, opposed to anaesthetic room induction.

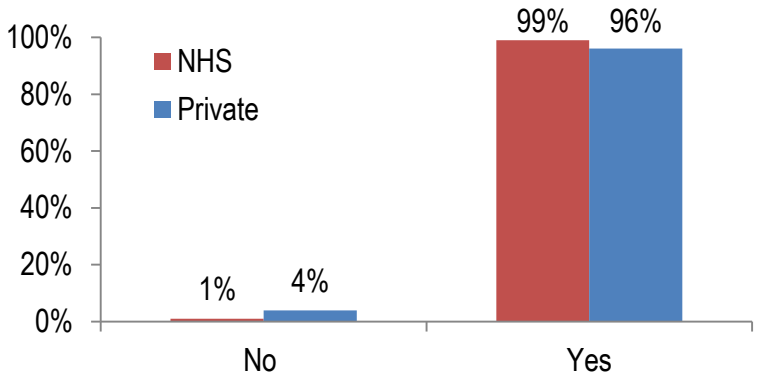
Hypothesis testing in regards to experience and training (hypothesis 1-5) will be presented in sections 3.5.4 and 3.5.7 as they related to clinical preference and change in anaesthetic practice.

3.5.2 Infrastructure & Organisational Policy

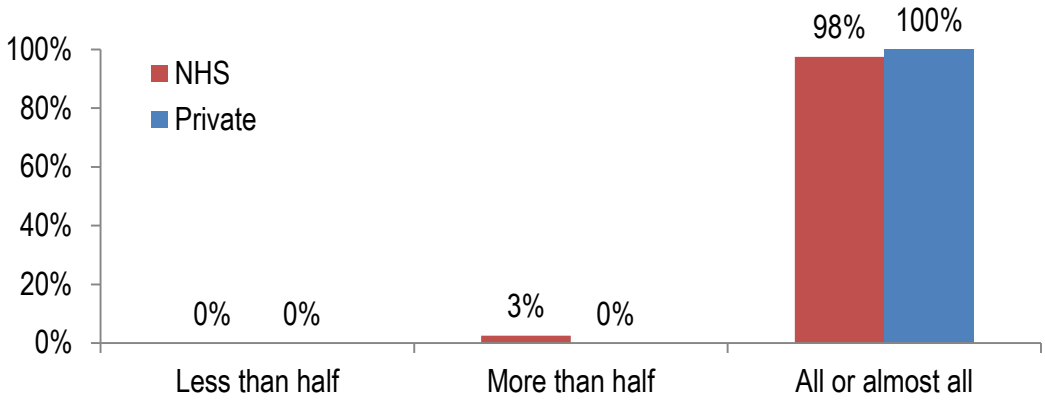
Prevalence of Anaesthetic Rooms (Hypotheses 6 & 7)

Responses resulted in an overwhelming consensus for the prevalence of anaesthetic rooms in current practice. All participants provided information regarding the

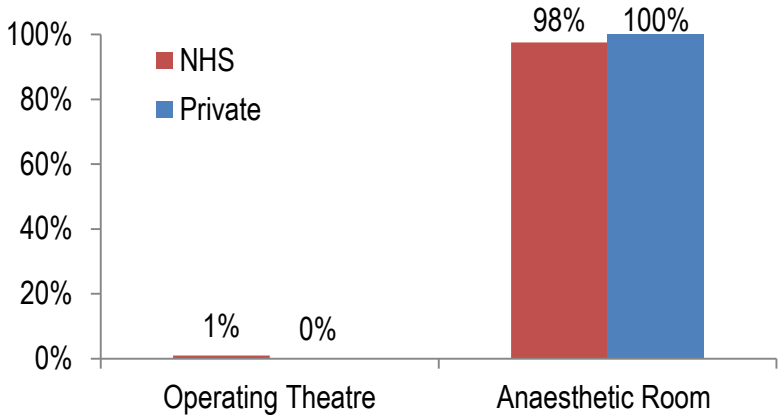
prevalence of anaesthetic rooms in the NHS hospitals where they worked, and the private hospital, if they also worked in the private sector. The survey revealed the existence and use of anaesthetic rooms as dominant in both the private and public sectors. **Figure 3.3** summarises the prevalence of anaesthetic rooms and the vast majority of patients who are induced in the anaesthetic room. These results support hypothesis 6, that the current majority of hospitals have anaesthetic rooms.



(a) Do you have anaesthetic rooms adjacent to your operating theatres?



(b) How many operating theatres have a corresponding anaesthetic room?



(c) Where are most patients induced for surgery in your hospital?

Figure 3.3 The prevalence of anaesthetic rooms in the public and private sectors

As shown in **Figure 3.3**, the incidence of anaesthetic rooms in private hospitals was slightly lower (3%) than within NHS hospitals, and more respondents (3%) indicated there were no ARs in their private hospitals. The results of a Pearson Chi-square (two-sided) test to determine the relationship between the healthcare sector on the existence of anaesthetic rooms violated the assumption of no more than 20% of expected counts being less than 5, due to the extremely low response rate for occurrences of hospitals without anaesthetic rooms. Therefore, the Fisher's exact test result was used and indicated a *p*-value = 0.131, meaning that the healthcare sector and the existence of anaesthetic rooms is not statistically significant. It can therefore be concluded that hypothesis 7 can be rejected and there is no significant relationship between whether a hospital is public or private and there being anaesthetic rooms built, within this sample.

Organisational Policy for Site of Induction

When asked if there were any hospital policies regarding the site of induction, over half indicated there was no policy (62.5% and 60.8% in the NHS and private hospitals, respectively). No respondents indicated the operating theatre to be the standard site of induction by policy. A third of respondents indicated that their hospital policy called for anaesthetic room induction (31% and 33.8%). The remaining respondents selected 'Other', which they explained meant they were unaware or unsure of any existing policy.

3.5.3 Team Composition

The number and type of staff members within the surgical suite are crucial to understand the typical work environment, as this may affect the general crowdedness, noise, activity level, available support, and the ability to turnover cases efficiently. Survey respondents were asked to indicate the typical number and type of non-medical staff per theatre. A comparison of responses on staffing between the NHS and private hospital are shown below in **Figure 3.4**.

The typical team composition was the same within the private and public sectors. A typical theatre team consisted of the following:

- 1 circulating practitioner
- 1 scrub practitioner
- 1 operating department practitioner (ODP) or anaesthetic nurse

- 1 support worker

One respondent clarified that although the above is the ideal staffing:

> *'... there are a number of times when there may be no support worker or circulating practitioner (i.e. 3 staff only).'*

Figure 3.4 Number of non-medical staff per theatre (NHS & private sector)

The highest occurrence of multiple staff members of the same role was the scrub practitioner, where a second scrub may be available. A total of 15% of respondents reported having two scrubs per theatre in their NHS hospital (9% in private).

Although the majority of consultants did not report having any non-medical first assistants or physician's assistants, 37.3% of consultants indicated they had a first assistant in the private sector (17.3% in the NHS).

Additional staff that were mentioned in the comments included a midwife in the case of obstetrics procedures, a recovery person who will take care of the patient following the operation, and a 'theatre technician'. As consultants were asked to provide the details of staffing for the operating lists they typically do, it may be possible that these individuals are regular team members for certain specialties at specific hospitals.

3.5.4 Clinical Preferences

Uses for the Anaesthetic Room

The respondents were asked to indicate in which ways they use the anaesthetic room, both in their NHS hospitals and within their private hospitals (if applicable). All 202 respondents completed this question for the NHS, whereas only 74 of 91 private practising respondents completed the same questions for their private hospitals. **Table 3.2** shows the most common uses for the anaesthetic room ordered by the highest to lowest frequency of response in the NHS.

Table 3.2 Common uses for the anaesthetic room in the NHS and private sector

Uses for the Anaesthetic Room	NHS	Private
Induction of anaesthesia	191 (95%)	72 (97%)
Establishing pre-operative monitoring	189 (94%)	71 (96%)
Placing invasive monitoring	185 (92%)	67 (91%)
Administering regional or peripheral nerve blocks	183 (91%)	68 (92%)
Store of anaesthetic supplies	170 (84%)	60 (81%)
Store of anaesthetic equipment	158 (78%)	53 (72%)
WHO sign-in	135 (67%)	51 (69%)
Pre-list team briefing	117 (58%)	30 (41%)
Communication with patients & family	104 (51%)	43 (58%)
End-of-list team debriefing	20 (10%)	7 (9%)
Store of surgical equipment	9 (4%)	2 (3%)
Other	23 (11%)	3 (4%)

The primary uses for the anaesthetic room, across both sectors, included provision of anaesthetics (general and regional), establishment of basic patient monitoring (e.g. intravenous lines, ECG leads, etc.), as well as invasive monitoring such as ART and CVP lines. The anaesthetic room is also used as a store for anaesthetic supplies and anaesthetic equipment, but not as commonly used for surgical equipment storage.

More than half of the respondents also use the space for communication purposes. The World Health Organisation (WHO) Surgical Safety Checklist has been adapted in many hospitals and requires a ‘Sign-in’ step, which double checks the patient information, clarifies allergies, and requires a verification from the surgeon, scrub team, and

anaesthetist that the anaesthetic can proceed. This is shown in Step 2 of the example safety checklist from the Nottingham University Hospitals NHS Trust in **Figure 3.5**. This check is typically conducted in the anaesthetic room. Additionally, team communication, both before and after the daily list, may take place there. The anaesthetic room was also shown to be used as a site for patient communication and family communication, likely in the case of paediatric patients where guardians may escort the child into the anaesthetic room prior to the commencement of surgery.

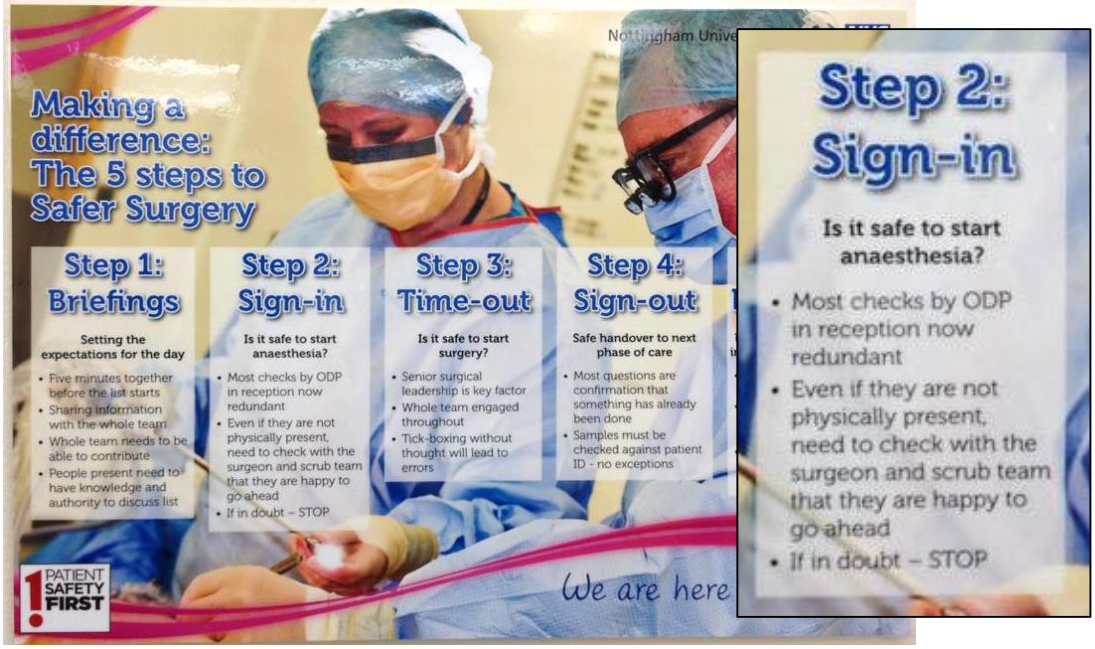


Figure 3.5 An example safety checklist for surgery

Some respondents provided additional uses for the anaesthetic room, which were not listed in the questionnaire. Seven respondents indicated that they use the room for coffee, refreshments, or lunch, particularly on long lists or when they are not able to get relief. Drug preparation was listed four times. The same number also used the anaesthetic room for orthopaedic surgical preparation, including patient positioning, skin preparation, draping, and catheterisation. Three consultants felt the need to specify that the anaesthetic room is used to prepare a patient when there is a patient already in the operating theatre to minimise the time between cases. Further uses of the anaesthetic room included teaching trainees, providing privacy or quiet for patients, a place to avoid radiation if lead aprons are not available, a passageway to access the operating room, and the location for various short surgical procedures.

Patient Specific Considerations (Hypothesis 9)

The consultants were asked to indicate their preferred site of induction based on various types of patients. Categories of patients included elderly, paediatric, standard adults, patients with an anticipated difficult airway, emergency patients, morbidly obese, and high risk patients. Although the term 'high risk' was not defined for the consultants and difficult airway, morbidly obese, and emergency patients could also be categorised as 'high risk', a separate category allowed for other high risk patients such as those with cardiovascular instability (e.g. abdominal aortic aneurysms) or obstetric patients where the time between induction and knife-to-skin should be minimised. **Table 3.3** shows the preferred site of induction for different types of patients.

Table 3.3 Preference for site of induction based on patient type by number of respondents (%)

	Site Preference			
Type of Patient	Anaesthetic Room	Operating Theatre	No Preference	Difference (AR-OT*)
Paediatric	177 (88%)	3 (2%)	22 (11%)	86%
'Standard' Adult	148 (73%)	21 (10%)	33 (16%)	63%
Elderly	143 (71%)	27 (13%)	32 (16%)	57%
Anticipated Difficult Airway	138 (68%)	52 (26%)	12 (6%)	43%
Emergency	95 (47%)	73 (36%)	34 (17%)	11%
Morbidly Obese	66 (33%)	118 (58%)	18 (9%)	-26%
High Risk	56 (28%)	129 (64%)	17 (8%)	-36%

*The difference in percentage of respondents is indicative of the relative strength of preference of one site over the other. A positive difference represents an overall preference for the AR, whereas a negative difference shows overall preference for the OT.

It was evident that the majority of consultants preferred to anaesthetise all types of patients in the anaesthetic room, with the exception of high risk (64%) and morbidly obese (58%) patients, with whom they preferred to anaesthetise in the operating theatre. Based on open responses, this is done to eliminate the transfer of the patient, to reduce the amount of time to surgery, or to induce in an environment with more staff available to help in case of deterioration of the patient. Two respondents stated that:

> *'… those patients who are obese, difficult airways, or life/death need to be done quickly or in a place where there is lots of help, should it be needed.'*

> *'We are used to having an AR available. We deviate from that routine only if there is a positive indication (i.e. patient safety; less transfers for an unstable or very obese patient).'*

The strongest preference to use the anaesthetic room for induction was in the case of paediatric patients, which resulted in an 86% difference in percentage of respondents in favour of anaesthetic room induction. Based on open responses, those who generally preferred to anaesthetise in the operating theatre found paediatric patients to be a compelling reason to induce in the anaesthetic room, or said it was not possible to induce children in the theatre. For example, one respondent wrote:

> *'I use the anaesthetic* [room] *only when anaesthetising children in order to enable parental presence. Otherwise I almost always anaesthetise in theatre.'*

In contrast, the patient type with the weakest overall preference was emergency patients, which only presented an 11% difference between proponents of anaesthetic room versus operating theatre induction.

In order to test hypothesis 9 and determine if a statistical difference exists between the type of patient and the preferred site of anaesthetic induction, a cross-tabulation was conducted. The result of the Pearson Chi-square test was $X^2(12) = 361.328$, $p = .000$, $V = 0.357$, which presents an omnibus result stating some significant difference within the various relationships assessed. **Table 3.4** shows the calculated adjusted standardised residuals (ASR) of the Chi-square test, and highlights which cells contributed the most to the test statistic. While the accepted critical value for small contingency tables is ±2, for larger tables, values of ±3 can identify cells that may reject the null hypothesis (Sharpe, 2015). This study merely highlights all ASRs of magnitude greater than ±2.

It is evident from **Table 3.4** that the same pattern from **Table 3.3** exists, as the largest residual magnitudes are in favour of the anaesthetic room for paediatric patients, and in favour of the operating theatre for both high risk and morbidly obese patients to a significant degree. A larger amount of respondents also indicated either 'No Preference' or in-theatre induction for the case of emergency patients compared to the expected numbers, which highlights the flexibility of use depending on specific circumstances.

Table 3.4 Adjusted standardised residuals (ASR) for the preferred site of induction

	Site of Preferred Induction		
Patient Type	Anaesthetic Room	Operating Theatre	No Preference
Paediatric	9.2	-9.5	-0.5
'Standard' Adult	4.7	-6.5	2.1
Elderly	3.9	-5.5	1.9
Anticipated Difficult Airway	3.1	-1.4	-2.8
Emergency	-3.5	2.1	2.3
Morbidly Obese	-7.9	9.6	-1.4
High Risk	-9.5	11.4	-1.6

Red = ASR > |±5|, Orange = ASR between |±3| and |±5|, Yellow = ASR between |±2| and |±3|

While the preference for inducing 'anticipated difficult airway' patients in the anaesthetic room was clear, this contradicted free responses which indicated the use of the operating theatre to induce patients with 'difficult airways', 'airway compromise', and for the purpose of 'emergency airway management'. It is possible, that as the survey specified *anticipated* difficult airway as a type of patient, that responses were indicative more of patients with known, challenging airways, where the anaesthetic room may be preferred as it is the primary location for all required anaesthetic equipment and supplies. It is therefore possible that patients with airways that may require surgical intervention or other emergency response were classified as 'high risk' or 'emergency' patients.

Relationship of Site Preference and Experience (Hypotheses 1 & 3)

Hypothesis 1 proposed that there was a relationship between the preferred sites of anaesthetic induction based on the experience level of consultants. The Pearson Chi-square (2-sided) test result indicated that 16.7% of cells had an expected count less than 5; however, this did not violate the assumption of 20% or more. Therefore, the test result can be interpreted, as $X^2(6) = 3.528$, $p = .740$, which is not statistically significant. The null hypothesis is therefore upheld and no relationship exists between the experience level of consultants and their preferred site of induction of a standard adult patient.

Hypothesis 3 suggested the presence of a relationship between having had international experience training or working as an anaesthetist, and the preferred site of anaesthetic

induction. The test result was $X^2(2) = 5.733$, $p = .057$, which demonstrated no significant relationship between the two variables.

Follow-up tests were also conducted in order to break down the international experience into different measures and compare to site preference. The variable categories compared are listed below:

- Type of Work Experience (Hypothesis 3a)
    - Trained Only / Worked Only / Trained & Worked vs Preferred Site of Induction in the UK
- Typical Site of Induction Outside of UK (Hypothesis 3b)
    - Operating Theatre / Anaesthetic Room / No Typical Location vs Preferred Site of Induction in the UK

Both chi-square tests violated the assumption of sufficient expected counts of more than 5 and would therefore provide unreliable results; however, the likelihood ratio presented very similar test statistics to those of the violated chi-square tests.

Hypothesis 3a resulted in a Pearson Chi-square result of $X^2(4) = 3.232$, $p = .520$, whereas the likelihood ratio was $X^2(4) = 2.881$, $p = .578$. Similarly, hypothesis 3b resulted in a Pearson Chi-square result of $X^2(4) = 1.922$, $p = .750$, and a likelihood ratio of $X^2(4) = 1.821$, $p = .769$. In either case, no significant association between the indicators of international experience and preference for site of induction in the UK exists for this sample of consultants.

3.5.5 Surgical Specialties

All respondents were asked to indicate how frequently they use the anaesthetic room to induce patients under anaesthesia in both the NHS hospital and their private hospital (if applicable), based on the specialties with which they work. As the section of the survey capturing the private sector data was optional, not all questions were answered by all respondents. Below is a presentation of the frequency of use of anaesthetic rooms in the NHS (**Figure 3.6**) and the private sector (**Figure 3.7**). Where all 202 consultants answered for all specialties in reference to the NHS, responses to the private sector were between 86 and 90 respondents of the 91 who reported working in the private sector.

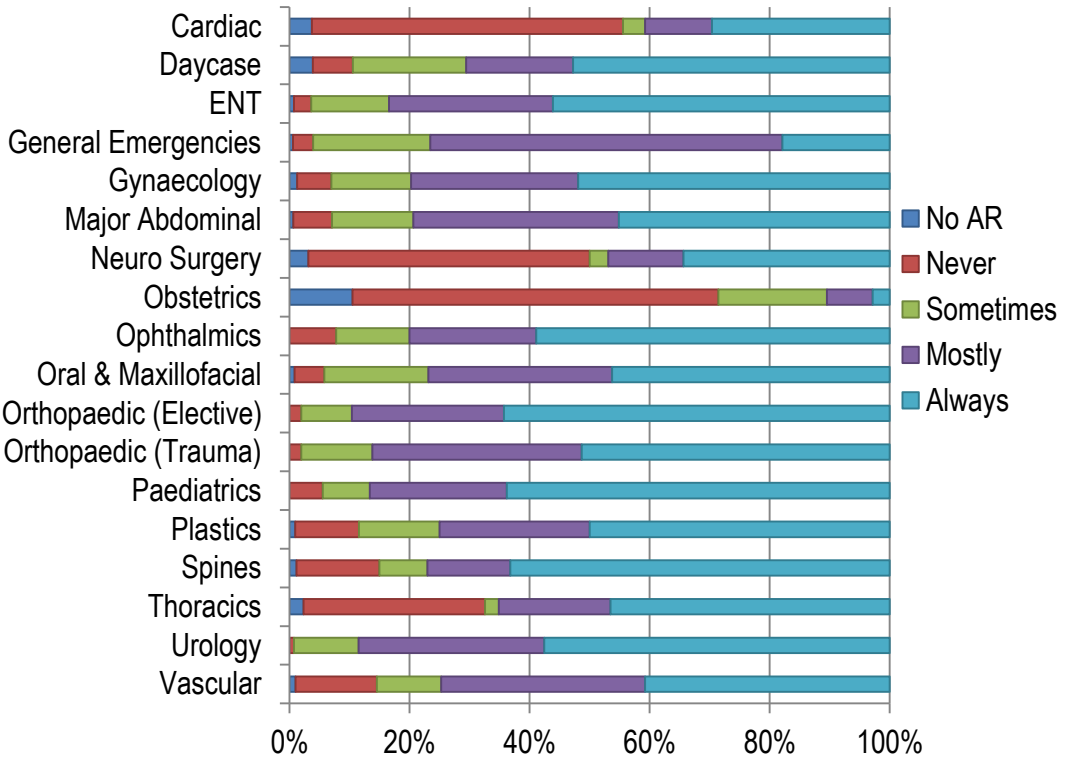


Figure 3.6 Frequency of use of anaesthetic rooms by specialty in the NHS

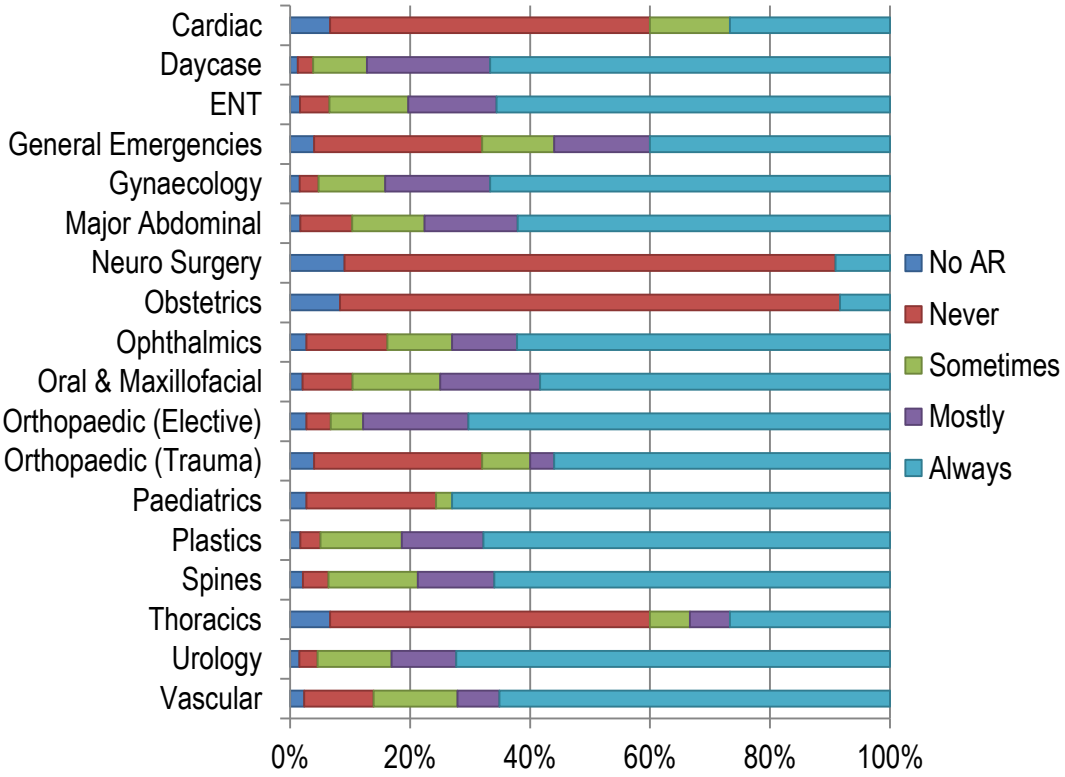


Figure 3.7 Frequency of use of anaesthetic rooms by specialty in the private sector

Relevance of Specialty on Anaesthetic Room Use (Hypothesis 8)

A cross-tabulation was conducted of the frequency for using the anaesthetic rooms against the surgical specialty for those cases and resulted in a Pearson Chi-square test statistic of $X^2(51) = 720.916$, $p = .000$, V = 0.341. Although the degrees of freedom for this contingency table were quite high, the significance was $p \leq 0.001$. This test accepts hypothesis 8, showing a significant difference in the use of anaesthetic rooms based on surgical specialty. **Table 3.5** identifies the largest contributors to the test statistic by showing the adjusted standardised residuals of the highest magnitudes, but highlighting those which are greater than |±2|. Due to the size of the contingency table, only the highest ASRs are discussed as potentially significant (see Sharpe, 2015).

Table 3.5 Adjusted standardised residuals (ASR) for the frequency of anaesthetic room use based on surgical specialty in the NHS

	Frequency of Anaesthetic Room Use			
Surgical Specialty	Never	Sometimes	Mostly	Always
Cardiac	7.4	-1.4	-1.9	-1.8
Daycase	-1.5	2.7	-3	1.9
Ears, Nose, Throat	-2.9	0	-0.3	2.0
General Emergencies	-3.2	2.7	9.4	-8.4
Gynaecology	-1.9	0.1	-0.1	1.1
Major Abdominal	-1.6	0.2	1.7	-0.7
Neuro Surgery	7.1	-1.6	-1.9	-1.4
Obstetrics	19.0	2.1	-4.4	-8.9
Ophthalmics	-0.8	-0.3	-1.6	2.1
Oral & Maxillofacial	-1.9	1.5	0.6	-0.3
Orthopaedics (Elective)	-3.5	-1.8	-0.9	4.2
Orthopaedics (Trauma)	-3.5	-0.5	1.8	0.8
Paediatrics	-1.8	-1.8	-1.5	3.6
Plastics	0.2	0.1	-0.7	0.5
Spines	1.2	-1.4	-3	3.0
Thoracics	4.5	-2.1	-1.4	-0.1
Urology	-3.8	-0.8	0.7	2.3
Vascular	1.2	-0.7	1.3	-1.5

Red = ASR > |±5|, Orange = ASR between |±3| and |±5|, Yellow = ASR between |±2| and |±3|

The frequencies which contributed the largest residuals are summarised below:

- Obstetric, Cardiac, and Neuro surgery had a significantly higher response rate for Never using the anaesthetic room for induction.
- Obstetrics also had far fewer Always responses than expected.
- General emergencies were less likely to be Always or Never responses, and had a larger frequency of Mostly using the anaesthetic room, which is similar to site preference for emergency patients.
- Thoracics had a higher percentage of Never responses than expected.
- Elective Orthopaedics and Paediatrics also had larger percentages of Always responses for anaesthetic room induction.

The private sector responses were not analysed in the same way because of the test assumption of sufficient counts in all cells. Due to the lower portion of consultants working in the private sector and also requiring representation of responses across the various specialties, the results would have been unreliable.

3.5.6 Factors Influencing Site of Induction

In order to understand the various reasons for choosing to induce patients in either the anaesthetic room or the operating theatre, and determining the relative importance of those reasons, consultants were asked to indicate the level of importance for each listed factor on a scale of Unimportant (0), Of Little Importance (1), Moderately Important (2), Important (3), and Very Important (4).

All 202 respondents indicated the importance for factors affecting the choice to anaesthetise patients in the anaesthetic room; however, the response rate varied from between 154 to 166 for the reasons to induce in-theatre. This lack of response could be due to respondents having had difficulty with the question. It is possible they did not know how to evaluate each factor, or chose not to respond to certain factors which did not apply to them. The option for ‘No AR’ was available for the questions evaluating reasons to choose to induce in-theatre, as a lack of an anaesthetic room would eliminate the need to actively choose to induce in-theatre. The factor for choosing to induce in the operating theatre with the largest amount of respondents (n = 166) was patient safety.

A Friedman test was conducted for all reasons to induce in the anaesthetic room to determine any significant difference between the factors. This was also done with the reasons to induce in-theatre. Both tests resulted in a *p*-value of .000, which concludes a significant difference in the importance of some factors. The Wilcoxon signed rank test was then used for each factor against the others for the paired samples. The resulting *p*-values for each factor can be seen in **Appendix C**.

The Bonferroni correction was used to adjust the significant *p*-values for each set of comparisons, as the higher the number of comparative tests would indicate an increased chance of finding a significant outcome (MacDonald & Gardner, 2000). Based on 6 factors and 8 factors measured for reasons to induce in the anaesthetic room and operating theatre, 15 and 28 comparative tests were conducted, respectively. This adjusted the significant p-values (formerly $p \leq .05$) to .05/15 and .05/28, or $p \leq .0033$ for the reasons to induce in the anaesthetic room, and $p \leq .0018$ for reasons to induce in-theatre. **Figures 3.8** and **Figure 3.9** graphically present the relative aggregated importance on a scale of 0 (Unimportant) to 4 (Very Important) for each factor for selecting the site of induction, and displays the significant differences between them. Factors of different colours are statistically different from one another based on the Bonferroni corrected alpha values for each set of tests, presented in **Appendix C**.

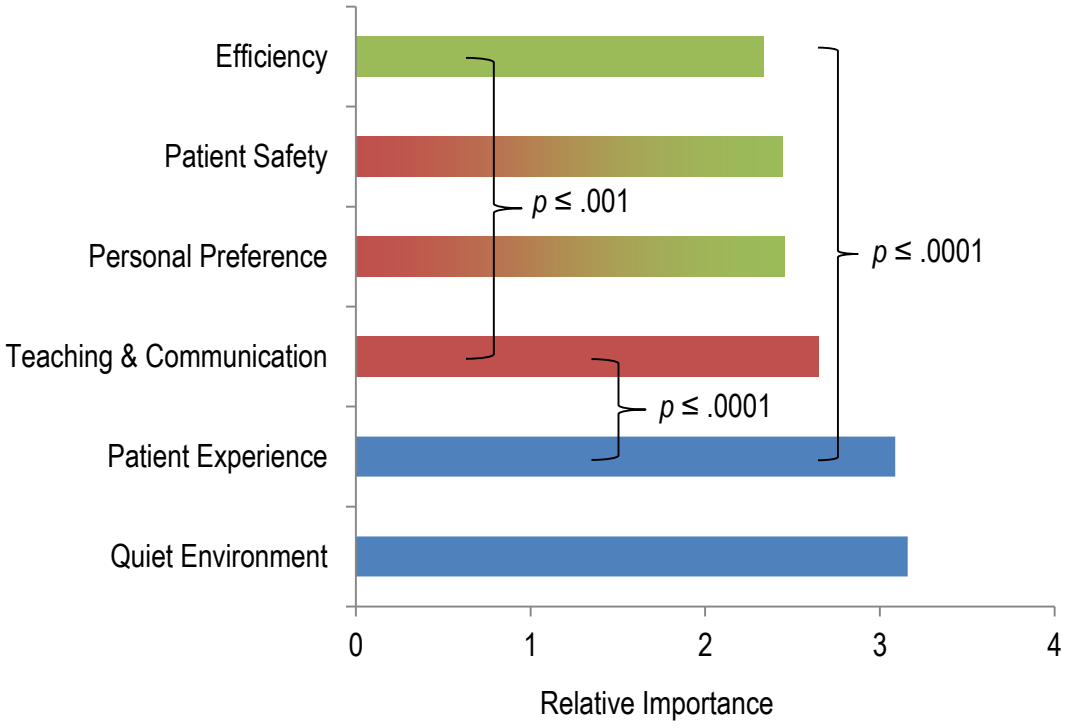


Figure 3.8 Significance of relative importance for reasons to induce in the anaesthetic room

For the factors which influence the choice to use the anaesthetic room, the factors which were most often ranked with higher importance were a quiet environment and patient experience. The use of the anaesthetic room for teaching and communication purposes was ranked higher in importance than efficiency. The least important factors were personal preference, patient safety, and efficiency for choosing to induce patients in the anaesthetic room.

Free responses were consistent with the high weight of a quiet environment, as this was referenced the most. Respondents valued the calm and quiet of the anaesthetic room in comparison with the theatre, as one anaesthetist stated:

> *'The theatre staff set up for each case in theatre and do not do it quietly. Anaesthetic rooms are essential for quiet and trouble free induction of anaesthesia…'*

Multiple respondents related the importance of a quiet environment to distraction which occurs in the operating theatre due to theatre staff behaviour. Where some responses briefly connected these topics (e.g. *'Low discipline of theatre staff, noise, distraction in theatres'*), one anaesthetist discussed the benefit of a controlled environment, saying:

> *'… once in theatre, distracting things, like the WHO checklist, start to get in the way of safe patient care.'*

The patient experience was also frequently mentioned as an important factor for choosing to induce in the anaesthetic room. Patient experience was referenced with regards to patient privacy and possible fear or anxiety from in-theatre induction.

Although efficiency was the lowest rated reason for choosing anaesthetic room induction, free responses expanded on the benefit of the anaesthetic room to simultaneously allow anaesthetics whilst the surgical team prepares the theatre. In some hospitals where a 'layup room' or 'prep room' was unavailable for surgical instrument set-up, the anaesthetic room was discussed as an essential logistical component:

> *'To run an efficient list, it* ***must*** (respondent's emphasis) *be possible to have a quiet area for induction whilst the scrub team do their preparation. If that can happen outside of theatre, then induction can happen in theatre.'*

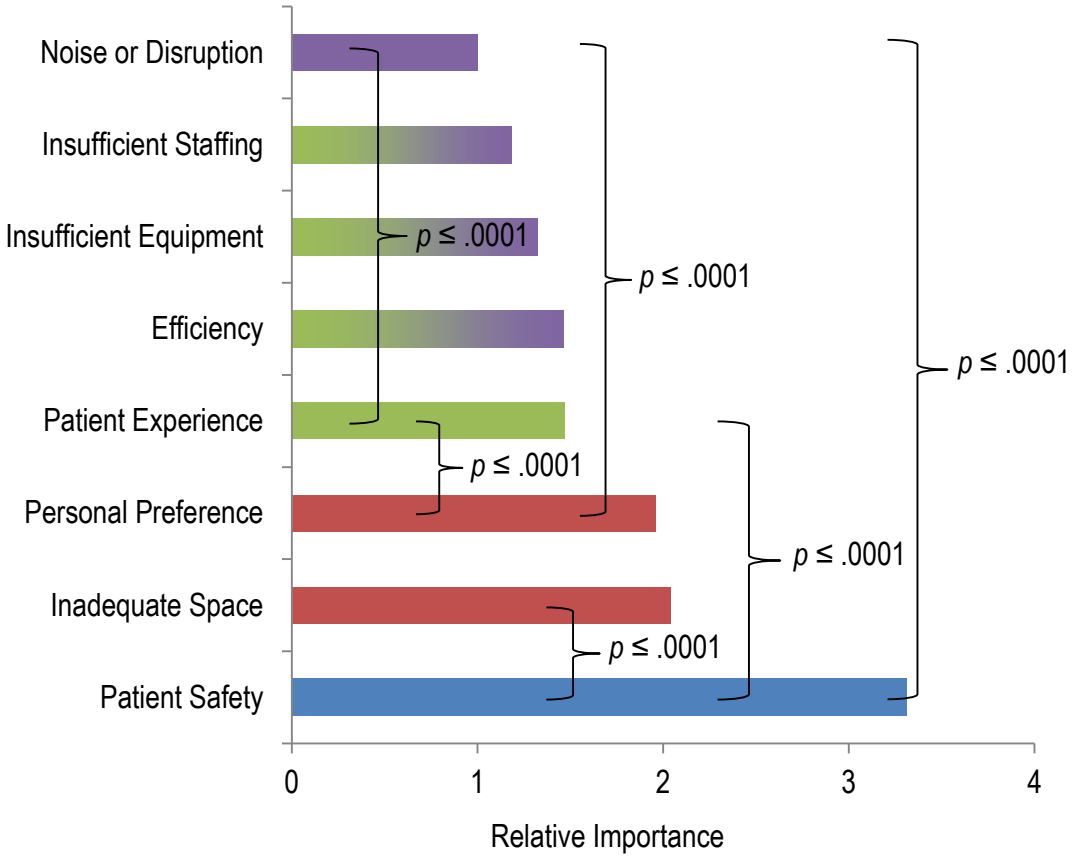


Figure 3.9 Significance of relative importance for reasons to induce in the operating theatre

The priorities and motivations for choosing to induce patients in the operating theatre were in contrast with those for the anaesthetic room. The most significantly important reason to anaesthetise patients in-theatre was for patient safety concerns. This factor was followed by the inadequate space in the anaesthetic room and the personal preference of the anaesthetist. This may suggest that the existing anaesthetic rooms are not of sufficient size for the preferences of anaesthetists. While patient experience was significantly more important than potential noise or disruption in the anaesthetic room, all of the remaining factors were not significantly differentiable in level of importance.

Consistent with these findings, respondents who chose to induce in-theatre did so to avoid the transfer of the patient between rooms and to maintain monitoring. Most safety considerations were related to patient characteristics which augmented risk of transfer. One anaesthetist summarised their reason for choosing the theatre, being:

> *'… not wanting to transfer an unconscious patient. This may be for a variety of clinical reasons, the main ones being obesity, lateral positioning, extremes of age, and marked cardiovascular instability.'*

Although the cost of the anaesthetic room and duplicated equipment was not included as a determining factor for why an anaesthetist would choose to anaesthetise in-theatre, several respondents discussed the benefit of saving on equipment costs, as one anaesthetist said:

> *'We could half the number of anaesthetic machines needed in a hospital!'*

3.5.7 Evidence-Based Change

Experience & Willingness to Change (Hypotheses 2, 4 & 5)

The vast majority of consultants, 88.6% (n = 179), did not want to see the site of induction changed from the place where it currently takes place –i.e. the anaesthetic room for most participants. This resistance to change was described by one respondent who stated that:

> *'I would absolutely resist any attempt to make me induce all of my patients in an operating theatre.'*

This apparent resistance to change in anaesthetic practice was tested against multiple experiential variables, including length of work experience (hypothesis 2), international experience (hypothesis 4), and working with the private sector (hypothesis 5).

Table 3.6 Hypothesis testing of willingness to change and various experiences

H	Independent Variable	Test Statistic	Support (Y/N)
2	Years of Experience	$X^2(3) = 3.229$, $p = .358$	N
4	International Experience	$X^2(1) = 5.533$, $p = .019$*, $\varphi = 0.166$	Y
5	Private Sector	$X^2(1) = 0.532$, $p = .466$	N

*Statistically significant, $p \leq .05$

The Pearson chi-square test was conducted on the consultants' willingness to change the site of induction (Yes/No) in comparison with experiential variables. **Table 3.6** presents the results of those tests. Neither the years of consultant-grade experience nor practice within the private sector had an influence on willingness to change anaesthetic practice; therefore, hypotheses 2 and 5 can be rejected. However, international experience was significant in the willingness to change practice, although only slightly, as indicated by a weak Phi coefficient of 0.166. This finding supports hypothesis 4, and

shows that consultant anaesthetists who have had international work experience are more likely to be willing to change the site of induction in the UK.

Importance of Types of Evidence

Consultants were asked to evaluate various influences on their individual anaesthetic practice, in order to gauge the most important forms of evidence which might be able to help change practice. Identical to the Wilcoxon signed rank tests for the factors to induce in either the anaesthetic room or operating theatre, consultants indicated the level of importance (Unimportant to Very Important) for nine forms of evidence.

An initial Friedman's test rendered a chi-square value of 210.53 which was significant ($p \leq .001$). After conducting 36 comparative tests and adjusting the significant *p*-value to .0013 with the Bonferroni correction, all significantly different pairs were determined and are shown below in **Figure 3.10**.

Patient feedback and infrastructure modifications were the most highly ranked influences on anaesthetic practice. Of the governing bodies which provide guidance or policy regarding anaesthetic best practice, college or association guidance, meaning that of the RCoA or the AAGBI, was more often selected as of more importance than the other national guidance, as well as local policy. However, the NHS guidance, which comes nationally but not directly from a professional body, was considered more important than organisational policy, peer-reviewed journal articles, and peer opinion.

The importance of infrastructure was reiterated through free responses, where anaesthetists expressed their preference for having the option to choose between the anaesthetic room or the operating theatre, as currently both options exist:

> '*I think it's better to have a choice*.'
>
> '*If I was only able to use the theatre for induction, I would be happy, but while there is an option of an anaesthetic room, I like that as well.'*

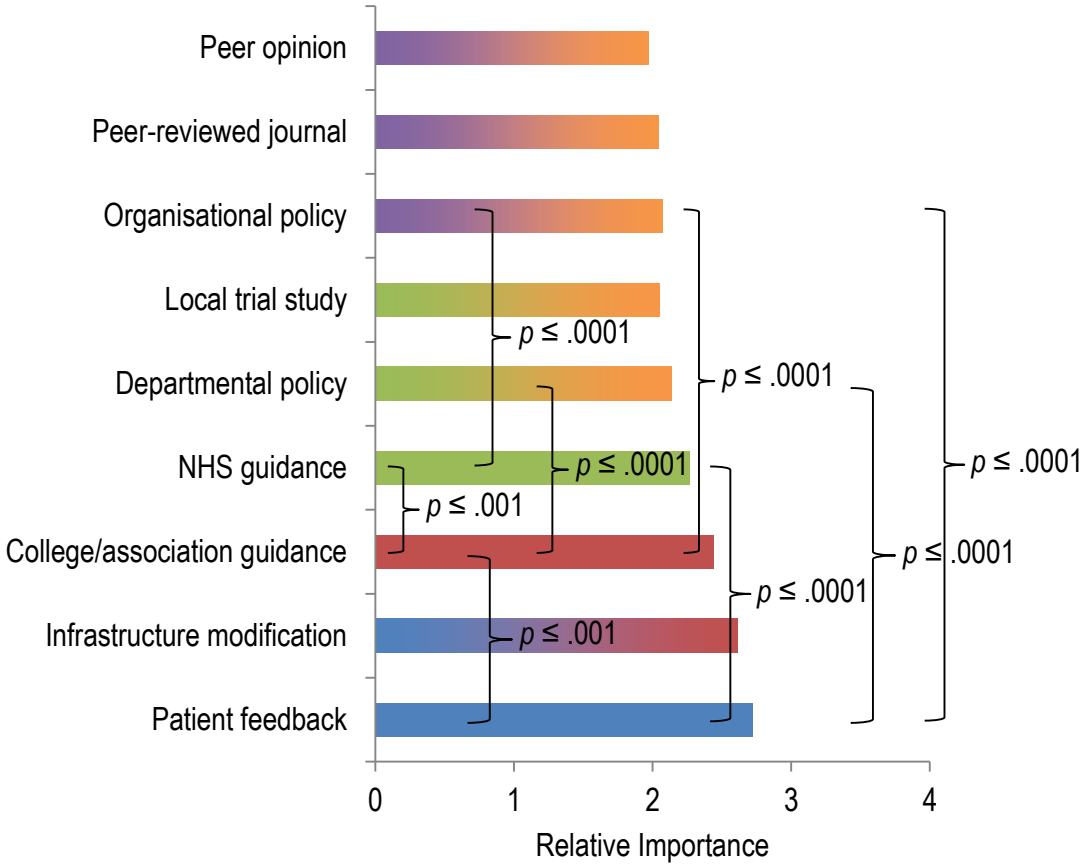


Figure 3.10 Significance of relative importance for types of influential evidence[3]

3.6 Discussion

The results of the consultant anaesthetist survey supported several important hypotheses regarding the landscape of anaesthetic rooms, attitudes of anaesthetists, and the factors which influence the use of the anaesthetic room. All hypotheses are summarised in **Table 3.7** and are discussed in the following sections.

[3] The relationships identified are significant to the Bonferroni corrected *p*-value of .001 (.05/36); however, not all significant relationships are marked. In general, factors of different colours are significantly different, although not all *p*-values are shown.

Table 3.7 Summary of hypothesis testing[4]

Number	Hypothesis	Support (Y/N)	Test Statistic	Result
Hypothesis 1	More experienced anaesthetists will prefer to use the AR more frequently.	N	$X^2(6) = 3.528$, $p = .740$	No significant result found.
Hypothesis 2	More experienced anaesthetists will be less willing to change their practice in regard to the site of induction.	N	$X^2(3) = 3.229$, $p = .358$	No significant result found.
Hypothesis 3	Anaesthetists with experience training or working outside of the United Kingdom will not prefer to anaesthetise in the AR as frequently as those who do not have international experience.	N	$X^2(2) = 5.733$, $p = .057$	No significant result found.
Hypothesis 4	Anaesthetists with experience training or working outside of the United Kingdom will be more willing to change their practice in regard to the site of induction.	Y	$X^2(1) = 5.533$, $p = .019$*, $\varphi = 0.166$	Anaesthetists with international experience were significantly more willing to change practice.
Hypothesis 5	Anaesthetists that practise in the private sector will be more willing to change anaesthetic practice than those who only work in the NHS.	N	$X^2(1) = 0.532$, $P = .466$	No significant result found.
Hypothesis 6	The majority of hospitals will still have ARs built adjacent to most every operating theatre.	Y	-	99% of respondents had an AR built adjacent to theatres.
Hypothesis 7	There will be a relationship between the healthcare sector and presence of ARs in the hospital.	N	Fisher's Exact: $p = .131$	No significant result found.
Hypothesis 8	Preference for ARs will vary significantly based on specialty of surgery.	Y	$X^2(51) = 720.916$, $p = .000$**, $V = 0.341$	Preference for using the AR is significantly based on specialty.
Hypothesis 9	Preference for ARs will vary significantly based on type of patient.	Y	$X^2(12) = 361.328$, $p = .000$**, $V = 0.357$	Preference for site of induction is significantly related to the type of patient.
Hypothesis 10	The majority of anaesthetists will be unwilling to change anaesthetic practice in regards to the site of induction.	Y	-	88.6% of respondents did not want to see the site of induction changed.

[4] All hypotheses with statistical support are highlighted in blue. *$p \geq .05$; **$p \geq .001$

3.6.1 Clinical Preferences

Patient Specific Considerations

This survey achieved its aims of identifying how the anaesthetic room is used and the significance of various factors affecting the site of induction, as chosen by consultant anaesthetists within the sample used. The type of patient being anaesthetised was of particular significance when determining the location for induction (hypothesis 9). Consistent with previous evaluations of anaesthetic practice in this regard (Bromhead & Jones, 2002), while the majority of all patients are likely to be anaesthetised in the anaesthetic room, patients whose safety could be at risk due to the transfer between rooms would be anaesthetised in the operating theatre. Similarly, morbidly obese patients are preferred to be induced in-theatre in order to limit lifting and handling of the patient, which could be an added risk to the patient and to the staff responsible for moving the unconscious patient (Evans, 2004). In addition, the strong preference for anaesthetising paediatric patients in the anaesthetic room can be explained by the standard practice of permitting the accompaniment of children by their parent or guardian into the anaesthetic room (McEwen *et al.*, 1994; Ryder & Spargo, 1991).

Surgical Specialties

The frequency of use of the anaesthetic room is significantly related to the type of surgical specialty of the case (hypothesis 8). No previous studies considered the difference in anaesthetic room use based on surgical specialties, besides individual studies of specific surgical units (e.g. orthopaedic surgery). Obstetrics had the strongest indication of preference for in-theatre induction of patients, which is consistent with a previous survey of members of the Obstetric Anaesthetists Association (OAA) that found the majority of clinicians have forgone the anaesthetic room for the sake of patient safety (Husain *et al.*, 2005).

The specialties which typically had more responses for infrequent anaesthetic room use, were obstetrics, cardiac surgery, neurosurgery, and thoracic surgery. In contrast, specialties which had an increased response rate for ‘Always’ using the anaesthetic room were elective orthopaedics, paediatrics, and spinal surgery. The commonalities of the specialties in which consultants tend to prefer not to use the anaesthetic room include aspects of complexity of surgery, long duration, and severity of cases. An

additional consideration may include the complexity of monitoring required. It is also likely that anaesthetists who perform thoracic, cardiac, and neurosurgery have a higher percentage of very sick and unstable patients, which based on patient type, would increase the likelihood of in-theatre preference.

An unexpected finding of the data showed a decrease in 'Always' and 'Never' responses for the frequency of use of the anaesthetic room in general emergency lists. It is clear from the patient type differentiations that high risk and emergency patients tend to be induced in-theatre; however, it is likely that the larger portion of 'Mostly' and 'Sometimes' responses are due to the tendency of anaesthetists to default to anaesthetic room induction, unless the patient proves to be an exceptional risk or hassle to transfer. Indicating as such, one respondent stated that:

> *'We are used to having an AR available. We deviate from that routine only if there is a positive indication, i.e. patient safety; less transfers for an unstable or very obese patient.'*

Consultants tended to prefer anaesthetic room induction of paediatric patients, which is compatible with previous discussions on paediatric accompaniment. Similarly, spinal and elective orthopaedic anaesthetics were most often indicated as always being done in the anaesthetic room. This is likely to be attributed to the use of regional anaesthesia for elective orthopaedics, and the set-up of surgical instruments in the theatre, thereby promoting the use of a second room for induction. A regional anaesthetic or regional blockade is a localised injection which provides a nerve block, thereby numbing the area where surgery will take place. Patients who are not under general anaesthesia (GA) and are able to breath on their own allow a certain level of flexibility for the anaesthetists. As explained in provided comments, some anaesthetists believe anaesthetic rooms improve operating list efficiency by allowing for the overlap of patients during case turnovers –meaning starting a second patient whilst the first is still in surgery.

As orthopaedic and spinal specialties are known for large amounts of surgical kit, such as a variety of implants and other equipment, it is essential to consider the requirements for set-up of instrumentation. Some anaesthetists specifically mentioned the lack of a separate prep room, where instruments can be set-up outside of the theatre. In addition, one consultant commented on the 'laminar flow' air ventilation (see **Figure 3.11**) in

theatre for orthopaedic surgery, under which the equipment should be opened, thus requiring the anaesthetist to wait until the sets have been prepared before the patient can enter theatre.

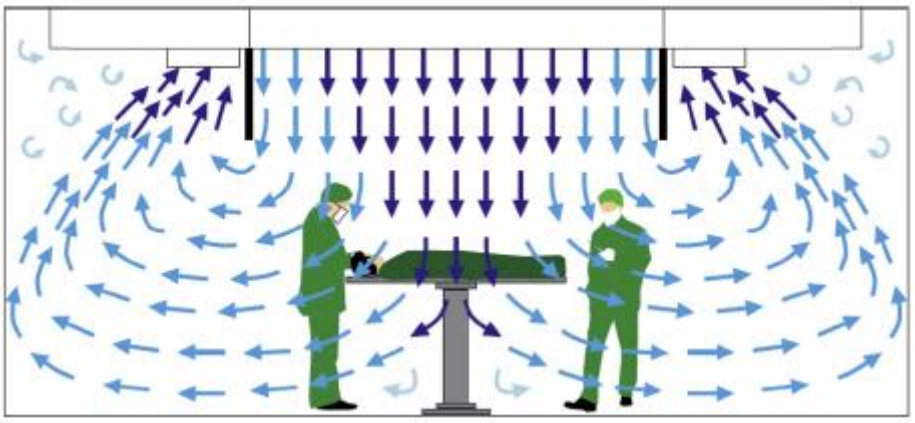


Figure 3.11 Schematic of a laminar flow ceiling canopy (McHugh et al., 2015, p.53)

Laminar airflow over the space where instruments are set-up has been shown to decrease bacteria colonisation and reduce surgical site infections (Andersson *et al.*, 2014; Smith *et al.*, 2013), however, there is some debate whether laminar flow is more than marginally effective, if not detrimental (McHugh *et al.*, 2014; Gastmeier *et al.*, 2012; Brandt *et al.*, 2008).

These findings suggest the use of anaesthetic rooms and their benefit to safe and efficient surgery provision must be assessed on a speciality specific basis. Further exploration is required for which specialties are benefited from anaesthetic rooms, and to what extent they enhance list efficiency, patient experience, or the work environment for its users.

3.6.2 Factors Influencing Site of Induction

Infrastructure & Policy

The presence of anaesthetic rooms proved to still be a norm in UK hospitals (hypothesis 6), with a nearly unanimous response of anaesthetic rooms being built in both the public and private sector (hypothesis 7). These findings were similar to previous surveys conducted some decades ago (Bromhead & Jones, 2002; Meyer-Witting & Wilkinson, 1992). Consultants used language such as ‘cultural norm’, ‘routine’, ‘practice has evolved in the UK’, and even ‘strange old British tradition’, to express the normality of the anaesthetic room in British practice.

The result of hypothesis 7 was unexpected as the researcher was informed in the planning stages of the study that one of the local private treatment centres had not built any anaesthetic rooms in their new theatre complex. Based on local collaborator feedback, it was estimated that more consultants also practised in this private sector organisation and would have reflected a higher response rate for there being no anaesthetic rooms.

Most consultants were not aware of any policy regarding the site of induction in their hospitals. While policy was assumed to be a relevant factor in the choice to use the anaesthetic room, it was demonstrated to be an individual preference rather than an organisational policy. When evaluating forms of evidence and how important they would be in helping to change anaesthetic practice (in regards to the site of induction), departmental and organisational policies were ranked amongst the lowest influential factors.

The mere existence of anaesthetic rooms may be self-sustaining in some ways, and should therefore be explored further as a reason for the continued use of the rooms. It is possible that inclusion of anaesthetic rooms in the design of new hospitals may be preferred in order to provide flexibility and normality to staff members who have been trained and worked in the UK. Although there was no significant relationship between preference for the anaesthetic room based on experience level (hypothesis 1), nor international experience (hypothesis 3), these factors may be relevant in hospital planning and choosing to integrate anaesthetic rooms into brand new theatres. This consideration and the relationship of current standards of practice on design of theatres will be investigated from a managerial/organisational level and individual anaesthetist level in Chapter 4.

Decision making

Several factors were evaluated by the consultants to rank in importance those which were relevant in the decision to induce patients in either the anaesthetic room or the operating theatre. The most significantly important factors for inducing in the anaesthetic room were that it is a quiet environment and in order to better patient experience. The most frequently mentioned topic in the free response questions had to do with the anaesthetic room being a quieter environment than the theatre. This was closely linked to the calmness, control, and separateness of the space from the busyness

of theatre. Patient experience was typically linked to either themes of patient anxiety or privacy. References to in-theatre induction and the impact on patients used words such as ‘intimidating’, ‘frightening’, and ‘stressed’.

Although personal preference was one of the lowest ranked factors in choosing to induce in the anaesthetic room, elements of professional domains, performance anxiety, individual adaptability, and teamwork were mentioned and should be expounded upon in a more in-depth evaluation.

Efficiency was also ranked amongst the least important factors to choose to use the anaesthetic room, which was counter-intuitive as literature has presented the anaesthetic room as a benefit to improve efficiency of turnovers. It is possible that this, although an advantage for the room’s usefulness, is not deemed as an important consideration for individual consultants in their decision making. Efficiency may be an organisational objective, but results seem to indicate it is not of utmost importance to anaesthetists in comparison to patient and environmental considerations. It is still, however, an important consideration in addressing the research question, so is examined further in Chapter 6.

Whilst patient safety was the dominant factor in choosing to induce in the theatre, most other factors were equally low in importance. The site of induction must be selected with an evaluation of what is an allowable amount of patient safety risk, and this rationale is crucial to understand the underlying safety culture and where the boundaries lie for when anaesthetic room induction is a benefit, to when it is an unacceptable risk.

Further investigation of rationale and individual decision making is presented in Chapter 4, and the patient experience relating to anxiety and the influence of the site of induction on satisfaction is presented in Chapter 7.

3.6.3 Evidence-Based Change

The current anaesthetic landscape appears to be highly resistant to change in practice, as evidenced by the vast majority of anaesthetists who would not prefer the site of induction changed (hypothesis 10) within this sample. This was not, however, linked to the experience of consultant anaesthetists (hypothesis 2), nor to the fact that some anaesthetists practised in both healthcare sectors (hypothesis 5).

Based on the experience of the East Midlands consultants, it was found that those who had trained or worked outside of the UK were in fact more willing to change the site of induction (hypothesis 4). This conclusion is logical as most of those who worked abroad had typically induced in the operating theatre, and were therefore able to translate similar practice to the UK, to varying extents. Whilst some anaesthetists chose to entirely abandon the anaesthetic room, some anaesthetists, although comfortable with in-theatre induction, stated they would still use the anaesthetic room if it is there to be used.

The most important forms of evidence which would influence a change in anaesthetic practice were patient feedback, followed by a physical modification of existing infrastructure, or guidance from professional bodies. The component of patient feedback is provided in the Chapter 7 study of patient experience. Chapter 4 will explore further what evidence is compelling in the hurdle to change British anaesthetic practice, where Chapter 5 will investigate further the actual impact of evidence on decision making.

3.7 Limitations

Sampling Bias

An open call for participants within all approved Trusts was made in order to maximise the recruitment of anaesthetists practicing within the East Midlands, however, this method could have affected the validity of the data collected. The participants who chose to respond to the online survey, advertised as a survey on anaesthetic room practice and opinions, were self-selected, and therefore may be biased. Those with interest in the topic of anaesthetic rooms and the debate surrounding their usefulness can be quite polarised, and may either be adamantly in favour of the rooms or resolved to abandon them. The likelihood of strong opinions on either end of the spectrum, may affect the generalisability of the results to the population as a whole.

Non-response

Whilst the survey was designed to allow participants to ‘switch hats’ and answer according to their experience working in the NHS and also in the independent sector, it is possible some respondents experienced some fatigue in answering the multiple

choice questions, particularly in the repeated questions section. Non-response did affect several question items in the private sector section, as all questions were optional, allowing consultants who only practised in the NHS to skip them. All consultants who also practised in the private sector did not answer all of the questions applicable to them. In an effort to capture a multitude of consultant experiences (NHS, private, multiple specialties, various theatre set-ups), but also ensuring completion of questions (mandatory), several questions required the options of 'N/A' for specialties that did not apply to the individuals or 'No AR' for theatres that did not have anaesthetic rooms built.

Lack of clarity

It was evident from the multivariate analysis and individual responses from consultants that the options provided for reasons to induce in-theatre were not relevant to some, and confusing to others. For example, the highest ranked reason for inducing in the anaesthetic room was because it is a 'quiet environment', whereas inversely, the option was provided that there may be 'noise or disruption in the anaesthetic room' which might logically encourage use of the theatre for induction. However, this response option did not apply to many individuals, and may have reduced respondent trust in the questionnaire's validity.

The survey results were very similar between the NHS and private sectors. Knowing the local NHS treatment centre, which is privately run, was built without anaesthetic rooms, a larger percent of respondents was expected without anaesthetic rooms in the private sector. This is possibly a misunderstanding as some local anaesthetists are paid by the NHS for the work done in the treatment centre. This could have resulted in a misunderstanding that the private treatment centre was not considered an NHS organisation because it is privately run.

Despite the limitations of this survey, the data clearly captures the general attitudes and factors which are most important in choosing to use the anaesthetic room. It is essential to explore these individual factors more thoroughly, which is done in the subsequent studies within this thesis.

3.8 Chapter Summary

This questionnaire of consultant anaesthetists revealed the prevalence and preference for anaesthetic rooms has remained unchanged in the East Midlands region and is the established standard of practice in those hospitals. Whilst consultants are willing to anaesthetise emergency and high risk patients in the operating theatre, the anaesthetic room still serves as an important space for anaesthetists and most are resistant to abandoning them. Preference for the space is affected by patient safety. This chapter has presented some key factors of importance to anaesthetist decision making and the challenge of changing anaesthetic practice regarding anaesthetic room use. The following chapters will build on these findings to identify areas for improvement.

Chapter 4 The Role of Anaesthetic Rooms

4.1 Chapter Overview

This chapter describes an interview study with perioperative managers and consultant anaesthetists. The study explores further the role of the anaesthetic room in standard practice and the decision making involved in the design and practice of surgical suites across multiple East Midlands Trusts.

4.2 Introduction

The purpose of Chapter 3 was to explore current practice relating to the anaesthetic room and to elaborate upon the reasons why anaesthetists may prefer to use the anaesthetic room. This interview study expands on the findings of the previous chapter and seeks to understand in more depth the choice to standardly use anaesthetic rooms and whether to include them in new theatre designs. At its onset, this interview study was directed at perioperative managers only in order to explore the rationale for incorporating anaesthetic rooms in future theatre planning. The main aims of the study were to:

- explore the important factors which impact the use of anaesthetic rooms, and their incorporation in new theatre designs;
- investigate the decision making for the use and design of theatre facilities;
- understand barriers to changing anaesthetic practice regarding the use of anaesthetic rooms.

After conducting 17 interviews with anaesthetic (n = 8), theatre (n = 4), and business (n = 5) managers, initial analysis showed a prevalence of responses identifying consultant anaesthetists as the leaders in the choice to include anaesthetic rooms in theatre design. The study was then opened to consultant anaesthetists; this involved modifying the interview topic guide by eliminating management directed questions, as well as rephrasing questions to enhance their clarity -following feedback from the first round of interviews.

By incorporating consultant anaesthetists in this study, those who had also participated in the online survey in Chapter 3 were given the opportunity to expand upon their stated attitudes and preferences.

4.3 Methods

4.3.1 Participants

In order to meet the objectives of this study, a purposive sampling method was employed. Purposive sampling is a non-probability sampling method that intentionally focuses recruitment on informants that are able to serve the specific purpose of the study, as judged by the researcher (Bernard, 2011). The specific knowledge as to why anaesthetic rooms are used and why they continue to exist in new hospitals could best be shared by perioperative managers and consultant anaesthetists who work within those spaces. Perioperative managers included anaesthetic, theatre, or business (general) managers or directors who were closely associated with theatres and would be involved in the design of new theatres. Estates managers, although involved in hospital planning, were excluded from the study, as it was presumed they may not have suitable direct knowledge of clinical activity in the anaesthetic room. All consultant anaesthetists were included as known 'experts' in the use of anaesthetic rooms, as demonstrated from the survey in Chapter 3.

Recruitment targets aimed for 20 perioperative managers and 20 consultant anaesthetists across all Trusts to encompass a range of contexts and perspectives of the sample population. As a non-probability sampling method was used, the number of interviews was not defined for the purpose of statistical comparison, but rather providing a robust range of views from both professional groups.

In order to obtain a manageable data set, Trusts within the East Midlands were approached for participation through established collaborator networks. Ten of the East Midlands NHS Trusts were approached for study approval and recruitment. The local collaborators in each of the ten NHS Trusts which approved the study acted as gatekeepers, and passed an email invitation to both consultant anaesthetists within their departments and the relevant perioperative managers. The invitation for managers specified that they must be either anaesthetic, theatre, or business managers, who would

be involved in the design of theatres. Potential participants were asked to contact the researcher directly to schedule a time for an interview.

4.3.2 Ethics

This study was included in a larger mixed-methods protocol which included all studies within Chapter 3 through 6. The protocol (version 3) was approved by the University of Nottingham Faculty of Engineering Research Ethics Committee on 22nd May, 2014. Due to the nature of the study as a staff only, non-interventional study, NHS Health Research Authority ethical approval was not required. Individual Trust approval was sought and granted in each of the ten NHS Trusts to allow for the recruitment of their employees.

4.3.3 Data Collection

Telephone interviews were undertaken with each participant, with the exception of two locally based manager interviews which were conducted in-person. A total of 17 interviews took place with perioperative managers and 20 with consultant anaesthetists. As invitations were distributed via the third party local collaborator, due to data protection restrictions, the final number of those invited is unknown. However, of those who contacted the researcher out of interest, 100% agreed to an interview.

All interviewees were informed in advance that the interview would investigate the decision making for the design of theatres, the use of anaesthetic rooms, and its connection with improving practice. A participant information sheet was provided to all managers and consultants in advance of the interview, where they were informed of the anonymity and confidentiality of their responses, as shown in **Appendix D**.

Before commencing, participants were given the opportunity to ask any questions, provided their verbal consent to participate, and to have their interview recorded and used for analysis and academic publication. The interviews were conducted over a conference telephone call and digitally recorded. The two face-to-face interviews were conducted in a private meeting room in order to maintain confidentiality of the participants and their responses. Interviews took place between 8th August to 22nd October, 2014.

A semi-structured interview schedule was used in order to elicit responses with regards to the research aims, the schedule provided flexibility in the questions asked and the order in which they were asked.

An overview of the interview schedule is shown in **Table 4.1**, comparing the differences between the questions asked of managers and anaesthetists. Some questions which were oriented toward manager specific knowledge were excluded from interviews with consultant anaesthetists, i.e. questions investigating design decisions.

Table 4.1 Sample of interview protocol for managers and anaesthetists

Questions	Managers	Anaesthetist
What is the name of your employing hospital?	✓	✓
How many operating theatres do you have?	✓	
What specialties for surgery do you provide?	✓	✓
Do you have anaesthetic rooms?	✓	✓
For what purposes do you use the anaesthetic room?	✓	✓
Do you prefer to use the AR for induction of anaesthesia? Why?		✓
Is there a policy in your hospital regarding the use of the AR?	✓	✓
What is the age of your oldest theatre? Newest?	✓	
Do you have plans for theatre re-design?	✓	
What factors were considered in the design of theatres in relation to the inclusion or exclusion of anaesthetic rooms?	✓	
What factors are most important in considering whether or not to use ARs?		✓
How do you deal with conflicting evidence?	✓	✓
Would you consider re-designing theatres to include or exclude ARs?	✓	
How do you feel staffing could be changed to improve throughput?	✓	✓
What would be compelling enough evidence to change anaesthetic practice?	✓	✓
What is the role of national guidance in changing practice?	✓	✓
To what extent does pre-existing infrastructure dictate practice?	✓	✓
Is design of theatres informed by practice, or is practice informed by design?	✓	✓

4.3.4 Data Analysis

Following verbatim transcription of the interview recordings, the data sets for managers and consultant anaesthetists were analysed separately in order to distinguish themes arising in one sample group from the other. Thematic analysis was used in order to identify and analyse patterns in the data (Braun & Clarke, 2006). An inductive approach to analysis was taken by allowing the themes to emerge from the data, without influencing the coding of data with preconceptions and biases (Patton, 1990). It is important to acknowledge, however, that the data cannot be coded in 'an epistemological vacuum' (Braun & Clarke, 2006, p.12), and the theoretical interest of the researcher will inevitably contribute to the analysis. The coding of data was driven by identifying themes which were explicitly stated, from which motivations and meaning could be theorised directly from the language used (Potter & Wetherell, 1987; Braun & Clarke, 2006).

Coding of qualitative data is an iterative process, where each stage refines the data into categories, themes, and theories. Hahn (2008) compares the stages of coding to a gold-panner who starts with large amounts of material, but sieves smaller amounts in the gold pan until small nuggets are found. Shown in **Figure 4.1**, beginning at Level 1, the qualitative data is reduced by initial coding and then focused as repeated rounds of coding refine the themes.

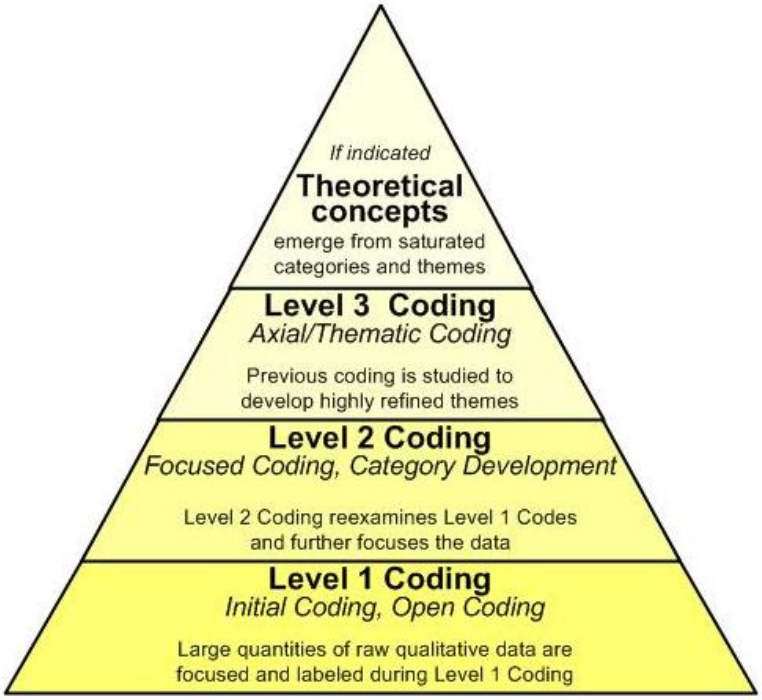


Figure 4.1 Qualitative coding (Hahn, 2008, p.6)

Using NVivo 10 qualitative data analysis computer software, the interview transcripts were initially coded based on the most basic elements of the data, involving specific terms, people, actions, or behaviours. Coding was done inclusively (coding phrases including surrounding text), in order to retain the context of the adjacent passages, and at times sections of text were coded under multiple themes. In the development of categories, some codes were aggregated with similar ones, or separated and promoted in the coding hierarchy if greater prevalence and significance was given to them. Links between major and sub-themes were considered in defining the major themes. This iterative analysis identified four main high level categories and eleven themes within them, shown in **Figure 4.2.** Although the coding was done by the author, the coding structure was presented and reviewed by two qualitative researchers to validate the formation of the higher level categories and themes.

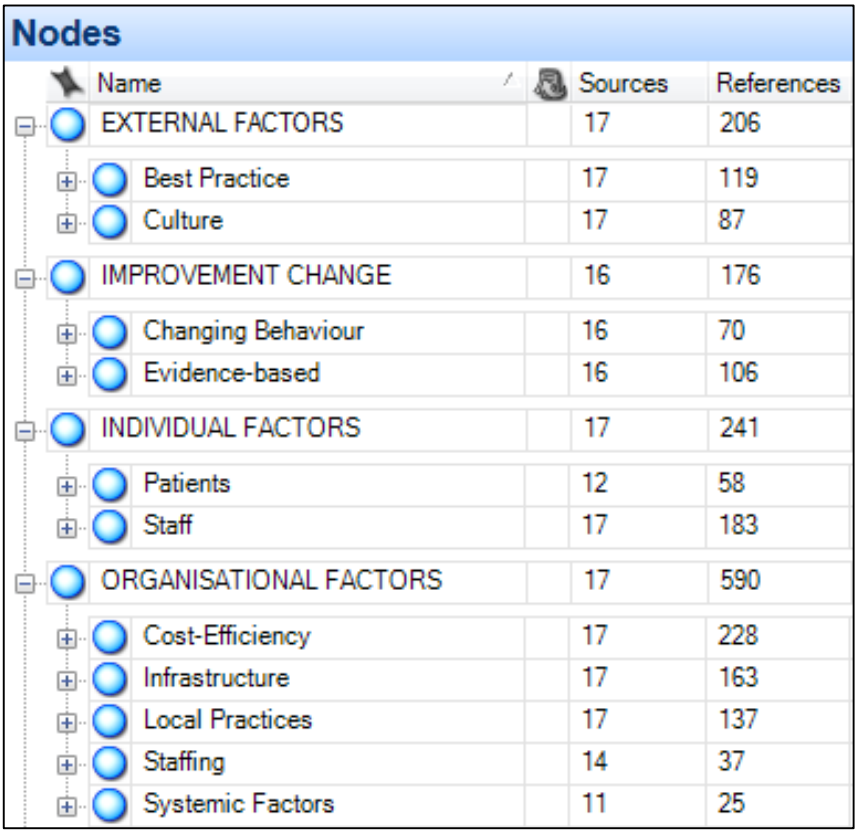


Figure 4.2 Node hierarchy of main high level categories and themes

4.4 Interview Results

The results of this study are presented on a macro to micro level, including the rationale for grouping codes within high level categories, themes, sub-themes, and will explain individual codes as supported by participant responses. The coding framework within

this section emerged from continuously comparing across the data set and was informed by the frequency of participant responses assigned to each node.

4.4.1 High Level Categories

The two data sets of interviews with perioperative managers and consultant anaesthetists were analysed separately. Nevertheless, the high level categories and themes which emerged from the data were relevant between both data sets, as presented within this chapter. The exploration of factors impacting the use of anaesthetic rooms and their presence in current and planned theatres can be explained with three main categories: individual, organisational, and external. A fourth high level category emerged which related to one of the key aims of the study, which was to explore the potential barriers to changing anaesthetic practice. Improvement change emerged as a unique category which was related to the other high level categories, influencing anaesthetic room practice, but considers specifically the challenges to changing practice.

4.4.2 Themes & Sub-themes

4.4.2.1 Individual Factors

The category of factors which are determined by the individual can be described by those which affect the patient and those affecting the staff members within the anaesthetic and surgical environment. Although there are some similarities between patient and staff issues, the unique experiences of the separate groups of individuals and the mechanisms for modifying those experiences would be different. **Figure 4.3** depicts the individual factors impacting anaesthetic room use.

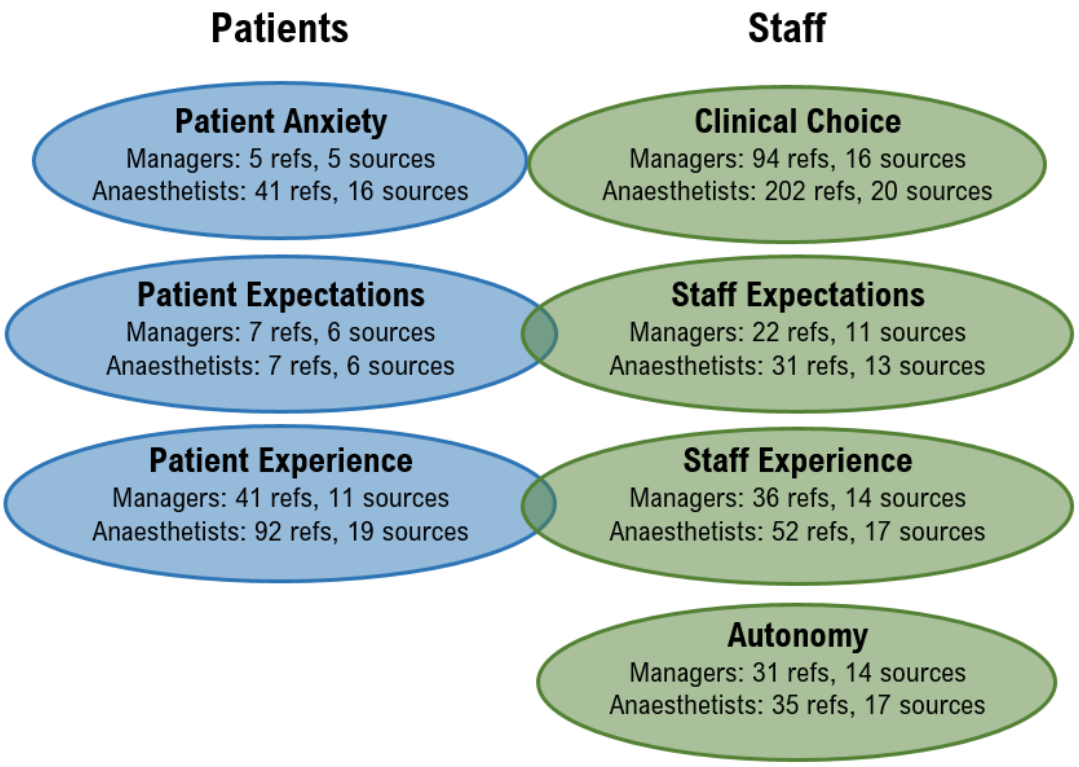


Figure 4.3 Individual Factors

4.4.2.1.1 Patients Factors

The theme of factors influencing the patient or being determined by the patient can be divided into the sub-themes of patient anxiety, patient experience, and patient expectations.

Patient Anxiety

The anxiety that a patient may experience leading up to their surgical procedure was referenced several times, primarily by the anaesthetists. The Oxford English Dictionary online (2016) defines anxiety as ‘a feeling of worry, nervousness, or unease about something with an uncertain outcome’. While anxiety disorders are known mental health conditions, the application of the word for this study relates to temporary worries or fears, instead of persistent anxiety. Statements referring to patients being distressed, frightened, scared, anxious, or upset were all coded to this sub-theme. One anaesthetist stated:

> *'... if I've got a patient that's very anxious and frightened, the theatre environment might not be appropriate for that and I'll choose to use the anaesthetic room.' (A3*[5]*)*

Anaesthetic rooms are perceived as reducing the anxiety of patients:

> *'... I think people do find it relaxes them quite a lot being in there instead of in the theatre suite itself.' (A16)*

Although some participants did not believe that in-theatre induction increased patient anxiety, it was still referenced as a common belief amongst their colleagues. Patient anxiety was most often linked to the theatre environment and what the patient may see. When prompted to explain the reason for anaesthetising patients in the anaesthetic room to reduce anxiety, one anaesthetist explained that anxiety occurs from walking into theatre, saying:

> *'... if you walk into an anaesthetic room, it's slightly less freaky than walking into theatre with all the monitors and machines hanging around, and all of the equipment and stuff out.' (A6)*

Some anaesthetists questioned the evidence base for heightened anxiety being attributed to in-theatre induction and suggested the rationale is mainly anecdotal. After changing her own practice, one anaesthetist shared her new perception:

> *'There's a lot of personal opinion that's been touted as evidence… before I started using theatres, I would have said patients are really anxious about going into theatre. Now, that I've don't it, they're not really… I don't feel like the patients are unduly anxious.' (A10)*

The benefit of the anaesthetic room for reducing paediatric patient anxiety, specifically, was expressed by anaesthetists several times. Whilst patient anxiety, in general, was referenced fewer times by managers than anaesthetists, many factors overlapped with the concept of patient anxiety, including the influence of environmental conditions and aspects of patient privacy and vulnerability. These are presented within the sub-theme of patient experience.

[5] Anonymous participants are indicated as A (consultant anaesthetists) or M (perioperative managers).

Patient Experience

Patient experience is a broad sub-theme as it covers multiple facets relating to personal requirements, the environment, and the behaviour of others. In the interviews, patient experience was frequently referenced as a significant consideration for the use of anaesthetic rooms, but lacked further explanation of what specific aspects of patient experience were important.

The environment, in terms of the theatre and anaesthetic room settings, was reported as an influence on patient experience. Recommendations for the ideal environment for patients referred to the anaesthetic room as a space which is 'nicer', 'calmer', 'smaller', than the operating theatre, and can provide 'protection' to the patient from the theatre environment. One theatre manager stressed that both settings can be quite clinical and recommended making changes such as:

> *'... colour schemes, pictures… I mean there's only a limit to what you can do because obviously it's a clinical area, but just try to make it less clinical.' (M16)*

Some respondents emphasised the importance of the environment as a mode of comfort for paediatric patients, as one anaesthetist explains:

> *'And specifically for the paediatric patients, we've got a couple of ARs that are actually plastered with cartoon characters… so that kind of helps a bit because they've got distractions everywhere and they're not in the theatre with tons of people around them.' (A2)*

The 'quiet environment' was referenced several times as a benefit of the anaesthetic room, as it is enclosed and has fewer people present for the time of induction. This aspect of noise seems linked to the number and behaviour of staff members while the patient is present and awake, as remarked by an anaesthetist and manager:

> *'It's mainly to have a peaceful, quiet environment for the patient. To have one where people are not constantly walking backwards and forwards in front of a terrified patient with unpleasant looking instruments and chatting about their lunch breaks.' (A8)*

> *'It's just that currently theatre is a shared space and that's the main driver for people to use ARs…there's a lot of noise pollution.' (M5)*

However, one anaesthetist countered this argument by asserting:

> *'There's a concept that the AR is a quiet environment, but it often isn't. A lot of noise comes through from the theatre… the rustling, and the clattering, and the coughing, and people calling, "Come on, wake up," can all be heard in the AR.' (A13)*

The aspects of noise which affect the patient in the theatre can be managed, but requires change in behaviour. One manager describes the situation:

> *'… a small problem is the fact of background noise that the nurses have to be aware that that patient is awake and they can't open tins and clatter things and rip open packages… and talk about what was on Coronation Street last night. They have to be quiet while the patient is going to sleep.' (M9)*

Noise and the behaviour of team members was also mentioned in relation to the effect on other staff members, this will be discussed in the theme of 'staff factors'.

An additional component of patient experience related to the number of staff present at induction is that of patient privacy. Interviews were coded to patient privacy with any statement of patient privacy, dignity and confidentiality. Where participants referred to patient privacy with little explanation, some described the vulnerability a patient may experience in the operating theatre stating:

> *'They're obviously feeling quite vulnerable. They're in a gown with an open back and everybody can see their backside and it's all not very private.' (A2)*

Many references to patient experience had to do with a desire to understand better what the patient wanted. When considering compelling evidence to change anaesthetic practice, one manager recommended:

> *'I think patient experience questionnaires, wanting to find out whether patients were concerned or whether that's just something that we worry about unnecessarily.' (M4)*

A few anaesthetists used their sense of empathy to relate to the patient's experience:

> *'…if I was put in the middle of an* [operating theatre] *with dozens of people rushing around trying to get equipment ready, I think the terror would just escalate hugely.' (A8)*

> *'Patient experience is important, but as a patient, if you told them, "We'll do it this way, which is the safest way, or we could do it this way, which is actually maybe a slightly nicer experience." I know which one I'd choose. I'd put my safety above everything.' (A13)*

Responses indicated that although consultants and managers were concerned with patient experience, the input of patients was lacking, therefore perceptions of patient experience were built on individual experience.

Patient Expectations

The sub-theme of patient expectations was distinguished from patient experience as it relates specifically to the expectations which patients bring to the (operating) table prior to influence from the environment or the people around them. Any statements relating to what beliefs and expectations the patient has prior to being brought to the surgical suite were coded to patient expectations.

Whilst the patients' experiences will affect their overall satisfaction with their care, the way the anaesthetist manages the patients' expectations will also impact the outcome. One anaesthetist shared thoughts stating:

> *'… those who haven't had any experience before, personal experience, first-hand experience, may have assumed that there would be an AR and then they wouldn't know anything else, so they wouldn't know anything about the operating room.' (A17)*

In reference to how to change practice to inducing in-theatre, one consultant stated:

> *'It's just a change in perception and managing things. So if your patient expects to walk into theatre, then that's fine. It's just standardly people expect to be in the AR, don't they? In the UK, anyway. So it's just a patient expectation. But I'm sure we could get around that. It's not a big deal.' (A6)*

Whilst respondents recognised the expectations patients may have when they come for surgery, they were considered to be manageable by care providers. It was not specified how these expectations could be changed.

4.4.2.1.2 Staff Factors

Some factors which influence the use of anaesthetic rooms are directly attributed to the members of staff and their preferences and experiences. These staff factors can be described within four sub-themes of staff expectations, staff experience, autonomy, and clinical choice.

Staff Expectations

In contrast to patient expectations, staff expectations for the use of the anaesthetic room may be more accurately understood as managers and anaesthetists were able to provide personal insight into their specific expectations, opposed to speculating regarding patients' expectations.

A large proportion of participants expressed the relevance of culture and tradition on the preference for inducing anaesthesia in the anaesthetic room. Whilst the theme of 'culture' will be discussed further in a broader sense in the high level category of 'external factors', there is a vast overlap of culture and the expectations which form as a result of said culture. Interview statements were coded to 'staff expectations' which made reference to anaesthetic training and experience abroad which may have shaped the ways in which staff prefer to practise.

One manager expressed the role of training on shaping expectations by stating:

> *'... people have professional sort of expectations and training… they're trained in a certain way and to work in a certain environment. And all of that plays a part in the cultural standard that you have in the way that we do things here…' (M7)*

An aspect of staff expectations is that arising from international experience or, in most cases, experience working in a theatre environment without anaesthetic rooms (as shown in Chapter 3). Whilst some anaesthetists expressed a preference to use the AR, despite their experience working without them, most others who have worked in both

manners are more willing to anaesthetise in the operating theatre. In reference to her training and time working in India, one consultant stated:

> *'I have no problems taking patients into theatres to anaesthetise, and probably this is from my experience back home.' (A7)*

One theatre manager referred to his experience working abroad, stating:

> *'I think most anaesthetists in Britain prefer ARs. I've worked in countries where they don't have ARs and to me, it works the same.' (M16)*

The interview findings suggest that standards of practice, which are shaped by cultural norms, play a role in staff expectations, and therefore their attitudes toward different ways of working.

Staff Experience

Data suggests that the experience of staff in the surgical suite environment is similar, yet distinct, from that of the patient. For example, theatre team members will not fear the operating theatre because they are familiar with that environment. Several elements within the interviews revealed an impact on the comfort of staff members in their work environment, most commonly linked to noise and disruption:

> *'… you've got a quiet, isolated area away from the noise in theatre. You can actually induce anaesthesia without interruption.' (M13)*

> *'It's a kind of quiet area where there's less distraction… Distractions are reduced by having a quiet space… so it helps the anaesthetist focus on the task in hand and in fact, distraction issues are not trivial.' (M11)*

Responses highlighting distraction and interruption were coded similarly to their inverses -focus and concentration on the task of inducing anaesthesia, which is provided by the separation of theatre and anaesthetic room. Several participants referenced policies and preferences to avoid entering the anaesthetic room while the anaesthetic is underway.

> *'…don't interrupt in the AR when the anaesthetic's being given. (M3)*

> *'I've walked into an AR thinking it's empty, and… I do get cross words from the anaesthetist like, "Oh, you should have waited. Could you not see I was doing this?"' (M6)*

Another aspect of staff experience which is unique to the clinician or auxiliary staff is the pressure or stress experienced due to the presence of other/additional clinical staff. This is a particular issue for junior clinicians.

> *'It sometimes takes pressure off time when you might feel that everyone is in there, sort of waiting for the patient to be asleep.' (A11)*

> *'You don't have people breathing down your neck and staring at you while you're doing your induction.' (A2)*

> *'It improves teaching opportunities. Allows more junior staff to learn techniques without being pressured by observers.' (A10)*

Generally, statements of stress and pressure appeared to be in relation to the surgical team pressuring the anaesthetic team in a negative manner; however, a degree of pressure was also indicated as a positive for incentivising more efficient working.

> *'A lot of people do take a lot of time in the AR that perhaps if they were intimidated in an operating theatre by people standing over them, ready to operate, they would go a little bit faster.' (A1)*

The interview findings suggest an improved experience for anaesthetists with the use of anaesthetic rooms, as noise, time pressure, and distraction are perceivably reduced. This sub-theme also relates to the concept of work autonomy.

Autonomy

A common sub-theme of staff factors was the topic of autonomy, which conveyed the elements of staff control of the environment, the concept of distinct domains (spatial and professional), and individual preferred practice.

The sense of control over one's work environment was mentioned typically in relation to protecting the space from other members of staff. This is heavily tied to the sub-theme of distraction.

> *'You can prevent interruptions when you're giving anaesthetics…you can put signs on the doors that say, "Anaesthetic in Progress. Please do not enter." So you've got control of the environment from the sort of personnel point of view.' (M1)*

Control was not only emphasised from the anaesthetic perspective, but also the need for theatre staff to feel control over their space, when preparing theatre for surgery.

> *'... what the theatre staff worry about is their clean trays. If you anaesthetise in the theatre at the same time they're getting the trays out for the next case…and there's an anaesthetist trying to do an anaesthetic, they worry about contamination of the tray and bits and pieces flying around.' (M11)*

Control over the work environment was linked to staff comfort and experience. One anaesthetist shared that:

> *'Some people just feel more confident working in a space that they feel in control of, I think. And it sort of de-stresses them, I think, having that sort of an environment.' (A11)*

Similar to the aspect of control, is that of domain, which relates to both the physical space separation of the anaesthetic room and the operating theatre, and the distinction of professional domains between the anaesthetic and theatre teams. Where the operating theatre is the surgeon's domain, the anaesthetic room serves as the smaller domain of the anaesthetist.

> *'I think anaesthetists like their anaesthetic room. It's their little domain –their area of work.' (M16)*

One manager (consultant anaesthetist) suggested that some anaesthetists might rationalise the anaesthetic room as:

> *'… somewhere where I can have a cup of tea during the list… somewhere I can put my bag… it's my space, or somewhere where the surgeons have to keep out of my way.' (M9)*

One anaesthetist compared the professional boundaries to a football pitch, saying that:

> *'... you've got an anaesthetic team and a scrub side, so it's like Derby County versus Nottingham Forest.' (A1)*

When asked what factors contributed the most to the continued use of anaesthetic rooms in the UK, many participants emphasised the importance of individual preferences. The coding of personal preference was categorised under autonomy, as it relates to the freedom of the clinicians to act upon their preferences.

Clinical Choice

Clinical choice is distinct from that of personal preference, as the specific patient characteristics or case type may dictate the site of induction, despite the clinician's personal preference. This is also categorised as a staff factor, not a patient one, as the clinician will use knowledge of the patient's condition to choose the site of induction.

Interview responses regarding clinical choice and decision making and the motivation for those choices related to three codes: convenience, efficiency, and safety.

The decision to anaesthetise a patient in the operating theatre or the anaesthetic room is sometimes made as a matter of convenience. Typically, statements which were coded in this manner related to the complexity of the surgical procedure or the anaesthetic given. No anaesthetic or local anaesthetic procedures were more often mentioned as being conducted in the theatre. Some references were made to utilising a minor procedure room, which is a theatre with no anaesthetic room, which would be used for dental cases or other minor cases. The tendency to bypass the anaesthetic room was seen in case lists with very fast turnover, and simple procedures such as day case, dental, maxillofacial, and ophthalmology procedures, and those within the short stay unit. Efficiency of theatre throughput and minimal turnover time between cases were also implicit motivators for selection of the site of induction, however, this concept is discussed further under 'organisational factors' as it is an organisational objective. In contrast to simple procedures, some major cases within vascular surgery, upper gastrointestinal surgery, interventional cardiology, and cases requiring invasive monitoring, were preferred to be done in the theatre.

> *'It's usually based on the fact that they have invasive monitoring and it's easier to set up invasive monitoring once, rather than twice.' (M5)*

One anaesthetist who prefers in-theatre induction, mentioned the difficulty of transporting infusion pumps which are used for injected general anaesthetic.

> *'It becomes inconvenient and I think the people who favour the AR, do so partly for convenience, and it's just the root cause analysis of what that convenience is, and does that convenience compromise safety?' (A17)*

Similarly, the anaesthetic room can be avoided in the case of obese patients, as transferring a morbidly obese patient is inconvenient. In general, the extra patient transfer between the AR and the operating theatre can be considered a risk to any patient's safety.

> *'... I cut out the stage of having to move a patient who I had just anaesthetised, unmonitored, into the* [theatre] *and avoided an extra transfer... especially these days, where we have an awful lot of large patients, there's one less patient movement to do.' (A15)*

The potential risk to staff due to transferring patients, particularly obese patients, is also an important consideration. In reference to bariatric patients, one anaesthetist stated:

> *'... it may be appropriate to keep them in the OT, simply because the difficulty in moving them from place to place. You've always got to bear in mind risks to staff with manual handling.' (A19)*

Conversely, anaesthetic rooms are also chosen as the site of induction based on convenience. As the anaesthetic room is typically the location for equipment and drug storage, it creates an inconvenience to anaesthetise a patient in-theatre, requiring movement into a separate room for anaesthetic supplies.

> *'All the drugs and equipment are so very readily available actually, which is what I like... They're all readily accessible if you needed a particular drug in a hurry, it's easily available.' (A18)*

An additional motivation for selecting the site of induction was based on patient safety. The three primary determinants for choosing the site of induction for safety were patient factors (i.e. difficult airway, very sick, etc.), the surgical specialty or procedure (i.e. emergency, obstetrics, etc.), or the risk involved in the patient transfer.

In regards to patient safety, clinical choice was one sided, as the majority opinion was that the operating theatre should be the site of induction if patient safety is a concern. Patient safety was coded with reference to transfer of an unconscious and very ill or unstable patient, or emergency specialties which require minimal time between induction of anaesthesia and surgical incision.

One manager described several nuances of the safety argument stating,

> *'... if you look at the ins and outs of the safety aspects of it, reducing a step of anaesthetised patient being transferred reduces the risk of airways falling out, and monitors falling off, and things like that... potentially, it could be safer to anaesthetise patients in theatre.' (M9)*

Specific specialty considerations which would be anaesthetised in the theatre for the benefit of patient safety would be emergency cases and obstetric patients.

> *'... emergency patients, you will take them into theatre and put them to sleep in theatre, if you want a minimum delay between the start of anaesthesia and the start of surgery. So obstetrics patients, for example, they always go straight into theatre.' (M13)*

Additional mentions of particular patients where the transfer time is considered a safety risk included those who were critically ill, had aortic aneurysms, major haemorrhages, or difficult airways requiring a tracheostomy.

4.4.2.2 Organisational Factors

Organisational factors were categorised as such as they are determining factors outside of the individual staff members working within the surgical suite, although they may have influence on the individual. Themes within the organisational category were related to priorities and agendas of individual NHS Trusts, management decisions, and operational standards. These factors could not be altered by the individual, and would require systems change in order to alter anaesthetic practice. **Figure 4.4** depicts the relevant organisational factors.

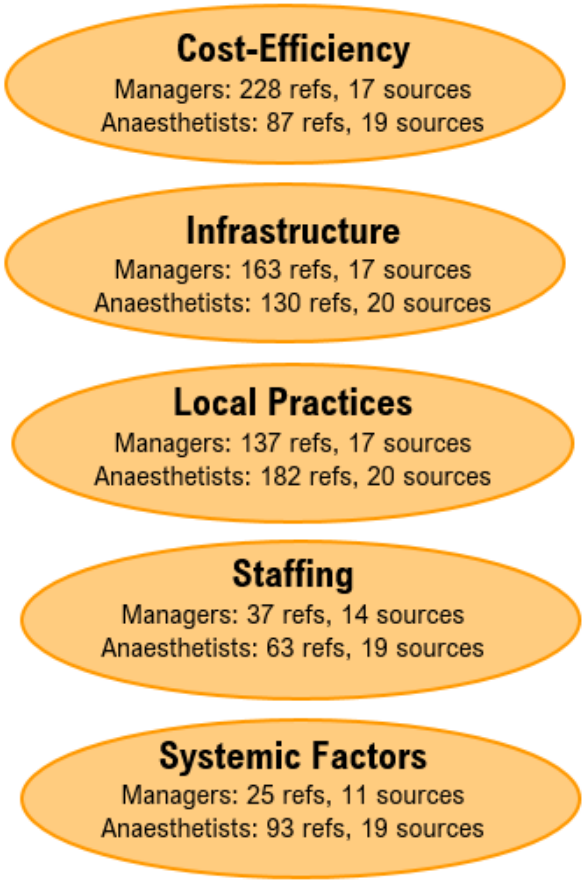


Figure 4.4 Organisational Factors

4.4.2.2.1 Cost-Efficiency

The definition of cost-efficiency relates to saving money by performing in a better way. The theme of cost-efficiency as it relates to anaesthetic rooms can be best understood by being broken down into its sub-themes of costs and efficiency.

Costs

The sub-theme of costs refers specifically to the financial expenses incurred from building and maintaining anaesthetic room. Whilst managers more often referenced the cost of financing renovation, staffing costs, and ensuring benefits outweigh costs (cost-benefit analysis), the anaesthetists identified equipment cost and the expenses of the physical available space being dedicated to the AR (space cost).

Half of the consultant anaesthetists mentioned the cost incurred of duplicating equipment in order to have a fully functional anaesthetic machine with suitable

monitoring in both the operating theatre and the AR. One anaesthetist explains the requirement for duplicated equipment:

> *'Well obviously you've got to have additional equipment because you've got to have the same level of safety in the AR as you do in theatre, and that's very expensive in terms of monitoring equipment and anaesthetic delivery.' (A12)*

In addition to the cost of equipment, several anaesthetic participants mentioned the cost of extra physical space devoted to the AR and the cost required to pay 'rent' or to heat the space.

Managers' cost concerns tended to focus on the existing infrastructure of their hospitals and the investment which had already been made in committing an anaesthetic room to each theatre. In considering any changes from the current layout of the theatres, most of the managers said that the financing of renovation of theatres would be considerable. One anaesthesia manager weighed the option of removing ARs from theatres, stating:

> *'You couldn't utilise the space you would free up by not having ARs... unless you completely gutted the whole theatre area and start all over again, which clearly would be a very challenging and very costly thing to do.' (M1)*

Managers were also attuned to the costs required for staffing the operating theatre and anaesthetic room. The AR is championed by the prospect of overlapping work and allowing for the preparation or induction of a second patient while the first is finishing up in theatre; however, this practice requires sufficient staffing to safely attend to both patients in separate rooms. While more than half of the managers referenced the cost of staff, only one anaesthetist mentioned it.

Balancing all of the costs incurred from staffing and utilising an AR was a dominant code which emerged from the manager interviews. This consideration of cost and benefit is primarily important in considering if the actual savings from improving throughput exceeds the cost to employ the necessary number of staff. However, this type of analysis requires someone who is able to do it as one manager stated:

> *'... if you're getting an extra case done every day, then there's a significant amount of income so you obviously need an accountant to work out whether it'd be worth it or not.' (M11)*

Efficiency

Efficiency was a frequently referenced theme within the interviews. The word 'efficiency' was often stated as an important consideration, without additional elaboration; however, aside from direct references to 'efficiency', topics relating to productivity and anaesthetic overlap were also coded under efficiency.

Productivity, whilst often used synonymously with 'efficiency', is defined in the Oxford Dictionary as the 'the effectiveness of productive effort, especially in industry, as measured in terms of the rate of output per unit of input.' Productivity was coded in both sets of interviews in relation to the anaesthetic room's impact on throughput of patients undergoing surgical procedures. Increased throughput was something that was often referenced as an individual or organisational goal that could be achieved by using an AR.

In contrast, seven anaesthetists suggested that bypassing the AR and taking patients directly into theatre may improve throughput and reduce delays. It was thought by some that avoiding the extra duties of transferring, handling, and positioning an unconscious patient could save time. One anaesthetist stated that

> *'It cuts down on the time taken to move from one place to the other, basically… What you can do is just get them to lay on the operating table, position them, induce them, and then invite everyone to come. It's much quicker.' (A10)*

One of the major topics of discussion regarding the usefulness of ARs with relation to efficiency improvements was that of anaesthetic overlap or doubling up. This practice of overlapping the treatment of two patients in order to minimise turnover time between cases was most often discussed in a hypothetical sense. Only 7 managers and 2 anaesthetists made precise reference to anaesthetic overlap presently occurring in their hospital's practice in some form.

The complete induction of a patient in the AR while another patient is in theatre was typically mentioned with regard to historic practice. Several participants stated that only limited overlap is able to take place, such as holding the patient in the AR or applying basic monitoring. In some cases, regional anaesthetic can be started, but only if the previous patient is also awake and only regionally anaesthetised, so the only

maintenance required is clinical presence in the theatre, enabling the anaesthetist to move to the AR to begin the next patient:

> *'… on the hand list, it's easy. My patients are all awake. They're blocked*[6]*… once they're settled and okay, I can leave them with a trained member of staff while I'm in the other room and they can shout me if there's a problem.' (A6)*

The possibility of anaesthetic overlap occurring is linked directly to the existence of the AR itself, as a separate space adjacent to theatre, and to a suitable number of qualified staff members to provide safe anaesthetic care. Participants indicated that in order to achieve true anaesthetic overlap, there is a requirement for a second anaesthetist (either a consultant or a sufficiently experienced trainee) and another designated anaesthetic assistant. These extra resources are rarely available as stated by one manager:

> *'Largely, I think partly because of staffing issues and partly because of changes in practice over the supervision of junior staff and things like that, we are rarely now in a position where we can have one patient being operated on and the next patient asleep or going to sleep…' (M1)*

Statements relating to the inability to overlap patients based on human resource limitations were coded as no overlap due to staffing and is therefore linked to the separate theme of organisational staffing, discussed in a later section.

4.4.2.2.2 Infrastructure

The physical infrastructure of the hospital, its wards, rooms, and corridors, was discussed specifically in regards to the current existence of ARs and the significance of this pre-existing architecture in current practice and designing for future theatre builds. The main sub-themes of the responses relating to infrastructure were the suitability of the AR in meeting the needs of its users; the flexibility and choice made available to clinicians by having an AR; how existing infrastructure can act as a design constraint for future building, and how to go about design planning for new builds or renovations.

[6] The term "block" refers to a regional anaesthetic or nerve block which provides a regional numbness in a part of the body by injection of anaesthetic.

Suitability

Frequently, participants made mention of the age of their theatres and hospitals and how practice has changed –sometimes before infrastructure has been changed. This has resulted in areas which are no longer fit for purpose. References to the AR being unsuitable were typically in relation to the size of the AR:

> *'... they made tiny little ARs that actually weren't fit for purpose, so in the end, people just abandoned them and went straight into theatres.' (M17)*

> *'And the ARs are so small that these days, now, over a decade down the road… we don't use them. They're used as storerooms, because they were just designed as too small.' (A17)*

The particular design of theatres has an intention behind it for what practice will be within the space. Many participants discussed a deviation between intended practice and actual practice in theatres due to perceived design flaws.

Questions about the suitability of the AR led to discussion of potential alternatives such as a block room or shared ARs. While a separate, designated, common room was suggested as a possible compromise for conducting regional blocks for surgical patients, the concept of a shared AR (i.e. one AR built to provide access to two or more theatres) was typically deemed inappropriate. From the experience of some anaesthetists who have some shared ARs in their hospital, one stated that:

> *'… we don't find it helpful to give anaesthetics in that room because of it being a shared environment, and so our general practice is to use the theatres for induction of anaesthesia, so they've ended up not being used as rooms to give anaesthetics in.' (A18)*

Choice

An important consideration in theatre planning and potentially eliminating the AR from operating theatre builds in the future is the resulting elimination of choice. Half of the consultants and half of the managers reported that the existence of the AR allows for the flexibility of using it or choosing not to. The infrastructure being in place provides clinical flexibility. One anaesthetist expressed this by saying,

> *'Well like I said, all theatres have ARs so it's only a clinical decision that dictates whether you use them or not. Infrastructure is there.' (A4)*

Whilst many shared a preference for being able to choose whether or not to use the AR facility, some also said there could be difficulty in changing practice based on their availability.

> *'... whilst we're given freedom to choose what, in each individual case, how we would like to do it, then I think we'll continue to do what's comfortable for us.' (A13)*

> *'If ARs are available, then they'll carry on being used. If they're not available, people will unlearn their habits.' (A16)*

Design Constraint

Apart from general limitations that hospitals face in redesigning (i.e. finances, building guidelines, etc.), several references were made to the restriction that ARs present. The design constraint sub-theme not only involves the actual layout of theatres, but can also be expressed as a constraint of design creation and decision making. For example, one manager considered what his employees might say with regards to new theatre design, stating:

> *'If you asked the anaesthetists today, "We're going to build two new theatres." They would say, they need some input into the AR. They wouldn't say, "No, we don't want an AR. We need to look at a different model."' (M16)*

The existing infrastructure of hospitals also poses a constraining factor for future design as another manager discussed:

> *'Taking them out would be easier than putting them in. The biggest problem we'd have would be the infrastructure… the walls that support the AR are also a part of the walls that support the building…' (M14)*

Respondents reported difficulty in making large scale change to current infrastructure and suggested the mere existence of anaesthetic rooms resists physical alterations.

Design Planning

The final sub-theme related to infrastructure was the design planning process, and more specifically who would be involved in such decisions. Within the set of manager interviews, the dominating response was that consultant opinions would need to be taken into account and that the decision should be made by the team and a consensus reached by the staff. These findings validate the decision to open the interviews to consultant anaesthetists, who would be able to provide additional insight into the rationale of the decision making behind the use of ARs and their inclusion or exclusion in new designs.

The responses of the anaesthetists supported those of the managers with regards to the need for design to come from team decision making and gathering opinions from the users:

> *'I would expect our managers to consult with us as a department. And to have us involved in the consultation process if they were producing plans for new builds.' (A18)*

The anaesthetists who had recent renovations or new builds were asked if they were consulted in the design planning process. Six anaesthetists said that they or their colleagues had limited input or no input into the plans. Some stated that they were only consulted after the design plans were developed:

> *'…once the anaesthetists get to see the plans, the plans are pretty much in position. Sometimes, we may make a comment about the direction, the processes… But that usually is a stage after the physical layout has been developed.' (A19)*

In discussing design planning, the respondents were asked a 'chicken and egg' question: 'Is design of theatres informed by practice, or is practice informed by design?' Whilst several answers related to practice being influenced by design (i.e. the significance of pre-existing infrastructure; areas that are no longer fit for purpose; etc.), several other responses suggested that decisions for theatre design are dictated by practice. This was often suggested as the ideal process in order to develop the most fit for purpose design with user involvement.

> *'... if that is what people are used to doing, then you do need to make whatever, the new theatres, or whatever you're building has to be whatever people are used to.' (M17)*

> *'I think the design has been set up by the practice, that's been the UK practice, of having an AR in the theatres. So that's how it's been.' (A9)*

There is a limitation, however, to theatre design being tied to current practice. Some managers discussed the need to consider long-term planning as new builds can take many years and do not occur very often. When considering how to go about a rebuild of theatres, one manager said:

> *'It would be a massive thing to do –a rebuild of theatres. You'd have to do a lot of research to get it right to try to future proof it.' (M3)*

4.4.2.2.3 Local Practice

Local practices were coded in order to identify the activities taking place in and around the anaesthetic room. Apart from the typical use of the AR for provision of general anaesthesia and regional anaesthesia, additional activities occur such as basic patient preparation, insertion of lines, and conducting the World Health Organisation checklist. The space also serves as an area for teaching trainees, and providing a space close to theatre for tea or lunch.

Theatre Preparation & Equipment

The most referenced local practice related to the AR was theatre preparation that needs to take place before the next patient can be brought into theatre. The theatre is prepared by cleaning the floor and equipment after the case has finished, removal of all instruments and personal effects of the previous patient, and setting up all required equipment and instrumentation for the next procedure. In order to improve throughput, minimise noise, disturbances, and patient anxiety, it is commonly believed that theatre preparation can and should occur in theatre while the patient is in the AR, which was reflected in the interview responses. In connection with the preparation of theatres, a separate space is available in some hospitals, in addition to the AR, called the prep room, where surgical scrub nurses can set-up instrumentation in a 'clean' environment outside of and adjacent to theatres.

The next most commonly referenced practice was the use of the AR for storage of supplies and equipment. All anaesthetic drugs and disposable supplies are typically stored in the AR, as well as the anaesthetic machine and monitoring. Even when specific specialties choose not to use an existing AR, the space can still function as a local storage space:

> *'In some areas where we've stopped using ARs, they're used more for storage.' (A20)*

Paediatric Patients & Accompaniment

One prevalent anaesthetic practice that was mentioned involved the use of the AR for the induction of paediatric patients. Typically, participants expressed a preference to induce all children in the AR to minimise anxiety and to allow for parent accompaniment. Even anaesthetists who are more open to in-theatre induction within their own practice will still consider the AR as a more suitable location for paediatric patient induction, as exemplified by one anaesthetist:

> *'... I still haven't got to the point where I bring parents straight into theatre with the child. And I'm still a little bit concerned whether the theatre environment might be a bit too intimidating for a child.' (A15)*

Preparing for Orthopaedic Cases

Several unique practices that utilise the AR were referenced for the orthopaedic surgical specialty. These local practices may have been unique to the Trusts in which the individuals who mentioned them practised, as they were not raised by all participants. Respondents described the specialised operating room airflow system, laminar flow, which is installed in certain orthopaedic theatres. This ventilation unit directs the air down over the area within theatre where the many surgical instruments are opened and set-up in an effort to reduce surgical site infections. The use of laminar flow assumes that surgical instruments cannot be set-up in front of a patient and therefore requires the patient to be kept out of the theatre while instruments are laid out under laminar flow, which would not be available in the prep room. One anaesthetist explains by saying:

> *'I'm not quite sure where the guidance comes from and how strong the guidance is, but there is an acceptance that it's best to prepare the surgical equipment under laminar flow.' (A20)*

Similar to the belief that laminar flow can reduce infection risks, some orthopaedic surgeons require double prep (a double application of skin antiseptic solution) of the surgical site.

> *'... if you're doing a hip replacement, knee replacement, they get prepped in the AR, so painted and draped. Then they get wheeled through into theatre, and they get re-painted and draped again.' (A6)*

This duplication of work takes advantage of the AR facility by allowing the surgical team the space to position and begin preparing the surgical patient before they even enter the theatre.

Hospital Policy

The hospital policy was thought to be an important factor in determining local practice with regards to the AR and its uses; however, 17 of the 20 anaesthetists indicated that there either was no policy or they did not know if there was a policy specifying the site of induction.

4.4.2.2.4 Staffing

The theme of staffing emerged with close connection to statements on staffing costs and the impact of staffing on efficiency. Some participants referred to historic staffing levels, recalling several years ago when it was a regular occurrence of having an anaesthetic trainee with the consultant on every operating list, which would allow for anaesthetic overlap. Some references were also made to generic staffing shortages, by mentioning 'staffing issues', 'staffing levels were inadequate', or as one anaesthetist shared:

> *'I think the staff are under a lot of pressure -theatre staff. I don't think there are sufficient at the moment.' (A13)*

Interviews suggested a common belief that extra staff improves throughput of patients. This was directly related to the idea of anaesthetic overlap or increasing throughput.

Some respondents discussed the benefit of additional recovery staff who could help retrieve the patient from theatres. Most other respondents discussed the benefit of employing additional anaesthetists, and/or a second ODP to enhance the turnover of procedures, as exemplified by this anaesthetist:

> *'It would be lovely if we had enough anaesthetists and ODPs to be able to get one patient off to sleep while another was being taken out to recovery… but we don't have the manpower.' (A18)*

4.4.2.2.5 System Factors

The theatre suite is only one component in a system of interconnected departments and processes. Interview participants were asked to list typical causes of delay that they experienced. Factors ranged from equipment issues and blood tests not available, to missing patient notes and communication errors. All of the processes from when the patients arrive at hospital to when they leave are important in moving the patient along in a timely manner, and can also cause delays throughout the system, as one anaesthetist said:

> *'It's a long chain and there's any number of weakest links.' (A11)*

Many of the factors influencing the flow of the patient in and out of surgery pertained to the pre-operative unit, the recovery unit, or beds being available for the patient to leave recovery. However, the most common delay was the transfer of the patient to and from required areas (portering):

> *'Waiting for the patient to get from ward to theatre is probably the biggest source of our frustration and delay.' (A10)*

The difficulty in portering in a timely fashion is also multifactorial as it can be due to a lack of porters available, not finding a trolley, patient not being ready, or sending for the patient too late. In order to see overlap, the ODP must send for the next patient at an appropriate time during the previous surgical procedure so that the theatre and AR are not both sitting empty.

4.4.2.3 External Factors

The final stratum concerning to the use of anaesthetic rooms in current anaesthetic practice is that of the external factors that are outside of both the individual and the organisation, yet deeply affect both in a significant way. This high level category encompasses some factors which guide practice, including elements that help to determine best practice, and attributes of the culture that is influencing standards of practice. **Figure 4.5** presents the external factors which emerged from the interviews.

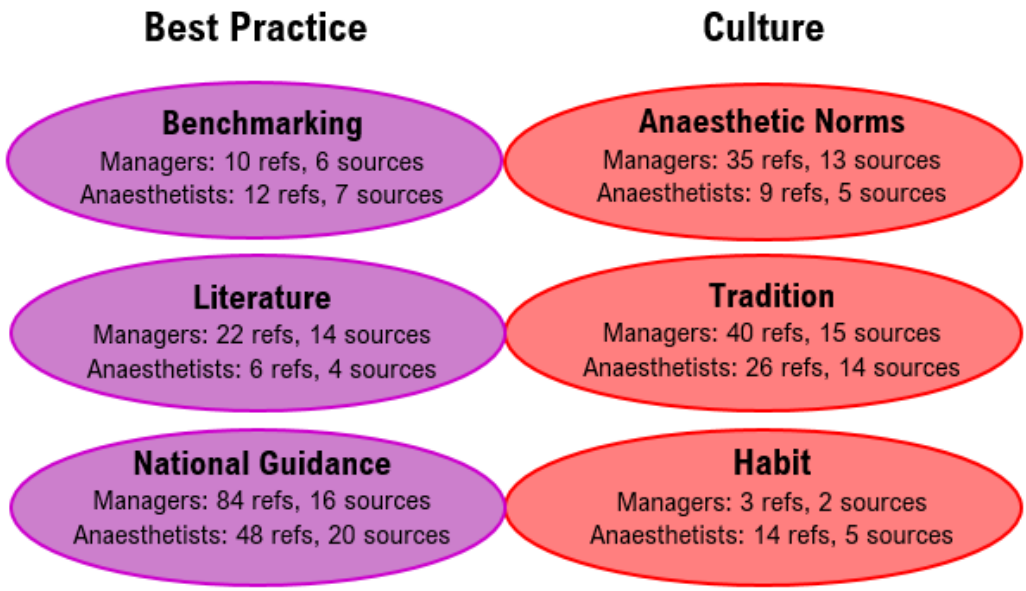


Figure 4.5 External Factors

4.4.2.3.1 Best Practice

The theme of best practice emerged as participants discussed how they know what is the safest and most effective way of working and whether the AR should be a part of that practice. The three sub-themes pertaining to best practice were benchmarking, published literature, and national guidance.

Benchmarking

Benchmarking was selected as a code for statements seeking to compare practice with other organisations, the private sector, and in other countries. Participants mentioned the Circle Treatment Centre in Nottingham, Guy's Hospital in London, and Ipswich Hospital in Suffolk where operating theatre induction is the norm. Some participants said that they would be looking overseas at countries that do not typically use the AR,

such as the USA, to determine the advantages and disadvantages. With regards to deciding whether or not to include ARs in new theatre design, one business manager described his plan:

> *'We would be looking at best practice all around the world because this is, as you can imagine, it is quite a* [sic] *significant, both in terms of cost and time, so we would be going out.' (M14)*

Literature

While managers were directly questioned on the relevance of literature on their decision making processes, their responses indicated that they did not know about any research regarding anaesthetic rooms, they would investigate the literature themselves in the future, or that someone else would. One business manager placed the responsibility of discovering the appropriate research on the anaesthetists, stating:

> *'… that would have been more of the professional literature for the anaesthetists and the anaesthetic environment they work in… you'd probably be better off asking them directly some of that.' (M7)*

Interestingly, very few anaesthetists discussed the relevance of literature on their practice and several anaesthetists confessed to not knowing.

> *'I haven't read any literature on this at all.' (A14)*

> *'I do not know if there have been any publications, but all I know is from my own practice and what I see…' (A9)*

National Guidance

The sub-theme of national guidance emerged from codes indicating specific types of guidance and attitudes toward guidance. In reference to the design of theatres and recommendations for the construction of ARs or guidelines pertaining to the appropriate use of ARs, participants referred to the following resources:

- Health Building Notes – design and construction requirements
- National Institute for Health and Care Excellence
- Royal College of Anaesthetists
- The Association of Anaesthetists of Great Britain & Ireland

The majority of respondents felt any guidance from the government or professional bodies would be important and helpful in changing anaesthetic practice. Some individuals believed that practice could change despite there being national guidance in place, but it would not be imperative, as one stated:

> *'I think in the absence of national guidance, change can still happen, can't it? We can just do it at a local level. But if there was national guidance, it would be helpful in making the change.'(A11)*

Although many were not aware specifically of what national guidance has to say about ARs, there were statements about trust and a willingness to be in compliance with their recommendations. Interviews did reveal possible limitations of national guidance and how it may be held up or discarded depending on the anaesthetist's perspective. One anaesthetist shared that guidance is in place for clinicians of limited experience to know what to do, however, for the more experienced clinicians, he said

> *'We'll quote national guidance if it fits with their practice. If not, they'll quote local policy… guidance is exactly that -it's guidance. It's not protocol… So it's a bit of a template and a route map. But for the more experienced clinician who is able to use their expertise, then they can justifiably migrate from guidelines, be they national or local.' (A17)*

4.4.2.3.2 Culture

The theme of culture was coded as such based on references to 'culture change' or simply stating the significance of 'culture' within the context of shared ideas and behaviours within the anaesthetic community that may influence the use of ARs. Additional sub-themes were identified that related to organisational culture and were coded as anaesthetic norms, habit, and tradition.

Anaesthetic Norms

The idea of 'anaesthetic norms' was tied to specific language referring to anaesthetic standards of practice, norms, or being used to a way of working. The normality of current practice within the anaesthetic and surgical teams is exemplified by this service manager's statement:

> *'Different people have different views, but our consultants are used to having an AR. Not just the anaesthetists, also the surgeons, and… the theatre teams. That's what they're used to, so again, I think that would be a potential issue.' (M10)*

Habit

Habit is very similar to anaesthetic norms and has overlap with tradition, however, references to 'habit' or practice being 'habitualised' is subtly more expressive of a tendency to resort to what is comfortable without questioning it. It assumes a default behaviour. This distinction was made from responses which referenced this 'auto-pilot' type behaviour, as one anaesthetist stated:

> *'I've always been able to use an AR. And there are times in my practice lately where I've used an AR and I thought, "Oh, I didn't actually need to do that," but I do that because I'm in the habit of doing that… I sometimes use them because I always have.' (A14)*

This may undermine evidence-based practice and requiring comprehensive rationale for practicing in a certain way, as one anaesthetists explained:

> *'… sometimes it's just habit… that I'm used to working in that space, so I go back to that space. But that's not a good reason.' (A11)*

Habitualised practice can then be linked to design constraints as it may play a part in limiting new theatre designs which would impact practice.

> *'And I think that we're all creatures, to some extent, of habit and so I think that if it was being planned anew, then the habits -practices that people have learnt- would inform the design.' (A16)*

Tradition

The sub-theme of tradition was the most frequently coded node under the theme of culture, as it encompassed all references to historical practice, specifically British practice, custom, and reference to the way things have 'always' been done.

In response to a question asking for what factors contribute to the continued use of ARs in the UK, one anaesthetic clinical director summarised the relationship of training and traditional practice by stating:

> *'It's the way almost everybody who is trained in anaesthetics in this country will have learned to give anaesthetics… that tradition and that comfort with that way of working is probably one of the strongest factors.' (M1)*

The embeddedness and systemic reinforcement of current practice in new generations of anaesthetists may be crucial to address in order to bring about change, if it were deemed necessary, as one anaesthetist explained:

> *'So I think it's just that we train people to do what they've always done, don't we? So until we challenge that and start changing their behaviour young, I think they'll turn into people set in their ways quite quickly –sadly.' (A11)*

4.4.2.4 Improvement Change

The final high level category that emerged from this study was that of improvement change. Interview questions about the hypothetical removal of ARs or what would be required to change anaesthetic practice was built into the interview topic guide. As survey results in Chapter 3 showed a dominant view in support of ARs, it was essential to question that practice and investigate the challenges that might arise in the effort to change practice. However, the goal of this research was not to propose change of current practice for the sake of change, but only with the support of sound evidence. The themes relating to improvement change were separated into participants' perceptions of changing behaviour and their views of evidence-based practice in this specific regard, which are shown in **Figure 4.6**.

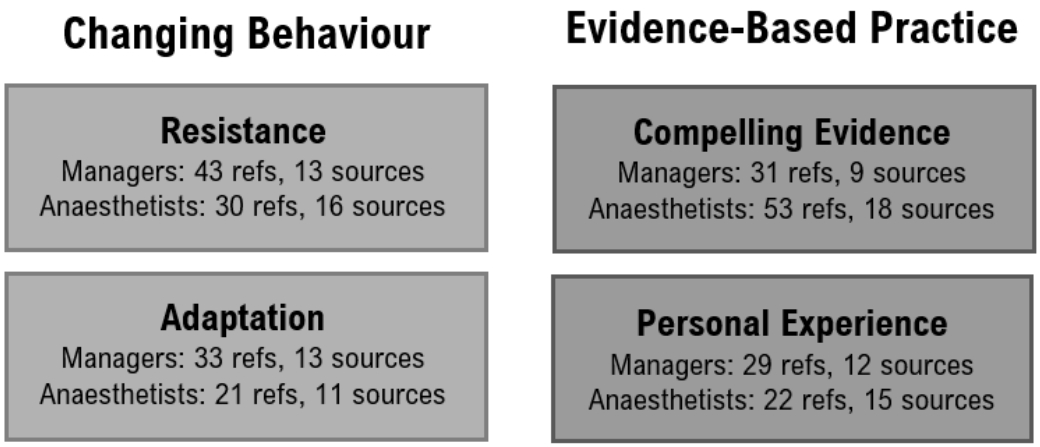


Figure 4.6 Improvement Change

4.4.2.4.1 Changing Behaviour

Many of the statements assigned to the theme of changing behaviour were simple statements of requirements for change or modifying staff behaviour and attitudes. Three minor sub-themes, which are not depicted in **Figure 4.6**, developed in relation to drivers for change, which were leadership, the speed of change in the healthcare environment, and the need for consensus amongst the anaesthetic community for change to occur.

In modifying long standing practice, a few participants emphasised the importance of good leadership and advocates of change to champion the effort. Many participants also noted the slow and gradual pace expected if change is to occur. This also related to the infrequency of infrastructure change. One business manager explained what may happen if ARs were no longer recommended to be used and new theatres were built without ARs, stating that:

> *'… towards the end of the life of the hospitals or the theatres that did have ARs, it would become quite unusual, but it would be quite glacial, I think, because of the cost of the infrastructure.' (M7)*

From the interviews, only anaesthetists mentioned the need for consensus to be formed within anaesthetics for the accepted standard for practice to be changed.

> *'If there is a national consensus that it is good practice, then I think people would change.' (A9)*

The most dominant sub-themes pertaining to changing behaviour related to clinical willingness to change. Many references were made both with regards to resistance to change, and adaptation to change.

Resistance

The interviews revealed the prevalence of ARs in historic and current practice, and the strength of cultural influences on their use. It is therefore evidence that the most dominant sub-theme relating to changing behaviour is resistance, or a perceived difficulty in changing practice from the status quo. Some participants referred to clinical willingness to change as 'virtually impossible', 'a bit of a struggle', or 'quite resistant'.

One anaesthetist related this resistance as a British characteristic, stating that any changes that do take place are similar to 'wading through treacle'. He stated that:

> *'…the British public at large are pretty conservative, pretty resistant to change. They don't tend to embrace it… It takes a while, and that's almost a British trademark.' (A17)*

Many individuals seem convinced and assured of their current practice:

> *'I suspect most people would be unwilling to change because they've seen the advantages and they've been trained to minimise any hazards…' (A16)*

Adaptation

While challenges to behaviour change do exist, as demonstrated by the sub-theme of resistance, participants shared a belief in the adaptability of staff members. Many anaesthetists admitted that despite their preferences to use the AR, they would adapt to new ways of working.

> *'I think anaesthetists and surgeons, as well as the staff on both sides, would very quickly adapt to the lack of an AR if that were the case, as we sometimes have to do even now.' (A16)*

> *'I'd probably get used to it. If everybody was anaesthetising children without an AR, I'd get used to it along with everybody else and we'd have a system for managing it.' (A14)*

It is interesting to consider that whilst many participants would seek consensus and team agreement on design of theatres and best practice, the clinicians and staff members would be adaptable, even if change is imposed.

> *'I'm not sure that anaesthetists need to be given a choice actually. If the Trust… said the ARs were being decommissioned, I would within the week be over it and get on with it.' (A11)*

In addition, one manager drew attention to the nature of a constantly changing NHS and how people, despite not liking it, have accepted it.

4.4.2.4.2 Evidence-based Practice

The most prevalent sub-themes regarding evidence-based practice were the idea of compelling evidence to change, or what would be strong enough evidence to sway opinions on anaesthetic room use, and the notion that perception and personal experience are suitable forms of evidence.

Compelling Evidence to Change

Throughout the interviews, references which were made to 'evidence' often emphasised the strength of the evidence, which the author interpreted as both the validity of the research findings and how compelling they are to the individual. Several participants linked strong evidence as being a mechanism for combatting resistance to culture change, as one manager explained that:

> *'… if there was definite evidence that it would be beneficial to get rid of the ARs, I think people would be happy with that, but you'd have to have concrete evidence because it's so engrained.' (M17)*

National guidance, which was coded as an external factor, was also associated with evidence-based practice because of common belief that any guidelines or recommendations made by the government or professional bodies would be based on robust research and evidence. As per the subject matter of the evidence which would be compelling to change practice, the most commonly desired topic was that of patient safety. The majority of anaesthetist responses valued evidence showing improved

patient safety above patient experience, cost, and efficiency outcomes. One manager summarises this by stating:

> '*I think national guidance has got a very strong role if it's a risk and safety issue. And I would expect that if there was strong evidence that continuing to use ARs was a genuine risk to patient safety, that we would very rapidly see guidance…' (M1)*

Additional evidence which participants most often reported would be compelling to them were that of patient experience, efficiency and cost savings. **Table 4.2** presents the evidence raised by the respondents, ranked in order of most frequently referenced, which would be compelling enough to change their practice. Managers valued cost, patient safety, and efficiency outcomes.

Whilst evidence-based practice may be a noble objective, one anaesthetist explains how it may not be sought after to support current practice, but only for proposed change.

> *I think change is a very difficult thing to achieve. When people are happy with how they work, they need to be convinced of why they should change… That's human behaviour. They'll want evidence to change, but they're happy that there's no evidence for what they do. (A3)*

Table 4.2 Responses related to compelling evidence to change practice

Rank	Anaesthetist Evidence Required	Anaesthetist Ref / Source	Manager Evidence Required	Manager Ref / Source
1	Patient Safety	19 / 14	Cost Savings	6 / 4
2	Patient Experience	9 / 7	Patient Safety	6 / 4
3	Efficiency	6 / 5	Efficiency	6 / 3
4	Cost Savings	6 / 5	Patient Experience	5 / 4
5	General Improvement	5 / 4	Clinical Outcomes	2 / 2
6	Patient Privacy	2 / 2	Patient Benefit (in general)	2 / 2
7	Infection Control	2 / 2	Patient Satisfaction	2 / 1
8	Patient Anxiety	2 / 2	Distraction Reduction	1 / 1
9	Quiet Environment	1 / 1	Patient Privacy	1 / 1
10	Patient Flow	1 / 1		

Personal Experience

A common view from participants was the importance of their own individual experience in supporting their chosen practice. When asked about knowledge of evidence regarding the use of anaesthetic rooms, one anaesthetist pointed out that:

> *'I've not read any articles particularly on the subject. It's based on 20 years of experience.' (A3)*

When discussing the patient experience and one anaesthetist's view that the theatre is less intimidating for patients, he was asked about the basis of that judgement.

> *'As in evidence or personal opinion? It would be more personal opinion and some speaking to the patients myself. So it's anecdotal.' (A5)*

The interviews revealed that many of the reasons behind practice are not evidence-based, but are based on perceptions and experiences of the clinicians and managers working within the theatre environment. When questioned on the foundation for their views on patient experience, some participants invoked their own personal experiences as patients. This experience and observational insight should not be diminished; however, determining practice solely based on experiential evidence may have weakness, in comparison to robust, measured, and verified research. One anaesthetist recognised the difference in value of evidence when he stated:

> *'I'm not aware of any hard, level 1 meta-analyses looking at it. Or even level 2, level 3 data. So everything I've said to you is entirely based on my personal opinion, which puts it at about level 4.' (A8)*

4.5 Discussion

The interview findings of this study were iteratively and thematically analysed to organise all emergent topics and themes. The nature of the questions asked to the participants were exploratory of current ways of working, thinking, and believing. The complexity of the socio-technical system surrounding the use and continuance of anaesthetic room practice is apparent from the range of topics which were presented by the participants. As the sub-themes and themes emerged, the four high level categories formed. These categories, depicted as three concentric circles with a segment cutting through them in **Figure 4.7**, were reminiscent of the influences presented in Moray's

(2000) onion model of socio-technical systems, and the four levels where change is required to improve quality of healthcare (i.e. Individual, Group/Team, Organisation, Larger system/Environment) from Ferlie & Shortell (2001).

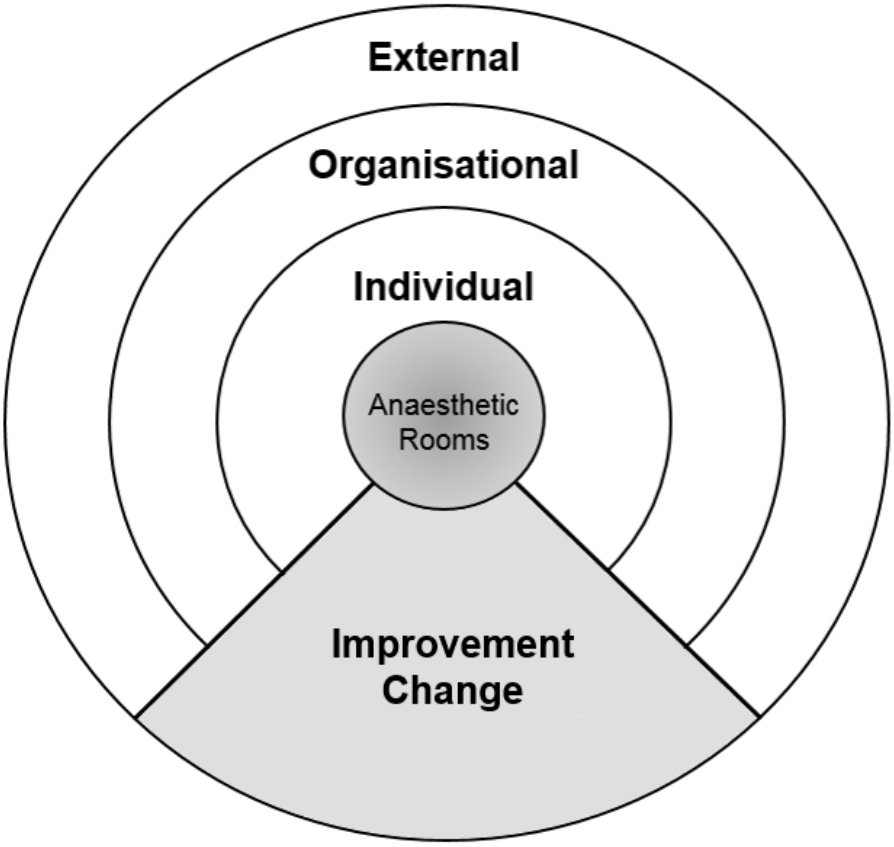


Figure 4.7 Main high level categories of the interviews

The interview coding hierarchy was organised into three primary categories, relating to the proximity of the factors to the physical environment (i.e. the anaesthetic room) and their general influence upon practice. Individual factors, as they relate to the experiences and decision making of individual persons plays a significant role in the perpetuation of anaesthetic room use. From an organisational perspective, many aspects which are outside of the control of the individual also influence design and practice. Finally, the most distantly related factors relate to external influences, which may have effects upon factors more closely linked to the anaesthetic room context, and therefore, ultimately impacting the use of anaesthetic rooms.

Improvement change was a major focus of this interview study and is depicted as a slice from the onion model as the themes related to changing anaesthetic room practice are linked to all high level categories, i.e. layers.

4.5.1 Individual Factors

The interview findings reinforced the suggestion that anaesthetists practising in the UK hold expectations for anaesthetic room use as a standard, in part, due to their training. Clinical choice for the site of induction showed a shared view of in-theatre induction as a safer option than anaesthetic room induction in the case of complex or high risk patients. These themes were consistent with findings from the survey of consultant anaesthetists in Chapter 3. As literature suggests, professional cultures have been shown to be barriers in interprofessional teamwork (Lingard *et al.*, 2002; Hall, 2005). The theme of autonomy highlighted the apparent professional boundaries separating the anaesthetic and theatre team domains. The anaesthetic room serves as a physical barrier separating the two professional teams. Goodwin *et al.* (2005) observed the containment of specific anaesthetic knowledge and shared practice within the spatial bounds of the anaesthetic room, in which access was controlled. Similarly, Hindmarsh and Pilnick (2002) identified the non-technical skills taking place within anaesthesia permit the anaesthetic teams to interact and understand their work tasks without direct communication. Based on literature and these interview findings, the distinction of the anaesthetic and surgical teams may pose a salient barrier to process change.

This study has identified many barriers (and incentives) for change at an individual level. These are similar to those identified by Grol and Wensing (2004) such as awareness, knowledge, attitude, motivation for change, and behavioural routines. The findings suggest barriers to change do exist in regard to practitioner knowledge and awareness of evidence, attitudes of strong resistance to change and preferences for current practice, and a normalisation of anaesthetic room practice which dominates clinical decision making.

The individual barriers to change were also attributed to patients. Patient experience and pre-operative anxiety were commonly reported concerns for changing anaesthetic room practice. Both managers and anaesthetists desired compelling evidence related to patient experience in order to change their practice (see **Table 4.2**), which affirms the lack of known evidence related to the patient's experience of the anaesthetic room. This gap in evidence will be explored specifically in Chapter 7.

4.5.2 Organisational Factors

Multiple factors impact the decision to use and build anaesthetic rooms on an organisational level. Although the effect of anaesthetic rooms on efficiency was not of highest importance for consultant anaesthetists compared to other factors (Chapter 3), both anaesthetists and managers demonstrated a desire for further evidence related to the financial and productive implications of anaesthetic room use (see **Table 4.2**). A few studies have evaluated the benefit of overlapping induction (Hanss *et al.*, 2005; Torkki *et al.*, 2005; Marjamaa *et al.*, 2009); however, participants did not show an awareness of published literature. The specific cost-benefit of anaesthetic rooms was shown to be a gap in knowledge and so is measured in Chapter 6.

The theme of staffing, including references to staff shortages and insufficient staffing, is supported by widely known trends of increases in nursing and doctor vacancies between 2013 and 2015 (ONS 2016 cited in Buchan *et al.*, 2016) and a report of registered nurse shortages in 93% of NHS Trusts in England (NHS Employers, 2015). Additionally, the publication of the Francis Report of the Mid Staffordshire inquiry in February 2013 brought awareness of the need for higher staffing levels to ensure quality (NHS Improvement, 2016). The respondents identified inadequate staffing as a limitation for obtaining overlapping induction, which is explored further in Chapter 6.

While exploring the specifics of anaesthetic room practice, this study revealed many local practices which were not standard across all surgical specialties, yet created new constraints, or capacity, for anaesthetic room use. Laminar flow ventilation and double prep practice seemed to give further purpose, or requirement, for anaesthetic rooms. Furthermore, the use of preparation rooms for the set-up of instrumentation was stated as freeing the operating theatre and permitting set-up prior to clean-up.

System factors (i.e. bed availability, patient transport, recovery capacity, and patient preparation on the ward, etc.) were identified as any forces outside of the anaesthetic room and theatre which can cause delay and affect efficiency. Many of these factors are out of the immediate control of the anaesthetic and theatre teams, yet they will have effects on the productivity and timeliness of operating lists –whether an anaesthetic room exists or not. These findings support literature on operating theatre efficiency, as Saha *et al.* (2009) identified long delays affecting theatre use were related mainly to

waiting for patient transport to and from the operating theatre. System wide factors are therefore essential to consider in rationalising the use of anaesthetic rooms.

The relationship between design and practice was explored within the interviews as the idea of modifying infrastructure (i.e. complete removal of anaesthetic rooms) was ranked highly in importance for changing practice in the survey of anaesthetists in Chapter 3. Shown in **Figure 4.8**, the 'chicken and the egg' question resulted in a split of responses, some saying design informs practice, others saying practice informs design, and some saying both. The link of design being informed by practice included references to the prevalence of tradition and anaesthetic norms in dictating design, or the need to consider the users in order to design for current practice. Whereas the link of practice being informed by design presented the impact of older existing infrastructure in constraining practice, the resulting lack of suitability of the usable space, or references to staff ability to adapt their practice to any design.

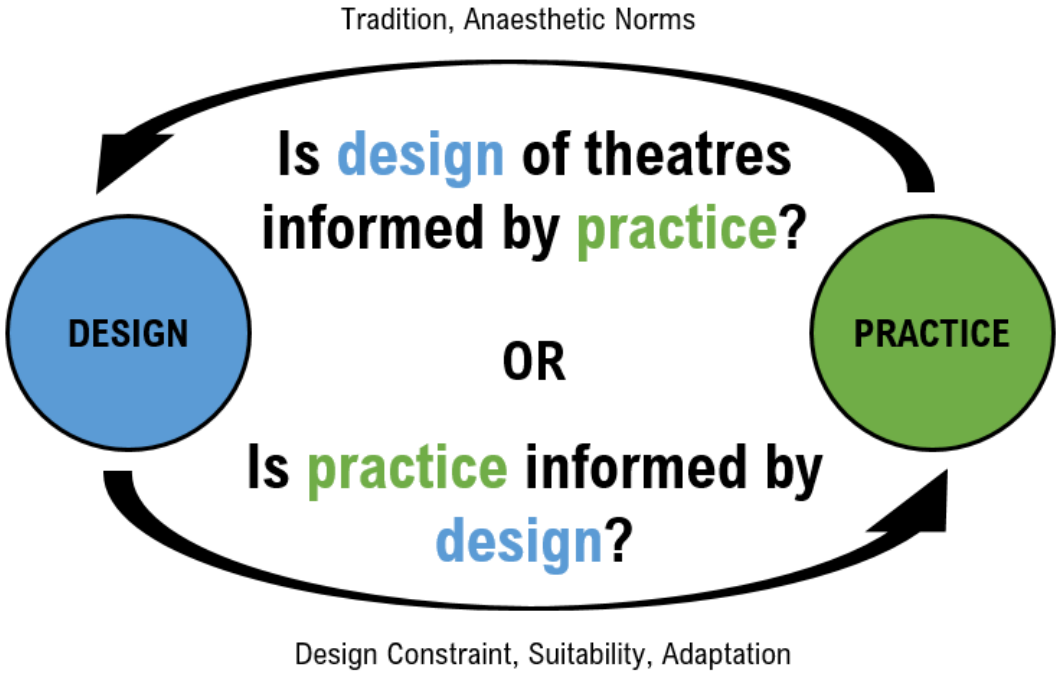


Figure 4.8 Links between design and practice

The reported impact of current design of theatres on practice, and vice versa, reveals that whilst theatres will tend to be designed in the future based on traditional practice, if design is changed drastically (i.e. to remove anaesthetic rooms entirely), anaesthetists would adapt to such changes. The adaptability of the practitioner is a facilitator for change, as major infrastructure modification may not be an insurmountable obstacle to

safe and effective care. This was exemplified in responses from anaesthetists and managers affiliated with one NHS treatment centre that was newly constructed without anaesthetic rooms. However, statements suggested that the prevalence and long standing use of anaesthetic rooms may limit innovation for future designs, resulting in the repeated construction of the status quo way of working. Despite the outcome, anaesthetists and managers agreed that design planning should be done as a team. Managers emphasised gathering consultant opinions and gaining consensus for future designs. Participatory design and gaining consensus will be investigated in Chapter 5.

4.5.3 External Factors

Many of the themes demonstrated an overlapping nature, as they are influenced by one another. External factors appeared to influence organisational and individual factors, such as the influence of anaesthetic norms and tradition on local practices and therefore clinical choice and expectations for practice. Culture was coded as an external factor due to the many references to British culture and tradition which refer to wider beliefs outside of the healthcare setting. Cultural influences extended through all of the layers (external, organisational, individual), as organisational and professional cultures are formed by shared beliefs (be they conscious or unconscious), values, behaviours, and norms of the individual constituents (Morgan, 1986; Davies *et al.*, 2000) who are a part of the wider cultural context. The impact of cultural norms on anaesthetic practice link to literature on the normalisation of risk in organisations. Although the safety risks incurred by disconnecting and transferring patients between rooms may not be recognised as deviant behaviour, this cultural understanding affects the individual's interpretation of the work done. An individual may view their behaviour as conforming although the action is objectively unsafe. This perspective is supported by Vaughan's (1999) theorisation of the dark side of organisations and the habitualised nonconformity of individuals which is rationalised by means of social and cultural expectations.

Knowledge of best practice is an external influence that can guide decision making within the organisation, management, teams, and individuals. The interviews revealed a general lack of knowledge of published literature surrounding anaesthetic room use, including any national guidance, from managers, Responsibility was displaced from the managers to the clinical professionals. It could be argued that literature relating to cost-efficiency, patient experience, or patient safety should be within the remit of healthcare

managers, as many hospitals employ clinical directors of a 'hybrid medical-managerial role' (Buchanan *et al.*, 2007). The national guidance provided by the UK government and professional bodies (DOH, 2007; DOH, 2004; RCoA, 2014, 2015a, 2015b; AAGBI, 2010b, 2015) was generally respected by managers and clinicians alike, as it was assumed any published guidance would be supported by strong evidence; however, the majority of anaesthetists were unaware of what the guidance said about anaesthetic rooms. Some respondents emphasised the role of national guidance as its name states - guidance. The guidelines are not intended to be a hard and fast set of rules to be prescriptively applied. Although the external influence of evidence, in the form of research literature and national guidance, were valued by participants, there was a lack of indication that benchmarking with regards to specific performance indicators or qualitative approaches have been undertaken. Ettorchi-Tardy *et al.* (2012) suggested the value of benchmarking for healthcare organisations in promoting continuous improvement and an element of competition in applying best practice. This recommends the need to compare to hospitals and localities such as the local NHS Treatment Centre, Guy's Hospital, and Ipswich Hospital, where practice without anaesthetic rooms can be evaluated and critiqued.

4.5.4 Improvement Change

It is understood that in order to change behaviour in the effort to improve practice, there must be an agreement as to what the improvement is and what can be changed. While evidence-based practice is an admirable goal, the availability of necessary research, the knowledge of research which is available, and making reasonable conclusions from that knowledge is not an easy endeavour. Interview responses presented a high reliance on individual experience and anecdotal evidence to support the continued use of anaesthetic rooms. The lack of knowledge of evidence and what is or is not compelling evidence will be integrated in the study design of Chapter 5.

The interviews provided many answers, but also raised several questions regarding evidence-based practice and how to achieve it. Whose responsibility should it be to evaluate evidence? What should be done if evidence is weak or conflicting?

Exploring clinical willingness to change current anaesthetic room practice demonstrated a clear resistance to change, meaning the abandonment of anaesthetic

rooms. This result is in line with the findings of Chapter 3, which revealed 88.6% of consultant anaesthetists did not want to see the site of induction changed. The sub-theme of adaptability did emerge from the interviews and highlighted, in contrast to the resistance, the ability of anaesthetists to be flexible and carry on with their work despite changes. This might be explained by the frequency and normality of restructuring and reorganising within the NHS since its creation (Braithwaite *et al.*, 2005).

4.5.5 Conclusion

The many factors influencing the design and practice of anaesthetic rooms in the UK are presented within their associated strata in **Figure 4.9**. While interviews reported relationships from the external towards the individual stratus, the interactions or relationships have been depicted as bi-directional based on the concept of implementing change across all factors. Holden *et al.* (2013) note that the many work system factors are mutually intertwined and shape the process as a whole, affecting the system performance in various ways. In a drastic example, the complete removal of anaesthetic rooms within a few hospitals across the UK might feed up from patients and staff experiencing only operating theatre induction, thereby affecting cost-efficiency, staffing, peripheral organisational processes, and even may eventually alter national guidance and standards of best practice. Interviews did not suggest that change was required to initiate externally, nor strictly on an individual level, but through all layers. This is exemplified in the executive summary of the Health Building Notes guidance (DOH, 2004) where change on the local level altered the national guidance:

> *'Another recent change in practice in a few hospitals is the omission of anaesthetic rooms in the theatre suite… Whilst a local decision should be made on the adoption of these models, this guidance points out the advantages and disadvantages…'* (no page number)

Anaesthetic room practice is a part of a very complex socio-technical system and in order to determine the value of anaesthetic rooms and if they should be included in new hospitals, all of its stakeholders should be involved in design and implementation of the system (Carayon, 2006). Questioning the accepted practice of using anaesthetic rooms is a theoretical challenge in order to re-evaluate and continuously improve practice

based on best evidence. Further analysis of the numerous work system factors and their specific interactions are discussed in full in Chapter 8.

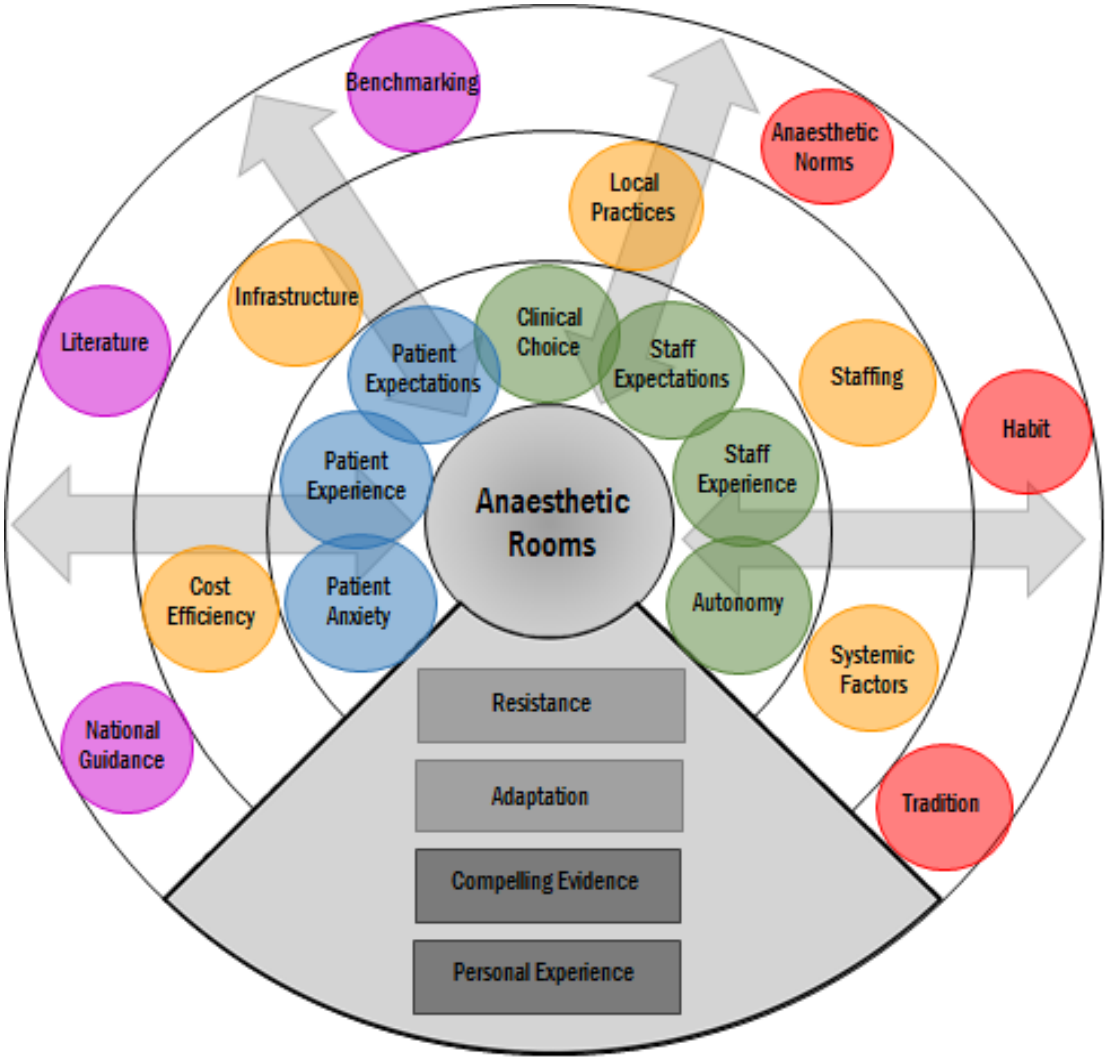


Figure 4.9 Factors affecting anaesthetic room practice

4.6 Limitations

A limitation of the purposive sampling method was that only managers who were known to the local collaborators (consultant anaesthetists) were approached. Management perspectives were sought from clinical directors and managers overseeing either theatres, anaesthetics, business, or a combination of the three. As most local collaborators were consultant anaesthetists, it is possible that anaesthetic managers were more easily approached with the study invitation by the collaborator; however, the resulting sample represented each type of role, with slightly more anaesthetic managers.

It is possible that some consultant anaesthetists were not invited, as it was the responsibility of the local collaborator to pass along the invitation. In most instances, this was known to be done via a secretary and sent to all consultant anaesthetists. Although the anaesthetists were self-selected, avoiding researcher bias, the perspectives of the anaesthetists may be biased as the occurrence of a minority viewpoint may be overrepresented compared to reality, as more anaesthetists who do not prefer the anaesthetic room may have come forward to express their opinions as they were interested in the topic due to their unique position.

Some of the manager questions, which related to theatre design, were hypothetical as new hospital planning was not taking place at the time. Although interviews with managers who had currently been involved with the theatre design process would have been useful, the experience of assisting in the design and planning phase of a new build or renovation could not be guaranteed.

The data analysis and coding of this study was conducted by the author and therefore the results must be considered to be influenced by that person. Some of the themes were also linked to specific questions, which were worded and selected for inclusion by the researcher. However, the interview protocol was reviewed and edited by two academic supervisors and two consultant anaesthetists, and the late stage coding hierarchy was validated by two experienced qualitative researchers.

4.7 Future Work

Many aspects of the patient's experience were not well founded in evidence. Many participants deemed this subject matter, including patient safety, to be the most important in determining best practice, and would consider findings in these areas to be very influential. The expectations that patients develop may be due to cultural factors, previous first-hand experience having a procedure, or the experience of a loved one or friend. These expectations have yet to be evaluated and would be helpful in understanding the significance of the site of induction on overall patient experience and satisfaction. The patient perspective of the anaesthetic room is explored further in Chapter 7.

The gaps and barriers for integrating evidence into decision making surrounding anaesthetic rooms were identified in this study. The need to test the significance of

evidence is predicated on the lack of awareness of research evidence reported by both managers and anaesthetists. This question is investigated further in Chapter 5.

4.8 Chapter Summary

This study has identified and discussed the key factors influencing clinician and management decisions for using anaesthetic rooms and supporting their continued use when the opportunity for change arises. The interviews revealed consideration of patient needs, but the dominant themes focused on the effect of the decision to use or lose anaesthetic rooms on staff and organisational priorities.

This chapter corroborated the findings of Chapter 3 in determining the most important considerations for using the anaesthetic room and explored further how these factors can act as barriers to change in practice.

Chapter 5 Evidence-Based Hospital Design

5.1 Chapter Overview

This chapter evaluates the prioritisation and decision making required in new theatre design and the importance of research evidence within this process. The outcomes of a Delphi process study are presented, along with a discussion of participatory and evidence-based group decision making in hospital design.

5.2 Introduction

The predication of integrating evidence into medical decision making has been contested by some (Mykhalovskiy & Weir, 2004; Upshur, 2002). The understanding of what 'evidence' is and how to make sense of it has also been the subject of much research (Rycroft-Malone *et al.*, 2004, Hoffmann *et al.*, 2013; Rosswurm & Larrabee, 1999). Although the importance of experiential, tacit knowledge, must be recognised and was explored in previous studies within this thesis, this chapter focuses on the role of scientific research and its critique. The topic of evidence-based practice has been explored throughout this thesis, considering the background and application of evidence-based practice in healthcare (Chapter 2), the importance of various types of evidence (Chapter 3), and how evidence is incorporated in the choice to use and build anaesthetic rooms in new hospital designs (Chapter 4). Highlighted in the literature review, there is a dearth of scientific evidence centred on the use of anaesthetic rooms (Husain *et al.*, 2005). Correspondences within the British anaesthetic community regarding anaesthetic rooms have also suggested the evidence-base for practice is weak. Where the research questions from the previous studies in this thesis have addressed the importance of evidence for anaesthetists and managers, and their awareness of that evidence, this study investigates the value of existing scientific research evidence to internal stakeholders.

Although a shortcoming of this research, the widespread establishment of anaesthetic rooms in surgical facilities and practice in the UK requires a hypothetical approach to decision making for their proposed exclusion in theatre planning. This study aimed at integrating a participatory approach with evidence-based decision making in order to

reach a consensus for the choice of build for surgical suites. This Delphi study was designed to simulate the process of a committee of staff members entrusted to reach an agreement for the design of new operating theatres, with the primary focus on determining if the theatres will or will not include anaesthetic rooms. The aims of this study were to

- investigate the importance of factors related to this theatre design scenario;
- understand the perspectives of a range of anaesthetic room stakeholders, including surgical staff, in addition to anaesthetic staff and managers, on the use of anaesthetic rooms;
- explore the impact of research evidence pertaining to anaesthetic rooms on opinions regarding the design of theatres;
- form a consensus for a recommended anaesthetic room build.

5.3 Methods

5.3.1 Participants

The objective of this study was to consider the diverse perspectives of multiple stakeholders who would typically be involved in the theatre design decision process. Based on the results of interviews with managers and consultant anaesthetists (Chapter 4), it was evident that while managers play a significant role in design decision making, best practice encompasses the collection and collation of the opinions and considerations of all staff members, including anaesthetic and surgical medical staff, and non-medical staff members such as operating department practitioners (ODP), nurses, healthcare assistant (HCA), and support workers (SW), rather than drawing on national guidance and recommendations. As such, in this study, only hospital staff who would (a) most likely be involved in the theatre design process, and (b) have a working knowledge of the anaesthetic room and its use were recruited. Participants for this study were recruited from four role categories:

- Managers (Anaesthetic, Theatre, Business, or Estates)
- Anaesthetists (Trainee or Consultant)
- Surgeons (Trainee or Consultant)
- Theatre Staff (ODP, Theatre Nurse, HCA, or SW)

Recruitment was distributed across all NHS Trusts within the East Midlands, in order to reduce bias of opinions based on local practice of individual hospitals. While all participants will have been influenced by the practice and policies of their own hospitals, the involvement of staff from multiple Trusts was an intentional way of providing representative responses which were not limited to a single hospital's context. Participants were recruited from seven of nine NHS Trusts which granted approval for the study. Recruitment targets were 20 participants within each of the 4 groups, with a total of 80 participants. An invitation email with a participant information sheet included was sent through each Trust to the relevant groups. A convenience sampling approach was used to include any participants who expressed interest to participate within the 4 staffing recruitment groups.

5.3.2 Ethics

This study was included in a larger mixed-methods protocol which included all studies within Chapter 3 through 6. This Delphi study was added to the research protocol (version 6) and was approved by the University of Nottingham Faculty of Engineering Research Ethics Committee on 27th July, 2015. Due to the nature of the study as a staff only, non-interventional study, NHS Health Research Authority ethical approval was not required. Individual Trust approval was sought again for the inclusion of this added study, and was granted in 9 of the 10 previously selected Trusts[7].

5.3.3 Data Collection

A consensus method is valuable when a unanimous opinion is not available due to a lack of scientific evidence or in the case of contradicting evidence (Jones & Hunter, 1995) such as in the case of the provision of anaesthetic rooms. One approach, the nominal group technique, is a consensus method which typically involves a face to face meeting (Jones & Hunter, 1995). In order to explore the decision making of theatre staff and managers from multiple Trusts, a Delphi approach was pragmatically selected as a means for gaining consensus using a panel of geographically dispersed experts. The 'Delphi technique' is a survey method, applied in several fields including the social

[7] Although all 10 previously involved Trusts were approached for the addition of this study, one did not grant approval prior to the commencement of the study with the other sites. This was due to lack of communication from the local collaborator with his/her research and development department to further the approval process.

sciences, health research, policy making, and forecasting, where it is used to generate discussion and decision regarding a specific real-world problem (Goodman, 1987; Gordon & Pease, 2006). The characteristics of the Delphi that distinguish it from other group decision making processes (i.e. focus groups, committees) are as follows:

- Using a panel of 'experts' or individuals who have specific knowledge of the field or problem in question (Keeney *et al.*, 2001).
- The guaranteed anonymity of participants encourages them to share opinions without the influence of peer pressure and dominant personalities (Landeta, 2006; Goodman, 1987).
- The study is conducted iteratively, where individuals will feedback in multiple rounds on the same questions, and a facilitator or coordinator controls the feedback shared with the group following each round (Landeta, 2006; Keeney *et al.*, 2001).
- Feedback from the repeated questionnaires are summarised statistically so participants can identify where their views align with the group's views. Group opinions are analysed quantitatively and statistically (Landeta, 2006; Goodman, 1987).

The purpose of this study was to explore the decision making of those who would be involved in the design of new operating theatres, and to determine the impact that research evidence related to anaesthetic rooms may or may not have on their rationales for their decision making. The Delphi process was implemented under the guise of a 'New Theatre Planning Committee', which was tasked to make a final recommendation for or against the inclusion of anaesthetic rooms for a new build within the (hypothetical) East Midlands NHS Foundation Trust. This scenario was devised to unite participants from different Trusts to accomplish the goal of proposing the best build design for all participants involved.

Participants were informed of the scenario and the objective of the New Theatre Planning Committee (NTPC). The Delphi study was designed to have the participants complete the same online questionnaire, to allow for prompt response and analysis, in three 'meetings' or phases. Each phase involved provision of new information, research evidence and previous responses from all participants, which participants were able to

evaluate prior to completing the questionnaire. The participants were given two weeks[8] to complete each round of the Delphi, allowing one week for the analysis and compilation of results. Local collaborators passed along a reminder email after one week and a final reminder in the last week of each cycle. The three phases of the Delphi are as follows:

- NTPC Meeting 1 – Measure of baseline responses.
- NTPC Meeting 2 – Review of research evidence related to anaesthetic rooms.
- NTPC Meeting 3 – Review of peer opinion of Phase 1 and Phase 2.

An overview of the modified Delphi process is shown in **Figure 5.1**.

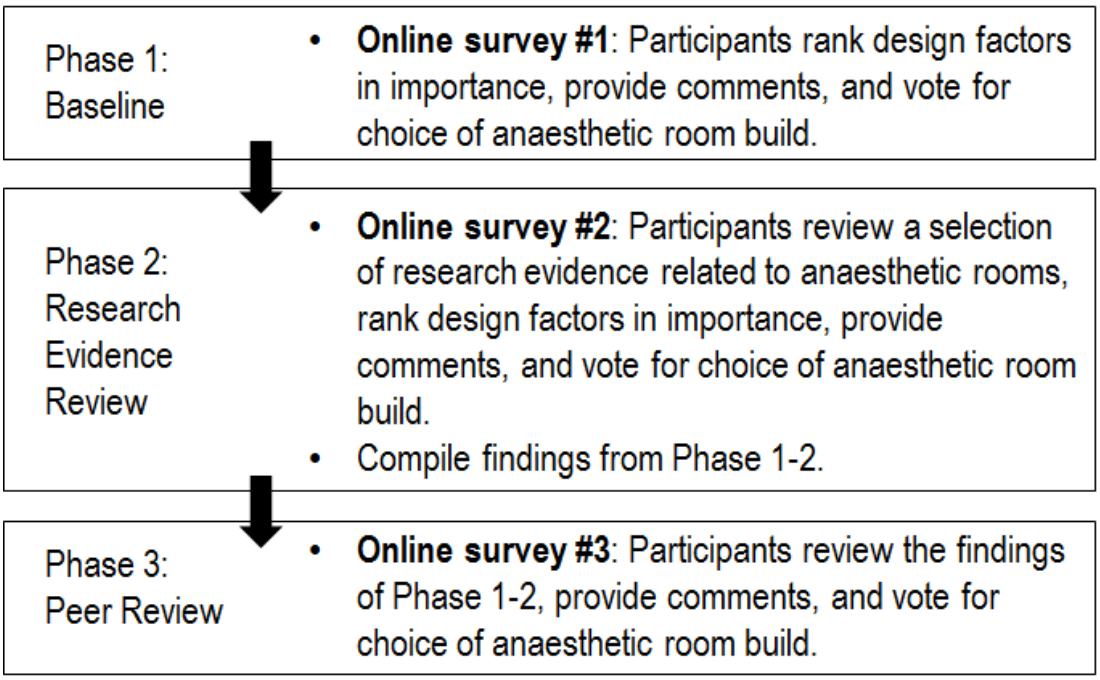


Figure 5.1 Administration of the modified Delphi process

Phase 1 – Measure of Baseline Responses

A short online questionnaire was created using Qualtrics software (eu.qualtrics.com). The first seven questions asked for the respondent's email address (for follow-up if clarification of responses was required), gender and age, NHS Trust, job role, and if the respondent had experience working without an anaesthetic room. These questions were linked to skip logic so as not to be repeated if the participant had responded to them in

[8] The first round was extended due to low recruitment numbers and one NHS Trust that granted late approval for the study. The participant drop-out is discussed in section 5.5.4.

a previous round. The remaining eight questions related to important factors in the design decision to include anaesthetic rooms in new theatres (as determined from research literature and the previous studies presented in Chapter 3 and 4), the choice of build for the new theatres, additional information that might be desired, and comments to be shared with other participants. One question required the ranking of 12 factors that might be important in the specific design decision for theatre suites, based on research literature and the results of the survey and interviews of Chapters 3 and 4.

The complete questionnaire from Phase 1 can be seen in **Appendix E**.

All recruited participants were sent a hyperlink to the first phase questionnaire. Consent to participate in the study was implied by completion of the online questionnaire. The participants were given two weeks to complete the survey in each round. All participants were subsequently sent the second and third phase questionnaires, regardless of whether or not they had responded in earlier rounds.

Phase 2 – Presentation of Research Evidence

The second phase questionnaire presented the same questions as the first with the addition of the presentation of some published research evidence pertaining to the use of anaesthetic rooms. A selection of research findings relating to the most important factors in theatre design (ranked as an outcome of Phase 1) were presented with citation prior to the survey questions. **Table 5.1** shows the research findings which were presented to the participants.

A semi-random selection of findings (taken from the literature review) was presented from published research papers that pertained specifically to anaesthetic rooms and topics most frequently referenced from the survey of current anaesthetic practice and interviews with consultant anaesthetists and managers (Chapters 3 and 4). The intention of presenting evidence to participants was not to persuade or alter opinion necessarily, but to explore the assessment of the provided literature and its value in comparison to participants' decision priorities (as ranked in Phase 1 and 2 of the Delphi survey).

Table 5.1 Ranked factors from Phase 1 and research findings

Rank	Factor	Citation	Main Findings
1	Patient Safety	Broom *et al.*, 2006	Observation of 80 patients (over 4-month period) transferred from the AR to the OT. Median (range) of disconnection from breathing system to first breath in theatre 54 (27-196) seconds. Disconnection of pulse oximetry probe to first reading in theatre was 90 (44-182) seconds.
2	Patient Dignity / Privacy	No findings	
3	Accessibility of Supplies / Equipment	No findings	
4	Turnover / Efficiency	Torkki *et al.*, 2005	Additional 2 nurses and one anaesthesiologist to perform parallel anaesthetic induction in an induction room for urgent orthopaedic permitted 1 additional case performed during 7-h working day.
5	Patient Satisfaction	No findings	
6	Patient Anxiety	Soni & Thomas, 1989b	100 patients, one group anaesthetised in AR, other group in OT. Linear analogue anxiety score (LAAS) measure of anxiety, heart rate, systolic arterial pressure, and respiratory rate compared at baseline and pre-induction. No significant difference in level of anxiety between the groups.

7	Financial Costs	Marjamaa *et al*., 2009	In a workflow analysis of four trauma theatres, the traditional (OT+AR) model and three parallel working models (four OT+AR rooms and additional personnel; additional circulating induction team; centralised induction room; and four teams in four ORs for three surgeons –no induction rooms) were compared. All induction models were more cost-efficient than the traditional model. Short procedures seem to benefit most from staffed individual induction rooms.
8	Noise Levels	Not included	
9	Distractions	No findings	
10	Teaching & Communication	No findings	
11	Staff Time Pressure / Performance Anxiety	No findings	
12	Staff Comfort / Preference	Not included	
	Accidental Awareness*	Pandit *et al.*, 2014	Based on a National Audit sponsored by the Royal College of Anaesthetists and the Association of Anaesthetists of Great Britain and Ireland, the NAP5 report found that the gap between the AR and OT can result in increased risk of accidental awareness under general anaesthesia.

*This factor was not included in the survey ranking question as it was not frequently mentioned in the survey or interviews of anaesthetists and managers; however, it was included in Phase 2 to incorporate national guidance and provide balance to presented research findings. AR = Anaesthetic room; OT = Operating theatre

The research selected was not done so entirely arbitrarily. In order to avoid bias, literature that was deemed in favour of, against, or neutral towards anaesthetic rooms were included, yet balanced to prevent persuasion in either direction. Topics regarding highly ranked design factors from Phase 1 were addressed, and although accidental awareness was not one of the ranked factors (see **Table 5.1**), it was included to balance findings from higher ranked factors. While the study results were summarised for participants, an evaluation of the validity of each study was not included, as the references were available to participants for further investigation and individual evaluation.

Participants who had completed Phase 1 were also asked to indicate if the presented literature findings changed their opinions from the previous round, and to provide explanation as to why it did or did not influence their opinions. All other questions remained the same.

Phase 3 – Presentation of Group Opinions: Results of Phase 1 & 2

The third phase was slightly modified by removing questions related to ranking and explaining the most important factors in the design decision, due to repetition of responses in the first and second phases. In order to prevent participant fatigue, where respondents may grow tired of the task and provide suboptimal responses, the third phase focused only on the recommended choice of build and a thorough explanation of that preference. The final questionnaire also required the review of the results from Phases 1 and 2.

A summary of all survey questions are shown in **Table 5.2** below. Phase 1 was launched on 7th December, 2015 and Phase 3 was concluded on the 12th February, 2016.

A primary component of this Delphi process was the ranking of factors which may be important in the design decision for including or excluding anaesthetic rooms from the theatre build. The ranking-type Delphi is a common variant of the method within the information systems sector (Schmidt, 1997). This Delphi serves as a modified ranking-type with its incorporation of research evidence to measure its effect.

Table 5.2 Delphi survey questions

	Phase		
Question	**1**	**2**	**3**
Email address for follow-up	✓	✓	✓
Which is your gender?	✓	✓	✓
In which NHS Trust do you work?	✓	✓	✓
To which group do you belong?	✓	✓	✓
What is your job role?	✓	✓	✓
How many years of experience do you have in your role?	✓	✓	✓
Do you have experience working without ARs?	✓	✓	✓
Did the literature findings change your opinion? Why (not)?		✓	
Rank which factors are most important in theatre design	✓	✓	
Comment on your Top 4 (most important) factors and why	✓	✓	
Select your preferred choice of build and explain why	✓	✓	✓
Do you feel you require additional information that would help you to make this decision? What additional information?	✓	✓	✓
Do you have any anonymous comments to pass onto the committee for the next round?	✓	✓	

5.3.4 Data Analysis

Descriptive statistical analysis was conducted on all responses. The mean rank of importance was calculated for the theatre design factors in Phase 1 and 2 and presented to the participants. The Friedman test and Wilcoxon signed rank test were used to analyse the difference in importance for factors related to theatre design and the anaesthetic room. Tally counts were used to present the choice of build responses categorised by the job role of the respondents. Open-ended questions were analysed in both NVivo™ 10 software and Microsoft Excel® where the occurrence of commonly referenced topics and ideas were counted.

5.4 Results

5.4.1 Demographics

The Delphi study recruited 41 participants who contacted the researcher in response to the invitation emails distributed through their departments, which resulted in the actual participation of 35 of those individuals. The remaining six participants did not complete the questionnaire in any of the three phases. Nine NHS Trusts within the East Midlands had granted approval for the study to take place; however, participants were only recruited from seven of the nine due to lack of responsiveness from local collaborators. The number of participants per Trust are shown in **Figure 5.2**, with the Trusts anonymised with letters.

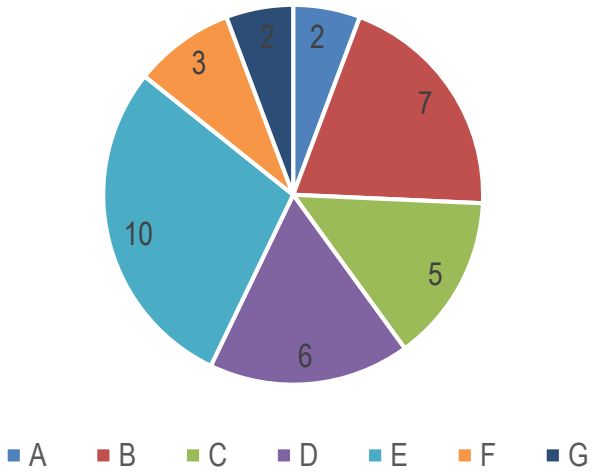


Figure 5.2 Number of participants per NHS Trust

Of those who participated in at least one part of the 3-part survey, 51% (n = 18) were female and 49% (n = 17) were male. Participation across the four role groups were represented as:

- 14 of 15 recruited anaesthetists (all consultant level)
- 5 of 7 recruited managers (4 theatre, 1 estates)
- 4 of 5 recruited surgeons (all consultant level)
- 12 of 14 recruited theatre staff (6 ODPs, 5 theatre nurses, 1 support worker).

Participants had varying levels of experience as shown in **Figure 5.3** & **Figure 5.4**. Most participants had been working in their current role for between 1-5 years (31%) and had experience working without an anaesthetic room (63%).

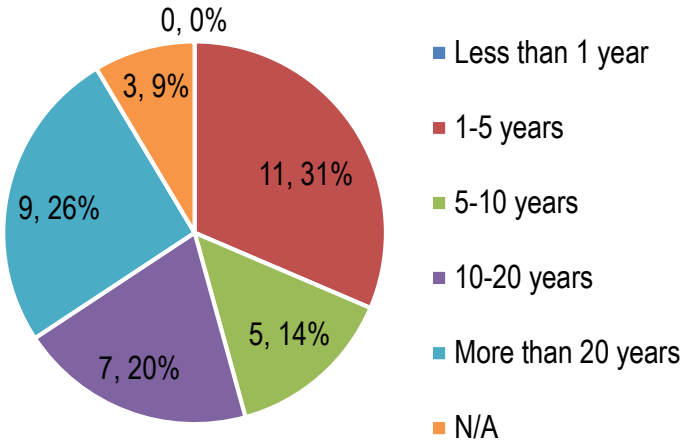


Figure 5.3 Diagram of the number of years in current role (n, %)

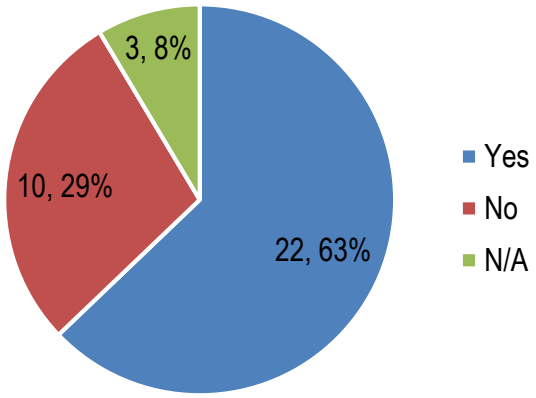


Figure 5.4 Experience working without an anaesthetic room (n, %)

Dropout of participants was expected over the course of the 3-part Delphi study. **Figure 5.5** demonstrates the retention of participants in Phase 1 and 2, whilst Phase 3 experienced a total loss of 5 participants (mainly from the anaesthetist and surgeon groups).

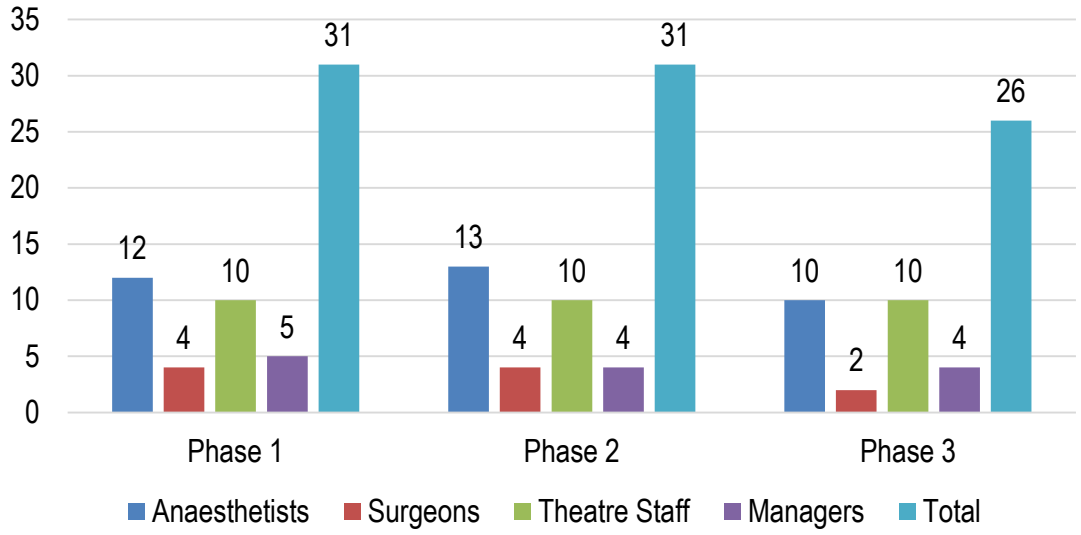


Figure 5.5 Numbers of participants in all phases of the study

5.4.2 Ranking of Theatre Design Factors

In Phases 1 and 2, participants were asked to rank, in order of importance from most important (1) to least important (12), the factors which they felt should influence the theatre design decision related to anaesthetic room inclusion. Unlike the ranking analysis of similar factors in Chapter 3, the ability to rank items (a feature available in Qualtrics - used for this study, and not Bristol Online Survey - used for the Chapter 3 survey) enabled the participant to easily move factors up and down in ranking to provide a distinct order of importance.

The design factors were analysed by ranking them by mean importance ranking. The change between the importance rankings from Phase 1 to Phase 2 are demonstrated in **Table 5.3**. It presents the design decision factors in the final rank order at the end of the Phase 2 analysis, showing the mean rank difference and the final rank difference. The factor of highest importance was patient safety, with a mean of 1.03, almost unanimously the most important. The next most important of mean 4.48 was patient privacy, with the remaining factors resulting in marginal difference of importance.

The primary intervention for the difference in ranks between Phase 1 and 2 was the introduction of research findings pertaining to some of the design factors (patient safety, efficiency, patient anxiety, and financial costs).

Table 5.3 Mean rank of design decision factors

Rank		Design Decision Factors	Mean Rank	Mean Rank Difference	Rank Difference
1		Patient Safety*	1.03	0.41	0
2		Patient Privacy	4.48	-0.39	0
3	∧	Efficiency*	5.71	0.20	1
4	∧	Patient Anxiety*	5.77	1.16	2
5	∨	Accessibility of Equipment	5.97	-0.81	-2
6	∨	Patient Satisfaction	6.19	0.43	-1
7	∧	Distractions	6.84	0.88	2
8	∨	Financial Costs*	7.39	-0.29	-1
9	∧	Staff Time Pressure	7.77	0.57	2
10	∨	Noise Levels	7.87	-0.40	-2
11	∧	Staff Comfort	9.10	0.00	1
12	∨	Teaching & Communication	9.87	-1.75	-2

*Indicates factors which were included in the research findings in Phase 2 and may have influenced a rank change.

The Friedman test was used to determine if a significant difference was present between the design decision factors in both the Phase 1 and 2 responses. The test resulted in a *p*-value of .000, indicating a significant difference is present within the factors for both Phase 1 and Phase 2. Additional testing was required to determine between which factors the statistical difference existed, so the Wilcoxon signed rank test was used comparing each of the 12 factors with all of the others. The *p*-value results of the 66 tests run for each of Phase 1 and 2 are shown in **Appendix F**. The Bonferroni correction was calculated for the 66 comparative tests run, which adjusted the significant p-value (formerly $p \leq .05$) to .05/66 or $p \leq .00076$.

Patient safety was the only design decision factor which was significantly more important than all of the others. This was consistent from analysis of Phase 1 and 2 data. The factor which resulted in the largest change in importance after the evaluation of research evidence was teaching & communication, which became significantly less important than 4 other factors (distractions, patient anxiety, patient satisfaction, and efficiency). This change is also shown in **Table 5.3** as the largest increase in rank difference, implying a reduction in importance compared to the other factors.

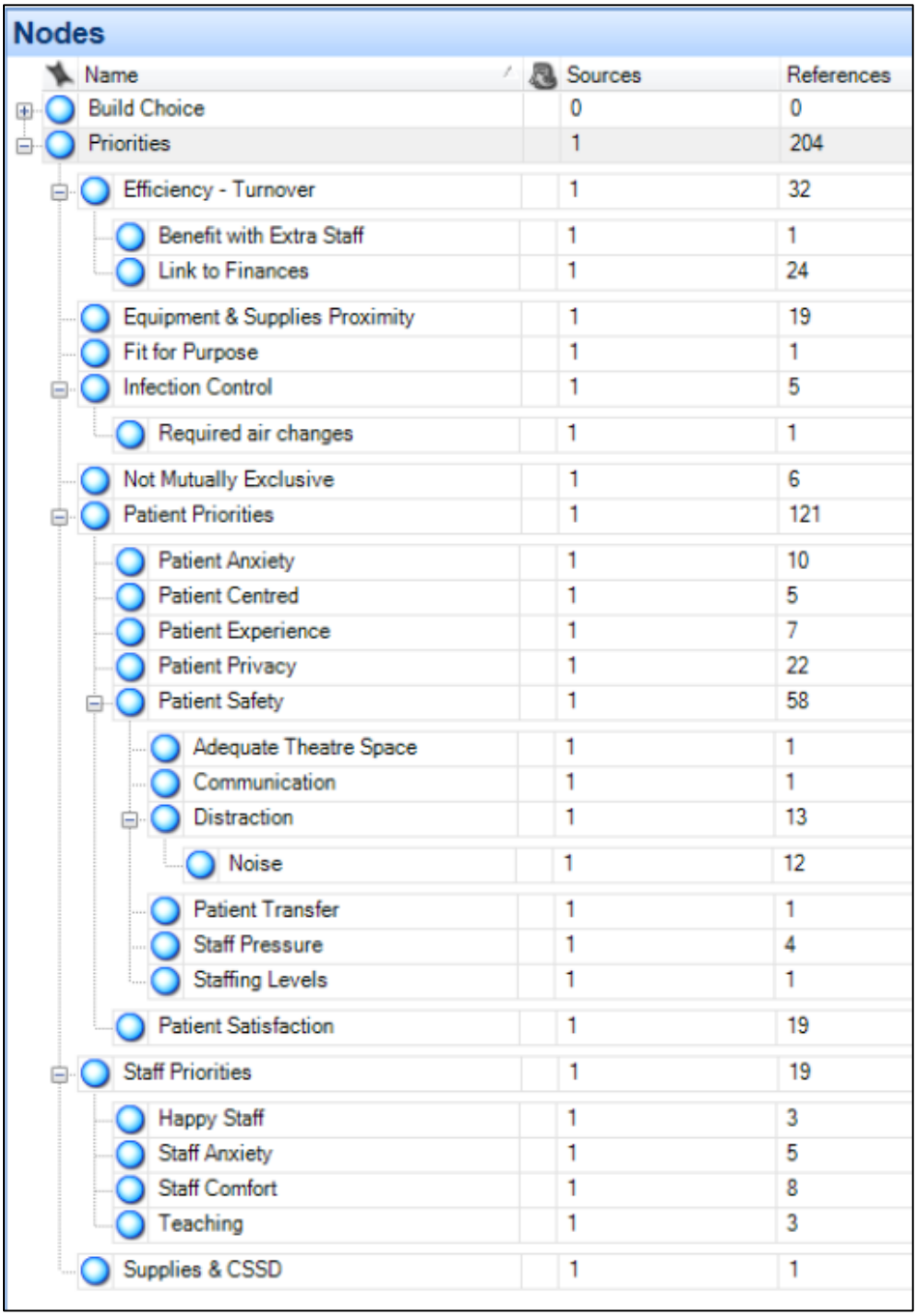
Additional changes included the distinction of patient satisfaction, which became significantly more important than staff comfort and teaching & communication. The importance assigned to patient privacy by surgeons, specifically, lowered between phases, as shown in **Table 5.4**. The four surgeons valued efficiency and financial costs more than other participants. The managers' importance ranking of efficiency dropped in Phase 2, whereas distractions were ranked of greater importance.

Table 5.4 Ranking of design factors by groups

	Phase 2 Rank (Change in rank from Phase 1 to 2)			
Design Factors	Anaesthetists	Surgeons	Theatre Staff	Managers
Patient Safety	1 (0)	1 (0)	1 (0)	1 (0)
Patient Privacy	2 (0)	7 (-3)	2 (0)	2 (0)
Efficiency	3 (0)	2 (0)	4 (+2)	9 (-4)
Patient Anxiety	4 (+4)	4 (+5)	6 (-2)	4 (+3)
Accessibility of Equipment	7 (-3)	5 (-2)	4 (-1)	3 (0)
Patient Satisfaction	6 (-1)	8 (0)	3 (+2)	7 (-2)
Distractions	5 (+1)	9 (-2)	9 (+2)	5 (+4)
Financial Costs	8 (+1)	3 (+2)	10 (-2)	5 (-1)
Staff Time Pressure	10 (+2)	6 (+5)	7 (+2)	11 (-3)
Noise Levels	8 (-1)	11 (-1)	8 (-1)	7 (+3)
Staff Comfort	11 (0)	12 (-1)	12 (0)	10 (+1)
Teaching & Communication	12 (-3)	10 (-4)	11 (-1)	12 (0)

The prioritisation of design factors for the planning committee were weighted equally for all participants. **Table 5.4** shows the final ranking of factors after Phase 2 and the order was most closely aligned with the anaesthetists' prioritisation, as the largest group of participants.

Participants were able to provide explanation on their prioritisations for the top 4 most important factors. Their coded responses following Phases 1-2 are presented in **Figure 5.6**. The majority of priorities which were explained in the free responses of participants were patient related priorities such as patient safety, privacy, satisfaction, and anxiety, similar to the quantitative ranking. Efficiency and accessibility of equipment were also among the most frequently referenced priorities.



Nodes

Name	Sources	References
Build Choice	0	0
Priorities	1	204
Efficiency - Turnover	1	32
Benefit with Extra Staff	1	1
Link to Finances	1	24
Equipment & Supplies Proximity	1	19
Fit for Purpose	1	1
Infection Control	1	5
Required air changes	1	1
Not Mutually Exclusive	1	6
Patient Priorities	1	121
Patient Anxiety	1	10
Patient Centred	1	5
Patient Experience	1	7
Patient Privacy	1	22
Patient Safety	1	58
Adequate Theatre Space	1	1
Communication	1	1
Distraction	1	13
Noise	1	12
Patient Transfer	1	1
Staff Pressure	1	4
Staffing Levels	1	1
Patient Satisfaction	1	19
Staff Priorities	1	19
Happy Staff	1	3
Staff Anxiety	1	5
Staff Comfort	1	8
Teaching	1	3
Supplies & CSSD	1	1

Figure 5.6 Codes for participant design priorities

5.4.3 Influence of Research Literature

Phase 2 of the New Theatre Planning Committee provided a selection of research findings for the participants to consider prior to completing the questionnaire ranking theatre design factors and selecting a choice of build for the new theatres. Only three participants (two anaesthetists and one theatre staff member) stated that the literature had changed their opinion from the previous phase (shown in **Figure 5.7**); however, 11 participants actually modified their choice of build between Phase 1 and 2 (not

including one of the anaesthetists who had stated a change in opinion, yet responded in the same way. The majority (n = 8) of these respondents changed their choice of build from 'Build ARs for *all* theatres' to an option with fewer ARs ('Build ARs for *some* theatres' or 'Build shared ARs).

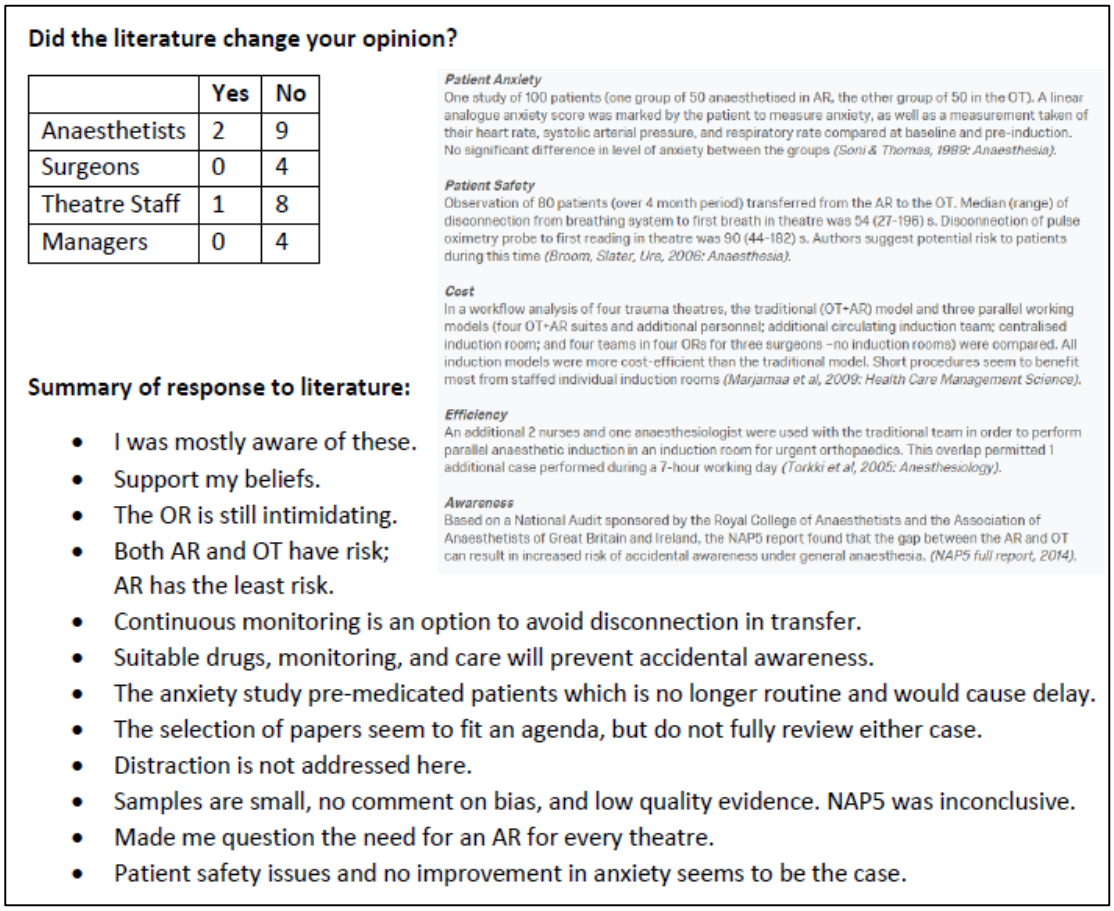


Figure 5.7 Sample of results presented to participants in Phase 3[9]

Participants were asked to explain why the literature had changed their opinion (or not). Six of the most frequent responses related to a lack of change due to the following:

- The participant was already aware of the literature (n = 6).
- The participant presented the limitations of the research provided (n = 4).
- Continuous monitoring is available to reduce risk (n = 4).
- The literature supported the participant's views (n = 3).
- Experience informs the decision (n = 2).

[9] **Figure 5.7** is a screenshot of the results from Phase 2 (responses regarding the research literature), which was presented in Phase 3 to allow participants to see responses from others. The image of the literature findings (top right corner) served as a reminder to the participants of what was shown in Phase 2, and can be seen in full in **Table 5.1**.

- Clinical risks are overstated (n = 2).

All participants were asked if they required any additional information to help them to better make their decision regarding the theatre design. Of the 12 participants (34%) who desired additional information throughout the study, the most common requests were for more robust research evidence (n = 5) pertaining to patient safety, patient experience, efficiency, and shared ARs. The pattern of work, otherwise referred to as the casemix of specialties, allocated to the theatres (n = 4) was requested. Alternative arrangements regarding set-up facilities, block room options, and the size of theatres without ARs were desired (n = 4). Budgetary constraints and costs of the builds were also requested (n = 3). Additional information requests included staffing levels, any possible service reconfigurations, which specialties do not use the AR, anaesthetic willingness to change practice, and Health Technical Memoranda regulations.

5.4.4 Theatre Build Consensus and Rationale

The final consensus for selected theatre build was 54% in favour of building ARs for *all* theatres in the hypothetical new hospital. The build choices selected in each phase of the Delphi are shown in **Table 5.5**, presented by individual groups of respondents.

Table 5.5 Frequency of build selections in Phase 1 / Phase 2 / Phase 3

	Anaes.	Surgeons	Theatre Staff	Managers	Total
Do not build any ARs	0 / 1 / 0	1 / 1* / 1	1 / 1 / 1	0 / 0 / 0	2 / 3 / 2
Build shared ARs	1 / 1 / 0	0 / 0 / 0	1 / 2 / 1	0 / 0 / 0	2 / 3 / 1
Build ARs for **some** theatres	6 / 6 / 4	0 / 2 / 1	1 / 3 / 3	1 / 1 / 1	8 / 12 / 9
Build ARs for **all** theatres	5 / 5 / 6	3 / 1 / 0	8 / 4 / 5	4 / 3 / 3	20 / 13 / 14
Other	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0

*This response was marked as 'Other' in Phase 2, so was presented to the committee as such. The participant did not respond to clarify his response until the study was finished, where it was clarified his choice of build had remained the same throughout.

The dominant view for all participants in Phase 1 was to build ARs for *all* theatres (63%), however following the provision of research evidence, the votes for *all* theatres reduced (42% from 63%) and were spread to *some* ARs (39% from 25%) and shared ARs (10% from 6%). This may indicate an increased doubt in the rationale that an AR is necessary in all theatres. Surgeons and theatre staff shifted from *all* to *some* ARs after the presentation of research evidence.

Following the presentation of results to the Delphi panellists in the final phase of the study, only 3 participants changed their selected choice of build. Two participants who had voted for shared ARs in Phase 2, changed to 'Build ARs for *some* theatres' and 'Build ARs for *all* theatres'. The third participant changed from building ARs in *some* to *all* theatres. The total responses increased from 31% to 54% in favour of a design with an AR for *all* theatres.

Free responses provided rationale for the selected choice of build for theatre. All statements explaining the participant's choice of build were coded under a total of 52 topics. Four major themes emerged from the topics discussed which included:

1. Benefits of anaesthetic rooms;
2. Disadvantages of anaesthetic rooms;
3. Shared anaesthetic rooms;
4. Changing anaesthetic practice.

5.4.4.1 Benefits of anaesthetic rooms

A total of 20 topics were reported relating to AR benefits. The most commonly referenced benefit was efficiency (67 references, 18 sources), which related to the possibility of achieving overlap of the cleaning and preparation of theatre with the initial monitoring and anaesthetic care of a patient, thus improving the turnover of theatres and minimising delays. The next most prevalent statements related to improved patient privacy (49 references, 13 sources), which also included patient dignity and confidentiality, having a separate space for theatre preparation (41 references, 13 sources), and the AR providing a quieter environment (48 references, 13 sources) for the patient to be put to sleep in. Improved patient experience (42 references, 11 sources) was mentioned several times mainly relating to reduced distress or anxiety of the patient from being anaesthetised in an AR. Despite the presentation of patient anxiety research showing an insignificant difference in anxiety between the AR and theatre (Soni & Thomas, 1989b), one ODP stated:

> *'I understand that patients can be stressed in AR rooms, but on the whole it is a less stressful environment and quieter than the OR.' (T4[10])*

Several anaesthetists referred to the benefit of the AR to paediatric patients (27 references, 9 sources), as it allows for the accompaniment of parents into the theatre suite while maintaining the sterility of theatre, which links to topics of airflow and infection control (23 references, 6 sources). Statements of AR advantage for paediatric cases did not relate to patient anxiety directly, but either regarding parental presence or broadly mentioning a clear benefit to children. An example of this broad assumption is presented in this statement from one anaesthetist:

> *'Paeds should have anaesthetic rooms for obvious reasons, using this argument why don't adults?' (A3)*

Additional topics discussed were fewer distractions (27 references, 7 sources) and the flexibility (24 references, 6 sources) the AR provides by being built for all theatres, thus allowing for future use if a speciality were to be assigned to the theatre which would value the presence of an AR. Contrary to the typical argument of patient safety risk due to the transfer of the patient from the AR to the operating theatre, patient safety (24 references, 6 sources) was also mentioned as being a reason for anaesthetising in the AR. The opinion of one manager stated that:

> *'Both models carry elements of risk. The anaesthetic room model carries the least risk.' (M1)*

5.4.4.2 Disadvantages of anaesthetic rooms

Eleven topics pertaining to the disadvantages of ARs were present. The three main topics related to the cost of the AR (24 references, 8 sources), the specialties that benefit from theatre induction (21 references, 7 sources), and staffing requirements of the AR in order to realise efficiency gains (20 references, 6 sources). The statements on cost referred to the expense incurred from building and equipping ARs for every theatre. The costs of duplicated equipment such as monitoring equipment were mentioned. Many participants stated that certain specialties did not need an AR, such as the case

[10] Participants are indicated by their professional groups as anaesthetists (A), surgeons (S), theatre staff (T), and managers (M).

for adult daycase and short stay patients which typically have a quicker turnover rate. While efficiency was most frequently referenced as an advantage of having an AR, several participants noted the requirement of additional staffing in order to make the overlap feasible and safe. One anaesthetist stated that:

> *'If used properly, anaesthetic rooms allow for greater turnover, but they need the staffing to back it up.' (A8)*

Participant responses also referenced the option of allowing for a larger theatre (7 references, 3 sources) for preparation if ARs were not built. Also mentioned was the wasted time (6 references, 2 sources) involved in the transfer of the patient between the AR and OR, and the benefit of having more staff present (6 references, 2 sources) for theatre induction procedures such as emergency and obstetrics. Only 2 participants (2 references) explicitly stated the improved patient safety from anaesthetising in theatre opposed to the AR.

5.4.4.3 Shared anaesthetic rooms

Responses regarding shared anaesthetic rooms were predominately negative (6 of 9 topics). Although 3 participants (6 references) felt a shared AR theatre configuration was satisfactory, most other topics referenced the inadequacy of shared AR spaces. Some participants stated that they are not of any use (11 references, 3 sources), including this anaesthetist who said:

> *'We have a couple of shared rooms which are never used, so pointless.' (A15)*

Some concerns were mentioned regarding waiting time (11 references, 3 sources) as an AR shared between two theatres requires careful coordination of patients who are being treated so as not to delay either of the theatres. Lack of productivity gains (8 references, 2 sources), minimal cost savings (4 references, 2 sources), and patient privacy issues (4 references, 1 source) were all stated as apprehensions for the shared AR set-up. The majority of negative statements on shared ARs came from anaesthetists. Theatre staff were the only other group to reference shared ARs, and referenced potential drug or document confusion (7 references, 2 sources).

Only one participant's statement referenced shared ARs (in a negative way), and was shared with the committee prior to the final vote; however, it seems as though these

negative sentiments were shared by nearly all anaesthetic participants from the beginning. Two anaesthetists supported the choice of *shared* ARs in Phases 1 or 2, but both switched to building ARs on *all* theatres by Phase 3.

5.4.4.4 Changing anaesthetic practice

The final theme of topics shared throughout the Delphi study were statements relating to changing anaesthetic practice. Responses were coded into 10 topics. The most prevalent being the difficulty in future planning (19 references, 5 sources), as the use of theatres may change. In reference to committing to building only some ARs, a participant stated:

> *'…this limits flexibility in the use of that theatre and does not allow for future changes in service configuration or clinical need.' (A7)*

Other topics included the requirement of change in **c**ulture (13 references, 4 sources), and both the resistance to change (13 references, 4 sources) and willingness to change (11 references, 3 sources). Despite the changes made to practice, a few anaesthetists referenced staff adaptation (7 references, 3 sources) and their capability of adjusting to change. From the personal experience of one anaesthetist, she shared that:

> *'…although I was initially sceptical of not using an anaesthetic room, I rapidly became a convert.' (A15)*

However, the experience and willingness of others presented more trepidation for a complete abandonment of ARs. While one anaesthetist shared that more cases could be standardly anaesthetised in theatres than currently are, he stated that if theatres were built without ARs:

> *'I would end up cancelling some cases from a list as I felt they ought to have their anaesthetic in an anaesthetic room.' (A6)*

While small changes were recommended such as shared equipment (8 references, 2 sources) between theatre suites, additional topics were only mentioned by individuals, such as a lessening of resistance as more colleagues are choosing in-theatre induction, colleagues having pro-theatre bias, practice changing faster than design changes, and the need for staff to be involved in the designing phase.

5.5 Discussion

The findings of this Delphi study support many of the results from the survey of consultant anaesthetists and interviews of both anaesthetists and managers (Chapter 3 and 4, respectively), as the consensus of opinion was in favour of anaesthetic rooms and retaining them in future builds. As a majority of 54% of 'committee members' agreed to build anaesthetic rooms for *all* theatres, a consensus was reached in the final phase of the 'New Theatre Planning Committee' meetings and the committee would have presented a proposal to continue building anaesthetic rooms for all new operating theatres. Over 92% of participants voted to retain anaesthetic rooms in some capacity, with only 8% advocating for their complete removal.

5.5.1 Priorities for Design

While the purpose of this simulated theatre planning committee was to reach a consensus on a preferred building option for theatres, an additional outcome of the modified Delphi study was the prioritisation of design decision factors. The ranking of importance for those factors was consistent with the findings from Chapter 3; however, several of the factors included in the Delphi study were related to broader factors specified in the Chapter 3 survey. For example, the individual factors of patient privacy, anxiety, and satisfaction were separated from the broader subject of patient experience. The most important design factors from this study were patient safety, privacy, efficiency and patient anxiety. In comparison to the importance given to similar factors by anaesthetists in Chapter 3, patient safety and experience were also of high importance, but in Chapter 3, high importance was given to patient safety as a reason to induce in the operating theatre, not the anaesthetic room. This was not expressed in the open responses, explaining the most important design factors and was unclear as to which design choice benefited patient safety the most. Open responses reported that the AR is safer than the theatre, whereas only 2 participants explained that safety is compromised within the AR. Whilst the result is consistent with expectations of patient safety being a number one priority, in regards to theatre design, it would seem that patient safety is prioritised, but the design choice to match that priority is not as clear.

The responses of participants were relatively inconsistent regarding noise and communication in the anaesthetic room. Interestingly, the primary reason for inducing

patients in the AR from Chapter 3 was having a quieter environment. Using the space for teaching and communication was also valued. However, noise levels and teaching and communication were two of the lowest ranked factors of the 12 design decision factors.

Patient experience was given high importance in the choice to induce in the anaesthetic room from Chapter 3 and expanded on in Chapter 4. Many aspects of patient experience (privacy, anxiety, satisfaction) were highlighted in Chapter 4 and individually ranked with the other factors affecting the choice of anaesthetic room. These factors were highly regarded within this study, particularly patient privacy and anxiety. The belief that the anaesthetic room helps to alleviate patient anxiety, improve privacy, and increase patient satisfaction were prevalent throughout Chapters 3 and 4; however, research evidence was not found to indicate as such. Only evidence linked to patient anxiety was found and presented to participants. Although the outcomes of the study by Soni and Thomas (1989b) found no significant difference between anxiety of patients induced in the AR or OT, patient anxiety was ranked of higher importance after the evidence was presented to participants. The specific relationship between the site of induction and the patient's experience is explored further in this thesis in Chapter 7.

Efficiency was ranked in the top 3 design decision factors. The widespread view that anaesthetic rooms are necessary for achieving improved theatre efficiency explains the value placed on efficiency in this study and the consensus choice to build theatres including anaesthetic rooms. Although efficiency was ranked of lowest importance as a reason to induce patients in the anaesthetic room (compared to other factors) in Chapter 3, literature regarding overlapping induction or parallel working models (Torkii *et al.*, 2005; Saha *et al.*, 2009) claim benefits in some surgical specialties. This view that anaesthetic rooms improve efficiency was supported by respondents within Chapter 4 and this study. Participants desired additional information to help in their design decisions including the casemix or specialty mix of the proposed theatres, costs involved, and further efficiency research. The cost-efficiency of anaesthetic rooms will be considered in Chapter 6.

5.5.2 Participatory Design

The Delphi method has been used within several participatory or co-design studies, involving users in the design development of products, tools, and processes (Bowie *et al.*, 2015; Carvalho *et al.*, 2007; Crosier *et al.*, 2002). A Delphi approach was used for this study as a way of confronting the individual perspectives of different professional expert groups and the knowledge that they could bring to the debate on anaesthetic rooms, by freely permitting the sharing of views.

The interviews of Chapter 4 revealed the desire of anaesthetists for team decision making, input from staff in hospital design, and the formation of consensus in making design decisions which impact practice. By involving theatre staff and surgeons, the surgical requirements were incorporated into the hypothetical design scenario, as they valued efficiency and space for theatre preparation. Theatre staff members also had the most references to concerns for the patient such as the quietness of the environment, patient privacy, and patient experience.

The focus of this participatory design scenario was to investigate decision making and the impact of research evidence on clinical and management design choices. While patients, also users of the anaesthetic room in some sense, were not involved in this activity, there is further need to research specific patient requirements regarding theatre design and set-up. The impact of the environment on the patient experience will be studied in more depth in Chapter 7 of this thesis.

5.5.3 Evidence-based Practice

The major deviation of this study from a typical Delphi process was the incorporation of an intermediate stage of evidence evaluation. Based on the low importance that published literature was given for changing practice in Chapter 3, and the reported ignorance to existing literature surrounding anaesthetic rooms from participants in Chapter 4, it was presumed that most clinical decisions regarding the use of anaesthetic rooms were not evidence-based. This study allowed for relevant stakeholders to discern evidence regarding various factors they deemed of high importance.

From the small sample of evidence that was provided to participants, most participants disregarded the research as being of insufficient quality. Others claimed they had

known about the specific evidence already or desired supplementary research evidence. It can be concluded that from the selection of anaesthetic room literature shown to this cohort of staff members, these particular research findings were not compelling enough to change practice away from the traditional model of constructing an anaesthetic room for every operating theatre.

The presentation of some research evidence to participants did allow for the individual assessment of findings and decision making related to the choice of build. From the open responses from participants, three anaesthetists and one surgeon were the only professionals to raise into question the quality and limitations of the data presented in Phase 2. This could be due to the nature of professional training and differing requirements for continuous learning for various staff members to be capable of discerning research literature (Gerrish & Clayton, 2004; Walshe & Rundall, 2001). Although inconclusive, this may suggest that non-medical theatre staff and managers may not have the skills required to critically analyse published research literature to assist in evidence-based decision making.

5.5.4 Limitations

Attrition

This study had a participant drop-out rate of 15%. A certain level of attrition was expected due to the repetitive nature of this study. The 6 individuals who were recruited but did not take part in any part of the survey could have been influenced by the late start of the study due to low numbers. After the link to the Phase 1 survey was distributed, the first round was extended due to a delay in receiving approval of one of the NHS Trusts until several weeks after the other Trusts. Additional recruitment from this final site was necessary due to fewer than expected participants, and therefore all participants were notified of a delay in receiving Phase 2.

Sixty-nine percent of participants completed all three rounds of the Delphi. Of the 17% who only participated in 1 round of the study, half completed Phase 1 and half completed Phase 2. This fallout after Phase 1 can be attributed to the winter holidays which postponed the distribution of Phase 2 until January. Some participants went on annual leave and missed the windows to participate in various rounds. This attrition

would still be a possibility in a real life committee due to the challenge of scheduling time, sickness, annual leave, and other circumstances.

Study Design of a Modified Delphi

While a Delphi method framework was applied in this study, the dual purpose of reaching a consensus and also testing the influence of research evidence on the opinions of the participants resulted in a modified Delphi study design.

The number of iterations for completing the survey were limited to only three phases. Landeta (2006) suggests at least two rounds of the Delphi in order for participants to revisit their answers. While the choice of anaesthetic room build was asked in each of the three phases, the judgement was made to only include the ranking of design priorities in Phase 1 and Phase 2. The participants were only presented the results of previous rounds in Phase 3, to ensure that any changes in response from Phase 1 to Phase 2 were a result of the research literature provided, and not based on peer opinion. While the study could have incorporated additional rounds, based on the lack of wide variation of build choice through the various phases, the third round was sufficient for a consensus to be reached.

Although the online questionnaire was not designed by the expert panel, for best use of time and resource, the design decision factors (priorities) were gathered from the findings of Chapter 3 and Chapter 4. This information was provided by some of the same participants of the Delphi study.

It is possible that participants did not know how to rank certain factors in relation to one another. Some participants commented on the design factors as not being mutually exclusive. For some participants, it is possible that topics such as patient anxiety seemingly overlapped with issues such as noise levels and resulting patient satisfaction.

The premise of the study design was to reach a group consensus for a theatre build from participants from all over the East Midlands. The fact that the East Midlands NHS Foundation Trust does not exist and the design ‘committee meetings’ were hypothetical, could have impacted participant motivation to participate and provide further explanation of their opinions. It is possible that a potential lack of buy-in due to the hypothetical nature of this study could have perpetuated a tendency to stick with original opinions and not to consider the input of others.

Despite these limitations, the aims of this study were achieved in reaching a consensus from the inter-professional group, and providing a prioritisation of design factors related to anaesthetic room inclusion or exclusion.

Sampling Bias

All recruitment emails were the responsibility of local collaborators to pass along through the necessary channels within their Trusts. As recruitment was originally low for all groups except for anaesthetists, local collaborators were prompted to target surgeons, theatre staff, and managers for subsequent invitation emails.

The actual composition of a typical theatre planning/steering committee, if one exists, was unknown. It is unlikely, however, that such a committee would have equal numbers of participants within each professional group. Due to a low representation of managers and surgeons in this study, as all data was evaluated equally, the group consensus was made with the dominating priorities of anaesthetists and theatre staff, who were largely ODPs. The study could have lacked participation from surgeons due to its clear focus on anaesthetic rooms, which surgeons may not have valued. In addition, recovery staff and portering orderlies were not included in the study, as specific knowledge of the anaesthetic room and its usefulness was required for this exercise.

Although the lower number of management representatives in the study is similar to the ratios of management individuals to frontline staff in reality, one must consider the prominence that managers would hold in a non-hypothetical planning committee. Are all stakeholders' views equal in real life hospital planning committees? The Delphi process of this study permitted the anonymous sharing of opinions from all staff, which forms consensus within groups of varying power dynamics and conflicting views without direct confrontation of opposing views (Dalkey & Helmer, 1963).

Evidence Bias

The specific selection of research literature included in this study was selected so as not to portray an overall bias in support or against anaesthetic rooms. The included literature was limited to the five studies presented to provide a range of topics and therefore a range of competing priorities regarding anaesthetic rooms. Not all of the twelve design decision factors for anaesthetic rooms had scientific studies related to them.

Although the authors, date, and journal for each study were provided to participants, and they were invited to evaluate them in more depth, the complete papers were not shared with participants. It is possible that participants did not go further to investigate and evaluate the citations and findings provided. While a full systematic review of all relevant literature would be ideal for the most complete evaluation of the question at hand, in reality this will not always be possible, nor available. Within a hospital planning committee, where individuals might provide research evidence, it would still be the responsibility of committee members to evaluate literature in as much depth as they deem necessary to form their decision.

The presentation of research literature to the decision making panel was an exploratory exercise to measure the impact of the intervention on the participants, and the subsequent dialogue that resulted from it. Despite the flaws of individual studies provided, and the lack of thoroughness of the selection, the participants were presented with a challenge of forming their decisions (prioritising factors and selecting a choice of build) on limited information, such as would be the case in real life.

5.5.5 Future Work

Consistent with the previous chapters, patient safety was of utmost importance to all professional groups in designing theatres. However, this study highlighted the view that some staff members find the anaesthetic room is safer for patients. Existing literature regarding the safety of patients and anaesthetic rooms have focused on the gap in monitoring and transfer of an unconscious patient (Broom *et al.*, 2006; RCoA, 2014). Other studies have investigated the prevalence of distraction during anaesthetic practice as a patient safety concern (Campbell *et al.*, 2012). Although outside of the scope of this doctoral research, future work should aim to determine if levels of distraction are different when inducing in the operating theatre than the anaesthetic room.

This study has only proposed and simulated a participatory design, group decision making process for hospital planning. Results from Chapter 4 also confirms the need for user involvement in theatre designs and the paradoxical relationship of design and practice. Further study should be focused on the possible benefits and challenges to participatory design, of all stages of design and development, for hospital planning and stakeholder participation.

Although in this study the presentation of research evidence did not greatly affect group decision making for anaesthetic room incorporation in theatre plans, there are numerous reasons why this should be of interest for future work. In order to solve complex problems in healthcare, such as the question of anaesthetic rooms, additional work should determine the best ways to merge the knowledge and requirements of all stakeholders for the (re)development of efficient, safe, satisfactory, and evidence-based practices.

5.6 Chapter Summary

This chapter tested the priorities of four relevant staff stakeholders in the design of operating theatres and anaesthetic rooms, and used a modified Delphi technique to reach a consensus for the build of new theatres. The consensus reached supported the continued construction of anaesthetic rooms for *all* theatres. As research evidence was judged to be of low quality or inconclusive, it made little impact on persuading change in opinion of participants. The most important considerations for the choice to include or exclude anaesthetic rooms were primarily patient-centred and related to efficiency of the anaesthetic room.

Chapter 6 Cost-Efficiency of the Anaesthetic Room

6.1 Chapter Overview

This chapter is an overview of an observational study and historical secondary data analysis study on the cost and efficiency of the anaesthetic room. The results of ethnographic observations of the anaesthetic room and theatre environment are presented to provide context to the quantitative analyses of cost, space, and efficiency data from the Nottingham University Hospitals NHS Trust surrounding the contribution of anaesthetic rooms to cost-efficiency. In addition, a brief visit to the independently run Circle Nottingham NHS Treatment Centre will present context to a theatre environment working without anaesthetic rooms.

6.2 Introduction

The challenge of measuring efficiency, productivity, and utilisation within hospitals requires the definition of these terms, which are often used synonymously (Pandit *et al.*, 2009). A common definition for 'efficiency' in health economics is that of Farrell (1957) who defined technical efficiency as the production of a maximum amount of an output for a given amount of input. Allocative efficiency is the minimisation of cost for given input prices, or an output that maximises revenue from given output prices. Overall cost efficiency of a firm, or decision making unit, is determined from its technical and allocative efficiency. An efficient firm, therefore, operates at a cost or revenue frontier, or the theoretical limit of efficient operations. Similarly, 'productivity' is commonly defined as the ratio of the volume of outputs that a firm produces and the volume of inputs required to produce them (OECD, 2001). When considering the operating theatre specifically, the throughput volume (i.e. number of patient procedures completed) is often the measure of productivity. Operating theatre productivity can, therefore, be increased by speeding up operating time or maximising utilisation of the theatre by reducing unproductive idle time (Lehtonen *et al.*, 2007).

Efficiency was a prevalent theme in the survey and interviews of consultant anaesthetists and managers in Chapters 3 and 4. Most participants referenced the ability to increase throughput by using anaesthetic rooms, which would improve (technical) efficiency. Interview participants also reported that they were unaware of any formal

analysis of cost and efficiency of anaesthetic rooms having been conducted. The Delphi study of Chapter 5 also confirmed the importance of efficiency in the choice to include anaesthetic rooms in future hospital planning. Theoretically, the anaesthetic room provides a space for the preparation and induction of a patient whilst the previous patient is still in theatre, therefore allowing parallel processing or 'anaesthetic overlap' of patients and minimising the turnover time between surgical procedures. The aim of this study is to investigate whether this claim can be supported, based on surgical data from one acute NHS Trust.

While the previous studies in this thesis highlighted the relative importance of cost and efficiency to the clinicians and managers with respect to the use of anaesthetic rooms, until now little research has been done to investigate the quantitative value of their perceived benefit. Some studies have evaluated overlapping induction models and concluded that additional staffing and parallel working can increase the number of surgical cases conducted in a day within orthopaedic theatres (Torkii *et al.* 2005), and for a variety of inpatient procedures (Hanss *et al.* 2005). However, no studies have quantitatively measured both the costs and benefits of anaesthetic rooms. Expanding on existing research by taking into account the diversity of a mixed-specialty service, this cost-efficiency study aimed to

- calculate the time savings gained by overlapping induction with the use of the anaesthetic room;
- calculate the frequency and amount of downtime experienced in theatre;
- evaluate the contribution of additional anaesthetists or physician's assistants on the realisation of overlap;
- calculate the estimated cost benefit from using anaesthetic rooms.

Hollnagel (2012) described the gap between 'work as done' and 'work as imagined' in complex socio-technical systems, which can result in false assumptions within the organisation of what the standard processes and tasks are compared to the realities of work and potential variations of work (i.e. workarounds) which may occur. To supplement quantitative analysis, an observational study was employed to explore 'work as done' to merge a real-world experience of anaesthetic room use with the information systems data gathered from that environment and the reflections of 'work as imagined' described in Chapter 3-5. The ethnographic observation also endeavoured

to identify the activities occurring within the surgical suite, the staffing utilised, causes of delay, potential costs, timing of the transfer between the anaesthetic room and theatre, and the occurrence of overlapping induction. These observations provided context for the analysis of theatre collected data.

6.3 Ethnographic Observation Methods

6.3.1 Ethics

Morse & Field (1996) raised the challenges of conducting qualitative research in clinical settings, where the researcher is in the presence of staff and patients and may be witness to unethical practice. In the observation of surgical patients, the presence of the researcher, a non-clinical care team member, could be upsetting for a surgical patient or the anaesthetic or surgical team members being observed. In a worst case scenario, the researcher could be present for an adverse incident or untoward event.

Taking these concerns into account, a protocol, participant information sheet and consent form were developed. The consultant anaesthetist (and trainee when present) and anaesthetic operating department practitioner (ODP) were the primary subjects being observed and informally interviewed, and were therefore asked to review a participant information sheet and sign a consent form to approve the observational study prior to the researcher attending a procedure. As a part of the agreed protocol, after acquiring consent from central subjects of the study, the researcher was introduced by the anaesthetist or ODP to the remaining theatre staff (e.g. surgeon(s), trainees, ODPs, healthcare assistants (HCAs), nurses, etc.) and the patients. The anaesthetist introduced the researcher to the surgical patient and requested patient approval for the researcher to remain in attendance for the procedure. If at any time a member of the care team or the patient wished for the study to cease, the researcher was required to leave immediately. All data collected was anonymous and remained confidential in order to protect the identities of the staff members in attendance and patients undergoing surgery.

This study was a part of a larger protocol including the studies from Chapter 3 through 6 and was approved (version 4) on 4th December 2014 by the Faculty of Engineering Research Ethics Committee.

6.3.2 Data Collection

An ethnographic study was designed to observe current anaesthetic practice across multiple specialities and observe the activities, staffing, and timing of the patient pathway from the anaesthetic room to the theatre. These observations aimed to provide insight into the credibility of the theatre management system data which would be used in the secondary data analysis, to compare against the responses from the survey and interviews of Chapter 3 and 4, and shed light on the contextual aspects of the anaesthetic and surgical environments.

Hughes *et al.* (2003) explain that the endeavour of observing a social context and drawing meaning from it involves interpretation of the beliefs and behaviours of others although they are a part of a cultural tradition which is different from the researcher. It is therefore essential to recognise that the social scientist (female, American, twenty-nine years old, engineer, American upbringing and education, raised with a privatised healthcare system, worked in American operating theatres) may have inherent biases and must be able to separate her own experience and opinions from those of the participants.

Additionally, when undertaking ethnographic research, investigators must address and be fully aware of their impact on the subjects who they are studying. The observer is incapable of complete objectivity, because the participants, observation site, and observer are interacting, in a very interpersonal way. In this observation, the researcher took on the role of an observer-as-participant, which permitted the researcher to mainly observe, but also to conduct short interviews with the subjects of observation (Pearsall, 1965). This observer role was taken out of necessity, as the researcher needed to be formally acknowledged by all theatre staff and the patient. Furthermore, as activities took place simultaneously within the operating theatre and anaesthetic room, it was essential to know the roles of all staff members and to be able to ask questions to verify the observations.

The aim of the observational study was to witness the daily routine in and around the anaesthetic room across multiple specialities of surgery. The key aspects which were observed were the following:

- Speciality and type of procedure;

- Functions of the anaesthetic room;
- Time study of patient movement from arrival to departure (where possible);
- Surgical and anaesthetic team composition;
- Causes for delays;
- Possible cost implications for using the anaesthetic room;
- Utilisation of the anaesthetic room for overlapping induction.

An observation sheet was designed to aid the observer in systematically collecting both field notes and time points. This observation sheet can be found in **Appendix G**. All fieldwork was conducted in the Nottingham University Hospitals NHS Trust. All theatre managers were contacted to request permission to conduct observations within theatres. Observations were then scheduled over the course of 6 days between the 11th-19th March 2015. A total of 37 procedures were observed across two hospital sites and 14 different operating theatres. **Table 6.1** lists the 12 specialties observed in comparison to those evaluated in the online survey distributed in Chapter 3 exploring current practice.

Table 6.1 Surgical specialties evaluated by research studies

Surgical Specialties	Survey	Observation
Cardiac Surgery	✓	✓
Daycase	✓	✓
Ears, Nose, Throat	✓	✓
General Emergencies	✓	✓
Gynaecology	✓	✓
Major Abdominal	✓	
Neuro Surgery	✓	✓
Obstetrics	✓	✓
Ophthalmics	✓	
Oral & Maxillofacial	✓	✓
Orthopaedic (Elective)	✓	✓
Orthopaedic (Trauma)	✓	✓
Paediatrics	✓	✓
Plastics	✓	

Spines	✓	
Thoracics	✓	
Urology	✓	✓
Vascular	✓	

In addition, a brief visit to the local privately run Circle NHS Treatment Centre will provide contrast to the procedures and processes observed in the NHS Trust. An informal meeting was arranged with the theatre lead at the treatment centre to understand the local processes for working without anaesthetic rooms. A summary of the discussion points were emailed to the theatre lead for confirmation and clarification and are referenced as an email correspondence, shown in full in **Appendix H**.

6.3.3 Data Analysis

Both qualitative and quantitative data were collected from observations of the anaesthetic room and the operating theatre. All field notes were transcribed and analysed in NVivo 10 software for common themes. All numerical data, including timing of the patient's transfer from the anaesthetic room to the operating theatre, number of staff, and the frequency of uses for the anaesthetic room, were compiled in Microsoft Excel®. Descriptive statistics of the data were calculated.

6.4 Secondary Data Methods

6.4.1 Methodology

Existing methods for measuring hospital efficiency and productivity have primarily used highly mathematical techniques such as non-parametric data envelopment analysis (DEA) and stochastic frontier analysis (SFA) (Hollingsworth, 2008). Both methods have been used to measure productive efficiency which could then be benchmarked to best-practice firms (Cook *et al.*, 2014; Hurst & Williams, 2012); however, such arduous techniques may be considered impractical for most anaesthetic and theatre teams (Pandit *et al.* 2009).

Focusing on surgical efficiency specifically, Pandit *et al.* (2007) proposed a formula to capture efficient performance by considering theatre time utilisation (under and over-

running) and cancellations. A revised version built on the formula and integrated productive components such as actual list durations, gap (idle) times, surgical speed, and patient contact to calculate efficiency (Pandit *et al.*, 2009). One criticism of the efficiency measure was the lack of consideration for costs and financial determinants (Siegmueller & Herden-Kirchhoff, 2010), which Pandit *et al.* acknowledged as being necessary, however difficult to determine.

Several methods exist for evaluating the benefit of health treatments or interventions such as cost-effectiveness analysis (CEA), cost-utility analysis (CUA), and cost-benefit analysis (CBA) (Johannesson & Jönsson, 1991). Methods such as CEA and CUA consider both monetary and physical units for decision making, and may consider measures such as the number of patients treated, life-years gained, or quality of life. Cost-benefit analysis has been criticised as being limited to only monetary analysis; however, for the purpose of this study, which is to measure the financial benefit of anaesthetic rooms and does not aim to quantify other perceived benefits, the CBA is an appropriate method. In healthcare, CBA has been employed for evaluation of various treatments and interventions including electronic medical records (Wang *et al.*, 2003) and alcohol intervention for trauma patients (Gentilello *et al.*, 2005), for examples. The purpose of a CBA is to evaluate a project (in this case, anaesthetic rooms) based on its consequences and therefore must consider the economy with and the economy without the project (Drèze & Stern, 1987). The trade-offs of costs (often opportunity costs) and benefits of the project are measured and the project is found to be desirable if benefits exceed costs.

For this study, a pragmatic approach was taken to utilise secondary data provided by one NHS Trust to measure the contribution of anaesthetic rooms to theatre productivity in financial terms (i.e. profit), compared to overall costs of anaesthetic rooms (i.e. expenses). While the data reflected the status quo (i.e. utilising anaesthetic rooms), it could be compared against the proposed alternative of having no anaesthetic rooms by theoretically assuming overlap of patients would be impossible without them.

6.4.2 Data Collection

6.4.2.1 Utilisation Data

For the purpose of analysing the efficiency of theatres, data relating to the timeliness of anaesthetic and surgical procedure completion was required. While other studies evaluating operating theatre efficiency have considered under or over running, and cancellations of procedures, these are efficiency factors outside of the scope of this study as they are issues that are not affected by the presence or absence of an anaesthetic room, and relate more to scheduling practice.

This study will focus on the aspects of operational timeliness and utilisation which can be attributed to anaesthetic rooms use such as the overlap of procedures and downtime, or idle time. The definitions for these terms are described below:

- *Overlap* – For this analysis, 'overlap' refers to the total time in which a second patient is in the anaesthetic room, while the first patient is still in the theatre.
- *Downtime* – Downtime refers to any gaps between cases where the first patient has left the operating theatre, but the second patient has not arrived to the anaesthetic room.

Based on interviews with managers from Chapter 4, it was evident that most NHS Trusts utilised some version of a theatre management system which contains data that would allow estimates of these times to be calculated.

ORMIS (Operating Room Management Information System) is one such software package where cases are booked, and stores information entered by theatre staff. A screenshot of the ORMIS user interface is shown above in **Figure 6.1**. The data that is reported using ORMIS includes the staff members involved in the procedure and time stamps throughout the perioperative pathway. In the Nottingham University Hospitals NHS Trust (NUH), a time stamp marking the time of arrival of the patient to each stage of the procedure from 'Porter Sent' to 'Patient Discharge Time' could be collected, however according to the NUH systems analyst, the only fields required of staff were 'Anaesthetic Induction', 'In OR', and 'Out OR' times, and yet no ORMIS fields were mandatory in forcing the user to enter data in order to progress.

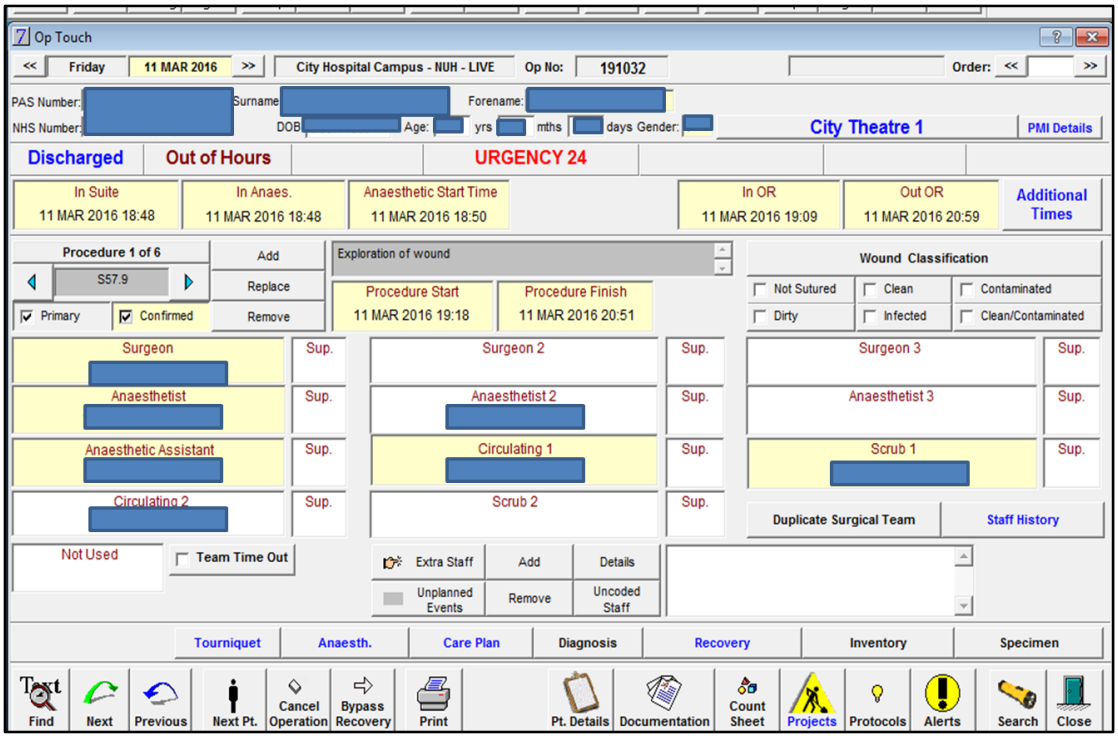


Figure 6.1 ORMIS user interface

Patient anonymised historical ORMIS data was requested from NUH for all surgical procedures conducted in both of its hospital campuses from 1st January 2013 to 31st December 2013. The data fields collected for each of 55,044 total procedures conducted can be seen in **Table 6.2**, including ORMIS and Medway data, described later.

Additionally, to meet the aims of this study, specific knowledge of the specialties in each theatre and the presence, equipment provision, and use of the anaesthetic room was necessary. All 52 theatres included in the analysis across two hospitals were toured with theatre managers in order to compare the infrastructure with floor blueprints provided by the NUH Estates Department. The use of spaces was noted and managers were asked specifically about use of anaesthetic rooms and theatres in 2013, which could provide context for the ORMIS historical data set being analysed.

Table 6.2 Secondary data fields analysed

Date / Time Stamp	Description
Operation Date	Date of the procedure
Porter Sent	Time when the porter was sent for to collect the patient from the ward or waiting area
Porter Left	Time when the porter received the notification and left to retrieve the patient
In Suite	Time the patient arrives to the holding area
In Anaesthetic Room	Time the patient arrives in the anaesthetic room
Anaesthetic Induction*	Time the anaesthetic induction takes place
In Operating Room*	Time the patient enters the operating room
Out Operating Room*	Time the patient leaves the operating room
Patient in Recovery	Time the patient enters the recovery area
Patient Ready to Depart	Time the patient is ready to depart
Patient Admission Time[M]	Time the patient is admitted to hospital
Patient Discharge Time[M]	Time the patient is discharged from hospital
Procedure	Type of procedure done
Specialty	Specialty of the procedure done
Theatre	Specific theatre or area where procedure is done
Anaesthetic Type	Type of anaesthetic used
Session Type	Levels of staffing (costing purpose)
Operation Type	Emergency, Urgent, or Elective
Anaesthetist 1, 2, 3	Name of anaesthetist(s) involved in the case
HRG Code[M]	Algorithm assigned tariff code

*Indicates 'mandatory' fields, [M] Fields stored in Medway; all others from ORMIS

6.4.2.2 Revenue

One major variable of cost-benefit analysis is the 'benefit', which can be calculated from the profit made after expenses. The revenue, or income before expenses, from surgical specialties can be split between non-clinical income and procedure tariffs as shown in **Figure 6.2**.

Figure 6.2 Calculation of surgical specialty profits -focus on revenue

Although clinical activity provides the largest amount of income for the Trust, there are other sources of non-clinical income within individual specialties which comes from areas such as pharmacy[11]. Both sources of income are important in understanding the total financial implications of anaesthetic rooms on entire specialties, as they are paid on a specialty level. This analysis includes non-clinical income as an off-set to organisational expenses which are allocated to specialties, explained further in the following section; however, procedure tariffs are of particular importance in this analysis. Sources for the revenue data are shown in **Table 6.3**.

Table 6.3 Revenue variables

Revenue	Data Analysis Variables	Data Source
Procedure Tariff	HRG Codes; Length of Stay (calculated); Operation Type (Elective/Non-elective)	Medway PAS; Medway PAS; ORMIS
Non-clinical Income (NCI)	NCI per month, per specialty	Finance Department

In order for acute NHS organisations to be paid for the work they do, all acute healthcare activities are assigned national tariffs, or standard national prices, which are defined by the National Casemix Office (NCO) from the Health and Social Care Information Centre. These tariffs relate to the amount to be paid to the NHS Trust by the Clinical Commissioning Group (CCG) responsible for each patient's healthcare

[11] During data analysis, specialty finances revealed a larger proportion of non-clinical income than overheads and depreciation for certain specialties per procedure. The NUH Finance Department clarified that pharmacy charges and income are shown within the Trust level non-clinical income due to internal trading, but does not actually represent income to the specialty. This indicates an overestimate of non-clinical income, thereby making all results more conservative, as actual costs would be higher. For the analysis, any specialties with more non-clinical income than overhead and depreciation costs were given zero overhead charges, but no gain in income per procedure.

(which is based on patient geography). The NCO developed a system called a Healthcare Resource Group (HRG) Casemix Classification that groups patient events which consume a similar level of resource. The most current revision of the HRG is the HRG4+, which was implemented in 2012. Additionally, some HRG codes are agreed on a local level between commissioners and Trusts.

Alphanumeric HRG codes, associated with specific tariffs, are derived from agreed upon procedure and diagnosis codes for individual patients, which help to standardise commissioning across the NHS. The coding is associated with the specialty and type of procedure, the patient's length of stay, patient's age, complications and comorbidities. Within NUH, following a patient's discharge from hospital, the patient notes, ORMIS data, and the patient administration system, Medway© (System C) are evaluated by a clinical coder who uses a software application called the HRG4+ Reference Costs Grouper, or the 'Grouper', that uses a complex algorithm to assign HRG codes to patient procedures based on all information of their stay in hospital. **Figure 6.3** shows the flow of information and payment through the various databases, departments, and organisations involved in the payment of surgical work in NUH.

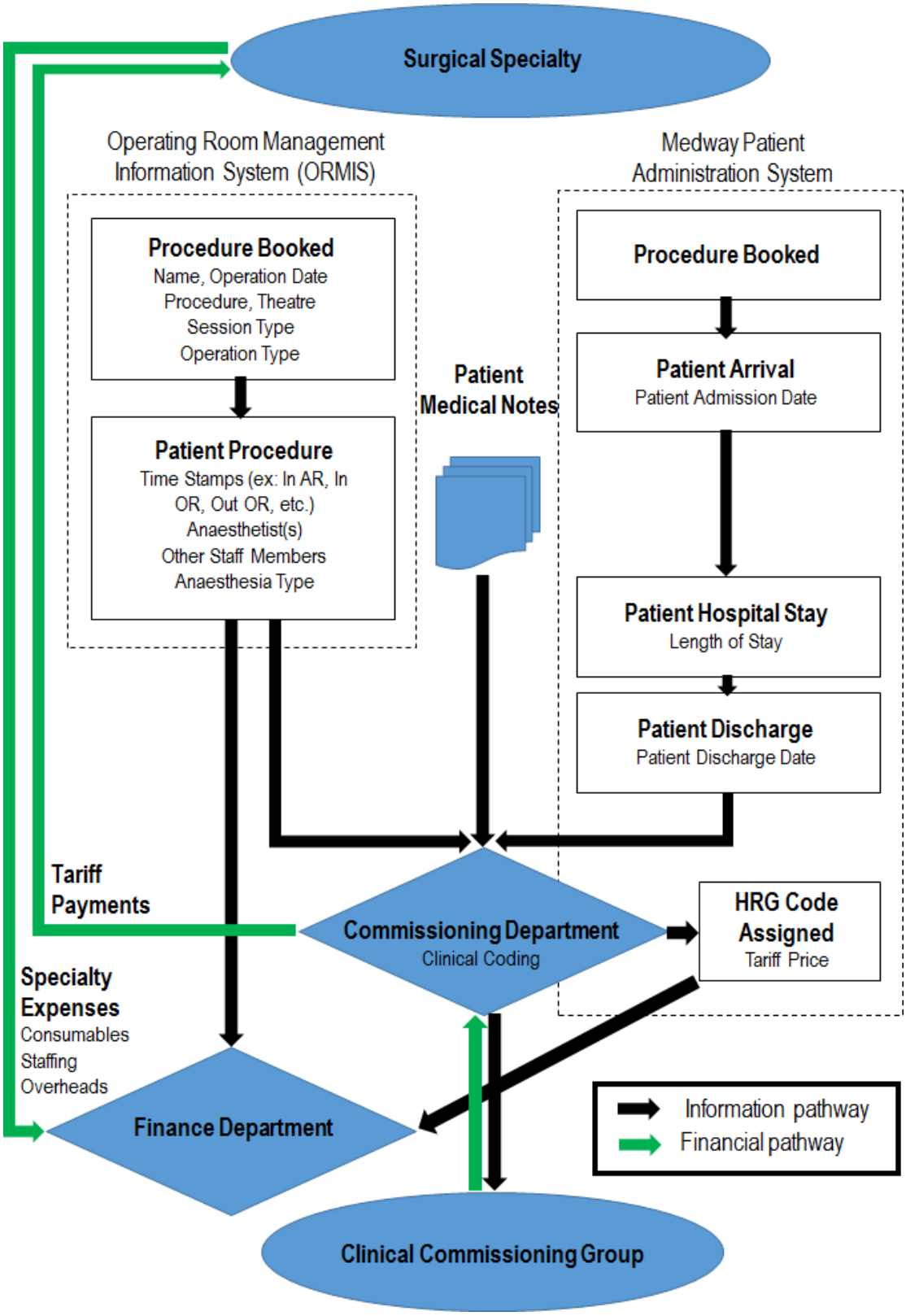


Figure 6.3 Payment and information flow diagram for surgical work

The hospital stay of a patient is called a 'spell', which is split into separate 'episodes'. Spells are defined by activities taking place from the admission to discharge of the patient. Episodes are distinguished by the transfer of responsibility from one consultant

to another. Generally, for spells which contain multiple episodes, the HRG assigned to all of the individual episodes will be that of the dominant episode or a specific tariff which encompasses the higher cost and complexity of undergoing multiple procedures. **Table 6.4** shows an example of a multi-episode spell where one patient underwent multiple procedures during his/her single length of stay (LOS) within the hospital. This example shows how various procedures from multiple specialties are assigned the same HRG code, therefore misrepresenting payment, as each individual episodes would not be paid the full HRG tariff multiple times. This HRG Code, EA167, represents the cardiac procedure 'Coronary Artery Bypass Graft (CABG) with Percutaneous Coronary Intervention, Pacing, EP or RFA'. The subsequent procedures would not be paid as multiple CABG procedures. Payment for the entire spell would be made once and distributed to all specialties involved.

Table 6.4 Example of a multi-episode spell

Date	Procedure	Specialty	Operation Type	HRG Code
9-Dec-13	CABG	Cardiac Surgery	Elective	EA167
12-Dec-13	Re-opening of chest	Cardiac Surgery	Emergency	EA167
20-Dec-13	Laparotomy	General Surgery	Emergency	EA167
25-Dec-13	Emergency laparotomy	General Surgery	Emergency	EA167

After assignment, all HRG codes are stored in Medway. For this analysis, the NUH systems analyst was required to merge ORMIS procedural data with HRG codes assigned to patients in Medway by matching unique patient numbers and operation dates falling within specific patient spells. This matching was not exact and required data cleansing to identify duplicated data.

National tariffs for admitted patient care and outpatient procedures from 2013-2014 were referenced to match HRG codes with prices. However, national prices vary for each type of procedure based on LOS and various national incentives for best practice. Price variances included in this study were the following:

- Day case spell tariff (i.e. same day admission/discharge)
- Ordinary elective spell tariff (i.e. elective procedures with LOS > 0)

- Combined day case / ordinary elective spell tariff (i.e. tariffs which do not vary between day case or ordinary elective cases)
- Non-elective spell tariff (i.e. emergency procedures)
- Ordinary elective and non-elective long stay trimpoints (i.e. the number of days above which will be charged a daily rate for exceeding)
- Per day long stay payment (i.e. the daily rate for exceeding the LOS trimpoint)
- Emergency reduced short stay tariff (i.e. a one-time incentive rate for some emergency cases which discharge patients below the long stay trimpoint).

A macro, or short programme that helps to automate repetitive tasks, was created in Excel to calculate the total tariff based on HRG specific rates and LOS information. Locally assigned tariffs did not vary based on the previously stated measures and were kept as constant prices. The coding for the HRG tariff calculations are shown in **Appendix I**.

6.4.2.3 Expenses

An analysis of commissioning income would be incomplete without a consideration of hospital costs, and in turn an estimate of total profit. **Figure 6.4** displays the relationship between these factors and the various forms of expenses associated with surgical specialties.

Figure 6.4 Calculation of surgical specialty profits -focus on expenses

The expense variables for this study's analysis are shown in **Table 6.5**. Some data were sent from finance department reports, while others were derived from ORMIS data. Several specialty costs and payments, although paid and charged on a monthly basis, were extrapolated to derive a per procedure estimated cost.

Table 6.5 Expense variables

Expenses	Data Analysis Variables	Data Source
Consumables	Consumables per month, per specialty	Finance Department
Overheads	Overheads per month, per specialty;	Finance Department
	Depreciation per month, per specialty	Finance Department
Staffing	Session Type (assigned hourly rate);	ORMIS
	Procedure Duration (calculated)	ORMIS

Consumables, which are the disposable items that are stocked in theatres and anaesthetic rooms and re-ordered from stores upon depletion, are measured on a specialty basis. As theatres are assigned to particular specialties, all consumables are charged to the specialty assigned to the theatre. In the case of mixed-use theatres, the total cost of consumables for the theatre is split against the specialties that used the theatre, proportionate to the number of procedures done per specialty. The NUH Finance Department provided a month-by-month total cost of consumables and the number of procedures done per surgical specialty for 2013-2014. This data provided an estimate of consumables costs per specialty per procedures.

Overhead costs are also charged on a specialty basis, which includes a monthly charge for corporate costs (management, payroll, human resources), estates costs (utilities, cleaning, maintenance), equipment depreciation, and building depreciation. Based on the number of procedures done monthly per specialty, overhead costs were extrapolated and estimated per procedure.

Staffing costs are assigned to time blocks within the theatre schedule, and are costed on an hourly basis for various staffing levels. The Session Type is a field in ORMIS which is specified by the administrator upon booking the procedure. The various Session Types are listed in **Table 6.6**.

Table 6.6 Staffing levels in ORMIS

Session Type	Hourly Rate[12]	Description	Category
Standard	£204	Surgeon, anaesthetist, 2 scrubs, 1 ODP, 1 runner, 1 recovery staff member, and 1 porter	Normal
WLI	£574	Saturday working, charged double time	Normal*
Emergency	£204	Out of hours with on-call staff members	Normal*
Extra ODP	£302	Normal team with 2 ODPs	Extra
Extra session	£185	Waiting list initiative session, but low staffing	Fewer
No anaesthetist	£161	Procedures not requiring an anaesthetist	Fewer
PA	£307; £219 (EO)	Lists employing PAs for overlap (either elective orthopaedic or other specialties, e.g. urology, gynaecology)	Extra
Planned overrun	£204	Standard rate, when whole day is booked	Normal*
Private Patient	£574	Private sector patient, charged as WLI	Normal*

*Out of standard hours' work incurs higher cost, but staffing levels may be highly variable so are assumed normal for analysis. PA = physician's assistant; WLI = waiting list initiative; EO = elective orthopaedic

Although specialties are charged based on theatre time blocks of certain session types, this analysis only considers staff costs for time in which the surgical suite is being utilised (i.e. no expenses for downtime). This provides a more conservative estimate of actual staff costs, where in reality specialties would be charged for total scheduled time, and not just time used. In order to calculate staff cost per procedure, procedure duration was calculated and multiplied by the specific session type assigned to the procedure. The Royal College of Anaesthetists has accepted the definition of a procedure from anaesthetic induction to handover to recovery (Norton, 2008). However, in 2013, the NUH standard (see footnote below[13]) defined the end of procedure as the 'Out of OR' time. Therefore, due to the higher reliability of the 'Out of OR' time and local standards

[12] The NUH Finance Department provided 2013/2014 session hourly rates; however, in 2013 the Trust was inflating session rates for all specialties to cover expenses from two maternity theatres which were not being charged. Corrections were made by 2015/2016 to have more accurate charges for actual costs. Upon suggestion from Finance, 2015/2016 rates were converted to present discounted values for 2013 rates by an inflation rate of 1.5% (ONS, 2016) over two years.

[13] The NUH systems analyst clarified that the NHS Modernisation Agency had taken Scottish Executive standards for defining procedures from anaesthetic induction to departure from theatre to define NHS England standards. This changed in 2014 when NHS Benchmarking Network revealed other Trusts were using 'In Recovery' as the end point for patient procedure times. Practice in NUH shifted to this in 2015.

for practice, procedure duration was calculated from 'Anaesthetic Induction' to 'Out of OR' times for this analysis.

As the Session Type data was exported from ORMIS retroactively, the additional field was merged by matching anonymous unique patient IDs and operation dates to the original ORMIS data set provided. While fields exist in ORMIS for tracking of staff assigned to roles within the surgical suite (e.g. ODP, scrub, nurse, surgeon, anaesthetist, etc.), the fields are not mandatory and are unreliable for accurate staffing numbers. Three fields are available for the anaesthetists involved in each case, and although inconsistently entered, the anaesthetist fields were beneficial in identifying the presence of two physician's assistants known to be working in NUH during 2013.

A physician's assistant (PA) qualification is a postgraduate diploma which trains individuals in all aspects of general anaesthetic delivery. Some hospitals also permit PAs to provide regional and local anaesthetics. In general, a 2:1 ratio is used where one consultant anaesthetist oversees two PAs in two theatres, or one trainee anaesthetist and one PA (RCoA, 2016). In NUH, the typical specialties which utilised the two trained PAs in 2013-2014 were orthopaedics, urology, and gynaecology specialties across five specific theatres. By identifying the procedures within those theatres which had a 2nd or 3rd anaesthetist with names matching those of the two PAs working in NUH at the time, the cases were able to be flagged as potential PA assisted cases (A. Carney 2016, personal communication, 18 May). These were able to be compared against the Physician's Assistant Session Types, which would have been entered at the time of booking.

Based on the Session Types, the procedures were also categorised as having Fewer, Normal, or Extra staff, as shown in **Table 6.6**. Fewer staff included Extra Session and No anaesthetists. Extra staff included Extra ODP and Physician's assistants. All other Session Types were assumed to be standard, or normal, staffing, despite variance in cost of staffing per hour, as case-by-case staffing was unknown.

6.4.2.4 Anaesthetic Room Costs

To assess the cost-benefit of anaesthetic rooms, an analysis was required of supplies and equipment exceeding those which are standard to theatre induction without an anaesthetic room. The cost of duplicated anaesthetic machines and the required

maintenance for the equipment was provided by the NUH theatre equipment manager. Moreover, disposable supplies which would be required in addition to the supplies used within theatre for anaesthesia were costed and provided for this analysis in 2015 prices, so all costs were converted to 2013 prices based on inflation. The maintenance schedule, labour requirement, and consumable supply cost for the anaesthetic room which were provided from the NUH equipment manager, are shown in **Appendix J**. Although cost could be associated with the time required to regularly check equipment and stock anaesthetic room supplies, these were excluded from the study as regular equipment checks and stocking of supplies would also be required for theatres without anaesthetic rooms.

6.4.3 Data Analysis

6.4.3.1 Data Reduction

The data obtained from NUH was a raw, anonymised, export from the ORMIS system for the period of 1st January 2013 to 31st December 2013 and therefore consisted of every surgical procedure during that time. A process of data cleansing was undertaken in order to remove procedures from the final analysis which did not abide by underpinning assumptions of the data analysis. After merging HRG codes from the Medway system to the ORMIS data set and including the Session Type field to existing data, several phases of data reductions were made as seen in **Figure 6.5**.

The final data set was compiled from various exports from the NUH data analyst over the course of nearly a year and a half. The initial data set was sent in January 2015. Operation types (i.e. elective, urgent, emergency) and number of anaesthetists data were requested and sent March 2016. HRG tariff data was not sent until May 2016. Session types were sent separately from the full data set in June 2016.

As the HRG codes were stored in a separate system (Medway), ORMIS data was imperfectly linked to HRG codes based on patient IDs and dates of stay in hospital. Additionally, several HRG codes were missing due to a change in patient identification when the two Trust hospitals were merged, which were identified and merged in a second version of the full data set. The column of Session type data was merged to the full data set and all cases from 2014, which were accidentally sent, were excluded.

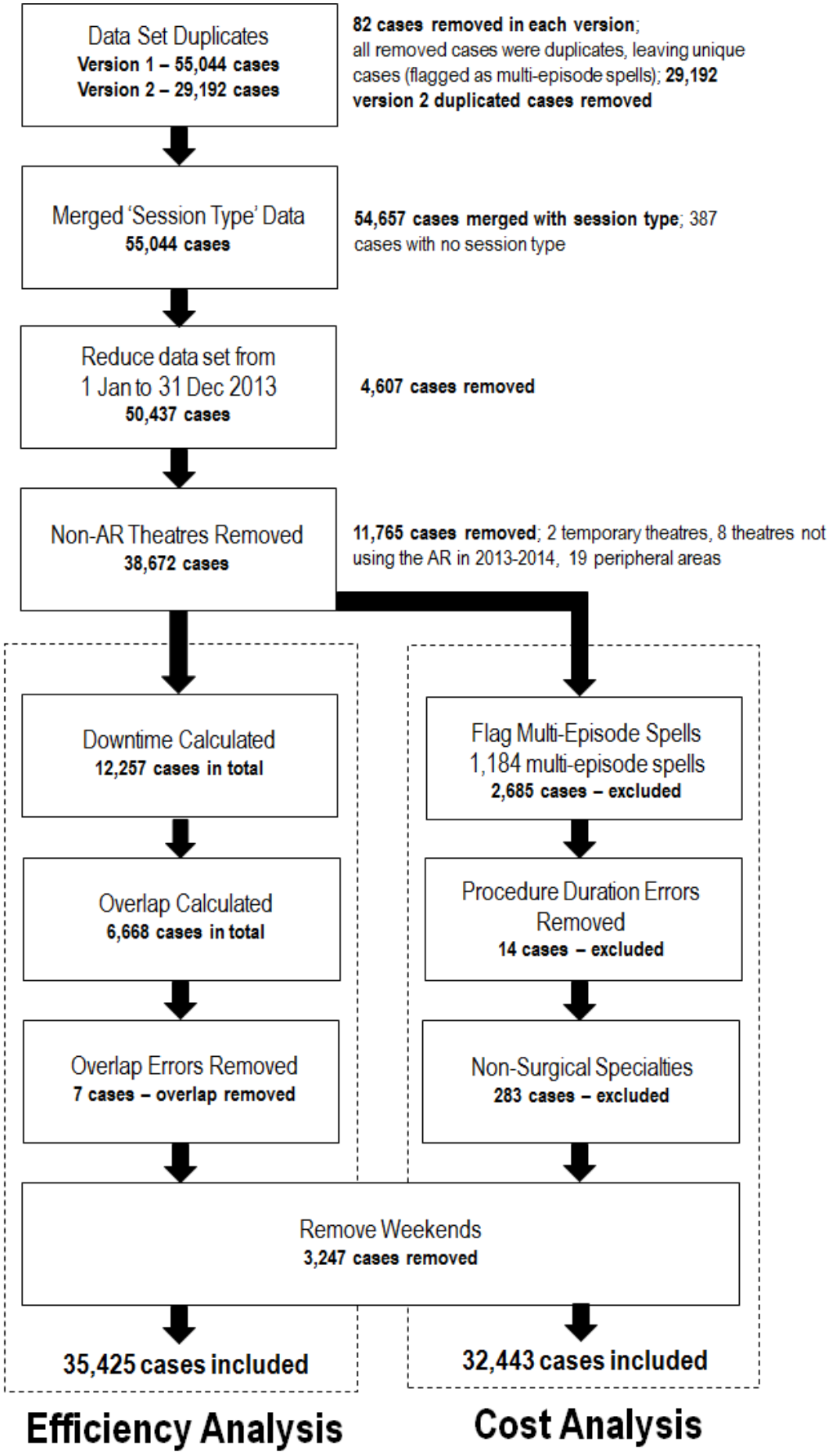


Figure 6.5 Data reduction flow diagram

Non-Anaesthetic Room Theatres

Firstly, the secondary data analysis aimed to identify the contribution of the anaesthetic room to the occurrence of overlapping patients. The fundamental assumptions that an AR exists adjacent to theatre and was used in 2013 meant that procedures were excluded that were done in theatres that did not have ARs, did not use them, or were areas outside of the main surgical operating theatres. Despite the option in ORMIS to enter AR times in all areas, based on a tour of theatres, some ARs were too small for standard use. Some areas had a shared AR between theatres, resulting in a preference to anaesthetise in theatre (consistent with interview findings in Chapter 4 pertaining to the lack of 'fit for purpose' of current shared or undersized ARs). Day surgery treatment rooms and obstetrics theatres did not use ARs for induction. Several satellite areas, such as cardiac catheter labs, main theatre recovery, x-ray, and MRI were excluded. Cases were removed from 2 temporary theatres (non-permanent structures), 8 theatres which did not have or did not use the AR, and 20 peripheral areas outside of the primary surgical theatres in NUH.

Overlap Errors

As the main purpose of the study was to determine the prevalence of overlap, sequential cases showing over an hour of overlapping time were reviewed by a consultant anaesthetist to provide clinical knowledge to determine the veracity of the timings. Seven cases were flagged as potential errors and were therefore excluded from the final efficiency analysis during data cleansing. Downtime was not data validated as the circumstances for having an empty theatre are not available within the data collected. Downtime was only calculated on the assumption that all work was scheduled.

Multi-Episode Spells

The only procedures that were included in the cost analysis of ARs were those which had been assigned a valid HRG code, accurately representing the procedure to which it was assigned. In the case of multi-episode spells, which as previously stated, are multiple procedures for a single patient in the same hospital stay that are provided a single HRG code, representing a tariff amount that is not indicative of any of the procedures individually. Prior to cost analysis, all profit data was removed for all multi-

episode spells, whilst still being included in the efficiency calculations as the time stamps and durations were still relevant for efficiency analysis.

Procedure Duration Errors

Total procedure length was calculated from the time of anaesthetic induction to the time out of the operating theatre to include all interventions done to the patient on both the anaesthetic and surgical sides. All procedure lengths equal to zero were excluded from the cost data analysis as they were reflective of time entry errors and would negatively impact staffing costs (dependent on procedure duration). In addition, standard staffing assumed the cost of one anaesthetist and ODP, so anaesthetic activity should also be included in the total procedure duration. Procedure duration lengths were also reviewed by a consultant anaesthetist to identify any entries that were clearly errors (i.e. were very large or very small procedure durations). Procedures over 8 hours long, and procedures under 20 minutes were reviewed. Fourteen cases were flagged and removed from the cost analysis.

Non-Surgical Specialties

The ORMIS data included cases from 48 specialties; however, only 30 were considered surgical specialties, based on input from theatre managers. Several non-surgical specialties were represented such as acute adult illness, anaesthesia, neurology, etc. While these procedures were included in the efficiency analysis (considering they did occur), as consumable, overhead, and non-clinical income figures were not provided for non-surgical specialties, they were excluded from the cost analysis.

6.4.3.2 Efficiency Data Analysis

Formulae and macros within Excel were used to calculate overlap time, downtime, intervals between time stamps (estimated time of each stage of the perioperative process), procedure duration, and theatre list utilisation. Descriptive statistics were calculated for all metrics to describe the frequency and magnitude of each time. All data analysis steps, assumptions, and formulae are presented in **Appendix K**.

Individual Theatre Utilisation

In chronological order, cases were analysed in sequence to one another to determine any overlap due to the use of ARs, or gaps in the theatre schedule where a patient was not in the theatre nor the AR i.e. downtime. All downtime and overlap calculations included formulas for identifying errors within the data such as 'Missing Times' or 'Not Sequential', if ORMIS showed the second patient having entered the AR before the first patient, for example. Neither overlap nor downtime could be calculated for first cases of the day, as there was no preceding case to overlap with or to delay starting from. Similarly, downtime could not be calculated with regard to emergency cases, so downtime was calculated only for two sequential elective procedures, as emergency cases are unplanned and any resulting theatre downtime may be due to a lack of planned procedures (i.e. completion of the list). Downtime sometimes be planned due to half day lists, staff shortages, or no planned activity; however, the distinction between planned and unplanned downtime is outside of the scope of this study.

Pearson chi-squared cross tabulations were used to test the significance of staffing levels, presence of physician's assistants, theatre casemix, and specialties on both overlap and downtime occurrence. Post-hoc comparisons were done by comparing against Bonferroni adjusted *p*-values (MacDonald & Gardner, 2000).

Time Intervals

Time intervals were also calculated to consider the total time for each stage of the patient journey through surgery. All time intervals calculated are shown in **Table 6.7**.

Table 6.7 Calculated time intervals

Time Intervals	Description
Response Time of Porter	Time between 'Porter Sent' and 'Porter Left'
Patient Transfer Time	Time between 'Porter Left' and 'In Suite'
Time Waiting In Suite	Time between 'In Suite' and 'In AR'; Can be simultaneous
Time in AR Waiting	Time between 'In AR' and 'Anaesthetic Induction'
Time Between Induction & OT	Time between 'Anaesthetic Induction' and 'In OR'
Surgery & Recovery Time	Time between 'In OR' and 'Out OR'
Delivery to Recovery Time	Time between 'Out OR' and 'Patient in Recovery'

Theatre List Utilisation

As theatre time is blocked out, or scheduled, with specific surgical specialties on certain days, a holistic analysis of full lists was required, not only an individual procedure analysis. Only theatre lists with a first procedure and last procedure which were elective cases were included in the theatre utilisation analysis, as these would be indicative of planned procedures, and not emergent cases and working out of standard operating hours. A macro was created in Excel to output all theatre lists, including day of the week, specific theatre, start and end times, number of procedures, and utilisation times as follows:

- Total list duration (first case to last case of the day)
- Total overlap time (sum of all overlap throughout the day)
- Total downtime (sum of all downtime throughout the day)
- Total time savings (overlap minus downtime)

The actual net positive time savings (or negative, indicating excess downtime) were then used for the overall cost-efficiency analysis. **Figure 6.6** provides an example of the data analysis conducted on a procedure-by-procedure basis, followed by the list utilisation gap analysis. In the example, Case 4 is out of sequence as the 1st patient is in the AR after the 2nd patient, although the 1st patient leaves the OR first, therefore no overlap or downtime can be calculated from it. In addition, as an emergency case the entire list was excluded from the gap analysis. Based on a total of 8,923 unique operating lists conducted in 2013 (unique date and operating theatre combinations), 6,185 were captured with elective procedures starting and ending the list. Therefore, all cost analyses are based on presumed elective lists, making up 69% of the total work done in NUH, with the remaining 31% consisting of emergency lists.

Procedure by Procedure Gap Analysis

Case	Date	Day	Procedure	Specialty	Theatre	Operation Type	In AR	Out OR	Overlap (min)	Downtime (min)
1	15-Feb-13	Friday	Laparoscopy	General Surgery	City 6	Elective	08:48	10:30	N/A	N/A
2	15-Feb-13	Friday	Haemorrhoidectomy	General Surgery	City 6	Elective	10:35	11:26	No Overlap	5
3	15-Feb-13	Friday	Repair of incisional hernia	General Surgery	City 6	Elective	10:57	16:58	29	No Downtime
4	18-Feb-13	Monday	Laparotomy	General Surgery	City 6	Emergency	09:21	11:23	N/A	N/A
5	18-Feb-13	Monday	Thoracoscopy	Thoracic Surgery	City 6	Elective	08:35	13:37	Not Sequential	Not Sequential
6	18-Feb-13	Monday	Thoracoscopy	Thoracic Surgery	City 6	Elective	13:26	16:00	11	No Downtime
7	18-Feb-13	Monday	Correction of pectus deformity	Thoracic Surgery	City 6	Elective	16:06	19:00	No Overlap	6

Summary of Gap Analysis by List

List No.	List Day	Theatre	List Duration (Hours)	No. Cases	Total Overlap (Min)	Total Downtime (Min)	Total Time Savings (Min)
1	Friday	City 6	8.17	3	29	5	24

Figure 6.6 Example of utilisation gap analysis

6.4.3.3 Cost Data Analysis

Following from the theatre list utilisation analysis, the mean time savings (i.e. positive time savings implying more overlap than downtime) were calculated per theatre list – each theatre on each day of the week (Monday through Friday). This analysis was used to indicate which lists (i.e. theatres and specialties) have achieved saved time due to overlapping induction using the anaesthetic room. From an estimate of the mean time saved, an analysis of what additional work, and therefore revenue, could be added to the specific lists was conducted. All assumptions for procedure selection and profit per hour calculations are explained in **Appendix K.**

Sensitivity analysis of three methods was used which employed separate sets of assumptions:

1. *Profit per hour* – This method implied an estimate of profit per hour for the primary specialty or specialties for the given list could be used to calculate a monetary savings attributed to the saved theatre time. This method was the most optimistic, as in reality, time savings of mere minutes would not result in additional income.
2. *By procedures done* – This method assumed only the profit from entire procedures that could be completed in the freed theatre time could be used for monetary gain. Based on this assumption, only procedures which had been done in the specific theatre historically, could be added to the theatre list. This protected from adding procedures to the theatre which might not be able to be done due to equipment requirements, etc. This method was the most pessimistic.
3. *By specialties done* – This method assumed only full procedures could be used for calculating monetary gain due to freed theatre time. However, this method assumed any procedure which was a part of a specialty that had historically been done in the theatre could be added to the list. It is a more optimistic than the second model.

Net potential profit was calculated for each list and summarised for the entire Trust, using each of the three cost analysis methods. Comparing against anaesthetic equipment and supplies costs and additional staffing costs, the cost-benefit was determined for several models of working.

The lifetime of an anaesthetic machine was said to be 7 years, up to 10 years. The total potential profit over a 10-year period of the life of the equipment was compared to the costs estimates of the 40 anaesthetic machines and supplies required to equip all NUH operating theatres with anaesthetic rooms. The cumulative costs and potential profits were modelled for each of the three cost analysis methods.

As cumulative cost and profit values were projected over a 10-year period, all projected costs and profits required adjustment to present value 2013 equivalents. Costs including equipment capital, supplies, and salary expenses were discounted by the relevant inflation rate of each year after 2013. As this analysis was done in 2016, the inflation rates were known from the years 2013-2015 from the Office of National Statistics. The yearly increase in inflation for the years 2016-2026 were estimated from the average increase in inflation from 1989 to the present. Similarly, potential profit was adjusted to 2013 present values using interest rates projected from average rate increases since 1989 from the British Government Securities 10-year yields (Bank of England, 2016).

6.5 Secondary Data Analysis Results

6.5.1 Theatre Utilisation

For all procedures analysed, of the cases where overlap could be calculated, excluding time errors, 24% of all cases (n = 6,206) were overlapped with previous cases. The occurrence of downtime was higher, despite the exclusion of all back-to-back emergency cases, as 69% of valid cases (n = 12,033) had downtime.

Table 6.8 Percentage of overlap and downtime occurrence per specialty

Surgical Specialties	Overlap	Downtime
Cardiac Surgery	74%	18%
Ophthalmology	54%	42%
Hand Surgery	53%	37%
Thoracic Surgery	43%	47%
Obstetrics[14]	33%	N/A
Elective Orthopaedics	29%	67%
Gynaecology	25%	69%
Urology	24%	72%
HPB	22%	57%
Trauma & Orthopaedics	19%	86%
Vascular Surgery	18%	72%
Trauma	18%	72%
Colorectal	16%	72%
ENT	14%	84%
Obstetrics & Gynaecology[3]	12%	N/A
General Surgery	12%	82%
Renal Surgery	11%	81%
Paediatric Gastroenterology	11%	88%
Oral Surgery	9%	89%
Paediatrics	9%	97%
Spinal Surgery	8%	89%
Neurosurgery	7%	89%
Plastic Surgery	7%	91%
Breast Surgery	6%	93%
Paediatric Surgery	6%	91%
Dermatology	6%	91%
Dental Medicine	5%	84%
Cleft Palate	4%	96%
Burns	0%	100%

[14] Downtime was not calculated for Gynaecology and Obstetrics & Gynaecology because these specialties were predominately done in maternity theatres which were excluded from the analysis as they do not have anaesthetic rooms. All specialty work done in other theatres is primarily unplanned emergencies.

The percentage of total cases in 2013 which experienced overlap or downtime are shown per specialty in **Table 6.8**. Only three specialties saw overlap over half of the time. Major specialties with complex anaesthesia such as cardiac surgery and thoracic surgery had higher occurrence of overlap than the average specialty. Hand surgery, which uses regional anaesthetic, also showed higher incidents of overlap. Ophthalmology may see frequent overlap due to the quick pace of their procedures, allowing for rapid succession. Specialties employing PAs, elective orthopaedics, gynaecology, and urology, performed only marginally better than the average. Intuitively, downtime was inversely proportional to overlap where highly overlapping specialties saw the lowest percentage of downtime. Paediatric specialties did not see high occurrence of overlap. Nor did specialties with typically long case durations such as spinal and neurosurgery.

The amount of overlap and downtime by specialty is presented in **Figure 6.7** and **Figure 6.8**, respectively. Although cardiac and hand surgery have some of the highest amounts of overlap times, they also tend to have the highest amounts of downtime.

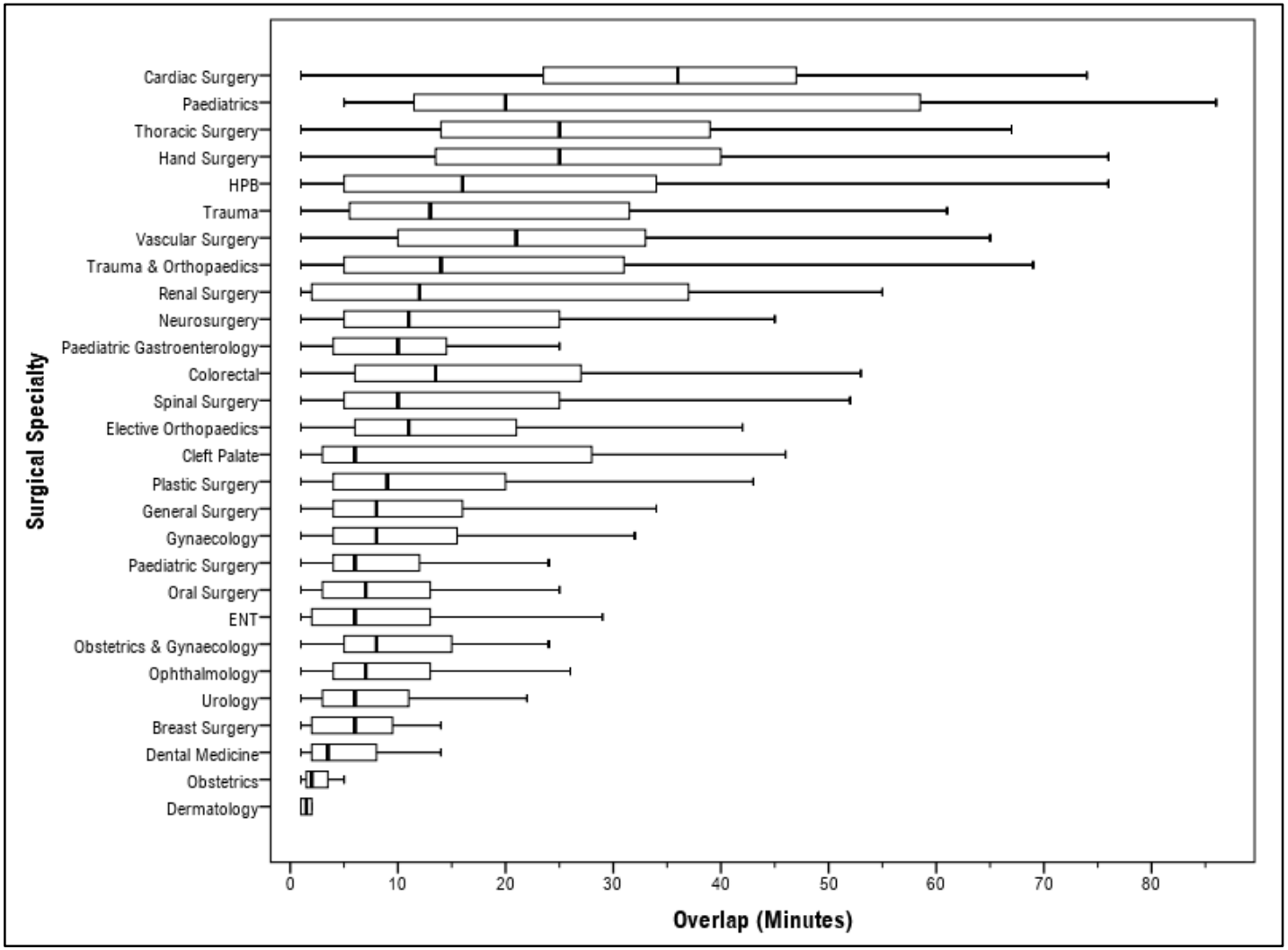


Figure 6.7 Boxplots of overlap time per specialty

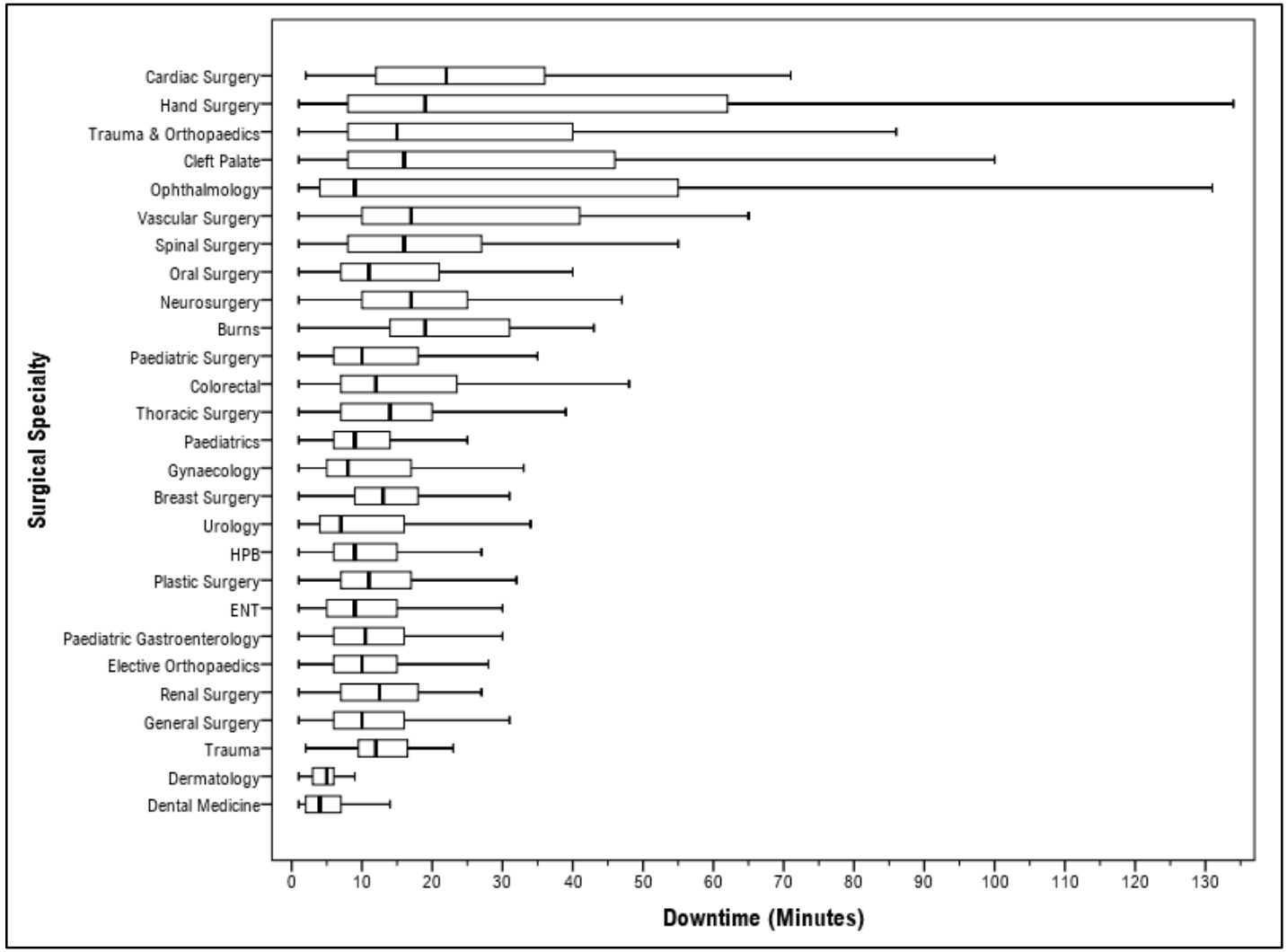


Figure 6.8 Boxplots of downtime per specialty

6.5.2 Time Intervals

The median time intervals for each activity along the perioperative pathway are shown in **Table 6.9.** While the longest time interval was theatre time, portering time was higher than total anaesthetic time, including initial patient preparation in the anaesthetic room. The amount of time the patient is in the anaesthetic room is approximately 11% of total time from when the patient is sent for to when the patient arrives to the recovery unit.

Table 6.9 Descriptive statistics of time intervals

			Time		
Activity	**Time Intervals**		Median (min)	25-75% Percentile (min)	**Number of Cases**
Porter Response	Sent For	Porter Left	2	0-6	30670
Portering Time	Porter Left	In Suite	18	11-28	31278
Holding Time	In Suite	In AR	12	5-26	35254
Patient Preparation	In AR	Induction	3	1-5	35168
Anaesthetic Time	Induction	In OR	14	7-25	33391
Theatre Time	In OR	Out OR	63	34-114	35371
Delivery Time	Out OR	In Recovery	2	0-4	35278
Total Time	Sent For	In Recovery	150	95-230	35425

Table 6.10 Missing and erroneous time data

	Missing Times	**Time Errors**
Time Interval	n (% of total)	n (% of total)
Porter Response	4684 (13%)	71 (0%)
Portering Time	4147 (12%)	0 (0%)
Holding Time	170 (0%)	1 (0%)
Patient Preparation	256 (1%)	1 (0%)
Anaesthetic Time	268 (1%)	1766 (5%)
Theatre Time	54 (0%)	0 (0%)
Delivery Time	23 (0%)	124 (0%)
Recovery Time	7699 (22%)	1 (0%)

Analysis of missing times and time errors, or non-sequential times, is presented in **Table 6.10**, showing the largest portion of missing times for recovery time points, and

porter time points. While only consisting of 5% of total cases, the anaesthetic times were the most frequently non-sequential. These time errors relate to incorrect entry of times.

During occurrences of downtime, the location of the patient, who was not in the anaesthetic room at the time of the previous patient's departure, could be determined by the time stamps. The location of highest frequency for a given specialty is shown in **Table 6.11**.

Table 6.11 Dominant location of second patient at downtime by specialty

%	Surgical Specialty	%	Surgical Specialty
Porter		***Suite***	
53	Paediatrics	74	Urology
52	Paediatric Gastroenterology	64	Gynaecology
51	Dental Medicine	62	Ophthalmology
Ward		60	Elective Orthopaedics
90	Cardiac Surgery	57	Hand Surgery
70	Vascular Surgery	56	Renal Surgery
63	Spinal Surgery	55	General Surgery
61	Colorectal	52	ENT
59	Burns	52	Dermatology
56	Cleft Palate	52	Trauma
54	Thoracic Surgery	44	Trauma & Orthopaedics
53	HPB	43	Plastic Surgery
47	Breast Surgery	36	Paediatric Surgery
46	Neurosurgery	74	Urology
39	Oral Surgery	64	Gynaecology

Thirteen specialties predominantly had their patient waiting in-suite, in the theatre department, at the time the previous patient left the theatre. In contrast, 11 specialties had the majority of their patients still located in the ward when the theatre became available. Major surgical specialties such as cardiac, vascular, and spinal surgery had the largest portion of their downtime patients located on the ward. Specialties with higher tendency to overlap, such as urology, gynaecology, and elective orthopaedics, had patients waiting close by to theatre when they were needed.

6.5.3 Staffing

The staffing level of the procedures, based on session type, was tested against the occurrence of overlap and downtime, using the Pearson Chi-square test. Staffing levels of Fewer, Normal, and Extra, were evaluated in a 2x3 contingency table. For a significance level of .05, the Bonferroni corrected *p*-value for 6 tests was $p < .008$.

- *Overlap occurrence* - $X^2(2) = 25.926$, $p = .000$
    - Post-hoc comparisons revealed procedures with Extra staff have a higher occurrence of overlap ($p = .000$).
- *Downtime occurrence* - $X^2(2) = 21.550$, $p = .000$
    - Post-hoc comparisons revealed procedures with Extra staff have a lower occurrence of downtime ($p = .002$).

Physician's assistants were indicated in the data by two different methods. The ORMIS data showed procedures booked as 'Physician's Assistant' as the Session Type. Capturing in higher frequency the use of PAs in NUH, all cases with 2nd or 3rd anaesthetists with the names of the employed PAs within the specified theatres where they were staffed in 2013, were flagged as PA procedures. The Pearson Chi-square test was used for both methods in 2x2 contingency tables.

- *Overlap occurrence*
    - Session Type: $X^2(1) = 14.223$, $p = .000$
    - PA Flagged: $X^2(1) = 147.674$, $p = .000$
    - Both methods showed a higher occurrence of overlap for PA cases.
- *Downtime occurrence*
    - Session Type: $X^2(1) = 6.613$, $p = .010$
    - PA Flag: $X^2(1) = 82.216$, $p = .000$
    - Both methods showed PA presence is related to a lower occurrence of downtime.

6.5.4 Specialisation

The specialty mix, or casemix, of each theatre list was analysed, and was categorised as specialised if greater than 75% of the procedures done within the list were from a single surgical specialty. If not, the theatre list was categorised as mixed. Additional

Pearson Chi-square tests measured the significance of casemix specialisation on the occurrence of overlap and downtime.

- *Overlap occurrence* - $X^2(1) = 835.777$, $p = .000$
    - Specialised lists had a higher occurrence of overlap than mixed.
- *Downtime occurrence* - $X^2(1) = 354.897$, $p = .000$
    - Specialised lists had a lower occurrence of downtime than mixed.

The presence of a PA was also analysed for relationship with specialisation using both methods, as above.

- Session Type: $X^2(1) = 94.829$, $p = .000$
- PA Type: $X^2(1) = 164.334$, $p = .000$
- Both tests revealed a significant relationship between the presence of PAs and the specialisation of theatres.

6.5.5 Cost-Benefit Analysis

The potential profit, net usable income from revenue minus expenses, was calculated across all theatre lists which experienced net positive time savings using the three sensitivity analysis methods. **Figure 6.9** presents the cumulative potential profit profiles for the three methods against the cumulative extra cost incurred over 10 years for (1) 40 anaesthetic rooms and equipment; (2) 40 ARs and 1 full-time physician's assistant; and (3) 40 ARs and 1 full-time consultant anaesthetist. If the potential profit exceeds the proposed extra costs by the 10^{th} year (the maximum lifetime of the anaesthetic machines), the proposal is viable and will return on investment (ROI).

This figure shows that for potential profits after overhead expenses, the cost of equipping and maintaining 40 anaesthetic rooms for the Trust is not paid for by either of the more realistic by procedure and by specialty models. The profit per hour method shows an ROI for both anaesthetic rooms and the inclusion of a PA, however, this is largely optimistic and unrealistic.

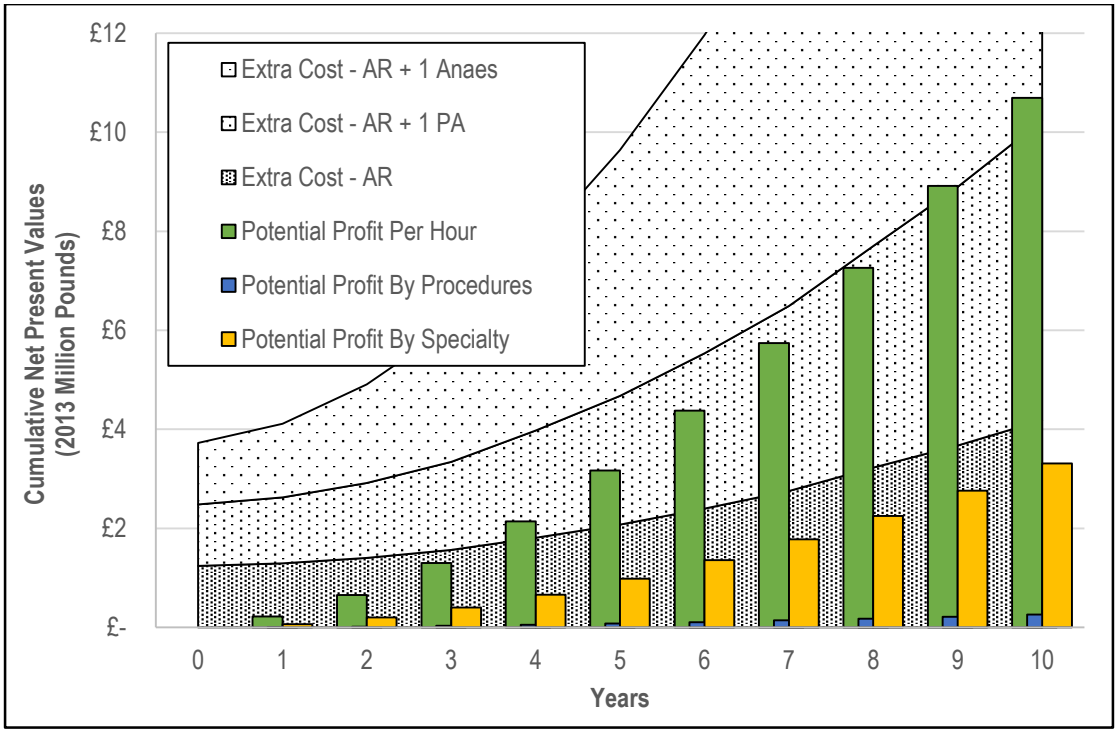


Figure 6.9 Cost-benefit graph of extra costs and potential profits (overheads included)

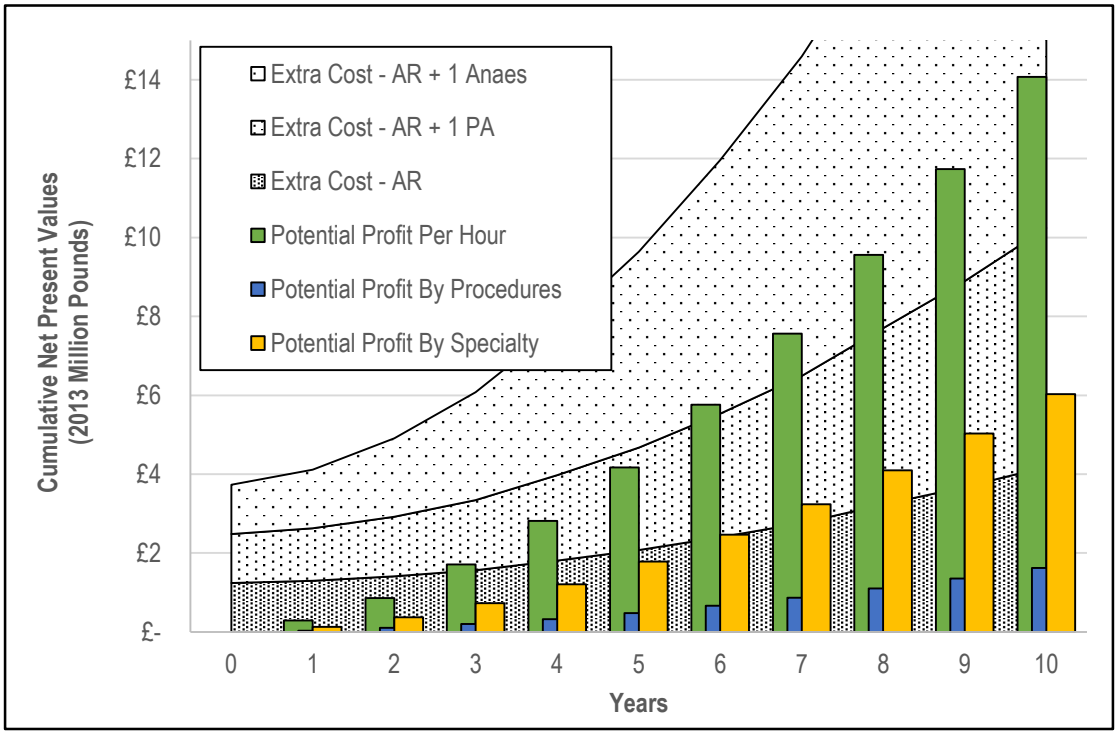


Figure 6.10 Cost-benefit graph of extra costs and potential profits (no overheads included)

Figure 6.10 presents the cost-benefit of the same cost and profit profiles, except it does not include overheads. If it is argued that the capital cost and continued maintenance costs of anaesthetic rooms would be distributed across all specialties through overhead charges, then **Figure 6.9** would already include payment for the anaesthetic room each

year. Excluding overheads, **Figure 6.10** shows the anaesthetic rooms are only viable in the two most optimistic methods for potential profit. If only procedures which have been done in specific theatres are selected to fill saved theatre time, the margin of profit does not exceed the expenses of the anaesthetic rooms.

Based on the five theatres known to have physician's assistants in 2013, the profit per hour and added cases methods were conducted specifically for the lists which had positive time savings. The potential profits for each of the three methods were compared to the cost of one PA or 2 PAs in **Figure 6.11.** Although the PA's salary should be paid for through the session type charge to the specialty, the contribution of the two PAs staffed in the five theatres in 2013 would not bring enough profit to pay for the added cost of an additional PA (or more) over 10 years, in even the most optimistic method of added profit per hour of time savings.

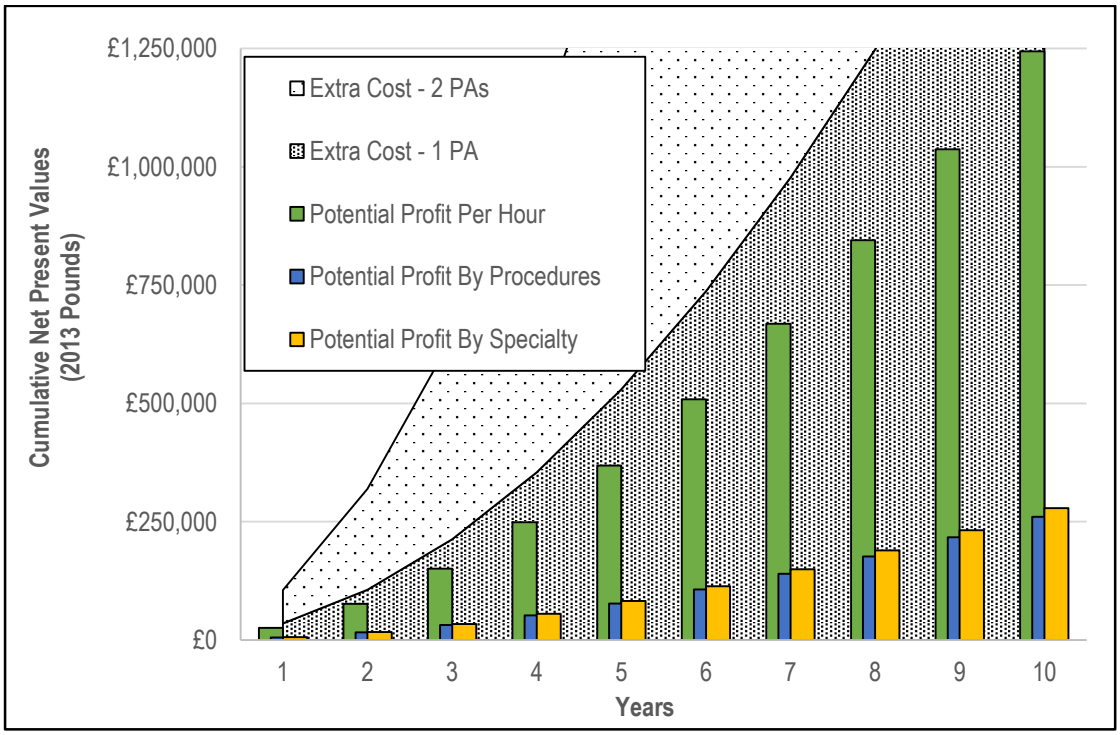


Figure 6.11 Cost-benefit graph of physician's assistants' contribution

The potential profit per hour savings (including overheads) for the entire Trust in one year was determined to be £224,044, due to the benefit of overlapping cases exceeding downtime. However, when the same analysis was conducted for the mean time savings from overlap alone, assuming no downtime, the potential profit per hour savings in one year were £1,373,677. From this optimistic analysis of profit from overlap, the NUH Trust lost £1,149,632, an 81% loss, in potential profit due to downtime contributions.

6.5.6 Space Allocations

An audit of hospital floor plans was conducted in May 2016. A total of 52 theatres were viewed across both hospitals within the Trust. Several variations existed across theatres including the following:

- 8 theatres did not use the anaesthetic room.
- 12 theatres had laminar flow ventilation.
- 4 theatres had shared anaesthetic rooms (2 total).
- 16 theatres had shared prep rooms (8 total).
- 11 theatres, all in one hospital campus, set-up instruments in the prep room.
- 12 theatres have exit bays, all in one hospital campus, which is an enclosed space adjacent to theatre, next to the anaesthetic room, where the patient in theatre exits, particularly if there is a patient in the anaesthetic room.
- 2 shared dirty utility spaces, or sluices, otherwise all individual dirty utilities.

The average size of theatres was 43.1 m^2, whereas the average size of the anaesthetic room was 14.2 m^2, which means on average, the anaesthetic room is 33% the size of the theatre. An above average and average sized anaesthetic room are shown in **Figure 6.12**. From the analysis of all theatre related floor space (including theatres, anaesthetic rooms, prep rooms, scrub sinks, dirty utilities, and exit bays, but not including corridors), the anaesthetic room contribution was 15% of the total space. The average size of a complete theatre suite (i.e. operating theatre, anaesthetic room, prep room, scrub sink, and dirty utility) was 92.9 m^2.

The space contribution of anaesthetic rooms proves that if anaesthetic rooms were discontinued from practice, operating theatres could be expanded by 33%, or 15% of total space could be freed up for an alternative use –the equivalent of 16 new operating theatres, or 9 theatre suites without anaesthetic rooms.

Based on the Department of Health's (2004) Health Building Notes for surgical procedure facilities, the minimum size requirement for anaesthetic rooms is 19 m^2. Only one of 47 anaesthetic rooms in NUH met the national standards, and it is a shared anaesthetic room in day surgery unit, which is not used for anaesthetic induction of patients. The anaesthetic rooms which were noted by the managers as being too small and no longer used in some cases, were 9.75 m^2, or merely 51% of the recommended

minimum size of an anaesthetic room. This is small even compared to older standards, as the UK Ministry of Health recommended anaesthetic rooms to be of at least 13 m^2 in floor area as far back as 1937 (Ministry of Health, 1937 cited in Meyer-Witting & Wilkinson, 1992, p.1021).

Figure 6.12 A large 17 m^2 orthopaedic anaesthetic room (Top) and an average sized 14.1 m^2 anaesthetic room (Bottom)

6.6 Ethnographic Observation Results

The quantitative and qualitative results of the ethnographic observations of Nottingham University Hospitals NHS Trust will be presented. To supplement these findings, a brief interview of a theatre lead and visit to Circle NHS Treatment Centre, which does not have anaesthetic rooms, will be summarised.

6.6.1 Quantitative Results

The timing of patients arriving and departing theatre as well as the time points indicating when anaesthetic monitoring was disconnected and reconnected, were collected for as many cases as could be witnessed. As the observations focused on anaesthetic room use only, upon commencement of surgery the observer rotated between theatres, which resulted in missing some time points. The mean times of observed times and the number of cases sampled are shown in **Table 6.12**.

Table 6.12 Measured time intervals

Time Intervals	Description	N / Total* / %	Mean Time (Std Dev)
Overlap Time	Time between 1st patient leaving and 2nd patient arriving	5 / 19 / 26%	27.3 (10.8) min
Downtime	Time with no patient present	14 / 19 / 74%	10.9 (6.4) min
Anaesthetic Time	Time between patient arriving and disconnection of monitoring	26 / 26 / 100%	27.0 (16.9) min
Disconnection Time	Time between disconnection in the AR and reconnection in the OR	27 / 27 / 100%	1.2 (1.1) min

*The total number of cases varies as some time intervals were not witnessed.

From the 12 specialties observed across the two hospitals, 24% of the procedures observed were within orthopaedics. Only 5 cases were observed where the overlap of two patients was witnessed personally; however, 2 other cases did experience overlap although the times were not collected. One cardiac procedure (aortic valve replacement) and the remaining orthopaedic procedures (open reduction internal fixation and total hip replacements) achieved overlap between cases. A total of 24% of all cases which could have potentially achieved overlap (excluding first cases of the day) did so. Downtime occurred in 74% of all cases where times were collected. Additionally, the mean disconnection time for monitoring while transporting the patient between the AR and OR was 1.2 minutes.

A tally of the activities seen being conducted in the anaesthetic room are shown in **Table 6.13**. The most typical uses of the anaesthetic room were for initiation of monitoring, insertion of cannulas, pre-anaesthetic checks, and provision of regional and/or general anaesthetics.

Table 6.13 Anaesthetic room activities

AR Activities	N
Basic monitoring	25
General anaesthesia	23
Pre-anaesthesia check	23
Inserting cannula	18
Regional anaesthesia	12
Anaesthetic overlap	7
Patient consultation	6
Parents enter	4
Invasive monitoring	3
Team briefing	2
Breakroom	1

The staffing for the observed cases were noted and the mean number of staff members were as described in **Table 6.14**. The mean non-medical staff count per theatre was 4.43. This is consistent with the standard team size, as specified by the NUH Finance Department, of a team of 4 non-medical staff consisting of 2 scrubs (one circulating while the other is scrubbed up), 1 ODP, and 1 runner.

Table 6.14 Mean number of team members

	Team Role	Mean
Medical	Surgeon	1.32
	Anaesthetist	1.05
	Anaesthetic Trainee	0.68
	Surgical Trainee	0.54
Non-Medical	Scrub	1.24
	Circulator	1.24
	Anaesthetic ODP	1.22
	Support worker / HCA	0.73

6.6.2 Qualitative Results

The field notes collected from observations of 37 procedures were coded into common topics areas. The most frequently coded topics are presented within this section.

6.6.2.1 Anaesthetic Room Use and Benefits

Typical anaesthetic room use was presented previously as typical activities were counted. Brief interviews with observation participants did highlight other uses.

The anaesthetic room was commonly referenced as a location to have lunch or a tea/coffee break. In one observation, the ODP and anaesthetist joked about using the anaesthetic room for a cup of tea, but also discussed the lack of time for breaks which requires a place that is nearby and out of the way to have one. The anaesthetist stated that an additional anaesthetist is not built within the theatre schedule to cover breaks. Both the ODP and anaesthetist reported that they rarely have cover for breaks.

Observations in the paediatric day surgery unit also provided insight into the perceived experience of paediatric patients and their guardians who may accompany them to the anaesthetic room. One anaesthetist stated that they believe the theatre is a scarier environment for children than the anaesthetic room, which is shown in **Figure 6.13**, showing colourful decals of popular animated characters. In addition, one anaesthetist said it is 'awkward' to bring patients' parents into the operating theatre. The ODP said the anaesthetic room should be sound proof. In reference to a screaming and inconsolable child, the ODP said, 'Imagine that in [the theatre].'

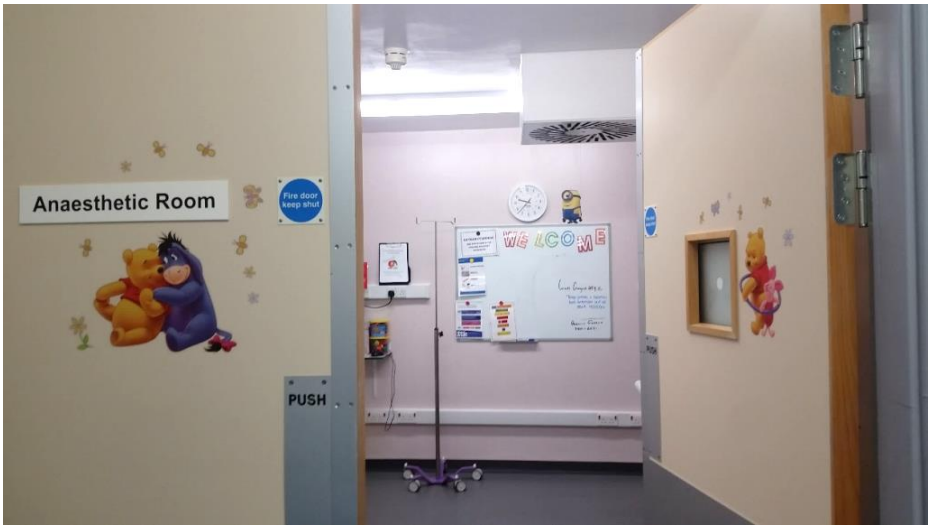


Figure 6.13 A view into an anaesthetic room in paediatric day surgery

A frequently referenced theme was that of domain and control, and the benefit of the anaesthetic room to define boundaries between the anaesthetic and surgical teams. In one observation, a surgical practitioner peeked through the door into the anaesthetic room and the anaesthetist shooed him away, in a friendly manner. The anaesthetist stated that surgeons will peek through the window in the door, but it can be closed. Another anaesthetist said the anaesthetic rooms benefit them by keeping the surgeon out, as they 'hoover', and will come into the anaesthetic room for the pre-anaesthetic check and will not leave. In a smaller space, the anaesthetist felt their presence to be interference, as it is difficult to keep the surgical team away from the patient before the time-out in theatre. One anaesthetist said it is a benefit to get away from the surgeons when they get so 'full of testosterone'.

The divisions between the anaesthetic and surgical teams was presented by on ODP who stated that the theatre staff will act as a team and leave the anaesthetic ODP, supposedly as they do not want to do someone else's job, so they do not come into the anaesthetic room. Another ODP mentioned a 'them and us' mentality, which was reinforced by an anaesthetic trainee who sensed a divide between the teams, mentioning the banter the theatre team will have when the anaesthetic team enters from the anaesthetic room. Whether it was unclear if the divide between the teams was acceptable to those who referenced it, one anaesthetist referred to the anaesthetic room as 'my domain', as she experienced performance anxiety and noise sensitivity within the theatre. Another anaesthetist called it 'your place', and referenced the added control which is possible in the anaesthetic room, particularly in emergencies.

6.6.2.2 Theatre Set-up and Preparation

Observations focused on simultaneous activity of anaesthetic room use and the theatre set-up and preparation. Theatre clean-up began immediately following the completion of the surgical procedure, sometimes while the patient was still being woken to be transferred to recovery. The theatre staff said it normally takes 10 minutes to turn-over the theatre, and have it ready for the next patient, at the point that the theatre is clean and everything from the previous patient is removed from the room.

After the theatre was cleaned, sterile instruments and tables were brought in; however, a variation of practice was witnessed across the many theatres and specialties observed.

Instruments were brought in at different points, either as soon as the theatre was clean, other times after the next patient had arrived in the anaesthetic room, or even after the patient was asleep. To avoid waste, several scrub nurses said they would not open packs and instruments until the patient arrived (either to the theatre suite or the anaesthetic room). Some would try to have the instruments counted before the patient came into the theatre, as one scrub stated that he would not want to count the instruments in front of the patient so as to avoid distraction.

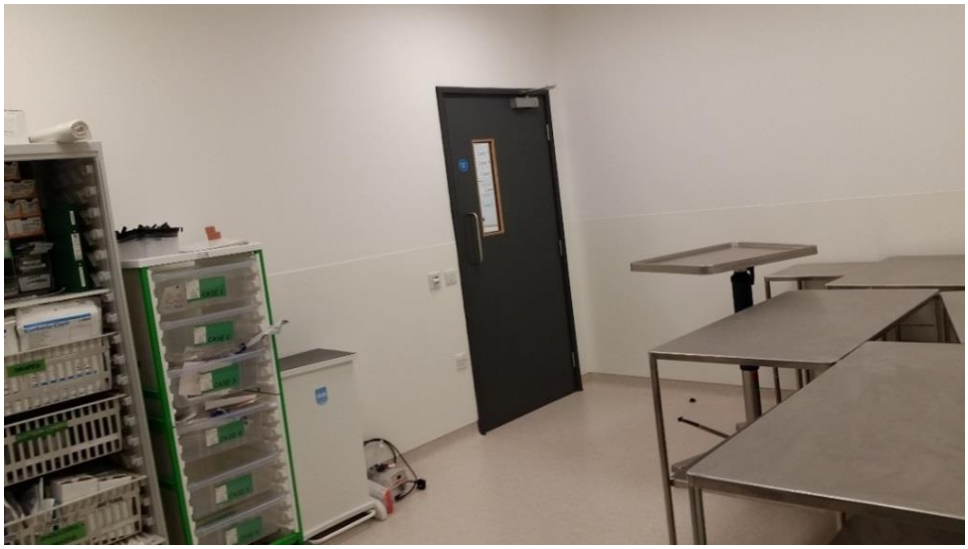


Figure 6.14 Theatre prep room

Some theatre teams used prep rooms for theatre set-up, shown in **Figure 6.14**, whereas others did not. In one observation, the instruments were opened in the prep room and covered by sterile packaging and the table of instruments was left unmonitored in the prep room to speed up the list, due to quick surgeries. When questioned on this practice, as the drape is not intended for this purpose, the scrub said she had not heard it was unsafe. She asked that if any research were to be found to indicate it to be unsafe, if she could be notified.

6.6.2.3 Patient Experience

The sounds and sights of the anaesthetic room were captured during observations. Within the anaesthetic room, clanging instruments and drilling sounds were audible through the door separating the operating theatre and the anaesthetic room. Chatter and laughter from staff were heard from both the operating theatre and the outer corridor from the anaesthetic room. On one occasion, the theatre staff were playing music loudly

while preparing the theatre while a patient was in the anaesthetic room and were asked by the anaesthetist to turn down the music. In one observation, the patient came into the anaesthetic room and the doors to the theatre were wide open so the patient could see inside at the previous patient. It was possible, particularly for patients who walked into the anaesthetic room, to see through the theatre door windows, or to see into theatre when staff would pass between the rooms.

Patient expectations and management of those expectations were important aspects of patient experience which were reported by anaesthetists and ODPs. One ODP believed that patients have pre-existing expectations of coming into the anaesthetic room in England, which could be influenced by reality television programmes such as 'One Born Every Minute', which shows activities taking place in real hospital environments. One anaesthetist referred to the anaesthetic room as a site for managing patient expectations for what to expect in the theatre, although no patient in her experience working without anaesthetic rooms had ever complained or asked for one. Similarly, another anaesthetist referred to work done in the local treatment centre which does not have anaesthetic rooms, and said that no patients had complained their either and that it is about modifying their expectations.

6.6.2.4 Requirements for Overlap

There were several requirements for the achievement of overlapping cases. This was observed to be influenced by specialty, equipment, facility, and staffing. Three anaesthetists mentioned a lack of benefit of an anaesthetic room for quick daycase surgeries, which is the primary work of the local treatment centre where some anaesthetists also worked without anaesthetic rooms. Some observed theatres were constrained by limited monitoring equipment. The portable monitoring 'brick' (e.g. Phillips IntelliVue, Phillips Healthcare, Andover, MA, USA), which is removed from the anaesthetic machine in the anaesthetic room and transported with the patient into theatre and reattached, may be a limitation as a second patient cannot be connected to monitoring and induced if only one 'brick' is available. Some observations revealed the use of prep rooms for the set-up of instruments in a space separate from the anaesthetic room and theatre. This way of working allows for the preparation of instruments regardless of the location of the patient(s); however, not all prep rooms are conducive for instrument set-up. Additionally, additional staff may be necessary for such practice.

In the day surgery unit, managers were considering employing an extra support worker to help in the prep room, so there could be staff to assist in theatre and in the prep room.

Staffing was a common requirement stated for achieving overlap. In cardiac surgery, a floating anaesthetist from the cardiac intensive care unit came to assist the theatre and allow the anaesthetist to induce the next patient. Similarly, in orthopaedics, an extra floating anaesthetist was employed to assist with throughput. One scrub nurse mentioned that if there is only one anaesthetist on the list, they would not open trays of instruments in advance. Extra non-medical staff are also necessary for overlap. An additional floating ODP was seen in cardiac surgery who would tend to the next patient, whilst the other ODP is in theatre, allowing for what he termed 'cross-over' of procedures. The ODP said it saves an hour per day and is best when a registrar anaesthetist can help with the next patient. One anaesthetist stated that the thoracic surgical specialty employed an extra ODP, as overlap is not possible without one, and the use of a physician's assistant can also help to recover a patient while the anaesthetist tends to the next patient.

6.6.2.5 Staffing

Break coverage was observed in multiple theatres for ODPs, scrubs, and support workers (SW). One ODP described how staff scheduled to arrive later would typically cover one 30-minute break; however, no other break was possible as no other anaesthetic ODP was assigned to the theatre to cover it. She stated that anaesthetic ODPs do not cross specialties to provide break coverage, whereas theatre staff are able to cover each other's breaks.

Short staffing was also a common topic that theatre and anaesthetic staff mentioned during observations. In an ears, nose, and throat specialty, one ODP said that 2 surgical scrubs and 2 circulators were allocated per theatre, 'if they're lucky'. Whereas, in a maxillofacial theatre, the ODP stated that they are understaffed with only 2 scrubs, 1 circulator, and 1 ODP. Consistent with this, one orthopaedic ODP said they were short staffed in orthopaedics, and there weren't always 2 scrubs and 1 circulator, which was the case on the day due to a closed theatre and extra staff available.

6.6.2.6 Orthopaedic Practice

Observations of orthopaedic practice presented several variants from standard practice in other specialties. Unique aspects of practice are presented as follows:

- Orthopaedic procedures were typically done in theatres with *laminar flow* ventilation, shown in **Figure 6.15**.

Figure 6.15 Laminar flow ventilation unit in the theatre

- *Prep rooms* were used for set-up of instruments and then brought into theatre under the laminar flow.
- *Double prepping* was standard for joint replacement and implant procedures where the limb being operated on was cleaned with antiseptic skin prep liquid in the anaesthetic room and again in theatre.
- *Multiple antibiotics* were given to patients. Upon questioning this practice, one surgeon said, 'Does it really make a difference? You wouldn't want to be the one that only gets antibiotics once.' He said that if no evidence to the contrary exists, then they would carry on doing so.
- *Surgical masks* were only worn by all members present in the theatre in orthopaedic, spines, and cardiac theatres.
- *Double gloving* was also mentioned by one surgeon as a standard in orthopaedic practice.

6.6.2.7 ORMIS Data Entry

The practice of recording ORMIS data was observed in the anaesthetic room and theatre. Time point definitions differed between various theatres and individuals. In maternity theatres (excluded from the cost-efficiency analysis) did not have anaesthetic rooms, and would collect times on a white board and later enter them into ORMIS. The 'Out of OR' time was not entered until the patient was out of recovery, unless another patient arrived. These obstetrics theatres and the day surgery unit theatres, which had shared ARs and were not used, entered simultaneous times for 'In AR' and 'In OR'. Some ODPs reported that the 'Anaesthetic Start Time' is when the patient enters the anaesthetic room, whereas others thought it was when the cannula was put in. In the new orthopaedic theatres (constructed in 2015, therefore excluded from the cost-efficiency analysis), the ODP stated that the 'In Suite' time stamp was entered when the patient entered the AR. However, the ODP was in the habit of waiting a few minutes in order to have a different time between 'In Suite' and 'In AR'.

There were several occasions where time points were either neglected, delayed in being entered, or overridden. In one observation, none of the OT staff entered the time of the patient leaving the theatre. An ODP stated that one will 'get to it when you get to it', in reference to time entry. The ODP shared that the ORMIS data is not reliable for the type of neither anaesthetic nor the start times. General anaesthetic is the default anaesthetic and must be overridden if local, regional, or combination anaesthetic is used. The ODPs in theatre also revealed that any of the data can be overridden.

6.6.2.8 Delays

Delays were experienced in commencing anaesthetics of certain patients and causes were identified by questioning staff members. Although causes for delay could be entered in ORMIS, they were not standardly recorded. Two of the surgical lists were delayed due to absence of the surgeon on multiple occasions. As on anaesthetic ODP said, 'It's always the case that the surgeon was here, in response to 'Where are the surgeons?'' In some cases, this was explained that lists can be split and one surgeon operates in the morning, whilst a second surgeon operates after lunch.

Another common cause of downtime was lack of timeliness of portering and sending for the next patient. One ODP said that being unable to find a porter can delay cases for

up to 45 minutes. The timing of sending, or calling the ward for the patient, can also attribute to delays. At times, the patient was not sent for until the first patient was leaving the theatre. The team was not always very quick to send for the next patient, which was explained to be difficult to time accurately.

6.6.3 NHS Treatment Centre: Operating without Anaesthetic Rooms[15]

The Nottingham NHS Treatment Centre run by Circle Nottingham Ltd was opened in 2008 and is the largest independently owned treatment centre in Europe. The centre has five operating theatres and three skin surgery theatres (Richards, 2015), and does primarily daycase elective procedures. The majority of work conducted at the centre is NHS commissioned work (95%), whilst the remainder consists of private patients. Due to the same commissioning structure, HRG tariffs are paid and finances are similarly aggregated, hiding cost-benefit at the procedure level.

The treatment centre was designed by Nations Healthcare, an American company, without anaesthetic rooms. Designed outside of the typical British modular layout of theatres, the centre's theatres do not have separate prep rooms which could be used for instrument preparations. Many of the anaesthetists who operate in the NHS using anaesthetic rooms also work within the treatment centre without them. In discussing Circle's ability to remain productive without anaesthetic rooms, as they reported a 30% increase of throughput compared to NUH for some lists, the following reasons were suggested:

- *Reduced patient transport* – Attributed to a lean design of theatres and wards, the patient journey remained in close proximity to theatres, eliminating long durations of patient transport and delay.
- *Eliminated patient transfer/handling* – By removing the need to transfer the unconscious patient from the trolley to the operating table in the theatre and allowing the patient to walk into theatre and position himself/herself, delays were avoided in waiting for the appropriate number of staff to safely transfer the patient.

[15] Unless otherwise cited, all information provided is from an informal meeting with the theatre lead of the treatment centre, Simon Hardwick, who provided email confirmation of this information on 29 October, 2016. The email correspondence is shown in **Appendix H**.

- *Increased incentives for consultants* – As surgeons and anaesthetists are paid per case, instead of in session blocks, there is an added incentive for improved productivity.
- *Reduced consultant delay* – Due to the patient being present in theatre during anaesthesia, the surgeon is less likely to leave the theatre and delay the case. Additionally, the anaesthetists may be influenced by time pressure from surgeons to work more quickly.
- *Increased staff productivity* – Accredited to the Circle credo and having a less unionised culture than the NHS, the staff were believed to be more productive.

The staffing of theatres at the treatment centre was similar to NUH, although most lists were staffed with 1 scrub nurse, 1 HCA, and 1 ODP. For more intensive lists, a model of 2 scrub nurses, 1 HCA, and 1 ODP were scheduled to allow for swapping of scrub duty. Although break coverage was not always possible, unless extra scrub staff were available, lists were generally scheduled to permit a lunch break. Culturally, staff members accepted the model of in-theatre induction without issue and maintained professional behaviour in the presence of the patient. Although theatre staff still needed to be reminded of noise levels at times, standard practice required that noisy tasks be done either before the patient was brought to theatre or after they were asleep.

Patient feedback was regularly collected, as Circle actively promoted the "Four Cs" process of collecting complaints, concerns, comments, and compliments (Richard, 2015). No patients had expressed negative experiences of being anaesthetised in the operating theatre.

The benefits of anaesthetic rooms were discussed as they were seen as an added barrier for infection control and spread of bacterial infections. As the treatment centre had recently begun doing orthopaedic procedures, double prepping was expressed as an issue without anaesthetic rooms. The initial skin preparation of the patient was not acceptable under laminar flow in theatre due to infection control, so neighbouring skin surgery theatres were used as an anaesthetic room to prevent delays.

6.7 Discussion

The findings from these studies have raised new questions in the areas of hospital design, financing, and management. As literature has not offered a cost-benefit analysis

of anaesthetic rooms specifically, this study provides a case study of the Nottingham University Hospitals NHS Trust and their 'investment' in anaesthetic rooms.

Using a cost-benefit analysis method to evaluate the contribution of anaesthetic rooms may help policy makers and hospital managers to determine if anaesthetic rooms will be appropriate in future builds. Valuable cost-benefit information is often lacking in quality improvement research as Alexander and Hearld (2009) observed, as only 12% of their systematic review of 188 quality improvement studies included a cost-benefit or cost-effectiveness analysis.

The results of the cost-benefit analysis in this chapter has shown that the benefit of anaesthetic rooms is contingent on maintaining a higher proportion of overlap, or saved time, compared to downtime in a theatre list. Consistent with the theoretical findings of Pandit *et al.* (2009, p.477) who stated that '… any time savings through increasing speed or reducing gaps need to be of sufficient magnitude as to be able to accommodate an extra case.' However, the financial benefit is only realised when additional cases are 'up-scheduled' within the saved time, therefore gaining revenue. If a theatre operates quickly and minimises gaps, yet finishes early, the theatre would be under-utilised. Reducing gaps can only improve efficiency if the opportunity for more patient contact is realised (Pandit *et al.*, 2009). Currently, on a Trust level, NUH is not seeing the full benefit of anaesthetic rooms due to large amounts of downtime and an inability to fill lists that finish sufficiently early with added-on, unscheduled patients. As the full cost of anaesthetic room equipment, maintenance, and supplies are distributed across all specialties through overhead costs, the analysis excluding overhead costs still revealed a challenge in realising sufficient additional income to pay for the full cost of anaesthetic rooms over the lifetime of the equipment they require.

The wide variation of practice across a mixed specialty service was evidenced by differing utilisation of anaesthetic rooms, varying medical and non-medical staffing, and other practices unique to some surgical specialties. Ethnographic observations and the investigation of space allocated to theatre resource revealed the diversity of infrastructure available within a single NHS Trust. Whilst most theatres utilised anaesthetic rooms, despite smaller than recommended sizes, obstetrics, short stay, and day surgery did not use anaesthetic rooms. Only some theatres, orthopaedic and spinal surgery, had laminar flow air ventilation. Prep rooms were only utilised for setting up

of instruments in cardiac, day surgery, urology, and orthopaedic theatres. The main specialties that achieved overlap were cardiac, ophthalmology, hand, thoracic, elective orthopaedic, and urology specialties, which was consistent with the specialties with known additional staffing for overlap in urology, thoracic, cardiac, and orthopaedic surgery. The survey of consultant anaesthetist use of anaesthetic rooms across the East Midlands in Chapter 3 is consistent with NUH specialties that most often use them; however, the survey indicated neuro, cardiac, and thoracic surgery frequently never used the anaesthetic room, which differed locally. Further to this, theatres with greater frequency of overlap were specialised lists and lists with additional staffing. This relationship could be due to the staffing of physician's assistants only on high turnover, regular and specialised lists. Theatres with a diverse casemix (i.e. multiple specialties on a day) did not see as much overlap.

There has been significant investment in anaesthetic rooms for orthopaedic surgery in NUH, as evidenced by four new orthopaedic theatres built with large prep and anaesthetic rooms and designation of physician's assistants, as well as investments in laminar flow ventilation, additional prepping, and practices aimed at reducing infection rates. However, some recent research calls into question the use of laminar flow for total joint arthroplasty (James *et al.*, 2015). While the practice of double gloving may help in preventing transmission of communicable diseases (Makama *et al.*, 2016), wearing disposable masks in the theatre may be insignificant in their effect on surgical wound infection rates (Lipp & Edwards, 2014). Accepted standards for orthopaedic practice have mixed support from scientific evidence, which calls into question the devotion to expensive infrastructure such as laminar flow ventilation units, large prep rooms, and large anaesthetic rooms for the specific purpose of improving the throughput of single specialties, thereby specialising surgical suites.

Although the use of induction rooms to overlap processes and minimise turnover time has been studied and found to be beneficial (Hanss *et al.*, 2005; Torkki *et al.*, 2005; Sandberg *et al.*, 2005), those same studies have also been criticised for evaluating differing scenarios of both staffing and patient flow (Dexter, 2005), and cannot be simplified to state that any hospital using induction rooms can benefit from them. Dexter *et al.* (2003) used OR information system data to show that reductions in turnover time did not reduce staffing costs as much as reducing allocated OR time. Factors regarding scheduling and staffing of cases are essential to optimise theatre cost-

efficiency. Staff shared the challenges of feeling understaffed and without break cover during observations; however, additional human resource commitments are needed for parallel working to achieve overlap. Observations showed an average of 4 non-medical staff per theatre, which falls short of the minimum team for a physician's assistant staffed theatre of 1 PA, 1 ODP, 3 scrubs, and 1 HCA (A. Carney 2016, personal communication, 18 May). Hospital management decisions for staff scheduling and break cover is also relevant to costing, as increased staffing in each theatre to cover breaks increases staffing costs. Specialisation is also an important management decision for staffing, as ODPs, although professionally trained to cover duties in anaesthesia, surgery, and recovery, have largely worked in the anaesthetic room, and more recently in the operating theatre (Timmons & Tanner, 2004), or within a single surgical specialty, both of which will reduce flexibility of staffing.

The broader socio-technical system also impacts the viability of anaesthetic rooms as a source of economic and productive gains. As affirmed in interviews of anaesthetists in Chapter 4, delays can often originate from outside of the surgical suite. Analysis of operating room information system data in this chapter supported literature in finding delays could be attributed to the ward and in portering of patients to the surgical department (Saha *et al.*, 2009; Meyer-Witting & Wilkinson, 1992). Despite the absence of anaesthetic rooms, the independent treatment centre showed the ability to provide high efficiency service (limited to daycase, non-emergent work) by preventing system wide delays and maximising the productivity of surgeons (see **Appendix H**). The differing payment structures and incentives for consultants between the public and private sectors may also affect the sense of urgency to complete scheduled procedures.

Finally, although the goal of the chapter was to assess the cost and efficiency of anaesthetic rooms, the challenges of refining costs and apportioning them appropriately to individual procedures reflects on the Payment by Results (PbR) payment system of the NHS. While PbR has aimed to incentivise quality care and efficient practice with payment, several issues may arise as tariffs can be reduced as a way of lowering costs and improving efficiency within the NHS (Newbold, 2006). Tariffs may not cover total expenses for certain procedures and income may be redistributed within specialty budgets to cover costs outside of the scope of individual procedures i.e. new equipment, training, etc. (Hamilton *et al.*, 2012). This study proved the difficulty in matching individual tariffs with procedures and pairing both the costs and revenues with the

procedure system data. Costs and revenues were aggregated at a Trust level within divisions and individual specialties. Many assumptions, as discussed in the next section, were required in order to determine profit margins on an individual procedure basis.

In 2010, the White Paper 'Equity and Excellence: Liberating the NHS' called for unprecedented gains in efficiency, with an estimate of £20 billion of efficiency savings by 2014 (DOH, 2010); however, with near zero real terms growth in NHS funding between those years, most NHS trusts have now found themselves in deficit (Walshe, 2015). The acute hospital sector has been looked to for improvements as the largest spender of NHS resources (Hurst & Williams, 2012). A recent figure of the Nottingham University Hospitals NHS Trust projected a financial deficit of over £42 million for 2015-2016 (Dunhill, 2015), which demands investigation into ways of increasing profit and reducing unnecessary costs.

6.8 Limitations

The primary limitation of the secondary data analysis was that of data reliability. Several assumptions were required of the ORMIS data, as presented in **Appendix K**, which took into account local practice and policies in 2013/2014 to ensure internal validity. Due to the use of multiple systems for surgical patient data, an imperfect merger was required to pair HRG coding, financial expenses, and patient pathway information. This step was unfortunately unavoidable, although NUH has since transitioned to a new system called 'Blue Sphere', which is capable of integrating such data in the future. While acquiring accurate expenses for measuring surgical efficiency in financial terms has proven difficult (Siegmueller & Herden-Kirchhoff, 2010), this study aimed at addressing the essential components of cost-efficient theatres and making a best estimate of the anaesthetic room contribution to theatres. Data integrity was of concern throughout the analysis; however, missing data and inconsistent timings were flagged to be excluded. Additionally, despite the presence of data anomalies and inconsistencies, ORMIS data was reviewed in weekly meetings of theatre staff and specialty general managers to discuss theatre utilisation and correct data errors. Although the external validity of this study is weak, as it is based on local costs and practices, the analysis framework may prove beneficial for other Trusts to determine the cost and benefit of anaesthetic rooms in their organisations.

Although this study did not take into account the specific and varying scheduling of the 52 theatres included, the individual utilisation of each theatre was beyond the scope of the study design. Scheduling strategies can differ between theatres due to many competing factors such as surgeon's desires and availability, scheduling policy, equipment limitations, and room size restrictions, among others (Hamilton & Breslawski, 1994). The actual time points of the patient's journey through surgery were used for this analysis, whereas the planned start and end times were unnecessary to capture the 'work as done'.

6.9 Future Work

Although this study compiled financial costs of anaesthetic room equipment, supplies, and maintenance, there were multiple costs which could not be quantified based on the available data. Examples of unaccounted costs, which should be considered in future evaluations include:

- the opportunity cost of space commitment to anaesthetic rooms;
- the potential risk to patient safety (i.e. financial liability);
- and the experience and satisfaction of patients and staff.

The space allocation of anaesthetic rooms in NUH revealed the overall space commitment; however, the costs of renovating or re-building to use the space for alternative purposes was beyond the scope of this study. The most common study of patient safety risk focused on the transfer and desaturation of oxygenated patients, and showed a disconnection of the breathing system for 54 seconds (range of 44-182 seconds) (Broom *et al.*, 2006), which is comparable to the observational study's finding of 72 seconds of disconnection. Due to lack of information of severe adverse incidences due to transfer from the anaesthetic room to theatre, possible financial implications of this gap have not been quantified. The qualitative costs and benefits of anaesthetic rooms on staff experience and satisfaction were explored in this thesis in Chapter 3, 4, and 5, whereas the impact on patients specifically will be measured in Chapter 7. Quantifying the costs and benefits of anaesthetic rooms on quality of care is difficult, yet essential in providing a robust measure of efficiency (Hurst & Williams, 2012) and should be incorporated in future studies.

6.10 Chapter Summary

This study presented the operational impact of anaesthetic rooms, and the effects of the larger complex socio-technical system on their value. The outcome of this cost-efficiency analysis demonstrated a potential benefit of anaesthetic rooms which is not fully realised. The financial benefit is the greatest for specialised theatres and those with additional staffing, such as physician's assistants; however, the costs of additional staff and the nominal expenses of equipping anaesthetic rooms must be exceeded by profit gains, which is only possible with the up-scheduling of cases on early finishing theatre lists. Similar to the difficulty of attributing profit to individual surgical procedures due to aggregation of costs and revenues in hospital finance, there is a challenge to hospital management in determining if anaesthetic rooms should be built for all theatres considering their cost, and benefit, will be spread across all theatres

Chapter 7 Patient Experience with Surgical Anaesthesia

7.1 Chapter Overview

This chapter presents a questionnaire study exploring the patient's perspective of the pre-operative anaesthetic experience. The study focuses on pre-existing expectations for anaesthetic care, while measuring the level of anxiety experienced at the time of anaesthetic induction, and post-operative satisfaction specifically related to the environmental conditions of the site of induction.

7.2 Introduction

A common theme throughout all of the preceding chapters has been the perceived impact of anaesthetic rooms on the patient's experience. The survey results in Chapter 3, interviews in Chapter 4, Delphi study in Chapter 5, and observations in Chapter 6, all reported the importance of the patient's perspective relating to their anaesthetic care and whether the site of induction could be a benefit or detriment to their experience, relating to their potential anxiety and satisfaction. Chapter 6 also presented findings from the private sector that patients did not report dissatisfaction with in-theatre induction of anaesthesia. Whilst the majority of anaesthetic room literature relating to patient experience focuses primarily on that of the paediatric patient and the benefit of parental accompaniment (Wollin *et al.*, 2004; Watson and Visram, 2003; Aguilera *et al.*, 2003), the only piece of research concerning adult pre-operative anxiety and the anaesthetic room was conducted by Soni and Thomas in 1989.

Soni and Thomas (1989b) conducted a randomised controlled trial of 100 patients, 50 patients were anaesthetised in the anaesthetic room (25 males, 25 females), and the same proportion were anaesthetised in the operating theatre. The study was designed to include only elective minor or intermediate surgeries in general, orthopaedic, or ENT surgery. Patients were excluded from the study if they had history of psychiatric illness, prescriptions for psychotropic or antihypertensive drugs, and any cancer-related or daycase surgeries. Randomly allocated to the anaesthetic room induction or operating theatre induction groups, patients completed a baseline heart rate, systolic arterial pressure, respiratory rate, and linear analogue anxiety score (LAAS) prior to the operation (often the day before). The theatres and anaesthetic rooms used were identical

in size, appearance, lighting and décor. The patients then had their vitals measured again and an assessment of anxiety using the LAAS just prior to anaesthetic induction. The study determined there was no significant difference in anxiety between the two groups prior to induction and is the most commonly cited study measuring patient anxiety with comparison of anaesthetic room and theatre induction. Although the study was robust, undertaking both qualitative and quantitative measures of anxiety, the study did not investigate other aspects of the patient experience in anaesthetic rooms such as patient preference, expectations, and satisfaction. The purpose of this study was to investigate the role of the anaesthetic room in the adult patient's pre-operative anaesthetic experience in the following ways:

- Exploring the expectations that patients have regarding the environment where they will be anaesthetised.
- Evaluating the levels and causes of anxiety leading up to surgical anaesthesia.
- Determining whether the site of induction impacts the anxiety score of patients.
- Measuring the satisfaction of patients concerning their anaesthetic care and the site of induction.

7.3 Methods

7.3.1 Participants

The participants for this study were adult patients between the ages of 18-65 years who were scheduled for elective surgery. The study excluded paediatric and elderly patients, as additional study protocols would be required for such vulnerable patients. In an effort to control for additional anxieties which could be present, patients undergoing cancer-related procedures were excluded due to heightened anxiety attributed to cancer diagnoses (Ballenger *et al.*, 2001). In addition, obstetrics patients were excluded from the study as the obstetrics specialty exhibited the highest occurrence of anaesthetic room not existing, as shown from survey results of Chapter 3. Only patients who could fully understand spoken and written English and were capable of giving informed consent were recruited.

The recruitment process was initiated by the waiting list coordinators or surgical secretaries who were responsible for assigning patients to specific theatre lists. The coordinators/secretaries sent the study participant information sheet to the patients via

post between 2-6 weeks in advance of their day of surgery. This timeframe ensured the patients had sufficient time to read the requirements of the study and to consider participation. Upon arrival at hospital, the patients were provided with a written consent form and the questionnaire to complete while waiting for their procedure.

The study was a multi-site study, recruiting patients from within the Nottingham University Hospitals NHS Trust and the University Hospitals of Leicester NHS Trust.

7.3.2 Ethics

As a patient-focused study, this multi-site questionnaire required ethical approval through the NHS Health Research Authority to permit access to and recruitment of NHS patients. The study was originally presented before the East Midlands – Nottingham 2 Research Ethics Committee (REC) and received an unfavourable opinion in June 2015. The primary concerns which were raised in the original study design were the following:

- The researcher (not a part of the direct care team) intended to approach patients who were assigned to the lists on which the anaesthetist was scheduled, in order to recruit and consent patients. The researcher was also to be present at the time of anaesthetic induction to complete a portion of the survey with the patient, in order to remove an element of burden to the anaesthetists.
- Confidentiality of patient data was a concern as it was unclear where questionnaires would be stored between stages of the study.
- Information was to be provided to the patient on the same day of surgery, to allow the patient time, while waiting for surgery, to consider taking part.
- Due to the vulnerability of patients, the REC believed there was no safeguard in place for any elicited fear or anxiety to be managed.

The research design was modified to ensure appropriate time in advance to consider participation in the study, and the non-clinical researcher was removed completely from the recruitment and data collection processes. With all concerns addressed, the study was finally approved by the same REC in February 2016 (REC Reference: 16/EM/0016).

The nature of this study could be considered sensitive as it deals with anxiety of surgical patients, who might be considered vulnerable even without being questioned on their level of anxiety. Despite several examples of similar questions being asked and the same measuring tool (linear analogue anxiety score or visual analogue scale for anxiety) being used in previous studies investigating pre-operative anxiety (Kindler *et al.*, 2000; Soni & Tomas, 1989b), questioning patients on what may be causing them anxiety might, in itself, elicit latent fears or anxieties. The research study was designed with the collaboration of consultant anaesthetists who confirmed the questions being asked within the study were consistent with questions already asked as a part of standard procedure for evaluating the patient prior to surgery. In the incident of fears or questions arising due to the study that could contribute to increased anxiety, the patients were to raise any concerns with their consultant anaesthetist who might be able to provide relief.

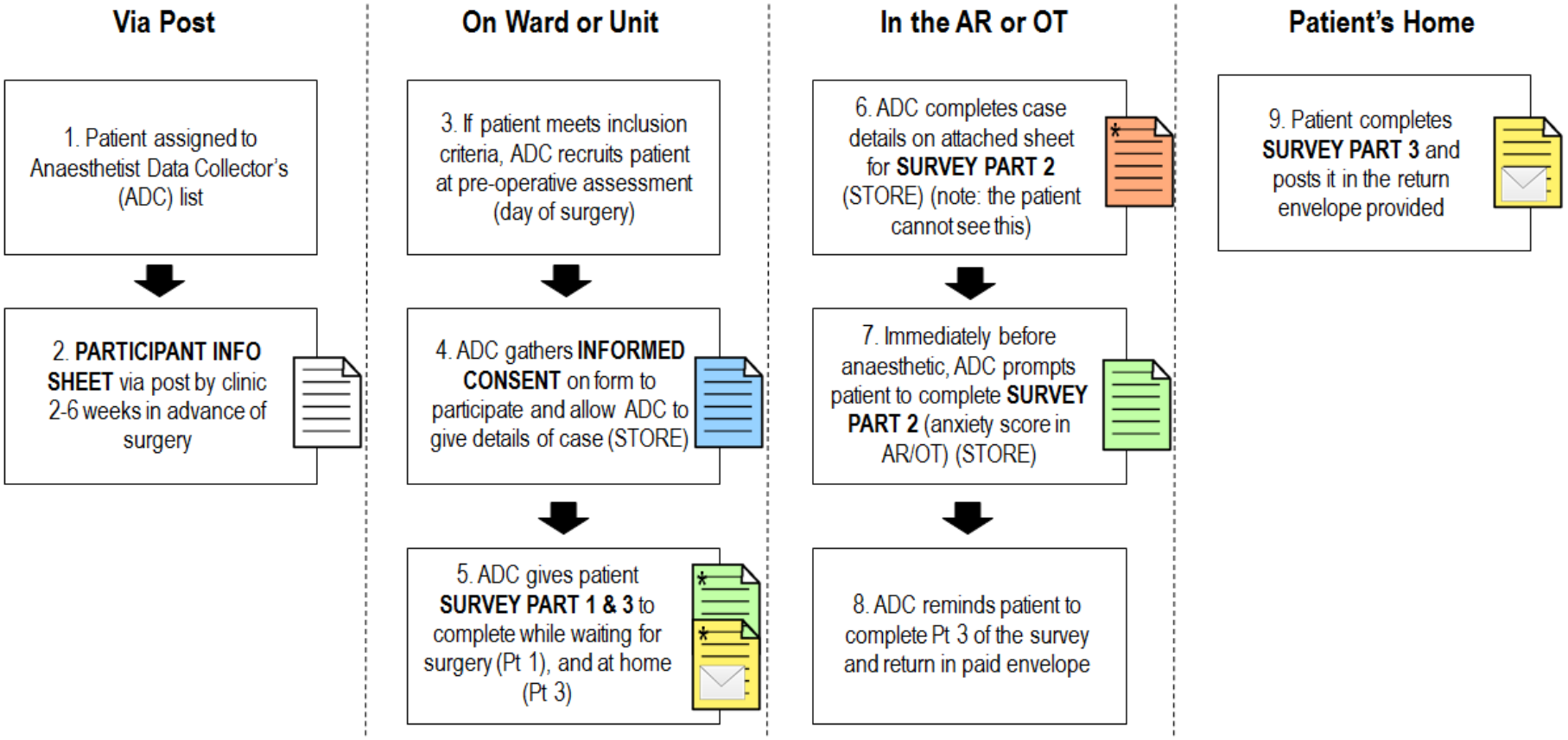
In order to preserve the confidentiality of patients, a unique code was used for each patient questionnaire. The anaesthetists collected consent forms from patients and submitted the consent forms to the research team physically separated from the completed questionnaires, so that individual questionnaires could not be matched to specific patients.

7.3.3 Data Collection

The questionnaire is shown in **Appendix L**, consisting of three parts:

(1) patient expectations and a baseline anxiety measure;
(2) pre-operative anxiety measure and anaesthetist provided case information;
(3) patient satisfaction and recommended ways to relieve anxiety.

The study process in **Figure 7.1**, shows the process of the study starting with patient information provision from waiting list coordinators and ending with the patient's completion of the final part post-operatively. The three-part questionnaire was iteratively revised after review by consultant anaesthetists. The final version of the questionnaire met all REC requirements and recommended changes.



*Indicates documents with unique identifiers which must match for all documents pertaining to the same patient. Different coloured sheets indicate separate sheets of paper.

Figure 7.1 Study process flow diagram

Part 1: Patient Expectations & Baseline Anxiety Score

Part 1 consisted of demographic information such as age and gender, as well as single and multiple response questions pertaining to the patient's expectations for the location where they would be anaesthetised and their previous experience having surgical operations. One open ended question requested explanation for any possible causes of anxiety, if any was experienced. Finally, the visual analogue scale (VAS), a single horizontal line from 0 to 100 millimetres was used to make a visual estimation of anxiety from 'No Anxiety' to feeling 'Extremely Anxious', as shown in **Figure 7.2**. The visual analogue scale has been proven to be equivalent in effectiveness as other known anxiety measures such as state-trait anxiety inventory and the hospital anxiety and depression scale (Kindler *et al.*, 2000; Millar *et al.*, 1995; Vogelsang, 1988) and has been used in multiple pre-operative anxiety studies (Braden *et al.*, 2009; Jawaid *et al.*, 2007). The VAS was measured in Part 1 as a baseline score of anxiety prior to the time of surgery as a point of comparison for anxiety scores taken within the surgical suite (either the anaesthetic room or the operating theatre).

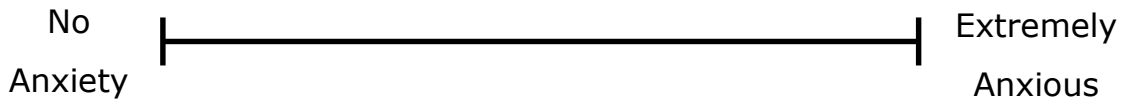


Figure 7.2 Visual analogue scale for anxiety

Part 2: Final Anxiety Score

In Part 2, the patient was asked to complete the VAS for anxiety a final time before the regional or general anaesthetic was provided. This score aimed to measure the anxiety experienced by the patient at the latest stage prior to either falling asleep in the case of a general anaesthetic, or before commencement of the procedure in the operating theatre. In addition, the anaesthetic data collector (ADC), as identified in Figure 7.1, was asked to complete a separate sheet with specifics of the patient's case which could impact anxiety (i.e. ASA grade, surgical severity, type of anaesthetic), and details of the environment which the patient may not recall (i.e. timing of the induction, induction location, who induced the anaesthetic, and the number of people present during induction). This section of the survey was based on the 2014 nationwide Spring National Anaesthesia Project (SNAP-1) survey investigating patient satisfaction and

patient reported awareness from anaesthesia (Pandit *et al.*, 2014). Patients who completed Part 1 and 2 were counted toward the target numbers, whereas patients only completing Part 1 were replaced, as a comparison of VAS measurements between the baseline and in-suite scores were necessary for evaluation of anxiety change. Participants were given the questionnaire to complete anxiety scores in Part 1 and 2 prior to any provision of anxiolytic, or anxiety reducing, medication.

Whilst the site of induction was the primary variable of consideration in the evaluation of anxiety scores, this study was not designed as a randomised controlled trial. The site of induction was chosen by the consultant anaesthetists, as a part of standard practice. This was deemed appropriate as a variation of in-theatre and anaesthetic room induction would be disruptive of standard procedure. Theatre teams who are not accustomed to in-theatre induction, for example, may not behave in a way which is appropriate for an awake patient, and could therefore impact anxiety. Although at least one consultant standardly anaesthetised in the operating theatre, no single anaesthetist anaesthetised in both the anaesthetic room and the operating theatre.

Part 3: Patient Satisfaction

The final part of the questionnaire, Part 3, was provided to the patient to complete following full recovery from anaesthesia, once the patient returned home. A return envelope was provided with postage. Part 3 consisted of seven VAS questions evaluating the satisfaction of the patient on a scale from 'Very Dissatisfied' to 'Very Satisfied'. Patient satisfaction has been measured using a VAS in several other studies (Bullens *et al.*, 2001; Brokelman *et al.*, 2003). The satisfaction questions related to environmental conditions such as the level of noise, the level of privacy, the specific room where they were anaesthetised, and their overall anaesthetic care. The patient was given the option of 'I don't recall' for any questions pertaining to elements of their care which they were unable to recollect. In addition, the patient was asked what factors were helpful in relieving anxiety, which allowed for open responses. Patients were also asked if they would have changed anything about their experience that would have reduced anxiety.

7.3.4 Data Analysis

The questionnaire collected both quantitative and qualitative data. The Statistical Package for the Social Sciences, version 22 (SPSS; IBM Corporation), was used to analyse all data distributions for normality. Due to a lack of normality, all data was analysed using non-parametric statistical tests. Descriptive statistics were used to measure frequencies, means, and standard deviations for all data fields.

The objective of this study was to test if the pre-operative anxiety that patients experience is higher for patients who are induced in the theatre compared to those who are induced in the anaesthetic room. Visual analogue scores for anxiety were analysed using the non-parametric Mann-Whitney U test for two independent samples to determine any significant difference.

Additional statistical testing was done to consider the impact of age, gender, waiting time, experience of previous operations, study site, and surgical specialty with anxiety. Statistical analysis was contingent on meeting all test assumptions, therefore some correlations were not evaluated due to lack of monotonicity. The patient's ASA grade and surgical severity was also tested for significance to anxiety scores using the Kruskal-Wallis test. Patient satisfaction was analysed in a using the same statistical tests against the same factors as stated previously.

Free responses regarding causes of and methods for relieving patient anxiety were categorised in Excel for frequency of responses.

7.4 Results

7.4.1 Demographics

Thirty-eight participants completed the questionnaire; however, three participants were excluded as they did not complete the final anxiety score due to procedure cancellation or a trainee neglecting to collect the final score, and one participant was excluded after completion as he exceeded the age inclusion criteria. Six declined participation in the study, and two were ineligible to participate (due to language barrier and lack of capacity to consent). Although three who declined did not give a reason for doing so, two patients did not participate due to feeling too anxious.

From the 34 participants who completed the questionnaire through Part 2[16], the measure of anxiety in the site of induction, 44% (n = 15) were male and 56% (n = 19) were female. The mean age was 40 (18-65) years old. Thirty-two percent (n = 11) of participants were between 35 to 44 years of age, whilst all other age groups between 18-65 years were represented, as shown in **Figure 7.3**.

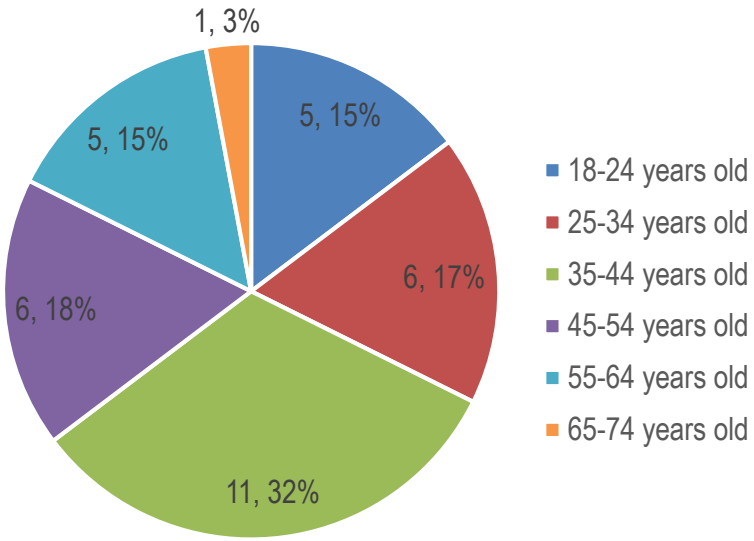


Figure 7.3 Diagram of participant age groups (n, %)

From Trust A, 38% of all participants were recruited by one anaesthetist practicing in one surgical suite. All 13 of these patients were anaesthetised in the operating theatre and underwent general surgery procedures -mainly excision of skin tags and inguinal hernia repairs. The remaining 62% (n = 21) of patients were recruited in Trust B, by 2 anaesthetists, across 5 surgical suites. However, 71% (n = 15) of 21 patients recruited in Trust B were brought to a single surgical suite. Most cases in Trust B were maxillofacial procedures such as dental extractions under general anaesthesia.

The majority of procedures, 94%, were general anaesthetic procedures of intravenous supplied anaesthetic (91%), whilst the remainder was given via inhalation agents (3%). Two cases were included that used regional anaesthesia instead of general anaesthesia. Due to lack of numbers, anxiety scores for regional anaesthesia patients were not compared against general anaesthetic patients. Regarding the site of induction, 76.5%

[16] Completion of the questionnaire was defined as completion through Part 2, so the comparison of anxiety scores was possible. Part 3 was a post-operative satisfaction questionnaire, which was not necessary for statistical analysis of anxiety measures.

(n = 26) of patients underwent anaesthetic induction in the operating theatre, whilst 23.5% (n = 8) were put to sleep in the anaesthetic room.

7.4.2 Patient Expectations

Part 1 of the questionnaire focused on patient expectations for their anaesthetic care. Length of residence in the UK and number of previous operations were key factors which could potentially impact the patient's familiarity with the anaesthetic room as a standard location for anaesthetic provision. However, due to the violation of the 'expected counts less than 5' assumption for Chi-square tests, the relationships of previous operations and length of residence in the UK could not be statistically analysed against knowledge of or preference for the anaesthetic room.

The majority of patients (62%) had resided in the UK for between 21 to 50 years, as shown in **Figure 7.4**.

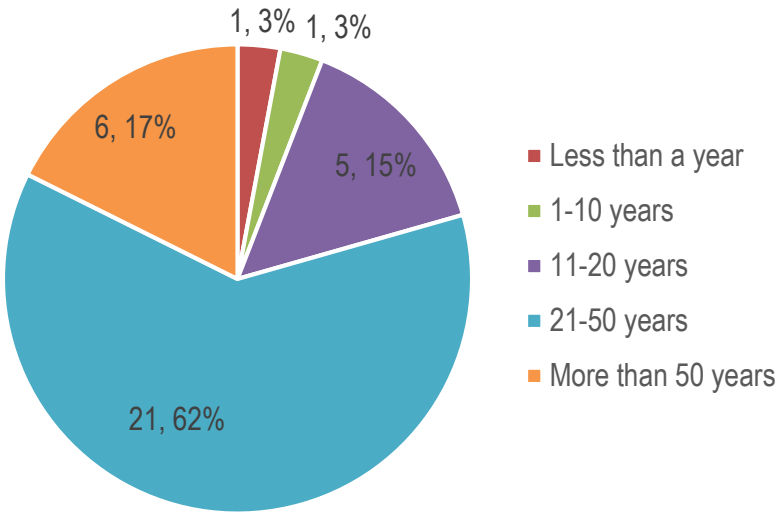


Figure 7.4 Diagram of patient length of residence in the UK (n, %)

The number of previous operations were requested from the participants and is shown in **Figure 7.5**, where most patients had either no, 1, or 2 previous operations.

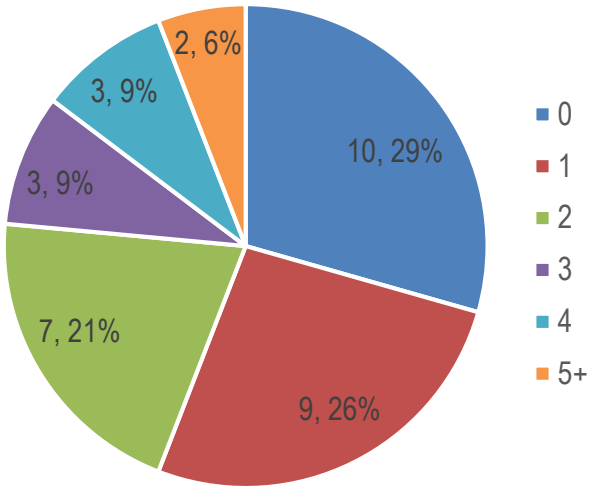


Figure 7.5 Diagram of number of previous operations (n, %)

Participants provided insight into their preferences for site of anaesthetic induction and their awareness of anaesthetic rooms, in **Table 7.1**, showing 46% of participants preferring the anaesthetist to choose the site of induction. Only one participant who was familiar with the anaesthetic room, would voluntarily choose to be induced in the operating theatre. All participants who preferred induction in the anaesthetic room had former knowledge of the anaesthetic room from various experiences, such as previous surgeries. Only three participants who preferred the anaesthetic room had no previous operations, and were aware of the anaesthetic room from television or movies (n = 2) or a patient information leaflet (n = 1).

Table 7.1 Patient preference for location of induction and knowledge of the anaesthetic room

	Awareness of Anaesthetic Room			
Preferred Location for Anaesthetic Induction	Yes (n)	No (n)	I'm Not Sure (n)	**Total of 32**
Anaesthetic Room	100% (10)			**30% (10)**
Operating Theatre	33% (1)		67% (2)	**12% (3)**
Wherever the Anaesthetist Chooses	53% (8)	27% (4)	20% (3)	**46% (15)**
I Do Not Know	25% (1)	75% (3)		**12% (4)**
Missing data*			5% (2)	
Total of 34	**57% (20)**	**20% (7)**	**23% (7)**	

*Of the 34 respondents, one did not respond and the other selected more than one answer regarding preference for site of induction, so was excluded.

The majority of participants, 57%, had previous awareness of the anaesthetic room. Patients were asked to provide explanation as to where they had first heard of the anaesthetic room. Most participants recalled their own experience (39%) of the anaesthetic room. Some did not know how they knew about the space (22%). Other participants were informed about the anaesthetic room from either the surgeon or anaesthetist (13%), television or movies (13%), patient information leaflet provided by the hospital (9%), or from a family member or friend (4%).

7.4.3 Pre-operative Anxiety

7.4.3.1 Anxiety Score Results

The change in anxiety between the two scores was calculated from the difference between baseline and final anxiety scores, where a positive change indicated a net increase in anxiety, and vice versa. Using Spearman's correlation, for non-normal anxiety scores, baseline and final anxiety scores were correlated with $r = 0.717$, $p = .000$, which demonstrated an increase of final anxiety for increased baseline anxiety scores. The mean time (± SD) between the taking of the baseline and final anxiety scores was 75.5 (± 56.6) minutes. The amount of time that the patient was present in the anaesthetic room or operating theatre prior to induction of anaesthesia was 8.4 (± 6.0) minutes.

Eighty-two percent (n = 28) of patients admitted to experiencing some level of baseline anxiety prior to their procedure. Of total participants, 80% of males and 84% of females indicated they had some anxiety. The mean anxiety scores (baseline, final, and change) are shown in **Table 7.2** in total and for male and female participants. Although the anxiety scores exhibited non-normal distributions, the Mann-Whitney U test revealed a significant difference ($p \leq .05$) between male and female participants' baseline scores, and also final anxiety scores. The change in anxiety from the baseline measurement to the final measurement (i.e. the point at which the anaesthetic induction was to be given), was not significantly different between genders.

Table 7.2 Mean anxiety scores (± SD) and test statistics by gender

		Anxiety Scores		
Gender	N	Baseline	Final	Change (F-B)
Male	15	23 (± 20.7)	30.9 (± 28.9)	7.9 (± 26.2)
Female	19	50.5 (± 34.2)	60.1 (± 37.4)	9.6 (± 29.4)
Total	34	38.4 (± 31.8)	47.2 (± 36.5)	8.8 (± 27.6)
Mann-Whitney U		79.0	80.0	109.5
p-value		.027*	.030*	.256

*$p \leq .05$; Visual analogue anxiety scores were measured in mm = millimetres

The relationship between age of participants and anxiety could not be calculated due to the lack of monotonicity of the data for a Spearman's correlation. Separated into age groups (i.e. 18-24 years old, 25-34 years old, etc.) and evaluated against final anxiety scores using non-parametric, Kruskal-Wallis testing revealed no significant relationship ($X^2(5) = 5.326$, $p = .377$). The number of previous operations a patient had were not significantly related to anxiety. Most participants were of either ASA grade 1 or 2 (65% and 32%, respectively), meaning they were either normal and healthy or patients with a mild systemic disease (AAGBI, 2010a). Additionally, the surgical severity of most patients was either minor (44%) or intermediate (50%). The highest ASA or surgical severity levels collected were level 3. However, neither ASA grade ($X^2(2) = 2.500$, $p = .286$), nor surgical severity ($X^2(2) = 1.095$, $p = .578$) resulted in significantly different final anxiety scores.

The number of people present at the time of anaesthetic induction was measured for comparison with anxiety and satisfaction scores; however, cross-tabulations were not possible due to low numbers and 'expected counts less than 5'. The mean number (± SD) of people present in the anaesthetic room was 3.6 (± 1.81), and 5.2 (± 1.35) in the operating theatre. This supports the observation that more people are present for in-theatre inductions. The anaesthetics were most often provided by a consultant anaesthetist (29 cases), but some were also assisted or given by trainee (10 cases) or senior anaesthetists (3 cases).

Participants were from maxillofacial (n = 19) and general surgery (n = 13), with two patients from ophthalmology. Participants were separated by surgical specialty and by study site (NHS Trust), because all general surgery and maxillofacial procedures were

done in Trust A and B, respectively. Baseline anxiety, final anxiety, and change in anxiety were all significantly different between sites, as Mann-Whitney U tests revealed a *p*-value ≤ .05 for all three anxiety measures. Similarly, Mann-Whitney U tests between maxillofacial and general surgery procedures also presented a *p*-value ≤ .05 for all three anxiety measures. **Table 7.3** shows anxiety scores were significantly higher in Trust B and for the maxillofacial surgical procedures. However, it is impossible to distinguish if study site or surgical specialty are the cause of differing anxiety scores. One respondent within Trust A (general surgery) had indicated an extreme change in anxiety from maximum to zero anxiety between baseline and final scores with no explanation for the change. This outlier was excluded to test the relationship of study site and specialty, also shown in **Table 7.3**. Tests of significance were the same for the total sample and the sample excluding the outlier, apart from change in anxiety, which was no longer significant between surgical specialties in the second iteration of testing.

Table 7.3 Mean anxiety scores (± SD) and test statistics by study site and specialty

		Anxiety Scores		
Study Site	N	Baseline	Final	Change
Trust A	13	22.5 (± 30.2)	22.2 (± 29.1)	-0.27 (± 33.9)
Trust A°	12	16.0 (± 20.1)	24.0 (± 29.6)	8.0 (± 16.5)
Trust B	21	48.2 (± 29.2)	62.7 (± 32.1)	14.5 (± 21.9)
Mann-Whitney U		68.5 / 47.5°	47.0 / 47.0°	70.5 / 70.5°
p - value		.016* / .003°**	.002** / .003°**	.019* / .038°*
Surgical Specialty	N	Baseline	Final	Change
General	13	22.5 (± 30.2)	22.2 (± 29.1)	-0.27 (± 33.9)
General°	12	16.0 (± 20.1)	24.0 (± 29.6)	8.0 (± 16.5)
Maxillofacial	19	48.6 (± 28.1)	61.1 (± 32.8)	12.6 (± 21.4)
Mann-Whitney U		60.5 / 41.5°	45.0 / 45.0°	67.5 / 67.5°
p - value		.015* / .003°**	.003** / .005°**	.031* / .059°

*$p \leq .05$; **$p \leq .01$; Visual analogue anxiety scores were measured in mm = millimetres; °One response indicated a change from 100 to 0 anxiety, which was excluded and tested without the outlier.

The focus of this study was the comparison of anxiety between patients induced in the anaesthetic room versus the operating theatre. As shown in **Table 7.4**, Mann-Whitney U tests did not present significant differences between anxiety scores of those induced

in either location. However, the in-suite anxiety scores of female participants were significantly higher in the anaesthetic room than the operating theatre (p = .041).

Table 7.4 Mean anxiety scores (± SD) and test statistics by induction site and gender

		Anxiety Scores		
Induction Site	N	Baseline	Final	Change
Anaesthetic Room	8	47.4 (± 34.9)	64.4 (± 37.0)	17.0 (± 26.6)
Operating Theatre	26	35.6 (± 31.0)	41.9 (± 35.4)	6.3 (± 27.9)
Mann-Whitney U		78	64	63
p - value		.290	.104	.096
Male	N	Baseline	Final	Change
Anaesthetic Room	3	21.7 (± 18.8)	28.8 (± 26.9)	7.2 (± 44.3)
Operating Theatre	12	23.3 (± 21.9)	31.4 (± 30.4)	8.1 (± 22.7)
Mann-Whitney U		17	17	17
p - value		.885	.885	.885
Female	N	Baseline	Final	Change
Anaesthetic Room	5	62.8 (± 34.1)	85.7 (± 22.7)	22.9 (± 11.7)
Operating Theatre	14	46.1 (± 34.4)	50.9 (± 37.9)	4.8 (± 32.5)
Mann-Whitney U		21	13	15
p - value		.194	.041*	.064

*$p \leq .05$

In order to control for specialty and theatre, 6 cases induced in the anaesthetic room of surgical suite A and 9 cases induced in the operating theatre of the same surgical suite (all maxillofacial procedures), were compared to no significance for final anxiety scores (U = 24, p = .724) and change in anxiety (U = 21, p = .479).

7.4.3.2 Causes of Anxiety

All patients were asked to indicate what was causing them any pre-operative anxiety. Eleven patients were not anxious at all. Of the 21 participants who provided comments on their anxiety, 3 merely indicated they felt a degree of anxiety without providing a cause. All other causes are shown in **Table 7.5**, where respondent fears are listed and categorised. The most dominant category for causes of anxiety was anaesthesia-related.

Table 7.5 Participant responses to causes of anxiety

Causes of Anxiety	Frequency
Anaesthesia	***9***
Fear of not waking up	4
Fear of anaesthetics	3
Fear of being asleep	2
Surgery	***5***
Fear of having surgery	3
Fear of the risks of surgery	2
Unknown	***5***
Fear of the unknown / not knowing	3
Fear of not being in control	1
Fear of unfamiliarity of the situation	1
Pain	***5***
Fear of feeling pain or discomfort	3
Fear of needles	2
Other	***6***
Fear of being in hospital	3
Fear of aftercare / recovery	2
Fear of panicking	1

7.4.3.3 Ways of Relieving Anxiety

In Part 3 of the questionnaire, patients were asked to give feedback on what was helpful in relieving their anxiety, and what they would have changed about their experience that would reduce their anxiety. Of the 34 respondents, 47% (n = 16) returned Part 3 and suggested the following as helpful in alleviating their anxiety.

- The amount of explanation by doctors and staff (12 respondents);
- The amount of reassurance given by the anaesthetist (11 respondents);
- Being given the opportunity to ask questions (10 respondents);
- Having been put to sleep in the location they were (7 respondents; 3 AR, 4 OT);
- Being provided educational materials about anaesthesia (5 respondents).

Table 7.6 Proposed ways of reducing anxiety

Ways of Reducing Anxiety	Frequency
Staff behaviour	***11***
Reassurance from staff	4
Calmness of staff	3
Attention regarding comfort	2
Connecting with the patient	2
Environmental conditions	***4***
Comfort of waiting area	1
Number of people present	1
Being put to sleep in AR	1
Not seeing inside theatre	1
Patient expectations	***4***
Communication of anaesthetist	1
Research into surgeon	1
Speaking to surgeon before day of surgery	1
Religious beliefs	1
Operational factors	***3***
Reduce waiting time	2
Timeliness of required information	1

On reflection of their experiences, respondents provided insight into other ways that could have helped to reduce their anxiety, shown in **Table 7.6**.

Most suggestions for ways to reduce anxiety were related to staff behaviour. Three participants recounted negative interactions with staff members where they were 'told off' by staff, where ward staff were abrupt, or where recovery staff did not inform the patient that he had awoken. The hurriedness of staff affected patients, as some recalled theatre staff appearing stressed while preparing the theatre, or rushing the patient to the bed. Patients spoke highly of experiences where they felt attention was paid to them and their comfort, as well as staff connecting to them by making jokes or speaking in the patient's native language.

Four participants responded to the environmental conditions of their care. Responses indicated a desire for improved comfort in the waiting area, controlling the number of

people present around the patient, and being put to sleep in the anaesthetic room or being prevented from seeing inside of the operating theatre.

Modifying patient expectations may be a way of reducing anxiety, as provision of information on what to expect can help the patient feel prepared. This information can be given to patients or patients can voluntarily engage in finding out more information (e.g. searching online). Ensuring the anaesthetist (and/or surgeon) are available to communicate with the patient in advance of surgery, may be an effective way of adjusting expectations.

Operational factors could be changed to manage anxiety by helping to reduce long patient waiting times, and ensuring patients are not caused to wait unnecessarily due to a lack of information being provided to team members. In one case, the patient was required to wait for his operation because x-ray scans and information regarding which teeth were being extracted had not been made available to his surgeon even just before the procedure.

7.4.4 Patient Satisfaction

The final aspect of this study evaluated patient satisfaction, as patients were asked to mark on a visual analogue scale their degree of satisfaction regarding several factors in the environment in which they were anaesthetised. Not all patients responded to every question, so responses ranged between 15 to 16 patients (44-47%) who provided VAS scores for satisfaction regarding the following areas (n, mean score, range, in mm):

- the information given before the operation (n = 16, 88.5, 48-100);
- the level of noise before the patient fell asleep (n = 15, 88.9, 70-100);
- the number of people present as the patient fell asleep (n = 16, 89.8, 47-100);
- what was witnessed happening as the patient fell asleep (n = 15, 88.9, 61-100);
- the level of privacy as the patient fell asleep (n = 15, 82.7, 32-100);
- the specific room where the patient fell asleep (n = 16, 82.4, 10-100);
- and the overall anaesthetic care (n = 16, 94.4, 70-100).

All mean satisfaction scores exceeded 82, with the highest rating being overall satisfaction with the anaesthetic care and the lowest being satisfaction with the specific room followed by the level of privacy for the patient, as shown above.

Table 7.7 shows the Mann-Whitney U test statistics for the satisfaction scores comparing Trust A and B, maxillofacial surgery and general surgery, and the satisfaction scores between the anaesthetic room and operating theatre. The table shows significant differences between satisfaction by study site, except satisfaction for the specific room where induction took place. Trust A had significantly higher patient satisfaction than in Trust B overall. The same relationships were seen regarding surgical specialty, as was evidenced in **Table 7.3**, where general surgery had higher satisfaction (although all general surgery cases were conducted in Trust A). Comparing between the site of induction, satisfaction was only significantly different regarding the amount of information given, the level of noise, and overall satisfaction. Unexpectedly, patients who were induced in the operating theatre rated their satisfaction of information given, noise at the time of induction, and overall satisfaction with their anaesthetic care higher than those induced in the anaesthetic room.

Table 7.7 Mean satisfaction scores (± SD) by study site, surgical specialty, and induction site

	Study Site		**Surgical Specialty**		**Induction Site**	
	Trust A vs B		**Maxfax vs General**		**AR vs OT**	
Satisfaction with…	U	*p*	U	*p*	U	*p*
Information given	6.5	.008**	6.5	.020*	5.0	.006**
Level of noise	0.0	.001***	0.0	.003**	5.0	.014*
Number of people	2.5	.002**	2.5	.005**	12.5	.057
Things witnessed	3.0	.005**	3.0	.010**	11.0	.059
Level of privacy	0.0	.001***	0.0	.003**	10.0	.065
The specific room	20.5	.243	16.5	.305	23.5	.480
Overall anaesthetic care	5.0	.005**	5.0	.012*	10.5	.033*

* $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$

Satisfaction scores also differed based on gender. Mann-Whitney U tests revealed that for anaesthetic room inductions, women reported significantly higher satisfaction for the specific room where they were located (p =.050), and their overall anaesthetic care (p = .050) than men. However, in operating theatre inductions, men were more satisfied than women regarding the level of noise (p = .017), number of people present (p = .010), and the level of privacy (p = .024).

7.5 Discussion

The study presented in this chapter aimed to measure the anxiety and satisfaction patients experienced with their anaesthetic care and the effect of the site of induction on their experience. Additionally, the study explored patient expectations for their anaesthetic provision and gauged the relevance of the surrounding environment on their satisfaction.

The findings of this study found that over half of the patients were familiar with anaesthetic rooms, largely in part due to personal experience gained from previous operations. Other patients were made aware of anaesthetic rooms through clinical resources such as communication with the surgeon or anaesthetist and hospital provided information booklets. Those who were aware of the anaesthetic room from previous experience largely preferred them. The majority of patients exhibited trust in the decision of their anaesthetist to choose where they should be put to sleep. This finding is similar to a recent service evaluation conducted by Frerk and Pinder (2016) in Northampton General Hospital (also in the East Midlands) which found of 100 consecutive patients, 55 patients had no preference (23 preferred the anaesthetic room, 22 the operating theatre). Of the patients who expressed a preference (45), 43 patients said it would not bother them if the anaesthetist chose the other room.

The study did not find a significant difference between the anxiety scores of patients induced in the anaesthetic room compared to those induced in the operating theatre. Although only a third of the sample size of Soni & Thomas (1989b), findings were consistent with their study, affirming the position that patient anxiety is not significantly different for patients in the anaesthetic room or operating theatre. Only one participant explicitly stated being induced in the anaesthetic room would relieve anxiety. Another participant desired to be spared from seeing inside the theatre. Although some participants found the location they were put to sleep helpful in relieving their anxiety, over half of those were anaesthetised in the operating theatre. Post-operative satisfaction was significantly higher for those anaesthetised in the operating theatre compared to those anaesthetised in the anaesthetic room. Although counterintuitive compared to the dominant view of anaesthetic rooms, it could also be attributed to the differing bedside manners of the anaesthetist and theatre staff, as these factors were not able to be controlled.

The experiences of male and female patients were different, as females had slightly higher occurrence of anxiety in baseline anxiety, which is consistent with previous studies (Kindler *et al.*, 2000; Moerman *et al.*, 1996; Badner *et al.*, 1990; Domar *et al.*, 1989). Men had significantly lower anxiety scores compared to women, although the change in anxiety between the baseline and in-suite anxiety scores was not significantly different. Female patients specifically experienced higher anxiety in the anaesthetic room than the operating theatre. Patient satisfaction also varied by gender as women experienced lower satisfaction regarding certain areas such as the level of noise, privacy, and people present at the time of induction.

The findings of this study have also provided insight into the best areas to intervene in order to manage and reduce patient anxiety. No patients gave reference to the site of induction in the pre-operative part of the survey. The causes of patient anxiety were common to other studies, such as fear of pain or discomfort, the anaesthetic, surgery, and the unknown (Shafer *et al.*, 1996; Soni & Thomas, 1989b; Ramsay, 1972). Post-operatively, participants were able to indicate ways in which they believed their anxiety could have been reduced. Patient responses highlighted the importance of staff behaviour and preparatory information in relieving anxiety. Ensuring physicians or other personnel along the perioperative pathway are able to provide reassurance and compassion to patients may be an effective anxiety management strategy (Fogarty *et al.*, 1999). Additionally, preparatory patient education has been proven to be an effective way of diminishing patient anxiety and increasing satisfaction for cancer patients undergoing radiation therapy (Poroch, 1995), and total hip replacement surgical patients (Bondy *et al.*, 1999; Gammon & Mulholland, 1996).

Literature regarding patient expectations (i.e. specific knowledge of the anaesthetic room) and satisfaction about the site of induction is lacking. Despite the need for such research, as expressed by managers and anaesthetists in Chapter 4, no previous studies have analysed the relevance of the site of induction specifically on patient expectations and satisfaction. This study has provided indication that the site of induction is not a major factor in anxiety reduction and increased satisfaction of patients.

7.6 Limitations

Participant recruitment and low response were limitations of this study. Upon receiving ethical and Trust approvals, the anaesthetists responsible for recruitment were unable to commence immediately due to a delay in provision of participant study information being sent to scheduled patients. The mechanism to provide patients with information regarding the study several weeks in advance of the day of surgery was through waiting list coordinators; however, despite communication and planning with the coordinators, some potential participants were not provided with information in advance and were unable to be recruited. In addition, lists were scheduled several weeks in advance, so following approval, there was a delay in initiation of the study to enable information sheets to be sent with surgical date notification letters.

An additional REC requirement was for recruitment of surgical patients and data collection to be carried out entirely by the clinical team to protect the anonymity of patients from the non-clinical researcher. Multiple anaesthetists who had volunteered to collect data for this study were not able to continue due to increased work demands or having large proportions of their patients not meeting inclusion criteria (cancer-related, paediatric, and emergency procedures). In addition, as the study took place over the summer, scheduled annual leave of primary data collectors reduced the number of possible lists from which to recruit patients. The possibility of Type II error and acceptance of the null hypothesis is increased with a small sample size.

Based on feedback from the anaesthetists, two patients had refused to participate in the study due to high levels of anxiety. It is possible that some patients did not participate for this same reason, therefore potentially biasing the data towards patients' experiences of low and moderate anxiety only.

Three patients were excluded from the study due to incompletion of the final anxiety score in the site of induction. One was due to cancellation of the case; however, the other two were due to possible anaesthetist distraction, or the junior anaesthetist not knowing to take the measurement from the patient, as was reported by the consultant anaesthetists. Data regarding specifics of the patient's case (e.g. ASA grade, operation name, theatre number, etc.) were not completed by the data collector in some cases. Follow-up was required to fill in data which could be checked in the operating theatre

information system; however, data which would rely on memory (i.e. number of people present at induction) could not be recovered. In an early meeting with one anaesthetist, it became apparent that he was verbally interviewing patients with the survey and writing their responses. Although he was reminded of the protocol, allowing the patient to self-administer the survey, it is possible that the open ended question regarding causes of anxiety were more brief than they would have been had the patient completed the survey in their own time. This could have also biased the data as the anaesthetist may have interpreted what the patient said, opposed to exact transcription. The limitations of a paper-and-pencil survey also allow for data quality issues such as lack of completion of survey items and brevity of response (Kongsved *et al.*, 2007; Kwak & Radler, 2002).

This study was not a randomised controlled trial where patients were randomly induced in either the anaesthetic room or the operating theatre. Consultant anaesthetists were not asked to intentionally induce patients in either setting, but to follow their standard practice and discernment for selection of site of induction. This decision was made in part to meet expectations of theatre staff, but also because some anaesthetists standardly anaesthetised in only one of the locations. The transferability of the findings of this study may be reduced, because anaesthetic room inductions only took place in a single site, and the influence of individual anaesthetists could be more prevalent due to low numbers of participants and data collectors.

7.7 Future Work

In studying the role of anaesthetic rooms on patient experience in the UK, the findings have identified an awareness of anaesthetic rooms that is present, but mainly due to previous experience. Further investigation should be done of the type of information and education provided to patients about what to expect regarding their anaesthetic care. If future research is to continue exploring the impact of anaesthetic rooms on patient anxiety and experience, it will be necessary to control for previous knowledge of anaesthetic rooms and determine if patients who do not know of anaesthetic rooms, that are not informed of them, and are not induced in them, will have any altered experience to those given full knowledge of anaesthetic rooms as the expected location for induction.

Based on the results of patient feedback suggesting ways to reduce anxiety, participants most frequently referenced the impact of personnel and their ability to provide comfort and reassurance. Further research should focus on the impact of staff behaviour on the pre-operative patient experience. Although anaesthetic room induction is a standard in the UK, previous studies in this thesis have shown a willingness of a minority of anaesthetists to standardly anaesthetise in the operating theatre (see Chapter 3 and 4), in a similar fashion as countries around the world that do not have anaesthetic rooms. There is presently a gap in literature, where the task breakdown and allocation of duties of anaesthetic and theatre staff have not been compared between anaesthetic room and operating theatre induction. There is no evidence to support the claim that operating theatre induction causes higher disturbance to patients in ways that are not manageable by altering staff behaviour.

7.8 Chapter Summary

This chapter has explored the patient experience, specifically anxiety and satisfaction, from pre-op to recovery, and measuring the effect of the anaesthetic room on anxiety and satisfaction. The study presented in this chapter asked the questions of patients that staff members desired to know from all previous studies (Chapters 3-6). The results demonstrated a lack of significant difference in anxiety between anaesthetic room and operating theatre inductions. Further to this, lower anxiety and higher satisfaction were experienced by patients induced in the operating theatre. These findings provide evidence that patients, through preparation and reassurance, may find operating theatre induction an acceptable, if not more satisfactory, experience.

Chapter 8 Discussion

8.1 Chapter Overview

This chapter summarises the key findings from the research conducted in this thesis, and discusses how the main research questions have been achieved. The novel contributions of the research and its limitations are addressed.

8.2 Summary of Research Findings

The main outcomes from the research investigations undertaken in this thesis are summarised in **Table 8.1**, including the main study objectives and key findings.

A systems approach was used to investigate the efficacy of anaesthetic rooms in UK hospitals. Mixed methods were employed to describe and quantify the value of anaesthetic rooms to their stakeholders. The decision making process and prioritisation of competing factors were explored to identify potential barriers to changing practice.

The current practice and views of the anaesthetic community was investigated in Chapter 3, where anaesthetists across the East Midlands shared their attitudes and opinions regarding the use of anaesthetic rooms.

An in-depth exploration of clinical and management decision making was undertaken in Chapter 4, which revealed the complexity and variability of anaesthetic room practice and the factors that influence it. Interviews also identified priorities in the decision making for the design of facility for the inclusion of anaesthetic rooms.

The team decision making of multiple stakeholders was studied in a hospital planning scenario in Chapter 5, which incorporated the evaluation of research evidence to reach a consensus for the inclusion or exclusion of anaesthetic rooms in a new theatre design.

Chapter 6 provided a case study of the financial and space implications of anaesthetic rooms for one NHS Trust.

Finally, the patient's experience was studied in Chapter 7 to understand the real impact of the anaesthetic room (or operating theatre) on patient anxiety and satisfaction.

Table 8.1 Summary of key research findings

Thesis Chapter	Main Objectives	Key Findings
Chapter 3 Evaluation of Current Practice	• Explore the role of ARs in current practice; • Determine how the AR is used; • Investigate the rationale for preferences of site of induction; • Test willingness to change; • Gauge best types of evidence to change practice	• There is still a prevalence of ARs built and preference for their use. • International experience promotes willingness to change practice. • The majority of anaesthetists do not wish to change to OT induction. • Preferences for the AR vary based on surgical specialty. • Preferences for the AR vary based on patient specific considerations.
Chapter 4 The Role of Anaesthetic Rooms	• Explore factors affecting AR use and inclusion in design; • Reveal the decision making for use of ARs and their inclusion in theatre design; • Identify potential barriers to changing anaesthetic practice	• Multi-level factors influence AR use, e.g. staffing, system delays, etc. • Patient experience is valued as compelling evidence to change. • Beliefs of AR cost-efficiency is based on perception. • National guidance is valued, although unknown. • Individual experience is presented as 'evidence'. • Infrastructure and tradition are powerful influences on practice. • ARs serve as physical boundaries, separating professional domains.
Chapter 5 Evidence-based Hospital Design	• Rank factors which would affect the inclusion of ARs in design; • Identify perspectives of other AR stakeholders; • Explore the impact of evidence on design decisions; • Form a consensus across all stakeholder professions	• The majority are in favour of retaining ARs in future theatre designs. • Patient safety was prioritised as the most important design factor. • Engagement with research literature was predominately by clinical consultants.
Chapter 6 Cost-efficiency of Anaesthetic Rooms	• Calculate time savings and downtime of theatres; • Evaluate the contribution of extra staff to overlapping induction; • Estimate the cost-benefit of ARs; • Determine the space commitment of ARs; • Observe the context from which the data was collected	• The monetary benefits of ARs may not exceed the capital costs and maintenance costs. • Financial benefit of AR is contingent on system factors supporting the overlapping use of ARs. • Variation of practice implies only certain surgical specialties financially benefit from ARs, and may require additional investments. • Specialisation of staff and surgical suites may reduce operational flexibility.
Chapter 7 Patient Experience of Surgical Anaesthesia	• Explore patient expectations for anaesthetic care; • Evaluate anxiety scores and causes of anxiety; • Measure the impact of the site of induction on anxiety; • Measure patient satisfaction regarding the site of induction	• Patients may come with expectations for the AR based on previous experience having operations. • Patients exhibit trust in the anaesthetist's choice for the site of induction. • The site of induction was not a significant modifier of anxiety levels. • Anxiety and patient experience can be managed through information provision and staff behaviour changes.

8.3 Achievement of Research Questions

The main research questions which were explained in Chapter 1 and the corresponding thesis study chapters are shown again in **Table 8.2**.

Table 8.2 Research questions and relevant thesis chapters

Research Questions	Ch. 3 Survey of Current Practice	Ch. 4 Clinical & Management Interviews	Ch. 5 Participatory Design Delphi	Ch. 6 Cost-Efficiency Analysis	Ch. 7 Patient Experience Survey
What is the role of anaesthetic rooms in UK anaesthetic and surgical practice?	✖	✖	✖	✖	✖
How cost-effective are anaesthetic rooms for mixed specialty providers?		✖		✖	
What are the clinical and management priorities for design and practice?	✖	✖	✖		
To what extent are design and practice of anaesthetic rooms evidence-based?	✖	✖	✖		

8.3.1 What is the role of anaesthetic rooms in UK practice?

As a foundation for this research, it was essential to explore the significance of the physical space and the purpose it presently serves to its users and engage stakeholders early in the research. This thesis has identified both the functionality of anaesthetic rooms as a healthcare facility and the attitudes and perceptions surrounding its use.

The utility of anaesthetic rooms was described in the literature presented in Chapter 2 and investigated further in Chapters 3-7, where stakeholders shared their knowledge and beliefs about the space. The practical contribution of the anaesthetic room is to provide a separate, and immediately situated location to the operating theatre. The designated site is, by name, reserved for anaesthetic activities such as the provision of anaesthetics, initiation of patient monitoring, pre-surgical checks, and storage of anaesthetic equipment, drugs, and supplies. All of these necessary operational activities are re-located, generally to the operating theatre, in organisations that do not have anaesthetic rooms. The widely held belief that patients should not be present for the set-up of surgical instrumentation underpins the use of separate spaces for the preparation of the patient and preparation of the theatre.

As it was in the past, anaesthetic rooms persist as a ubiquitous component of anaesthetic practice in the UK, largely due to existing infrastructure which was originally built to the standard of anaesthetic room use. In the absence of specific policies or national guidance that dictate the required site of induction, the choice is left to the discretion of the anaesthetic professional. The flexibility and degree of individual autonomy permitted by current practice is valued by anaesthetists, as was demonstrated in Chapters 3 and 4.

The evaluation of current practice revealed the variety of accepted practice dependent on individual preference, patient specific characteristics, surgical specialty, and the usability of available infrastructure (Chapters 3 through 6). The versatility of practice raised questions of how decisions should be made regarding the continued inclusion of anaesthetic rooms in hospital planning for mixed specialty services.

Throughout this research, participants were invited to share their perceptions of anaesthetic room use. The perception that the anaesthetic room improves patient experience was a widely shared belief, as the anaesthetic room was thought to safeguard the patient (and staff) from the noise, distraction, and busyness of the concurrent activities taking place in the operating theatre, which was presumed to affect anxiety. Perceptions of increased noise and distraction in the operating theatre are warranted (Campbell et al., 2012; Savoldelli et al., 2010; Liu & Tan, 2000); however, the link between the site of induction and anxiety was tested in Chapter 7, which concluded that the anaesthetic room is not a strong modifier of patient anxiety, nor satisfaction for all

patients. Although the investigation of pre-operative anxiety in Chapter 7 was not as controlled as previous work, findings were supported (Soni & Thomas, 1989b).

Improved efficiency from using the anaesthetic room for parallel working was also a common perception of use. The literature surrounding the overlap of anaesthesia to increase surgical throughput provided evidence that the anaesthetic room can be utilised for productive increases; although the studies included additional staffing or focused in specific specialties (Torkki *et al.*, 2005; Hanss *et al.*, 2005; Saha *et al.*, 2009). The cost-benefit of anaesthetic rooms working within standard practice (without intervention) was analysed in Chapter 6.

This research revealed an overwhelming resistance to changing anaesthetic practice and abandoning the use of anaesthetic rooms. As Oxman and Flottorp (2001) suggested, the areas affecting behaviour change are the environmental context, leading opinion, and knowledge and attitudes of those who undergo the change. Chapters 3 through 6 utilised qualitative and quantitative methods to uncover the relevant factors to the use of anaesthetic rooms and the possibility of shifting practice to in-theatre induction.

Investigation of the attitudes and opinions of anaesthetists presented underlying motivators for the continuation of current practice. The anaesthetic room was seen as a 'safe haven', not only for the patient, but to protect the anaesthetist from the impatient and watchful eyes of the surgical team. The boundary dividing the medical professions was defined by the set of doors physically separating the anaesthetic room from the operating theatre. Professional identities and boundaries are well-recognised barriers to improving patient care and knowledge sharing (Powell & Davies, 2012; Currie *et al.*, 2007). Intra-professional rivalries have been identified within operating room teams and between surgeons and anaesthetists as their professional boundaries are defended from role change (Lingard *et al.*, 2002; Powell & Davies, 2012). Consultant anaesthetists shared their understanding of the anaesthetic room as their personal domain, whereas the operating theatre is a space requiring the navigation of power dynamics with the surgeon(s). Non-medical, more junior staff members were also affected by the division of the anaesthetic and surgical teams, as it impacted team-working, definition of role responsibility, and break coverage.

The findings of this research have corroborated the longstanding opinion of the British anaesthetic community that anaesthetic rooms are the preferred site for anaesthetic induction of patients, which has remained relatively unchanged since the late 90's and early 2000's (Bromhead & Jones, 2002; Masters & Harper, 1990). The overwhelming preference to continue using anaesthetic rooms persists despite recent criticism of the practice surrounding the publication of the NAP5 report on accidental awareness during general anaesthesia (Frerk & Pinder, 2016; Nightingale, 2015; Lawrence & Ball, 2015). This resolution can be largely attributed to the cultural norms of anaesthetic care in the UK and an adherence to traditional ways of working. The transfer of the anaesthetised patient has become a normalised risk, which is reinforced through the tacit knowledge gained through problem solving and learning taking place within the sociotechnical system. This investigation has evidenced the embeddedness of shared beliefs, due to a standard of practice accepted by the majority of anaesthetists; the physical infrastructure of the hospitals in which they work; and the anaesthetic training that reinforces this standard to junior doctors. These organisational structures and cultural norms are fixed and serve to reinforce the status quo (Nutley & Davies, 2000), impacting expectations of both staff members and patients.

A major challenge to changing the site of induction is the tight coupling of interrelated sub-systems within the larger system. If anaesthetic rooms were to be decommissioned, additional facility would be required for the preparation of the patient including pre-medication, insertion of the cannula, and initiation of basic monitoring. In the US, a centralised pre-operative holding area is used for the preparation of patients close to theatres where nurses start intravenous fluids, antibiotics, check allergies, and the anaesthetist conducts the pre-assessment. The potential delays caused from requesting the transport of patients from the ward may be avoided by providing a sufficiently large centralised holding area for patient preparation. A similar movement to centralisation of facility can be exemplified by the shift from individual theatre sterilisation rooms to a central sterile supply department (Essex-Lopresti, 1999).

Furthermore, based on the commonly held belief, reported by stakeholders, that patients should not be present for the set-up of surgical instruments in the theatre, either the use of a separate space such as a prep room would be required, or else a coordinated effort would need to be made to prepare theatre prior to the patient arriving, or in a non-

disruptive way with the patient present. Modifying these beliefs will require behaviour change of professionals, agreed social arrangements, organisational culture, and possibly national guidance. Several factors highlighted within this research perpetuate the existence of anaesthetic rooms in the British surgical suite on multiple levels, and therefore require a targeted approach at all levels, in the aspiration of whole systems change.

8.3.2 How cost-effective are anaesthetic rooms?

As discussed in Chapter 6, the financial climate of the NHS and lack of government funding necessitates sound investments in NHS resources, including new infrastructure. Although the costing for construction of new facility or renovation of old facility was beyond the scope of this research, it aimed to measure the financial value of anaesthetic rooms as it relates to productivity potential and return on investment for the duplicated equipment made necessary by equipping anaesthetic rooms.

Chapter 4 presented findings that anaesthetists and managers held the perception of improved efficiency by using the anaesthetic room. This shared belief in the productive value of anaesthetic rooms was not based on research evidence, as stakeholders were largely unaware of any evaluations of anaesthetic room cost-effectiveness. Clinical experience and memory of historical ways of working supported the idea of parallel working, although it was acknowledged to be more infrequent. Literature has generally supported the use of anaesthetic rooms for increased patient throughput and profit (Hanss *et al.*, 2005; Sandberg *et al.*, 2005; Torkki *et al.*, 2005; Sokolovic *et al.*, 2002). The studies which investigated alternative work models required additional staffing of anaesthetists and additional personnel to suit the various specific models employed. This research question aimed to determine, not if, anaesthetic rooms are theoretically cost-effective, but if in reality, they are cost-effective. Research studies have not sought to capture the complexity and variability of surgical productivity, including the true cost of the anaesthetic room as a technological investment. In fact, economic evaluations and cost analyses are quite often lacking from implementations of improvement interventions (Grimshaw *et al.*, 2004).

The cost-benefit analysis conducted in Chapter 6 found anaesthetic rooms to be potentially beneficial in terms of throughput and revenue; however, the reality of

operational downtime, system delays, staffing requirements, scheduling, and internal trading all serve to diminish returns. Whilst several anaesthetic room stakeholders trusted that efficiency would decline if anaesthetic rooms were to be abandoned, they also acknowledged the difficulties in realising productive gains even with them being available. This case study of one NHS Trust's productivity and finances was also able to consider the implications for a mixed specialty service to invest in anaesthetic rooms despite lower returns for certain specialties by procedure (e.g. dental medicine, ophthalmology, urology, and oral surgery). Where certain specialties see higher than average profits per procedure (e.g. spinal surgery, cardiothoracic, vascular surgery, renal surgery, neurosurgery, elective and trauma orthopaedics, hepatobiliary, and general surgery), in a mixed specialty service, management decisions must be made to ensure all specialties are viable. The variance of anaesthetic room cost-effectiveness must be a consideration for future hospital designs as further specialisation of theatres to have anaesthetic rooms for only high profit specialties may also reduce the flexibility of use for surgical facility. The problem of anaesthetic rooms may not have a one-size fits all solution.

Criticisms of anaesthetic rooms can be understood through the lenses of quality improvement and lean, by using the results of process analysis (i.e. ORMIS data analysis) for goal setting and measuring improvement and eliminating causes of waste (i.e. duplicated equipment, extra tasks, see Phipps *et al.*, 2008). Additionally, this research has measured the opportunity cost of anaesthetic rooms by considering the space allocation of anaesthetic rooms in Chapter 6, and the theatre space that could fill the same space. According to Hurst and Siciliani (2003) increased theatre capacity could also have positive effects on waiting lists and health.

8.3.3 What are the priorities for design and practice?

Patient safety was the highest priority for those who preferred in-theatre inductions. Although it was not highly ranked in importance as a reason to use the anaesthetic room, in the Delphi study (Chapter 3) investigating design decision making, all stakeholders ranked patient safety as the highest priority for the theatre design scenario, despite a consensus agreement to build anaesthetic rooms adjacent to all operating theatres. The group consensus was inconsistent with the view of improved patient safety by inducing in-theatre. The disconnection of monitoring and breathing circuit of an unconscious

patient being transferred to the operating theatre is perceived as dangerous, particularly for high risk or obese patients. This risk to patients, although avoidable by eliminating the need for transfer between rooms, is diminished, as stated by one anaesthetist who wrote in *Anaesthesia* journal:

> *'Disconnection time during transfer is minimal (seconds), and so having the patient unoxygenated and the lungs unventilated remains a theoretical rather than a real clinical risk'* (Grimshaw, 2015, p.886).

Although the anaesthetic room may inadvertently provide latent conditions for the enabling of error and adverse incidents to occur (Reason, 2000), there have been no major accidents reported due to the use of anaesthetic rooms and transfer of the patient, apart from Brahams' (1990) telling of an accumulation of events leading to the accidental death of a patient. No reports were identified from this research that indicated a prevalent occurrence of harm due to the transfer of the patient to the operating theatre, which may contribute to the minimisation of perceived risk. The discrepancy of stated priority for patient safety and preference for anaesthetic rooms either reflects a lack of concern for the risk of disconnection and transfer, or an increased perception of patient safety risk related to in-theatre induction.

The belief that the anaesthetic room is safest to prevent anaesthetic distraction in the operating theatre emerged in Chapters 4 and 5. These findings presented a conflicting account of the shared understanding of what is safest for the patient. This evidenced the social construction of what is believed to be safe or unsafe. Although patient safety is promoted in health policy with the effort of improving safety culture, the perception of safety has been argued to be a social construction requiring interpretation by people, which is impacted by collective agreement and socialisation (Simpson, 1996). While organisations widely consider clinical risk as an objective and observable measure, the interpretation of risk is inter-subjective, reliant on context, and emotionally involved (Waring, 2009). The localised knowledge of patient safety can reflect cultural beliefs regarding professional responsibility, which doctors may minimise when interpreting risk and reapportion blame to others in order to protect themselves (Waring, 2007; Mizrahi, 1984). This understanding of the social construction of patient safety grants legitimacy to the conclusion that the majority of British anaesthetists find the risk to patients during transfer to be acceptable and manageable (minimising their own

responsibility), yet find distraction by others in the theatre to be a danger to patients (reallocating blame across professional boundaries). The normalisation of this risk is integrated into individual beliefs and clinical routines, thereby increasing perception of safety in the practice (Vaughan, 1999).

The patient experience was also highly regarded in the choice to use the anaesthetic room for induction which was demonstrated by high importance of perceived quietness of the environment (benefiting both patients and staff) and the perception of an improved patient experience. Similarly, all stakeholders considered patient privacy, anxiety, and satisfaction to be important in designing new theatres. Patient feedback was viewed as the most important form of evidence required to change practice, in Chapter 3, yet findings from Chapter 7 revealed a relative indifference by patients for the site of induction.

Efficiency was identified as one of the most important factors for design of theatres, predominately valued by anaesthetists and surgeons, though efficiency was not of high importance to anaesthetists in determining their preferred practice. Although managers expressed an interest in cost and efficiency data as compelling evidence for change during interviews in Chapter 4, efficiency was surprisingly not prioritised as a design factor for theatres by the few managers who participated in the Delphi study.

This research has made explicit the priorities motivating design and practice decision making regarding anaesthetic rooms. Interviews of managers and anaesthetists in Chapter 4 revealed a need to involve anaesthetic room users and stakeholders in the future planning and (re)design of theatres, which was done in the Delphi study in Chapter 5. This participatory approach to design revealed the differing priorities of various stakeholder groups and their involvement in the evaluation and critique of research evidence. This misalignment of goals between user groups poses a challenge to organisational change, as the competing priorities or beliefs of various individuals may conflict. For example, if managers chose to eliminate anaesthetic rooms completely for cost saving purposes (a likely management priority), they may face resistance from anaesthetists in order to retain their autonomy -even if it conflicts with best evidence (Oxman & Flottorp, 2001; Traynor, 2002). How then should organisations improve their practice in light of competing priorities of its members? The human factors approach to systems improvement encourages optimisation of

human performance, quality, and safety; however, improvement interventions or technologies may have both positive and negative effects on the optimisation criteria, making decision making more problematic. The modified Delphi study aimed to unite all relevant stakeholders to form a consensus opinion on recommendations for anaesthetic room construction and design factor prioritisation. A participatory approach to systems change may be the best way forward for organisational management and design, in order to design or select the best solutions for the whole system.

8.3.4 To what extent are design and practice evidence-based?

The outcomes of this research have provided insight into the rationale of various clinical personnel and managers with regards to anaesthetic room induction and the degree to which those decisions are evidence-based. As stated in the literature review of this thesis, the typical understanding of 'evidence' is that of research evidence, scientifically conducted, and peer-reviewed. The survey in Chapter 3 revealed that peer-reviewed journal publications were near the bottom of the most important forms of evidence to bring about change in practice. This research demonstrated the upholding of tradition and individual experience as a support for current practice, in lieu of full knowledge of best available research evidence. While personal experiences are important in developing tacit knowledge within professions, in isolation it is not regarded as high quality evidence as justification for practice, but may be the default source of evidence for many decision makers in healthcare.

Rycroft-Malone *et al.* (2004) suggest that clinical experience is required alongside patient experience, context, and research evidence to make evidence-based decisions for patient care. Although the aspiration of evidence-based practice (EBP) is appreciated, suggested by participants' stated desire for evidence, this research has shown three major challenges to EBP implementation:

- *Relevant research does not exist*. This challenge focuses on the gaps in literature, where certain treatments, practices, or interventions have not yet been investigated.
- *Research is unknown*. This is important in the case that scientific evidence is available; however, it is not known to the practitioner either due to a lack of

engagement in the pursuit of EBP, or due to an inability to access and/or critically evaluate research.

- *Research is not strong/compelling enough*. This challenge is pertinent to situations unlike the previously mentioned, as research is available and practitioners are both engaged and have the skills to make discernments of the quality and applicability of research evidence.

Research Does Not Exist

As will be discussed, there were various areas identified through this research which require study and evaluation with regards to the anaesthetic room. Studies evaluating specific incidents of harm to patients or staff members from the physical transfer of the anaesthetised patient have not been conducted. Another area that has not been explored is the amount of work stress experienced from anaesthetising in the anaesthetic room compared to in theatre. Infection control is a topic of further consideration, which was beyond the scope of this thesis. Further examples of research which was not available regarding anaesthetic rooms can be found in **Table 8.3**. The absence of specific research also draws attention to those who are conducting research and for what reasons. The incentives for research investigations and funding opportunities also impact the depth and breadth of specific research topics.

Research Is Unknown

Chapters 3 and 4 revealed that the evidence base for national guidance was highly trusted by anaesthetists; however, many anaesthetists did not know what national guidance had to say regarding anaesthetic rooms. Most anaesthetists and managers in Chapter 4 also showed a lack of awareness of any evidence pertaining to the patient perspective of anaesthetic rooms, which was of great interest to all stakeholders. When presented with a sample of research evidence in Chapter 5, the impact of the research findings on the choice of build for theatres was minimal, partly attributed to poor quality of evidence. The study lacked engagement from surgeons and managers specifically, which could have been due to the nature of the study and its emphasis on anaesthetic rooms. Interviews showed an apparent deflection of responsibility from managers to anaesthetists for knowing about current research on anaesthetic rooms. This research has begged the question, “Whose responsibility is it to seek out and evaluate evidence

for designs or practices which impact multiple stakeholders across whole systems?" It can be argued that although anaesthetic rooms are central to anaesthetic practice (at least in the UK), the greater implications of the room on organisational factors such as cost, productivity, staffing, scheduling, and patient experience should not solely be the responsibility of the anaesthetists who use them. Evidence-based management may help to improve the uptake of EBP in complex systems. The findings necessitate improved collaboration between management and clinicians to integrate best evidence with organisational decision making, particularly in design decisions for the built environment, which will permanently impact upon practice.

As mentioned previously, the professional boundaries of the anaesthetic and theatre teams hinders change of practice. The varying priorities of these stakeholders require involvement of all relevant people for the design of practice -optimising the objectives of the whole system. By involving all stakeholders in a participatory design approach, whilst incorporating EBP in decision making, it is important to consider the abilities of those stakeholders to participate fully in the process. The Delphi study showed more criticism of the research presented by the medical staff, whereas theatre nurses, ODPs, HCAs, SWs, and managers were less critical of the quality of the research or the veracity of the findings. This may be indicative of non-medical staff being less engaged in the process of EBP or lacking the skills to access and critique scientific research. Although nurses are formally trained in EBP and have the skills necessary to review research evidence, Gerrish and Clayton (2004) found that nurses still relied mostly on tacit knowledge than research, partly due to lack of time, resources, and perceived authority to enact change. Other theatre staff members, OPDs and auxiliary staff, may not have EBP requirements within their educational training, thus creating a barrier to their involvement in EBP decision making. Walshe and Rundall (2001) also suggested the difficulty in healthcare managers using EBP/EBM due to a lack of training in evidence appraisal and reliance on personal experience.

Research Is Not Strong Enough

Participants desired evidence as a motivator to change practice; however, they required the evidential findings to be sufficiently compelling. Much of the literature regarding the efficacy of anaesthetic rooms has been found to be conflicting (see **Table 8.3**, identifying evidence supporting both positive and negative perceptions of anaesthetic

rooms), depending on the specific quality of anaesthetic rooms that is being assessed. Strength of evidence was not defined as such by participants, but it has been interpreted to mean the quality of the research findings, the agreement of studies, and the topics to which the evidence addresses.

Although research of the patient experience was valued by stakeholders in all studies of this thesis, the patient survey in Chapter 7 did not show a significant difference in anxiety or satisfaction based on the site of induction. Interviews suggested findings would have to show an improved patient experience in the operating theatre, for change to occur, whereas inconclusive or insignificant evidence may only serve to reinforce the status quo. This is supported by Ferlie *et al.* (1999) who stated that research evidence has more power when it matches clinical experience. Several participants indicated that even if research does not support current practice, if it did not prove an alternative to be better, they would retain current practice. Antman *et al.* (1992) found practitioners to be resistant to changing practice even after a treatment was determined to be ineffective. The strong resistance to change exhibited throughout this thesis may also be connected to the threat on professional autonomy of eliminating the anaesthetic room and sharing the operating theatre, as has been seen in the acceptance of information systems (Walter & Lopez, 2008).

The varying skill levels of different healthcare practitioners in appraising research evidence and the absence of high quality evidence can create great challenges to making evidence-based decisions for the design of healthcare systems. This thesis has reflected the challenges and barriers to making change based on research evidence. The subjective critique of evidence, lack of evidence, in ability to participate in EBP, and tendency to interpret findings to reinforce current practice all inhibit improvement change. The reliance on experiential knowledge, perceptions shaped around the current context and standards for training and accepted practice, all serve to reinforce the status quo.

8.4 Balancing the Work System of Anaesthetic Rooms

The holistic exploration of factors influencing the use of anaesthetic rooms throughout this thesis has identified the necessary components to construct a SEIPS 2.0 model (Holden *et al.*, 2013) for anaesthetic rooms.

The use of anaesthetic rooms can be described as mainly professional work, although there will be some elements of collaborative professional-patient work at times. While the main agents are anaesthetists, additional co-agents include anaesthetic and theatre non-medical staff, surgeons, managers, patients, and sometimes patient family members, such as the case of paediatric patients, where they can be involved with the communication and comfort of the patient.

The factors relevant to the work system were reported, explored further, and are described in **Table 8.3**, considering factors within the categories of person(s), tasks, tools and technology, organisation, and both internal and external environments. **Figure 8.1** depicts the presence of numerous simultaneous interactions of system factors. The relative importance of some factors to system agents and co-agents, as shown with larger nodes, was made evident by the frequency of expression of those work system factors in study chapters 3 through 7 of this thesis.

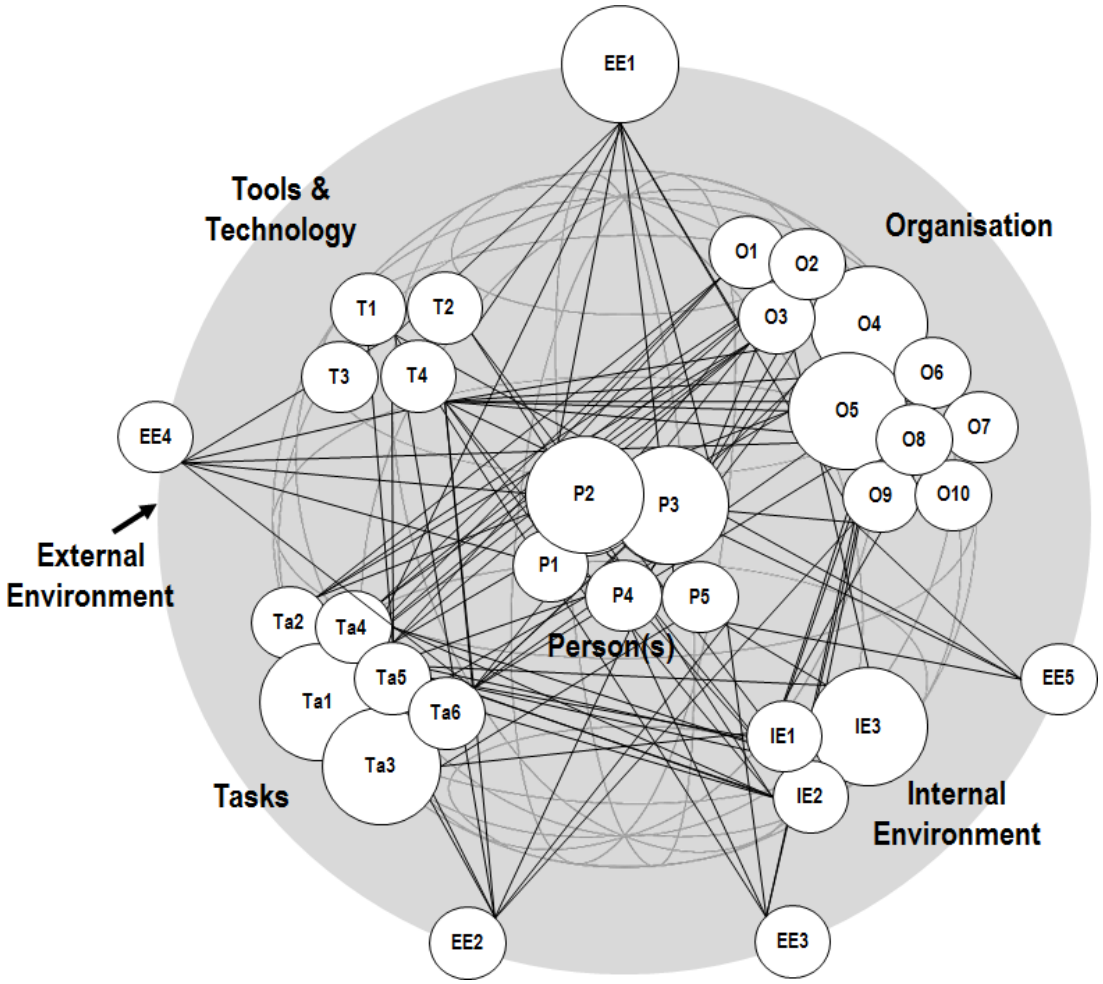


Figure 8.1 The interacting work system diagram of factors influencing anaesthetic rooms

Table 8.3 Work system factors and interactions for anaesthetic room contribution to performance and well-being

Work System Factors	Factor Descriptions	Interactions	Chapter(s)
Person(s)			
P1. Patient expectations	-The expectations patients have for their anaesthetic care.	O2, EE1	Ch 4,6,7
P2. Patient experience	-Elements of privacy, comfort, and satisfaction of their care.	P1,3, IE2,3	Ch 3,4,5,7
P3. Patient anxiety	-Specific patient experience related to fear and anxiety, also linked to parent/guardian experience for paediatric patients.	P1,3, Ta3, O2, EE1	Ch 3,4,5,7
P4. Patient health & needs	-Individual patient health background and requirements for anaesthetic/surgical care (i.e. surgical specialties).	Ta5,6, T4, O3,4,5, IE2, EE2,3	Ch 3,4,6
P5. Staff expectations	-The expectations staff have for provision of care in the UK.	Ta3, EE1-5	Ch 3,4
Task			
Ta1. Staff autonomy	-Factors of job control, autonomy, and professional domains.	P5, Ta2-6, O1-3, IE1-3, EE1-2.	Ch 3,4,6
Ta2. Staff time pressure	-Perceptions and realities of job stress and time pressure.	Ta5, O1-3,5	Ch 3,4,5,6
Ta3. Anaesthetic norms	-Links to the ease of abiding by familiar work norms.	P5, Ta1,2,4, IE3	Ch 3,4
Ta4. Distraction	-Related to interruptions and cognitive load on staff.	P5, Ta1-3,5, O1-3, IE2,3	Ch 4,5
Ta5. Theatre preparation	-Sequence of tasks for preparing and turning over theatres.	Ta3, T1,4, O1,3,5, IE1-3, EE2	Ch 3,4,5,6
Ta6. Orthopaedic practice	-Variety of practices based on specific specialty requirements.	Ta3,5, T4, O3-5,8, IE2, EE4	Ch 3,4,6
Tools & Technology			
T1. Patient monitoring	-Availability of monitoring equipment and provision of continuous monitoring or anaesthetic for patients.	Ta5, EE1-4	Ch 4,5,6
T2. Accessibility of supplies	-Accessibility of required anaesthetic drugs and supplies.	IE1-2, EE1	Ch 3,4,5
T3. ORMIS Data Entry	-Usability of the ORMIS system and inputting reliable data.	O4-7, EE2	Ch 6
T4. Laminar flow	-Specialised technology limiting flexibility of theatre use.	Ta6, O8, IE2, EE4,5	Ch 3,4,6
Organisation			

O1.Teamwork	-Elements of team coordination and shared understanding.	Ta1,3,4, O2,3	Ch 3,4,5
O2.Teaching & communication	-Communication to patients, staff, and training staff.	P1,5, Ta1,2, IE3	Ch 3,4,5,6
O3.Staffing	-Work scheduling, staffing numbers, and staff shortages.	Ta3-6, O2,4,5, EE1	Ch 4,5,6
O4.Cost & revenue	-Organisational objectives for cost reduction and profiting.	T3, O3,5,10	Ch 4,5,6
O5.Efficiency	-Organisational objective for enhancing efficiency (i.e. linked to the occurrence of anaesthetic overlap).	Ta2,5,6, T3, O3,4,10	Ch 3,4,5,6
O6.Patient transport system	-Peripheral systems affecting AR system performance.	P2, T3, O5,7, IE1	Ch 4,6
O7.Pre-op & recovery units	-Peripheral systems affecting AR system performance.	P2, T3, O5,6, IE1	Ch 4
O8.Infection control	-Organisational objective to contain hospital infections.	Ta6, T4, IE1,2, EE3,4	Ch 3,5
O9.Organisational policy	-Policies that would guide facility use and safe practice.	EE1-5	Ch 3,4
O10. Incentives/rewards	-Incentive system for promoting organisational performance.	Ta1,2, T3, O4,5	Ch 6
Internal Environment			
IE1. Existing infrastructure	-Relevance of the remnants of older infrastructure.	Ta1,5, T2, O6-8	Ch 3,4
IE2. Size & layout	-Elements of physical size and layout affecting practice.	P2,4, Ta1,3-6, O8	Ch 3,4,5,6
IE3. Noise	-Noise in the surgical suite environment and its effects.	P2, Ta1,3-5, O2	Ch 3,4,5
External Environment			
EE1. Tradition	-Elements of cultural tradition (not bound by an organisation) that reinforce the use of ARs for service provision.	P1,3,5, Ta1, T1,2, O3,9	Ch 3,4
EE2. Anaesthetic Training	-The influence of norms within anaesthetic training.	P4,5, Ta1,5, T1,3, O9	Ch 3,4
EE3. National guidance	-Relevance of guidance from UK professional bodies.	P4,5, T1, O8,9	Ch 3,4,5
EE4. Literature	-The impact of journal publications and relevant literature.	P5, T1,4, O8,9	Ch 3,4,5
EE5. Benchmarking	-Seeking guidance for best practice with external organisations.	Ta6, T4, O9	Ch 3,4

The work processes of anaesthetic rooms can be understood as physical, cognitive, and social performance processes. Although the anaesthetic room is a facility for the physical transformation of a patient to a state of being monitored, anaesthetised, and made ready for surgery, its use requires decision making, communication, and teamwork of healthcare practitioners and other cognitive and psychosocial processes.

A key proximal outcome of using anaesthetic rooms is the timeliness of preparing a patient for surgery to enhance overall theatre efficiency, although there may be distal outcomes for the organisation such as socialised reliance on the facility despite varying impact on efficiency across all specialties. A systems approach to understanding the use of anaesthetic rooms, shows the distal outcomes affecting professionals (i.e. normalising patient safety risk), and patients (i.e. forming social expectations for the location of anaesthetic provision).

Although SEIPS 2.0 provides a holistic macroergonomic approach to modelling the complexity and interactions of system factors as obstacles and facilitators for improved performance and well-being, the identification of these relevant factors is only the beginning to optimising the system. The Balance Theory (Smith & Sainfort, 1989) is a useful conceptualisation of the needs to counteract job stresses and negative aspects of the work system to make overall improvements; however, it does not provide the tools for decision makers to reconcile perceptions and actualities of their processes, and making value judgements with regards to the competing objectives of individual patients, care givers, managers, and the organisation. This thesis has identified the competition of factors, such as patient safety, quality of care, and performance objectives (i.e. efficiency and cost), but a method is required to confront the positive and negative aspects of the work system and find balance for all participants of the system. The following section draws upon research evidence as a central component to challenging perceptions and embeddedness of the status quo, and developing best solutions for safety, quality, and performance process improvement.

8.5 Analysis of the Evidence Base for Anaesthetic Rooms

The evidence available to compare the continued use of anaesthetic rooms to an alternative of in-theatre induction without anaesthetic room is compared in **Table 8.4**.

8.5.1 The Analysis Framework

The two options for site of induction, the anaesthetic room (status quo) or operating theatre ('intervention'), were evaluated using an ad-hoc analysis method based on a human factors and ergonomics (HFE) systems approach with the incorporation of evidence for the basis of decision making. This analysis method aimed to systematically and explicitly address the trade-offs involved in choosing between the status quo or intervention in both design and practice. As HFE emphasises optimisation of performance and well-being (Dul *et al.*, 2012), this framework draws from Holden *et al.*'s (2013) SEIPS 2.0 work systems model to improve safety, quality, and performance of the system. Whilst the SEIPS model is used to systematically identify barriers and facilitators to performance, an additional tool or method was required to take the knowledge of important work system factors and formulate solutions. This framework aims to provide a decision support method to optimise competing priorities. Ideally, this type of analysis could be undertaken with multiple stakeholders and evaluated together to reach consensus on prioritisation, importance, and evaluation of evidence.

Perceived (Dis)advantages

Based on the studies conducted in this thesis, a list of outcomes, advantages and disadvantages, were compiled to be compared between the status quo option and intervention alternatives. Emphasis was placed on describing the (dis)advantages as 'perceived' in order to address the possibility of lack of evidence to support the claims. A column of perceived (dis)advantages is listed for the status quo option, and related perceptions are listed for the intervention -discussed further at a later point. Each perception is given a (+) or (-) sign to indicate whether the perception is a positive or negative outcome of the option being evaluated.

Table 8.4 Summary of evidence for safety, quality, and performance of anaesthetic rooms

Anaesthetic Room Inductions (AR + OT model)						Operating Theatre Inductions (OT only model)					
±	**Perceived (Dis)advantages**	**E**	**S**	**I**	**Source(s)**	**±**	**Perceived (Dis)advantages**	**E**	**S**	**I**	**Source(s)**
SAFETY											
+	Fewer distractions in the AR	Y	Y	H	Broom et al., 2011	-	Increased risk of distraction in OT	Y	M	H	Campbell et al., 2012; Savoldelli et al., 2010
-	Risk of patient apnoea/hypoxia	Y	Y	L	Broom et al., 2006; Riley et al., 1988	+	Apnoea/hypoxia risk avoided	Implied			
-	Risk of accidental awareness	Y	Y	L	Pandit et al., 2014	+	Gap in anaesthesia avoided	Implied			
-	Disconnection of monitoring	Y	Y	L	Broom et al., 2006; Riley et al., 1988	+	Continuous monitoring	Implied			
-	Risk of harm during transfer	N		L	(See Evans, 2004)	+	Transfer risks avoided (partially)	Implied			
+	Improved infection control	N		L		-	Reduced infection control	Implied			
QUALITY											
+	Reduced patient anxiety	Y	N	H	Soni & Thomas, 1989b; Chapter 7	-	Increased patient anxiety	Y	N	H	Soni & Thomas, 1989b; Chapter 7
+	Improved patient satisfaction	Y	N	H	Chapter 7	-	Reduced patient satisfaction	Y	N	H	Chapter 7
+	Quieter space	Implied				-	Louder space	Y	Y	H	Liu & Tan, 2000; Hodge & Thompson, 1990
+	Parental presence is possible	Y	Y	H	Ryder & Spargo, 1991	+	Parental presence may still be permitted in the OT	N		L	(See O'Connor et al., 2003)
+	Increased professional autonomy	Y	Y	H	Chapter 4	-	Reduced professional autonomy	Implied			
-	Reduced teamworking / learning	Y	Y	L	Goodwin et al. 2005	+	Improved teamworking / learning	Implied			
+	Less time pressure / work stress	N		L		-	More time pressure / work stress	Implied			
+	Improved teaching & communication	N		L		-	Impaired teaching & communication	Implied			
-	Less space for anaesthetics	Y	Y	L	Chapter 6	+	More space for anaesthetics	Y	Y	L	Chapter 6

PERFORMANCE											
+	Potential for anaesthetic overlap	Y	Y	H	Torkki et al., 2005; Hanss et al., 2005; Sokolovic et al. 2002; Chapter 6	-	Lost potential for anaesthetic overlap	Y	Y	H	Torkki et al., 2005; Hanss et al., 2005
-	Duplicated equipment	Y	Y	L	Chapter 6; See Bromhead & Jones, 2002	+	No duplicated equipment	Implied			
-	Additional tasks required	Y	Y	L	Phipps et al., 2008	+	Fewer tasks required	Implied			
-	Higher staffing requirement	N		L	(See Torkki et al., 2005)	+	Lower staffing requirement	Implied			
-	Fewer usable theatres in the same space	Implied				+	More theatres, waiting list reduction	Y		L	Hurst & Siciliani, 2003
+	AR usable as staging area	Implied				-	Staging area required, possible delay	N		L	

± Negative (-) or positive (+) perception; E = Evidence available (Yes/No); S = Evidence supports perception (Yes/Mixed/No); I = Importance to stakeholders (High/Low)

Several of the perceived advantages/disadvantages are inversely related to perceptions of the 'intervention', therefore evidence in support of one perception may logically support its complementary part (i.e. implied). Red highlighting marks perceptions with no evidential support; Yellow highlighting marks mixed or conflicting evidence; Blue highlighting marks specific perceptions of anaesthetic rooms that have evidence comparing between the status quo and the intervention, i.e. anaesthetic room versus operating theatre inductions.

The perceptions were grouped in three broad categories of safety, quality, and performance, to assist in the optimisation of these potentially competing priorities. Using the priorities stated in the earlier studies, the perceptions were ordered in order of safety, quality, and performance, relating to stakeholder value in patent safety foremost, followed by patient experience, and lastly efficiency.

Evidence / Support

The existence of research evidence is indicated by the column 'E' for evidence, which is marked with a Yes (Y) or No (N) for the presence of some form of evidence addressing the specific perceived (dis)advantage. If evidence is available, the source reference is provided and the column 'S' represents support for or against (Y or N) the perceived (dis)advantage. If multiple sources of evidence are available with conflicting findings, then support can be indicated as mixed (M), and is highlighted orange to emphasise the uncertainty of the mixed evidence for the perception.

For example, in **Table 8.4**, the risk of patient apnoea due to disconnection of ventilation in the transfer of the patient is marked as (-), Y, and Y, because the perception is a negative outcome of anaesthetic room induction, research is available addressing this perception, and the evidence (Broom *et al.*, 2006; Riley *et al.*, 1988) supports the claim of patient apnoea being a patient safety risk.

For patient anxiety, under quality, anaesthetic induction is thought to reduce patient anxiety, which is an advantage (+); however, evidence does not support this to be a fact (Soni & Thomas, 1989; Chapter 7 results), so is therefore marked as Y and N. All (dis)advantages with either relevant evidence (N), or evidence that does not support the perception (Y and N), are marked in red to highlight the inaccuracy of or lack of support for the perception.

Importance

Importance of each (dis)advantage is marked in column 'I' as either high (H) or low (L). This categorisation of perceptions means to assist in the decision making process to address the perceptions of highest importance to stakeholders with greater weight, or highest priority. The allocation of high or low importance was made to the factors listed in **Table 8.4** based on stakeholder feedback.

Implied Relationships

As mentioned earlier, the relationship between perceptions of the status quo and intervention may be inversely related. For example, the disconnection of monitoring required due to the transfer between rooms of the patient using anaesthetic rooms is inversely related to the intervention of having no anaesthetic rooms. In the absence of anaesthetic rooms (operating theatre only), the disconnection is no longer required and continuous monitoring is achieved. As this is logically related, and no study would need to be done to prove continuous monitoring would be achievable, the relationship is indicated as 'Implied'. Therefore, any evidence to support the claim that having anaesthetic rooms require the disconnection of monitoring, would by extensions confirm the alternative.

Studies which have evaluated certain (dis)advantages between the two alternatives, such as patient anxiety, are highlighted in blue. These studies do not require an implied relationship and evidential support, as they have explicitly been evaluated. For example, studies such as Torkki *et al.* (2005) specifically compared between an induction room model of working and an operating room only. The noise study, commonly cited in the debate on anaesthetic rooms, Liu and Tan (2000), did not measure noise levels with intention to compare between anaesthetic room induction and operating theatre induction, therefore the finding that induction is a louder phase of anaesthesia does not have direct implications as a comparison of the same processes undergone in two different locations.

8.5.2 Evaluation Using the Analysis

Using this ad hoc method has provided a transparent, and systematic way of addressing various stakeholder perceptions and priorities and integrating knowledge of best evidence into the decision making process in an explicit, intentional way. Drawing from the Balance Theory (Smith & Sainfort, 1989), as described in the literature review, this method balances the work system to optimise individual and organisational goals. As negative elements of the work system (disadvantages) cannot always be eliminated, a compensatory balance of positive elements outweighing negative elements or overall system balance can be achieved. The difficulty of balancing work system elements is

whether to assume all (dis)advantages are equal. In this analysis, some factors are given higher importance, as they have been prioritised by stakeholders.

Safety

Patient safety was the most important factor for the decision making regarding both design and practice regarding the induction of anaesthesia. In comparison of the traditional model and operating theatre only model, research evidence was available for the highest rated perception of higher distraction in the operating theatre, and also risks associated with disconnection and transfer of the patient. Although evidence exists to indicate a lower occurrence of distraction in the anaesthetic room, distraction research is mixed as to if there is a higher occurrence in a theatre only model. The remaining perceptions are supported by evidence to indicate a more prevalent patient safety risk for anaesthetic room inductions. Further research should consider the infection control implications for changing to in-theatre induction with current standards of air handling.

Quality

Several of the perceptions related to quality (for both practitioners and patients) were referenced frequently, and so rated of high importance. Although perceptions of increased patient anxiety and reduced satisfaction in the operating theatre exist, evidence does not support those perceptions. Evidence was available to support several advantages of anaesthetic rooms, such as quietness, parental presence, and retaining professional autonomy.

Performance

Finally, regarding performance the most important factors was the potential for achieving anaesthetic overlap using the anaesthetic room, which is made impossible in the intervention alternative. Based on several research studies of parallel working using the anaesthetic room (Torkki *et al.*, 2005; Hanss *et al.*, 2005; Sokolovic *et al.*, 2002; Chapter 6), there is clear support for the potential for increased performance with proper staffing and scheduling using anaesthetic rooms. Overall, of factors of lower importance, there are more disadvantages related to duplicated equipment and work for the status quo model.

The conclusions made from this analysis along with recommendations will be expressed in Chapter 9.

8.5.3 Benefits and Limitations of the Analysis

This analysis method was a novel technique for systematically evaluating best evidence and aligning priorities and goals of individuals and the organisation. The table of perceptions and evidence considers system wide factors, such as the potential need for a staging or holding area for patients if the anaesthetic room is dismantled. For perceptions that are not based on evidence, gaps in the research literature are identified for suggestion of future investigation. For perceptions which are disproved by evidence, readjustment of those perceptions and both individual and organisational learning can take place.

This analysis method is intended to incorporate involvement from all relevant stakeholders to the problem being solved or the question being asked. For the application of this type of analysis to hospital planning, the consequences of the potential designs must be considered along with best evidence, but responsibility for such an effort can be uncertain. By undertaking a participatory design approach, involvement of all stakeholders can determine all perceptions, priorities, and evidence for evaluation. By utilising such a method and increasing involvement in the design of practice, infrastructure, and technologies, engagement in the EBP initiative will be enhanced, new skills for research utilisation can be transferred, and organisational learning can occur.

A limitation of this ad hoc analysis is the lack of evaluation of the quality of evidence. Whilst grading systems do exist, which could be integrated into the analysis, examples such as the Grades of Recommendation, Assessment, Development, and Evaluation (GRADE) system (Oxman & GRADE Working Group, 2004), may not be as appropriate for systems redesign and optimisation, as the GRADE system is oriented toward evaluation of medical interventions and treatments. Although high value is placed on randomised controlled trials and systematic reviews, there may not be such high level research for the complex problems that need addressing in designing healthcare systems. For this reason, a grading system which is open to qualitative research methods and rich contextual evaluations would be beneficial.

The listed perceived outcomes, the order in which they are prioritised, and the importance given are suggested to be done by a group of stakeholders. The importance given to each outcome could be quantitatively weighted, and determined statistically through a Delphi study similar to the one done in Chapter 5. This analysis did not weight the importance besides High and Low, because the importance was not evaluated for all outcomes listed.

Additionally, the use of this analysis for comparison of anaesthetic rooms to operating theatres only did not consider alternative models such as shared anaesthetic rooms or centralised block rooms. This was in order to compare the systems of having anaesthetic rooms for all theatres or no theatres, as available literature focused on those two options as the most prevalent for hospital design.

8.6 Novel Contributions to Knowledge

This body of research has provided several novel contributions to knowledge in the areas of anaesthesia, healthcare management, evidence-based practice (EBP), and human factors and ergonomics (HFE). The purpose of this thesis has been to critically analyse a deeply embedded part of anaesthetic practice in the UK to determine the appropriateness of change, the readiness for change, and the best strategies for implementation of change.

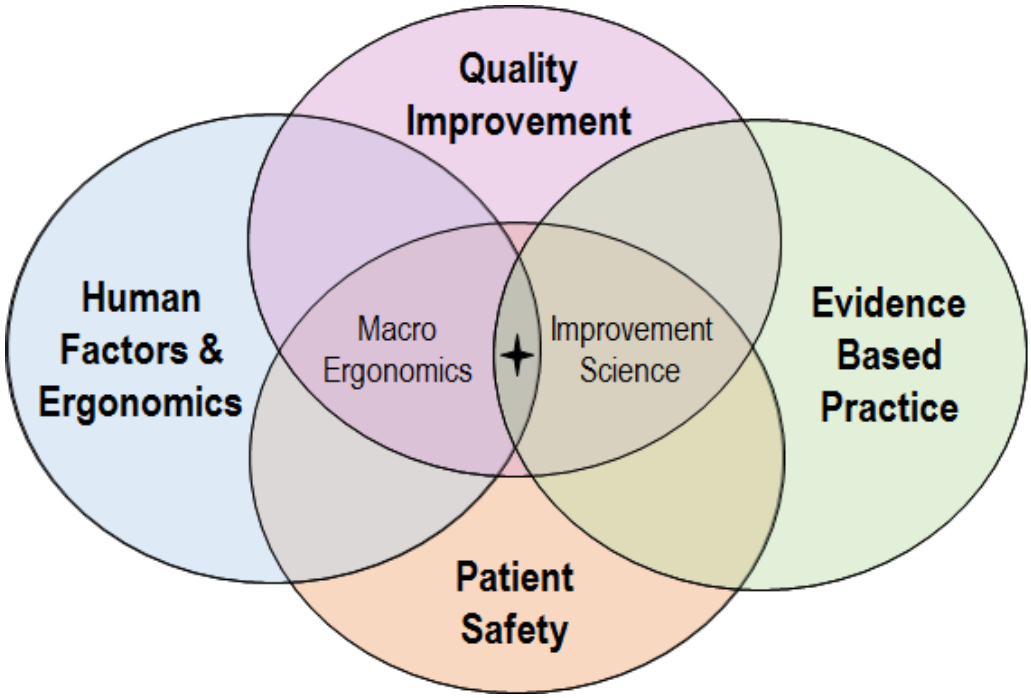


Figure 8.2 The multi-disciplinary approach to healthcare improvement

There are several approaches to healthcare improvement, all with overlapping agendas. As presented in the literature review, there are four dominant disciplines which are called upon for the improvement of systems and practices in healthcare: quality improvement, patient safety, evidence-based practice, and human factors and ergonomics. As shown in **Figure 8.2**, this thesis has identified the need for an integrated, multi-disciplinary approach to healthcare improvement, which utilises HFE systems thinking and methods to bring about improvement change guided by best evidence. The existing HFE healthcare literature does not integrate the EBP agenda, and therefore presents a gap in understanding how to optimise work systems and make decisions which are best for the competing needs (and desires) or the organisation, the practitioner, and the patient.

The six studies conducted within this thesis have provided the most comprehensive evaluation of anaesthetic rooms available using a human factors systems approach. It has integrated best evidence from published literature, and investigation using both quantitative and qualitative methods to formulate recommendations (see Chapter 9). This research captured the most current views of anaesthetic preference and practice regarding anaesthetic rooms. Expanding on earlier surveys, editorials, and correspondences voicing consultant opinions, this research has systematically studied the decision making of anaesthetists and relevant stakeholders, which has evidenced the resistance to changing practice based on prevalent cultural norms and tradition, the role of existing infrastructure, embedded professional boundaries, and a normalisation of risk. Moving beyond a listing of advantages and disadvantages of anaesthetic rooms, this research has made explicit the decision making priorities of both the standard use of anaesthetic rooms in practice and their perpetuation in future planning of theatres. This research has identified the need to involve all users in the development of hospital design and practice, address deeply rooted assumptions and perceptions, and challenge the status quo to enhance innovation and forward thinking in terms of hospital planning for the future.

The case study of the cost-benefit of anaesthetic rooms in one NHS Trust has provided a comprehensive evaluation of the on-going expenses of anaesthetic rooms and the implications for staffing and scheduling within a multi-specialty service. This cost-effectiveness study has presented the results and methods of the most holistic and

inclusive model for estimating the costs and benefits of anaesthetic rooms, which may be valuable for other Trusts to determine the financial implications of anaesthetic rooms within their own organisations.

Exploration of the patient's experience, including expectations, has helped to fill the gap in literature regarding the impact of the site of induction on the patient. As customer expectations are regularly studied in business research, it is also beneficial to conduct such research with patients to improve the health service industry. Although the involvement of patients in the delivery of care is sought in EBP, this research has demonstrated the importance of engaging patients in the design of practice, as their experiences may differ from the assumptions of the healthcare practitioner.

The modified participatory design Delphi used within this research to integrate research evidence in decision making is a novel contribution to healthcare management, participatory design, and EBP, by proposing a new method for evidence-based team-decision making. This method makes explicit the research evidence which is relevant to the decision at hand. In this research, a small sample of evidence was compiled by the researcher in order to compare opinion before and after; however, in practice, all stakeholders involved in the participatory design process could present their own evidence. This integration of EBP and participatory design may serve as a way to gain consensus in light of conflicting evidence, and transparently form design decisions to suit multiple stakeholders and address available research.

The analysis of anaesthetic room research evidence, presented in section 8.5, proposes a novel and integrated approach to synthesising research evidence, challenging perceptions of practice, involving multiple stakeholders, and transparently balancing priorities and evidence in order to optimise patient safety, quality of care, and performance. This combination of improvement approaches, like the modified Delphi, is a valuable method for challenging the status quo (in practice, design, and thinking) and making decisions which are aligned with stakeholder priorities and available scientific evidence.

8.7 Limitations of the Research

Where specific limitations of individual studies are presented within each study chapter, this section will discuss the overarching limitations of this piece of research.

The nature of this research topic is controversial as views were diametrically opposed and politically charged. Investigations may have been viewed by some participants as having an agenda to decommission anaesthetic rooms. A sensitive approach was used in communicating study information to all participants in an unbiased way, although the patient information sheets, invitations, and questionnaires will have influenced participants. It is essential to acknowledge both personal and epistemological reflexivity within the research and the inevitable impact of the researcher's values, experience, and beliefs on the design and analysis of the research (Willig, 2001). The evidence-based Delphi study, for example, required a selective balance of research so as not to be perceived as leading participants to a certain conclusion. Triangulation was employed to corroborate findings within the surveys, interviews, observations, and Delphi process. Sampling bias was a risk, as participants who were more passionate about the anaesthetic room debate (in favour or opposed) may have been more inclined to participate, therefore limiting the account of more passive participants.

Several elements of this research required theoretical decision making, as exemplified by the following questions asked of participants:

- *If ARs were found to be unnecessary, how easy or difficult would it be for the hospital to modify its practice?*
- *What would be compelling enough evidence to change anaesthetic practice?*
- *If you were to redesign theatres, would you include or exclude anaesthetic rooms?*

As anaesthetic room practice was so pervasive and not all participants had the opportunity to re-evaluate design and practice, questions were unavoidably speculative. Additionally, the entire Delphi study was based on a hypothetical scenario where the participants acted as members of a new theatre planning committee. Their selected choice of anaesthetic room build was intended for a non-existent NHS Trust. Due to the infrequency of hospital planning and limited participation of staff members in actual hospital planning activities, decision making inquiries were presented hypothetically out of necessity. This may have altered the perceptions of participants on the importance of the activity, as it would not in reality affect their practice, and may have reduced their level of engagement in the discernment of evidence and willingness to

change design from the accepted norm. The method still benefited the field of research by providing a case study exercise of the integration of EBP in participatory design.

As explained previously, recruitment was a major limitation of this research. Although early studies received high participation, the Delphi study and patient experience survey had lower numbers than expected. Although the Delphi recruitment strategy was the same as the high response survey of anaesthetists and individual interviews, approval delays, the timing of the study, and possible fatigue of local collaborators may have limited the participation of the study. Additionally, due to the focus of the study on anaesthetic rooms, non-anaesthetic staff and managers may have found the study to be irrelevant to them, or at least better suited to anaesthetists. The patient survey also resulted in low recruitment due to limitations of the research team. Low response may also affect the external validity of the results, and may require more careful consideration before transferring findings to other populations.

Finally, one significant limitation of this research was the reliance on 'gatekeepers' to provide both clinical input into the formation of the research design and access to the hospitals in order to recruit participants. In order to gain Trust approval, individual local collaborators, mainly consultant anaesthetists, were identified for each Trust to pass information along to potential participants within their organisations. Over the course of several studies, however, some local collaborators became unresponsive and may not have sent recruitment invitations as requested. Despite the most well-conceived research design, healthcare research relies on the altruism of participants and the research collaborators who act as points of access for the researcher to the healthcare setting. This reliance on clinicians in the localities of the research was made evident in the requirements of the research ethics committee in Chapter 7, where the research was not permitted to access patients nor assist in data collection. This places the burden of important research on healthcare practitioners and suggests a need to better incorporate academic researchers and experts within organisations. Although healthcare research relies on the contribution of practitioners to provide expertise and insight into the clinical context, the barriers to external involvement can negatively impact research and expire the available time and resources of healthcare professionals.

8.8 Chapter Summary

This chapter has presented a summary of the research findings and discussed their fulfilment of the overarching research questions and their alignment with existing literature. An analysis method was presented which integrated the perceptions and priorities of stakeholders regarding anaesthetic rooms and best available scientific research. The research undergone in this thesis was situated in its larger contribution to knowledge and the limitations inherent in the research were discussed.

Chapter 9 Conclusions and Recommendations

9.1 Chapter Overview

This chapter will present the main conclusions of this research and recommendations for the anaesthetic community, perioperative managers, and researchers. Opportunities for future work which have been inspired by this research will be presented.

9.2 Conclusions and Recommendations

The research presented within this thesis provides a comprehensive exploration of a unique practice within the British health service, and incorporates a systems approach to examine both its perceived and actual value to relevant stakeholders. The implicit question throughout this research has been, '*Should anaesthetic rooms continue to be used for anaesthetic induction?*' The answer that this research has come to conclude has carefully considered the best available scientific evidence, investigated areas which were previously unexplored, and weighed against the priorities of the stakeholders who are affected the most by the anaesthetic room.

Patient safety has been stated of utmost importance in both design and practice for all anaesthetic room stakeholders; however, the prevalent choice to use and include anaesthetic rooms in future design does not support this priority. The safety risks of patient apnoea and accidental awareness during the transfer of patients from the anaesthetic room are viewed as manageable, whereas environmental conditions such as noise and distraction are not. As the anaesthetic room is already abandoned in the case of obstetric, morbidly obese, and high risk patients, the operating theatre should be viewed as the safest space for anaesthetic induction in the majority of cases, in terms of risk minimisation.

Patient well-being with regards to privacy, anxiety, and satisfaction are valued by all stakeholders. The evidence-base for the belief in improved patient experience using anaesthetic rooms is largely guided by the tacit knowledge and shared beliefs of personnel formed by longstanding tradition and training within the UK. In the absence of research evidence clearly identifying either the anaesthetic room or the operating theatre as best for patient experience, individual choice based on lesser priorities is sustained.

The final compelling argument for anaesthetic rooms is that of potential benefit due to overlapping induction; nevertheless, the realities of anaesthetic room payoff may not be living up to their imagined advantage. Although more specialised providers could utilise anaesthetic rooms for improved throughput, the financial constraints within the NHS may not permit the full utilisation of such facility in mixed specialty hospitals where increased staffing to support parallel working may not be possible, and large amounts of downtime and delay may inhibit potential gains.

The recommendations of this thesis are for NHS managers to strongly consider their strategic priorities moving forward and to involve all stakeholders in the long term planning of NHS facility. As the existing infrastructure of the NHS continues to age and plans are made for renovation or construction of new facilities, it will be essential to consider the opportunity cost of anaesthetic rooms, as an alternative investment in additional operating theatres without anaesthetic rooms may help to reduce long waiting lists and meet the increasing demand of the service. As this research has demonstrated a minimal impact of anaesthetic rooms on the quality of care for patients, and an inability of the system to support the intended use of the facility, it is recommended to make steps toward in-theatre induction with the intention of phasing out the structure in new builds. Although this recommendation may not be appropriate in some Trusts, a shift in practice has been seen in hospitals which have already moved from anaesthetic room practice such as Guy's Hospital in London and Ipswich Hospital, and the importance of this commitment to facility requires re-evaluation when the time approaches for substantial change to occur.

This research has shown the need to involve all users and best available research to confront resistance from deep rooted traditional values. Adaptation is a theme of improvement literature in human factors and lean thinking (Holden *et al.*, 2013; Wilson, 2014; Ohno, 1988), which requires feedback to continually improve and readjust the process as it changes over time. This is true for engrained systems, which have gone unchallenged for long durations, and may require re-evaluation as internal and external environmental circumstances, individual and organisational needs, and new research evidence becomes available. The main outcomes of this research have identified an inconsistency in design and practice and stated priorities. The foundation for decision making may be overly reliant on experience and cultural norms, as research evidence which does not strongly oppose the status quo is diminished or may not exist. The

barriers to changing practice are system wide, therefore requiring change through all areas of the complex work system, both internal and external to the organisation.

Several recommendations were made within the discussion of this thesis to provide resources and methods for change agents within the UK healthcare system, whether they be healthcare practitioners (HCP) or managers who will lead the decision making for process and infrastructure change. The primary recommendation for introducing controversial changes to widely accepted practice, such as the phasing out of anaesthetic rooms, is the participation of all relevant stakeholders in the active and systematic evaluation of perceptions (held individually and organisationally) and best research evidence. Managing change of attitudes and behaviours of individuals, in addition to system wide changes, requires wide involvement and collaboration in gathering appropriate research evidence to compare against tacit knowledge and lived experiences of all stakeholders. Although this appears to be a large undertaking, this type of group decision making can become a regular exercise for healthcare system (re)design, if management can be engaged in evidence based management and encourage active involvement of HCPs in the implementation of evidence based practice/medicine. The role of management is essential to foster a culture of continuous adaptation, willingness to change, and integration of research evidence. For this type of systematic approach to be used in healthcare system decision making, the onus is on management to both raise awareness for such a transparent way of forming system design decisions, and providing the resources necessary to support it (i.e. training on research evidence, available time for HCP participation).

9.3 Recommendations for Future Work

Although this thesis has aimed to provide a comprehensive evaluation of anaesthetic rooms, some stakeholders may seek further investigation of the influence of anaesthetic rooms in the effort to maintain accepted practice or to make a stronger argument for their abandonment. Further research should incorporate a larger sample of patients and healthcare personnel across the UK, as this research was limited to the East Midlands region. Further study may be necessary to capture the experiences of more patients and the circumstances of practice for healthcare practitioners in a larger number of Trusts.

It may be of interest in future research to focus on the experiences of individuals and organisations who are due to, or recently transitioned from anaesthetic room standards of practice to exclusively in-theatre induction. A longer term evaluation of anaesthetic attitudes leading up to and following change, and the factors leading to and identification of those involved in the change may provide greater insight into what the larger community of British anaesthetists and healthcare managers can expect if they too choose to promote a shift in practice for their organisations.

While an evidence-based, participatory design Delphi was tested within this research, further development is required to test the utility of the method and validate it for future use in healthcare team decision making. The modified Delphi also poses an opportunity to study individual participant involvement, interest, knowledge, and ability to assess research evidence in healthcare. Future work can be done in HFE to improve healthcare design and practice by integrating EBP into decision making. More research should be done which can provide guidance in EBP decision making in the absence of RCTs and systematic reviews, challenging the reliance on expertise alone, but not holding EBP of systems design to the same standard as medical trials, as it is not always possible.

9.4 Concluding Statements

The research presented in this thesis provided a holistic, systems approach to evaluating the efficacy of anaesthetic rooms in UK anaesthetic and surgical practice. This comprehensive investigation utilised human factors methods to identify the underlying barriers to changing practice. Findings support the existing literature pertaining to anaesthetic room use, and provide novel research outcomes related to the cost-effectiveness of anaesthetic rooms and patient expectations, which fill existing gaps in the literature.

Common themes emerging from these studies were the power of tradition and individual experience as barriers to change. While the anaesthetic room was believed to serve as a physical barrier to protect the patient from the operating room, it has also acted as a boundary dividing the surgical and anaesthetic teams and protecting the anaesthetic domain. These underlying motivators for practice have perpetuated this tradition despite patient safety risk which has become normalised in accepted practice.

The new approach proposed within this thesis for the cooperative evidence-based (re)design of practice and infrastructure is a promising method for synthesising multiple user priorities and decisions founded on best evidence. Further work is required to validate the modified Delphi and possible analysis methods which integrate HFE and EBP approaches; however, the outcomes of this research provide the groundwork for more holistic and systematic evaluations of other practices within the healthcare sector which may be long overdue for reconsideration.

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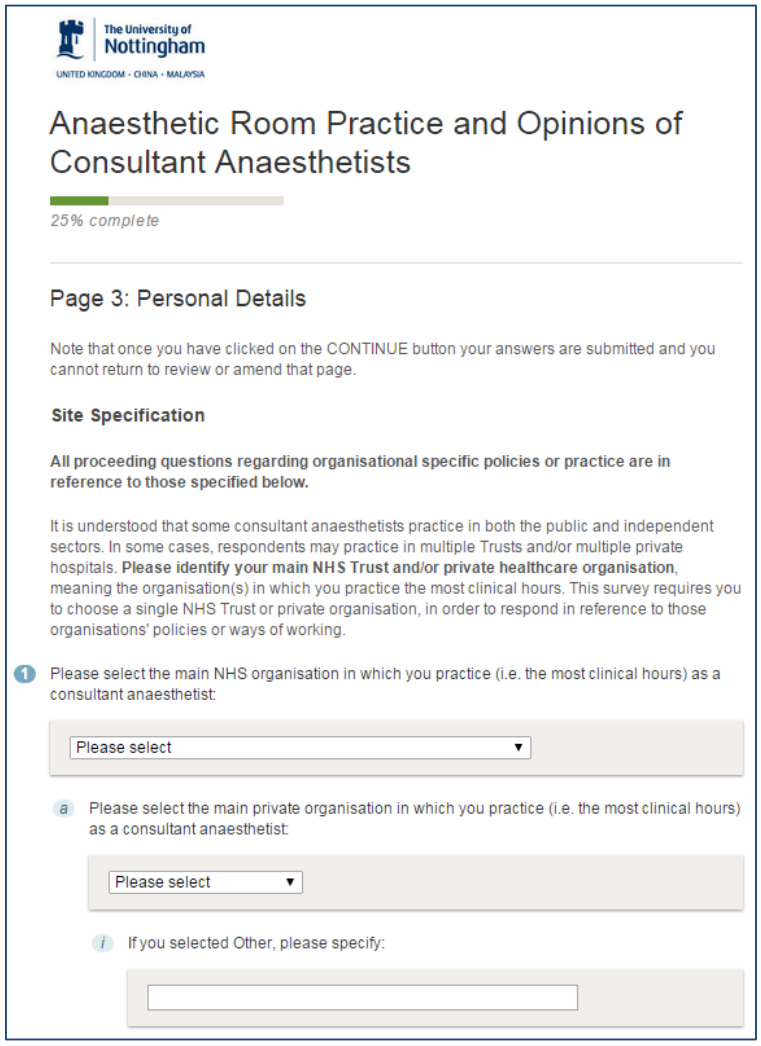
Appendix A Sample of the Anaesthetic Room Survey



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Anaesthetic Room Practice and Opinions of Consultant Anaesthetists

25% complete

Page 3: Personal Details

Note that once you have clicked on the CONTINUE button your answers are submitted and you cannot return to review or amend that page.

Site Specification

All proceeding questions regarding organisational specific policies or practice are in reference to those specified below.

It is understood that some consultant anaesthetists practice in both the public and independent sectors. In some cases, respondents may practice in multiple Trusts and/or multiple private hospitals. **Please identify your main NHS Trust and/or private healthcare organisation**, meaning the organisation(s) in which you practice the most clinical hours. This survey requires you to choose a single NHS Trust or private organisation, in order to respond in reference to those organisations' policies or ways of working.

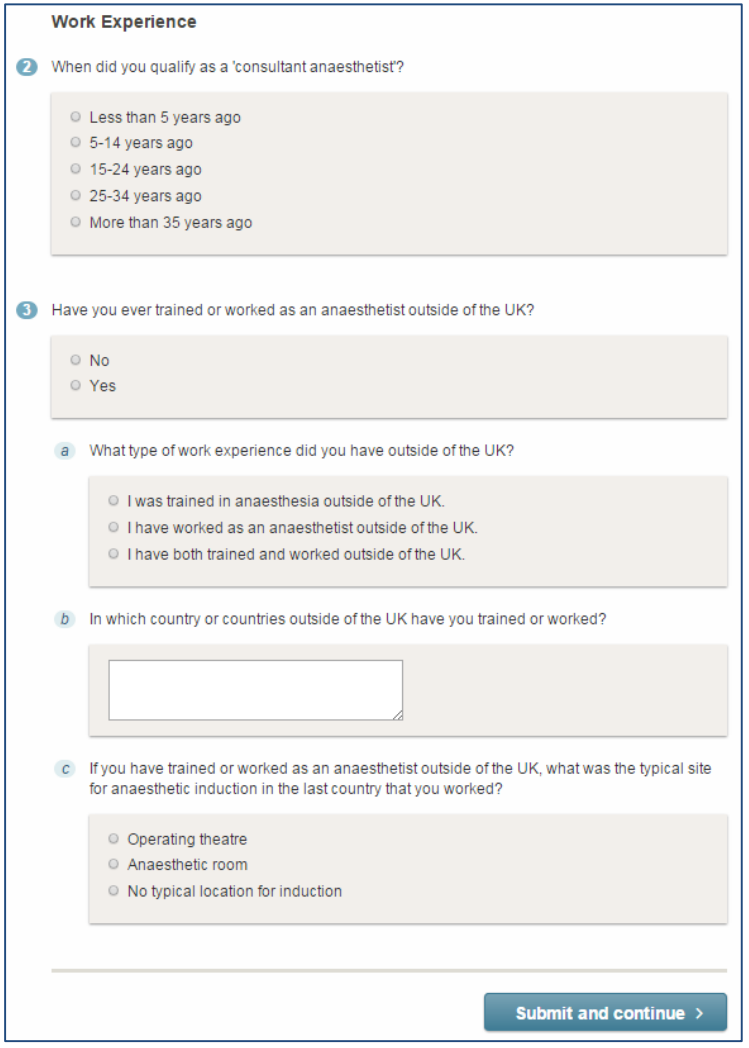
1 Please select the main NHS organisation in which you practice (i.e. the most clinical hours) as a consultant anaesthetist:

Please select

a Please select the main private organisation in which you practice (i.e. the most clinical hours) as a consultant anaesthetist:

Please select

i If you selected Other, please specify:



Work Experience

2 When did you qualify as a 'consultant anaesthetist'?

- Less than 5 years ago
- 5-14 years ago
- 15-24 years ago
- 25-34 years ago
- More than 35 years ago

3 Have you ever trained or worked as an anaesthetist outside of the UK?

- No
- Yes

a What type of work experience did you have outside of the UK?

- I was trained in anaesthesia outside of the UK.
- I have worked as an anaesthetist outside of the UK.
- I have both trained and worked outside of the UK.

b In which country or countries outside of the UK have you trained or worked?

c If you have trained or worked as an anaesthetist outside of the UK, what was the typical site for anaesthetic induction in the last country that you worked?

- Operating theatre
- Anaesthetic room
- No typical location for induction

Submit and continue >

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37% complete

Page 4: Current Anaesthetic Room Practice

Note that once you have clicked on the CONTINUE button your answers are submitted and you cannot return to review or amend that page.

About your NHS Organisation

These questions should be answered in reference to your main NHS Trust, as specified in Question 1.

4 Please indicate the typical team of non-medical staff that work on the list you do most often in your main NHS Trust.

Having trouble with the format of this question? View in tableless mode

	Please select the staff number of each non-medical role (per theatre).			
	0	1	2	3
Physician's Assistant (anaesthesia)	○	○	○	○
First Assistant (non-medical)	○	○	○	○
Circulating Practitioner	○	○	○	○
Scrub Practitioner	○	○	○	○
ODP/Anaesthetic Nurse	○	○	○	○
Support Worker	○	○	○	○

5 If you employ an individual in a different role as those stated, please specify and explain.

6 Do you have anaesthetic rooms (ARs) adjacent to your operating theatres?

- ○ No
- ○ Yes

a Please specify *how many anaesthetic rooms* you have in your main NHS hospital.

- ○ Less than half of the theatres have a corresponding AR.
- ○ More than half of the theatres have a corresponding AR.
- ○ All or almost all of the theatres have a corresponding AR.

b What is the *policy* for the site of induction in your main NHS Trust?

- ○ Anaesthetic Room
- ○ Operating Theatre
- ○ There is no policy
- ○ Other

i If you selected Other, please specify:

c Where are most patients induced for surgery in your hospital?

- ○ Anaesthetic Room
- ○ Operating Theatre
- ○ Other

i If you selected Other, please specify:

d In which way(s) do you use the anaesthetic room?

- ☐ Administering regional or peripheral nerve blocks
- ☐ Communication with patients & family (e.g. final questions)
- ☐ End-of-list team debriefing
- ☐ Establishing pre-operative monitoring (e.g. IVs, ECG leads, etc.)
- ☐ Induction of anaesthesia
- ☐ Placing invasive monitoring (e.g. art lines, cvp lines, etc.)
- ☐ Pre-list team briefing (e.g. huddle)
- ☐ Store of anaesthetic supplies
- ☐ Store of anaesthetic equipment
- ☐ Store of surgical equipment
- ☐ WHO sign-in
- ☐ Other

i If you selected Other, please specify:

The use of anaesthetic rooms varies between surgical specialties.

If you **do not have anaesthetic rooms** in your NHS organisation, please select **NO AR.** If you do not regularly practice a specialty, select **N/A**.

7 Please select the specialties for which you, as an individual, regularly practice.

Having trouble with the format of this question? View in tableless mode

	How frequently do you use the AR for induction of anaesthesia for each specialty?					
	No AR	Never	Sometimes	Mostly	Always	N/A
Ears, Nose, Throat	○	○	○	○	○	○
Cardiac	○	○	○	○	○	○
Daycase	○	○	○	○	○	○
General Emergencies (e.g. NCEPOD lists)	○	○	○	○	○	○
Gynaecology	○	○	○	○	○	○
Major Abdominal	○	○	○	○	○	○
Neuro Surgery	○	○	○	○	○	○
Obstetrics	○	○	○	○	○	○
Oral & Maxillofacial	○	○	○	○	○	○
Ophthalmics	○	○	○	○	○	○
Orthopaedic (Elective)	○	○	○	○	○	○
Orthopaedic (Trauma)	○	○	○	○	○	○
Paediatrics	○	○	○	○	○	○
Plastics	○	○	○	○	○	○
Spines	○	○	○	○	○	○
Thoracics	○	○	○	○	○	○
Urology	○	○	○	○	○	○
Vascular	○	○	○	○	○	○

8 If your specialty is *not* listed, please **specify it below** and **indicate the frequency of use of the AR for induction** for that specialty (Never, Sometimes, Mostly, Always).

If you ONLY practice in the NHS, you can skip Page 5 and progress to Page 6 - Personal Opinions on Anaesthetic Rooms.

Submit and continue >

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Anaesthetic Room Practice and Opinions of Consultant Anaesthetists

62% complete

Page 6: Personal Opinions on Anaesthetic Rooms

This page aims to assess individual anaesthetic perspectives on the preferred site of induction and rationale for those preferences.

Note that once you have clicked on the CONTINUE button your answers are submitted and you cannot return to review or amend that page.

Preferred Site of Induction

14 Personal preference for site of induction based on patient type.

Having trouble with the format of this question? View in tableless mode

	Please select your preferred site of induction:		
	Anaesthetic Room	Operating Theatre	No preference
Elderly	○	○	○
Paediatric	○	○	○
"Standard" adult	○	○	○
Anticipated difficult airway	○	○	○
Emergency	○	○	○
High-risk	○	○	○
Morbidly obese	○	○	○

Inducing in the Anaesthetic Room

15 If you use anaesthetic rooms for induction (in any organisation in which you practice), please indicate the importance of each reason for doing so. If your hospital does not have anaesthetic rooms, **please mark 'No AR'**.

Having trouble with the format of this question? View in tableless mode

	Using this scale from 'Unimportant' to 'Very Important', how important is each reason to induce in the **anaesthetic room**?					
	Unimportant	Of Little Importance	Moderately Important	Important	Very Important	No AR
Efficiency	○	○	○	○	○	○
Patient experience (e.g. anxiety)	○	○	○	○	○	○
Patient safety	○	○	○	○	○	○
Personal preference	○	○	○	○	○	○
Quiet environment	○	○	○	○	○	○
Teaching & communication	○	○	○	○	○	○

16 Please expand on selections from above. If there are any other reasons for using the anaesthetic room for induction not listed, please list below with an explanation. Also provide the level of importance from 'Unimportant' to 'Very Important' for each reason.

Inducing in the Operating Theatre

17 If you have anaesthetic rooms (in any organisation in which you practice), but choose to induce in-theatre, please indicate the importance of each reason for doing so. If your hospital does not have anaesthetic rooms, **please mark 'No AR'**.

Having trouble with the format of this question? View in tableless mode

	Using this scale from 'Unimportant' to 'Very Important',, how important is each reason to induce in the **operating theatre**?					
	Unimportant	Of Little Importance	Moderately Important	Important	Very Important	No AR
Efficiency	○	○	○	○	○	○
Insufficient equipment in AR	○	○	○	○	○	○
Inadequate space in AR	○	○	○	○	○	○
Insufficient staffing to utilise the AR	○	○	○	○	○	○
Noise or disruption in AR	○	○	○	○	○	○
Patient experience	○	○	○	○	○	○
Patient safety	○	○	○	○	○	○
Personal preference	○	○	○	○	○	○

18 Please expand on selections from above. If there are any other reasons for using the operating theatre for induction not listed, please list below with an explanation. Also provide the level of importance from 'Unimportant' to 'Very Important' for each reason.

Submit and continue ›

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Anaesthetic Room Practice and Opinions of Consultant Anaesthetists

75% complete

Page 7: Changing Practice

Note that once you have clicked on the CONTINUE button your answers are submitted and you cannot return to review or amend that page.

Evidence-Based Change

19 Have you previously participated in a study (e.g. questionnaire, interview, intervention, etc.) that explored the use of anaesthetic rooms?

- ○ No
- ○ Yes

a What was the outcome of the AR study?

- ○ I do not know the outcome of the study.
- ○ The study made no implications for best site of induction.
- ○ The study suggested it is best to induce in theatres.
- ○ The study suggested it is best to induce in ARs.

b If you participated in a previous study on anaesthetic rooms, has practice changed since the results of the study? And how have things changed?

- ○ No, practice has not changed.
- ○ Yes, practice has changed toward favouring theatres for induction.
- ○ Yes, practice has changed toward favouring ARs for induction.

20 What influences would change your current standard for site of induction? How important is each influence?

Having trouble with the format of this question? View in tableless mode

	Using this scale from 'Unimportant' to 'Very Important', how important is each influence on your individual anaesthetic practice?				
	Unimportant	Of Little Importance	Moderately Important	Important	Very Important
A departmental policy (e.g. anaesthesia dept)	○	○	○	○	○
An organisational policy (e.g. hospital, Trust)	○	○	○	○	○
NHS guidance (e.g. NICE, NHS England, DoH)	○	○	○	○	○
College or association guidance (e.g. RCoA, AAGBI)	○	○	○	○	○
A peer reviewed journal article	○	○	○	○	○
A trial study conducted within your organisation	○	○	○	○	○
Feedback from patients	○	○	○	○	○
Infrastructure modification (e.g. AR construction or demolition)	○	○	○	○	○
Peer opinion or practice	○	○	○	○	○

21 Would you like to see the site of induction changed from where it currently takes place?

- ○ No
- ○ Yes

a Please explain any opinions regarding changing anaesthetic practice in reference to the use of anaesthetic rooms.

22 Any other thoughts or comments?

Submit and continue ›

Appendix B Survey Results Newsletter

Anaesthetic Room Practice & Opinions of Consultant Anaesthetists

The University of Nottingham
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February 2015

THANK YOU for your participation in the online survey which was distributed to you in late 2014. The survey closed on 31st December 2014 and resulted in **202 participants** from across 9 NHS Trusts. I have included some of the interesting findings from the survey below, and would be grateful if you refrained from publishing any of the findings from this newsletter, as this may jeopardise my PhD result.

Reasons for Inducing in the AR

Importance

Quiet Environment
Patient Experience (e.g. anxiety)
Teaching & Communication
Personal Preference
Patient Safety
Efficiency

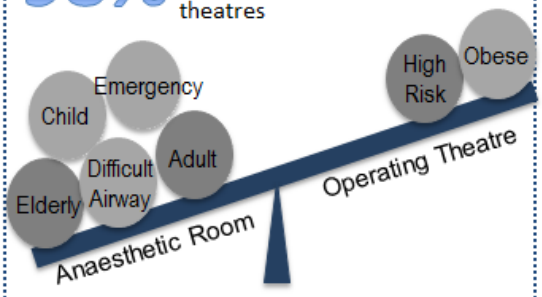
Reasons for Inducing in-theatre

Importance

Patient Safety
Inadequate Space in AR
Personal Preference
Patient Experience
Efficiency
Insufficient Equipment in AR
Insufficient Staffing to Use AR
Noise or Disruption in AR

Using the Anaesthetic Room

98% Of respondents have AR adjacent to *all or nearly all* theatres



The majority of respondents ALWAYS use the AR across all specialties, except **Cardiac, Obstetrics** & **Neuro Surgery**

89% Of respondents would **not** like the site of induction changed from the anaesthetic room

CALL FOR PARTICIPANTS

Please contact me if you are interested in a brief **phone interview** (< 30 min) further discussing your perspectives on anaesthetic rooms. Please email me to schedule an interview:
ezxjv@nottingham.ac.uk

LET YOUR VOICE BE HEARD
Further planned studies for this research will include observations, focus groups, and cost analyses.

NHS

Appendix C P-values for Factors for Choosing Induction Site

P-values for the reasons to induce in the *anaesthetic room*

Reason to induce in the **anaesthetic room**	Quiet environment	Patient experience	Teaching & communication	Patient safety	Personal preference	Efficiency
Quiet environment	-	.070	.000*	.000*	.000*	.000*
Patient experience (e.g. anxiety)	.070	-	.000*	.000*	.000*	.000*
Teaching & communication	.000*	.000*	-	.043	.011	.001*
Patient safety	.000*	.000*	.043	-	.957	.355
Personal preference	.000*	.000*	.011	.957	-	.232
Efficiency	.000*	.000*	.001*	.355	.232	-

* $P \leq .0033$, significant to the .05 level after Bonferroni correction

P-values for the reasons to induce in the *operating theatre*

Reason to induce **in-theatre**	Patient safety	Inadequate space	Personal preference	Patient experience	Efficiency	Insufficient equipment	Insufficient staffing	Noise or disruption
Patient safety	-	.000†	.000†	.000†	.000†	.000†	.000†	.000†
Inadequate space (AR)	.000†	-	.546	.000†	.000†	.000†	.000†	.000†
Personal preference	.000†	.546	-	.000†	.000†	.000†	.000†	.000†
Patient experience	.000†	.000†	.000†	-	.784	.255	.021	.000†
Efficiency	.000†	.000†	.000†	.784	-	.250	.067	.002
Insufficient equipment (AR)	.000†	.000†	.000†	.255	.250	-	.449	.017
Insufficient staffing (AR)	.000†	.000†	.000†	.021	.067	.449	-	.165
Noise or disruption (AR)	.000†	.000†	.000†	.000†	.002	.017	.165	-

† $P \leq .0018$, significant to the .05 level after Bonferroni correction

Appendix D Interview Participant Information Sheet

The University of Nottingham

Consultant Anaesthetist Interview
Participant Information Sheet – Work Package #6
(Final version 1.0: 03/11/14)

A mixed-methods approach to improving the design and practice of operating theatres and anaesthetic rooms in the UK

Name of Researcher(s): Jeena Velzen, Emma Rowley, Sarah Atkinson, Jennifer Martin

We would like to invite you to take part in our research study. Before you decide we would like you to understand why the research is being done and what it would involve for you. One of our team members will go through the information sheet with you and answer any questions you have. Talk to others about the study if you wish. Ask us if there is anything that is not clear.

What is the purpose of the study?

The purpose of this study is to determine the efficacy of anaesthetic rooms (AR) in improving efficiency of operating theatres. The study has several parts including a survey of how anaesthetic rooms are being used in the East Midlands, interviews with managers regarding AR incorporation in hospital design, cost and efficiency analyses, and a focus group on clinical priorities for anaesthetic practice.

This part of the study aims to understand the decision-making surrounding the use of anaesthetic rooms and priorities for clinical practice.

Why have I been invited?

You are being invited to take part because you are a consultant anaesthetist for a mixed-specialty surgery provider within the East Midlands region. We are inviting 20 participants like you to take part.

Do I have to take part?

No. It is up to you to decide whether or not to take part. If you are willing to take part in the interview, verbal consent will be taken at the time of the interview. If you decide to take part you are still free to withdraw at any time and without giving a reason. This would not affect your legal rights.

What will happen to me if I take part?

If you agree to take part in this part of the study, you will be asked to schedule and participate in a 30 minute interview either in person, over the phone, or via Skype®.

Expenses and payments

Participants will not be paid to participate in the study.

What are the possible disadvantages and risks of taking part?

There are no risks to yourself or your employer by you participating in this study.

What are the possible benefits of taking part?

We cannot promise the study will benefit you directly, but the information we get from this study may help in better defining best practice for UK theatres and ways to improve it in the future.

What if there is a problem?

If you have a concern about any aspect of this study, you should ask to speak to the researchers who will do their best to answer your questions. The researchers contact details are given at the end of this information sheet. If you remain unhappy and wish to complain formally, you can do this by contacting NHS Complaints. Details can be obtained from your employer.

Will my taking part in the study be kept confidential?

We will follow ethical and legal practice and all information you share with us will be handled in confidence.

If you join the study, some parts of the data collected for the study will be looked at by authorised persons from the University of Nottingham who are organising the research. They may also be looked at by authorised people to check that the study is being carried out correctly. All these people will have a duty of confidentiality to you as a research participant and we will do our best to meet this duty.

All information which is collected about you during the course of the research will be kept **strictly confidential**, stored in a secure and locked office, and on a password protected database. Any information about you or your employer will have names and addresses removed (anonymised) and a unique code will be used so that you cannot be recognised from it.

Your personal data (address, telephone number) will be kept until the end of the study. All research data will be kept securely for 7 years. After this time your data will be disposed of securely. During this time all precautions will be taken to maintain your confidentiality and only members of the research team will have access to your personal data.

What will happen if I don't want to carry on with the study?

Your participation is voluntary and you are free to withdraw at any time, without giving any reason, and without your legal rights being affected. If you withdraw then the information collected up until that point will not be erased and this information may still be used in the project analysis.

What will happen to the results of the research study?

The results of the research will be written up as part of an educational qualification. Participants will not be identified in any publications or presentations from the study. Results will be written up for journal and/or conference papers. Any publications will be disseminated to participants, if desired.

Who is organising and funding the research?

This research is being organised by the University of Nottingham and is being funded by the Faculty of Engineering, through the Dean of Engineering Research Scholarship for International Excellence.

Who has reviewed the study?

All research is looked at by independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given favourable opinion by The University of Nottingham's Faculty of Engineering Research Ethics Committee.

Further information and contact details

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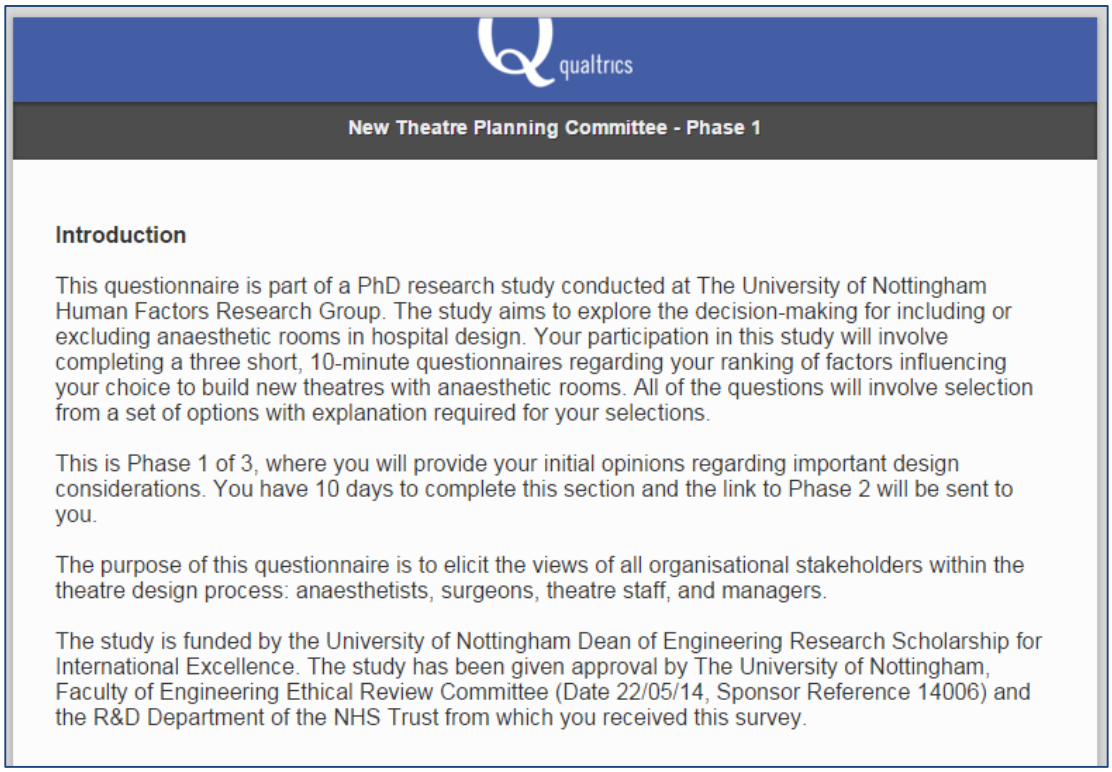
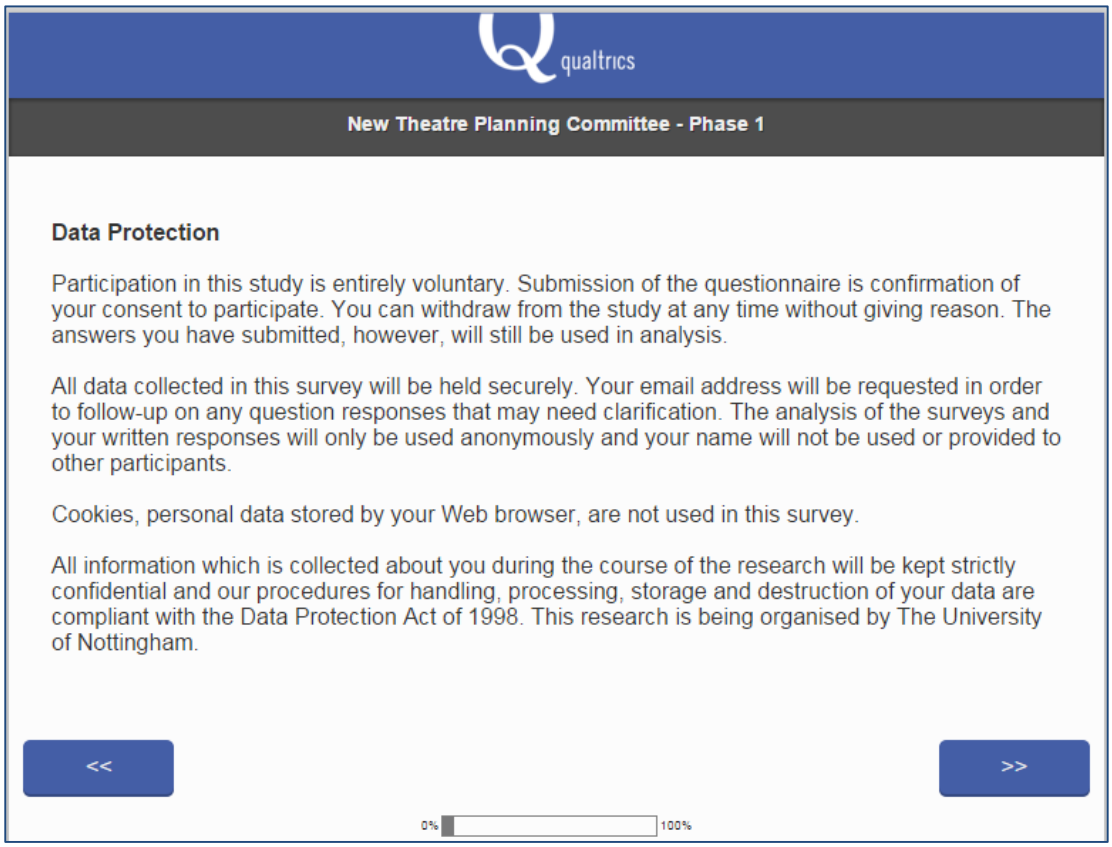
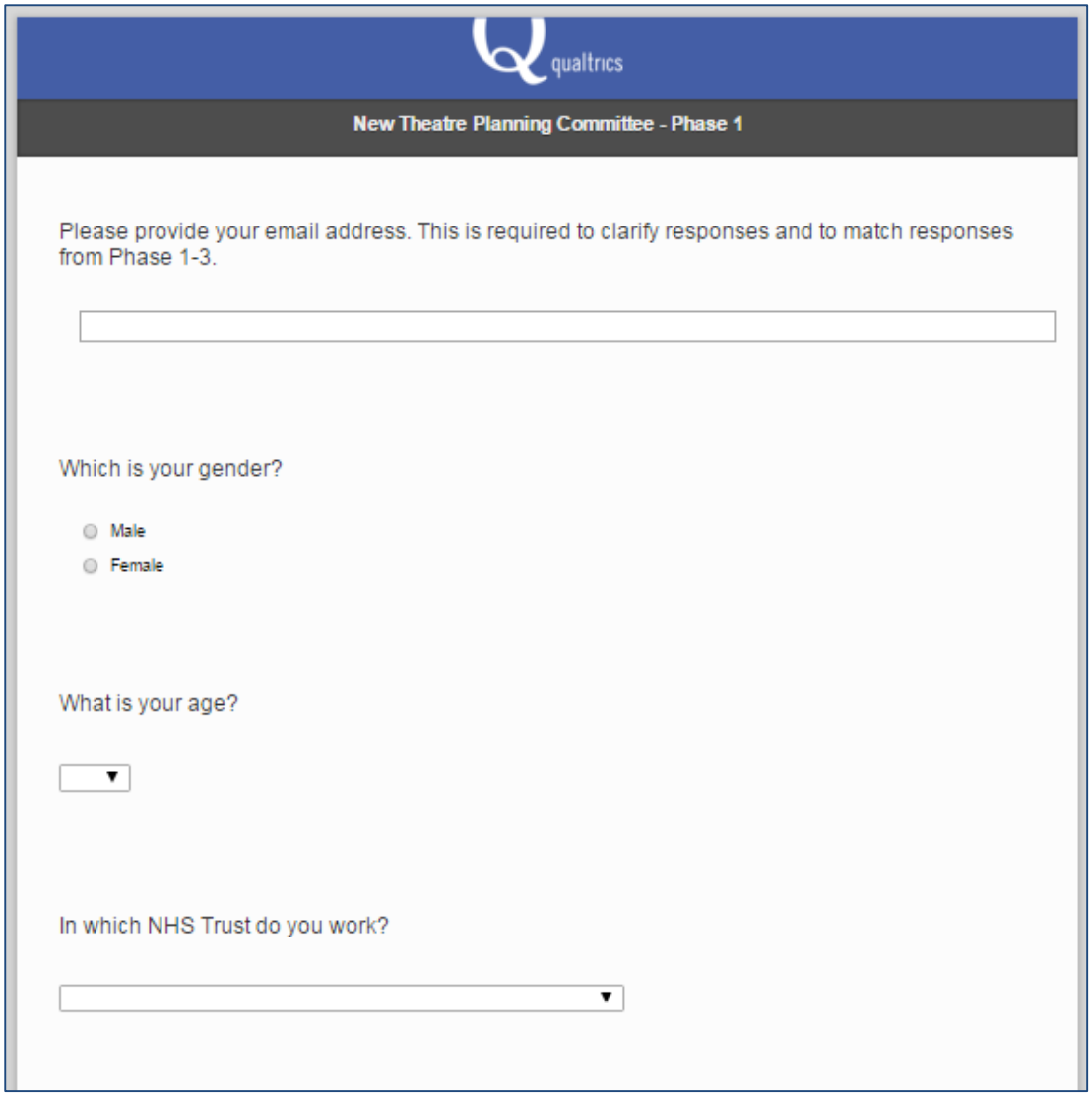
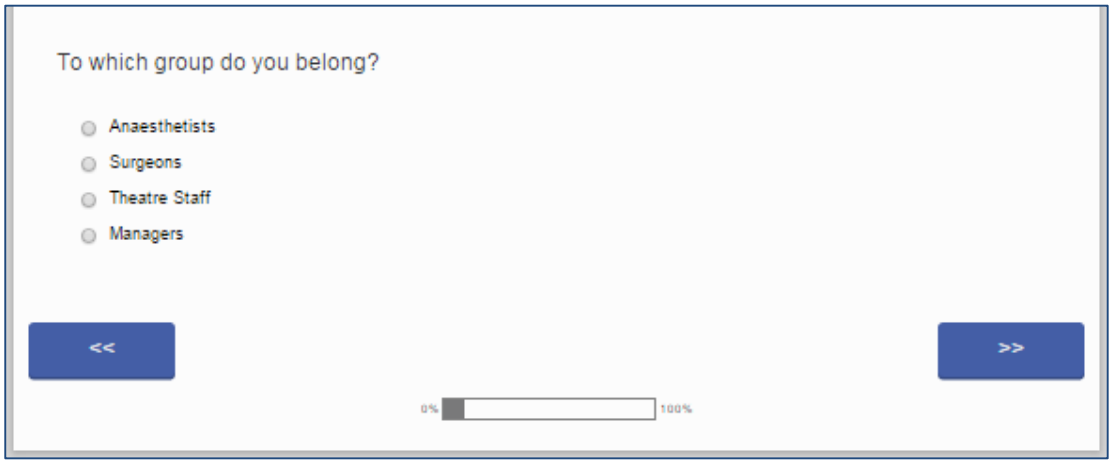
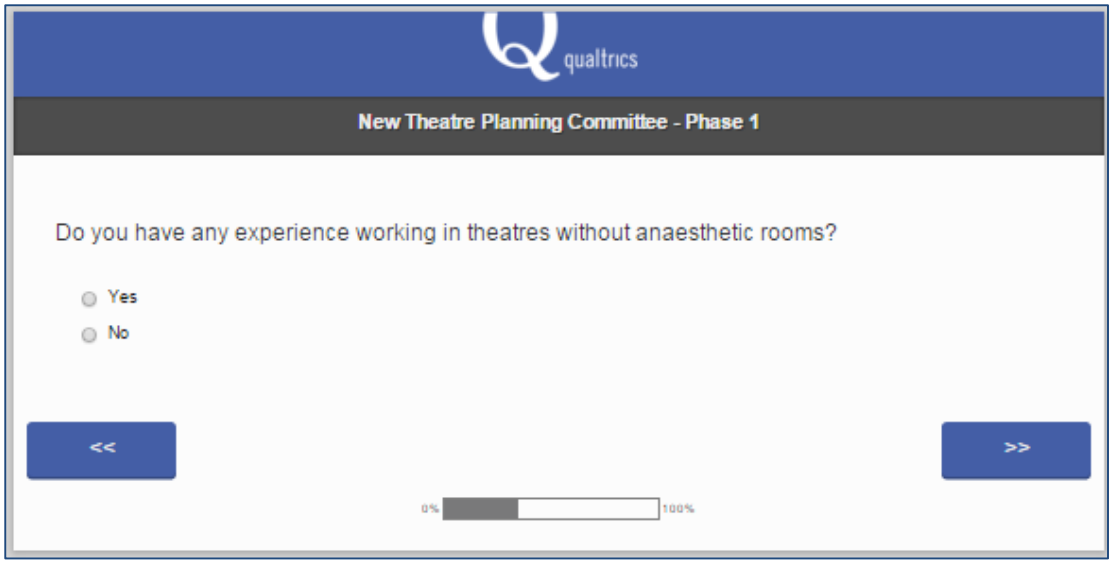
Appendix E Phase 1 Delphi Survey

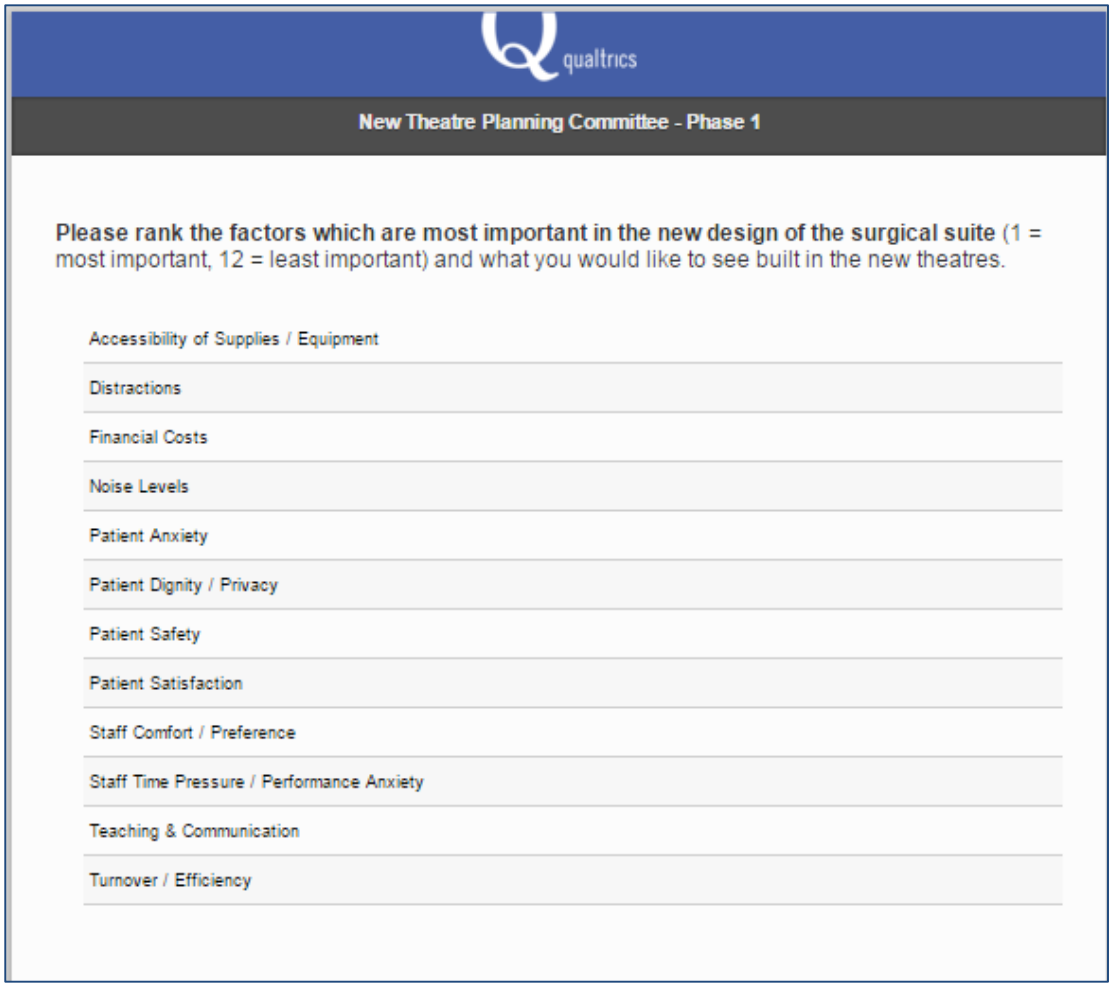





qualtrics
New Theatre Planning Committee - Phase 1
Please provide your email address. This is required to clarify responses and to match responses from Phase 1-3.
Which is your gender?
Male
Female
What is your age?
In which NHS Trust do you work?


To which group do you belong?
Anaesthetists
Surgeons
Theatre Staff
Managers
<<
>>
0%
100%


qualtrics
New Theatre Planning Committee - Phase 1
Do you have any experience working in theatres without anaesthetic rooms?
Yes
No
<<
>>
0%
100%


qualtrics
New Theatre Planning Committee - Phase 1
Please rank the factors which are most important in the new design of the surgical suite (1 = most important, 12 = least important) and what you would like to see built in the new theatres.
Accessibility of Supplies / Equipment
Distractions
Financial Costs
Noise Levels
Patient Anxiety
Patient Dignity / Privacy
Patient Safety
Patient Satisfaction
Staff Comfort / Preference
Staff Time Pressure / Performance Anxiety
Teaching & Communication
Turnover / Efficiency

Please comment on your Top 4 (MOST important) factors in the design, and why you selected them.

Please comment on your Bottom 4 (LEAST important) factors in the design, and why you ranked them as you did.

Please select your preferred choice of build and explain why below.

- Do not build any ARs
- Build shared ARs
- Build ARs for some theatres
- Build ARs for all theatres
- Other

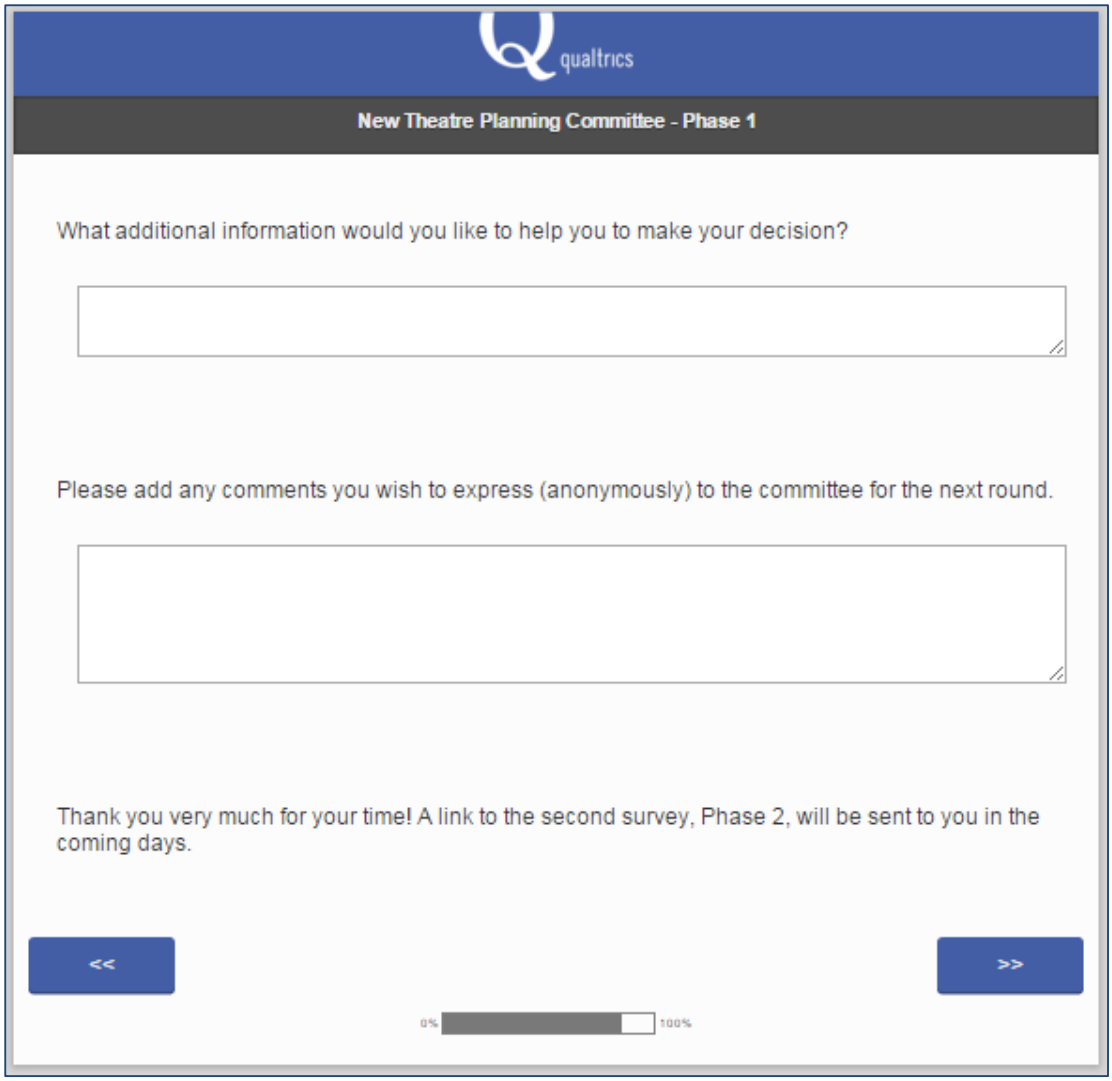
Please explain your preferred choice of build (as selected above) and how it will benefit your service.

Is there additional information that would help you to make this decision?

- Yes
- No

<< >>

0% 100%

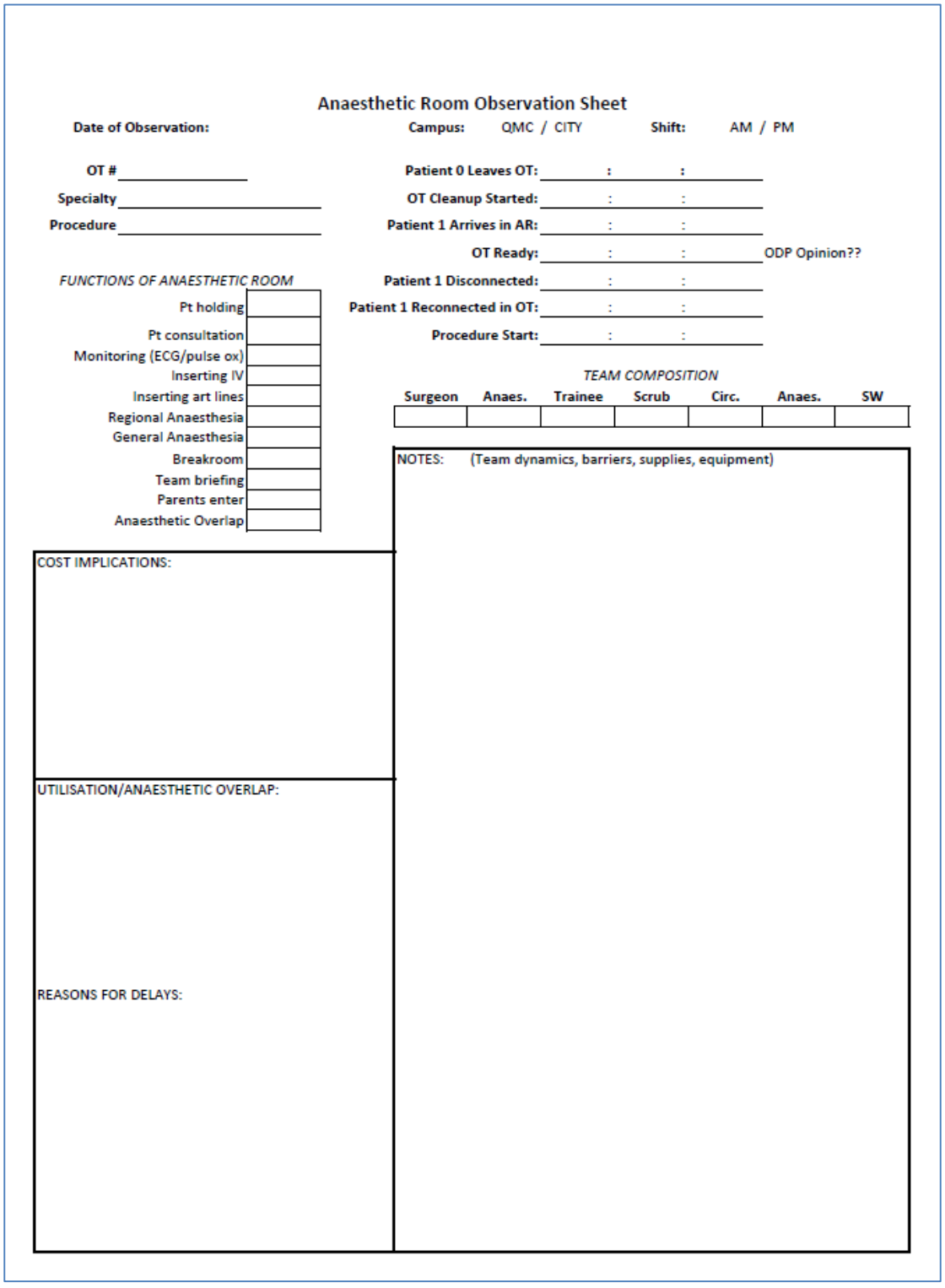

qualtrics
New Theatre Planning Committee - Phase 1
What additional information would you like to help you to make your decision?
Please add any comments you wish to express (anonymously) to the committee for the next round.
Thank you very much for your time! A link to the second survey, Phase 2, will be sent to you in the coming days.
<<
>>
0%
100%

Appendix F P-values for Delphi Design Factors

		Accessibility of Equipment	Distractions	Financial Costs	Noise Levels	Patient Anxiety	Patient Privacy	Patient Safety	Patient Satisfaction	Staff Comfort	Staff Time Pressure	Teaching & Communication	Efficiency
Phase 1	Accessibility of Equipment	-	.0010	.0479	.0027	.0430	.0876	.0000*	.0512	.0000*	.0013	.0003*	.5410
	Distractions	.0010	-	.4419	.8721	.3524	.0002*	.0000*	.1563	.0569	.3683	.6525	.0864
	Financial Costs	.0479	.4419	-	.5417	.8658	.0048	.0000*	.5611	.0471	.1801	.3023	.0733
	Noise Levels	.0027	.8721	.5417	-	.4701	.0001*	.0000*	.3632	.0325	.2854	.4592	.1602
	Patient Anxiety	.0430	.3524	.8658	.4701	-	.0006*	.0000*	.5401	.0023	.0499	.1336	.1892
	Patient Privacy	.0876	.0002*	.0048	.0001*	.0006*	-	.0000*	.0012	.0000*	.0001*	.0000*	.0750
	Patient Safety	.0000*	.0000*	.0000*	.0000*	.0000*	.0000*	-	.0000*	.0000*	.0000*	.0000*	.0000*
	Patient Satisfaction	.0512	.1563	.5611	.3632	.5401	.0012	.0000*	-	.0015	.0205	.0419	.3065
	Staff Comfort	.0000*	.0569	.0471	.0325	.0023	.0000*	.0000*	.0015	-	.1496	.2273	.0013
	Staff Time Pressure	.0013	.3683	.1801	.2854	.0499	.0001*	.0000*	.0205	.1496	-	.7928	.0097
	Teaching & Communication	.0003*	.6525	.3023	.4592	.1336	.0000*	.0000*	.0419	.2273	.7928	-	.0211
	Efficiency	.5410	.0864	.0733	.1602	.1892	.0750	.0000*	.3065	.0013	.0097	.0211	-
Phase 2	Accessibility of Equipment	-	.0804	.1461	.0025	.7678	.0380	.0000*	.6510	.0001*	.0249	.0000*	.7901
	Distractions	.0804	-	.5891	.1169	.1125	.0063	.0000*	.3350	.0061	.1227	.0007*	.2845
	Financial Costs	.1461	.5891	-	.5891	.0739	.0028	.0000*	.1660	.0855	.7532	.0049	.0569
	Noise Levels	.0025	.1169	.5891	-	.0040	.0001*	.0000*	.0567	.0447	.9215	.0178	.0374
	Patient Anxiety	.7678	.1125	.0739	.0040	-	.0567	.0000*	.5886	.0016	.0032	.0001*	.9140
	Patient Privacy	.0380	.0063	.0028	.0001*	.0567	-	.0000*	.0082	.0000*	.0006*	.0000*	.2976
	Patient Safety	.0000*	.0000*	.0000*	.0000*	.0000*	.0000*	-	.0000*	.0000*	.0000*	.0000*	.0000*
	Patient Satisfaction	.6510	.3350	.1660	.0567	.5886	.0082	.0000*	-	.0003*	.0769	.0000*	.4491
	Staff Comfort	.0001*	.0061	.0855	.0447	.0016	.0000*	.0000*	.0003*	-	.0891	.1955	.0012
	Staff Time Pressure	.0249	.1227	.7532	.9215	.0032	.0006*	.0000*	.0769	.0891	-	.0065	.0292
	Teaching & Communication	.0000*	.0007*	.0049	.0178	.0001*	.0000*	.0000*	.0000*	.1955	.0065	-	.0001*
	Efficiency	.7901	.2845	.0569	.0374	.9140	.2976	.0000*	.4491	.0012	.0292	.0001*	-

Wilcoxon signed rank test results; Bonferroni correction value =.05/66; *$p \leq .00076$

Appendix G Ethnographic Observation Sheet



Anaesthetic Room Observation Sheet

Date of Observation: **Campus:** QMC / CITY **Shift:** AM / PM

OT # _____

Specialty _____

Procedure _____

Patient 0 Leaves OT: ___ : ___

OT Cleanup Started: ___ : ___

Patient 1 Arrives in AR: ___ : ___

OT Ready: ___ : ___ ODP Opinion??

Patient 1 Disconnected: ___ : ___

Patient 1 Reconnected in OT: ___ : ___

Procedure Start: ___ : ___

FUNCTIONS OF ANAESTHETIC ROOM

Pt holding	
Pt consultation	
Monitoring (ECG/pulse ox)	
Inserting IV	
Inserting art lines	
Regional Anaesthesia	
General Anaesthesia	
Breakroom	
Team briefing	
Parents enter	
Anaesthetic Overlap	

TEAM COMPOSITION

Surgeon	Anaes.	Trainee	Scrub	Circ.	Anaes.	SW

NOTES: (Team dynamics, barriers, supplies, equipment)

COST IMPLICATIONS:

UTILISATION/ANAESTHETIC OVERLAP:

REASONS FOR DELAYS:

Appendix H Correspondence with Circle Treatment Centre

RE: Circle Visit

Simon Hardwick [Simon.Hardwick@circlenottingham.co.uk]
Sent: Friday, October 28, 2016 6:12 PM
To: Velzen Jeena

Hi Jeena,

Many thanks for your visit today. I am glad you found it useful.

I have answered your queries as below and am happy with the content. Good luck with everything.

Best wishes

Simon

Circle Nottingham

Simon Hardwick
Theatre Lead
CircleNottingham
Nottingham NHS Treatment Centre
Queen's Medical Centre Campus
Lister Road
Nottingham
NG7 2FT
DT: Via Daycase Office - 23062
M:
F:
simon.hardwick@circlenottingham.co.uk
circlenottingham.co.uk

From: Jeena Velzen [mailto:Jeena.Velzen@nottingham.ac.uk]
Sent: 28 October 2016 16:41
To: Simon Hardwick
Subject: Circle Visit

Hi Simon,
Thank you again for allowing me to come by and visit. You were exceedingly helpful in describing your process for me. Please see some main points I'd like to include in my thesis, if possible. If you could check, clarify if necessary, and respond with confirmation, I will refer to this email in my thesis.

- Based on the bottom line alone, you would not have ARs, although you would like them to reduce turnover time even more.
- ARs are useful for quick turnover daycase, but not longer major cases.
- Theatres were built based on the American model. Who helped design them? An American company? – Nations Healthcare designed the TC. They are an American company

- Circle is able to focus on lean principles and keep the surgeon 'cog' going because of predictable elective, non-emergent work.
- Productivity: Some lists at Circle see up to a 30% increase in throughput compared to NUH, despite not having ARs, due to
    - Time savings in transport -attributed to lean design of theatres and wards;
    - Not waiting for others to transfer the patient, i.e. patient can position him/herself;
    - Surgeons have more incentive to be productive, i.e. payment per case opposed to session block payment;
        - Simon, what is the incentive for anaesthetists? How are they paid? Like surgeons or like contract staff? – Anaesthetists are paid like surgeons unless employed by us.
    - Additionally, surgeons don't wander off between cases, as the next patient is present.
    - Possibly anaesthetists are more productive based on time pressure from surgeons.
    - Staff are more productive than in the NHS thanks to the Circle credo and less unionised culture than the NHS;
- Patient experience:
    - Based on regular patient feedback, patients have not expressed negative perceptions of being anaesthetised in the OT.
    - Staff are reminded to keep noise levels low and to do noisy tasks either before or after the patient is brought in.
    - Staff have adapted culturally to remaining professional and quiet in the presence of the patient.
- Staffing:
    - Relies on contract, bank, and agency staff.
    - Most lists use 2 + 1 staffing with 1 scrub nurse, 1 HCA, 1 ODP
    - Other lists have 3 + 1 with 2 scrub nurses, 1 HCA, 1 ODP, to swap scrub duty on long, tiring lists.
    - Lists with 3+1 staffing can cover breaks. If extra staff are available, can staff 1 scrub extra per 2 theatres to cover break (not typical).
    - Lunch break in the list is standard from 12:30 -2, if not overrunning.
- Commissioning:
    - HRG tariffs are paid by the CCG, 95% of the work is NHS work.
        - As above
    - Finances are not able to be broken down by procedure, but they are looked at aggregated and also by speciality.
- Surgeon's perspective:
    - ARs are beneficial as an extra barrier for infection control.
    - Does not allow the same processes for patients with contagious bacterial infection, not having an AR.
    - A prep room would be beneficial for set up of instruments; ideal process in City's new orthopaedic theatres.
    - Double prepping is not possible without an AR, due to infection control, as double prep cannot be done under laminar flow.
        - I forget, did you say you do not do double prep then? Or where do you do it, on the ward? – We use one of the skin surgery theatres as an anaesthetic room
- Cultural:
    - You had 30 years of experience in theatres with ARs, and when you came to Circle, you didn't think it would be possible to operate without delay.
    - Staff have accepted this model.

- ARs in other organisations serve as a physical barrier. Anaesthetists like to keep the surgeon out.
- Theatre space:
    - If possible, could you pass along the area of your theatres? – Don't have this information readily available but can obtain

I think these were the main things we discussed. If there is anything I missed, please feel free to add. If you could clarify the yellow, I'd appreciate it.
Many thanks again, Simon, for your time and sharing your experience.
Kind Regards,
Jeena

Appendix I Coding Logic for Tariff Calculation

```
Sub TariffCalc()
'Coding to stop screen from updating, improves speed of macro
Application.ScreenUpdating = False
'Set each Dim to respective values
Set HRGCodes = ActiveWorkbook
Set Tariffs = HRGCodes.Sheets("Formulas")
''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
Dim rowIdx As Long
startRow = 2
Endrow = 38672
OpTypeCol = 27 'Elective or Emergency
LOSCol = 50 'Length of Stay
CombinedCol = 51 'Combined day case / ordinary elective spell tariff
DaycaseCol = 52 'Day case spell tariff
ElectiveCol = 53 'Ordinary elective spell tariff
ELSTPCol = 54 'Ordinary elective long stay trimpoint
EmergCol = 55 'Non-elective spell tariff
NELSTPCol = 56 'Non-elective long stay trimpoint
LongStayCol = 57 'Per day long stay payment
RSSETCol = 58 'Reduced short stay emergency tariff
CalcTariffCol = 59 'Calculated Tariff
For rowIdx = startRow To Endrow
OpType = Tariffs.Cells(rowIdx, OpTypeCol)
LOS = Tariffs.Cells(rowIdx, LOSCol)
Combined = Tariffs.Cells(rowIdx, CombinedCol)
Daycase = Tariffs.Cells(rowIdx, DaycaseCol)
Elective = Tariffs.Cells(rowIdx, ElectiveCol)
ELSTP = Tariffs.Cells(rowIdx, ELSTPCol)
Emerg = Tariffs.Cells(rowIdx, EmergCol)
NELSTP = Tariffs.Cells(rowIdx, NELSTPCol)
LongStay = Tariffs.Cells(rowIdx, LongStayCol)
```

```
RSSET = Tariffs.Cells(rowIdx, RSSETCol)
   If OpType <> "EMERGENCY" Then
      If LOS = 0 Then
         If IsNumeric(Daycase) = True Then
            Tariffs.Cells(rowIdx, CalcTariffCol) = Daycase
         Else: Tariffs.Cells(rowIdx, CalcTariffCol) = Combined
         End If
      Else
         If IsNumeric(Elective) = True Then
            If LOS > ELSTP Then
               Tariffs.Cells(rowIdx, CalcTariffCol) = Elective + (LongStay * (LOS -
ELSTP))
            Else: Tariffs.Cells(rowIdx, CalcTariffCol) = Elective
            End If
         ElseIf LOS > ELSTP Then
            Tariffs.Cells(rowIdx, CalcTariffCol) = Combined + (LongStay * (LOS -
ELSTP))
         Else: Tariffs.Cells(rowIdx, CalcTariffCol) = Combined
         End If
      End If
   Else
      If LOS > NELSTP Then
         Tariffs.Cells(rowIdx, CalcTariffCol) = Emerg + (LongStay * (LOS - NELSTP))
      Else
         If IsNumeric(RSSET) = True Then
            Tariffs.Cells(rowIdx, CalcTariffCol) = Emerg + RSSET
         Else: Tariffs.Cells(rowIdx, CalcTariffCol) = Emerg
         End If
      End If
   End If
Next rowIdx
End Sub
```

Appendix J Anaesthetic Equipment Costs

					Agenda for Change - pay bands			
No. Anaesthetic Machines		40			Servicer is Band 6 - Max salary £35,000 per annum			
Life of 1 machine = 7 years - 10 years, replaced					Point 21	£ 25,783	Point 29	£ 34,530
Cost Per Machine	£16,000.00	+VAT			1950	hours per year		
Cost of Monitoring	£16,000.00				£ 13.22	per hour	Point 21	
					£ 17.71	per hour	Point 29	
PV Calc					£ 15.46	per hour	average	
Total machine cost	£31,061.18	(2013 GBP)						

Years	Maintenance Costs per			Hours Work		Part Cost	
0.5	**6-month**	£	46.39	3	£	-	
1	**1-year**	£	415.99	7.5	£	300.00	
1.5	**6-month**	£	46.39	3	£	-	
2	**2-year**	£	473.72	8	£	350.00	hoses changed
2.5	**6-month**	£	46.39	3	£	-	
3	**1-year**	£	415.99	7.5	£	300.00	
3.5	**6-month**	£	46.39	3	£	-	
4	**4-year**	£	631.45	8.5		500	battery for ventilator replaced
4.5	**6-month**	£	46.39	3	£	-	
5	**1-year**	£	415.99	7.5	£	300.00	
5.5	**6-month**	£	46.39	3	£	-	
6	**2-year**	£	473.72	8	£	350.00	
6.5	**6-month**	£	46.39	3	£	-	
7	**1-year**	£	415.99	7.5	£	300.00	
7.5	**6-month**	£	46.39	3	£	-	
8	**4-year**	£	631.45	8.5		500	battery for ventilator replaced
8.5	**6-month**	£	46.39	3	£	-	
9	**1-year**	£	415.99	7.5	£	300.00	
9.5	**6-month**	£	46.39	3	£	-	
10	**2-year**	£	473.72	8	£	350.00	hoses changed
	Maintenance Labour & Parts:	£	5,227.94				

			Cost Per Part		Per Year
Replace Circuit every Monday	£	809.64	£	15.57	52
1.6m Anaesthetic Circuit Basic	£	87.36	£	1.68	52

PV Calc		
Replace Circuit every Monday	£785.89	(2013 GBP)
1.6m Anaesthetic Circuit Basic	£84.80	(2013 GBP)

End of	Year	Total Cost Per OR	Total Cost Per Trust (40 ORs)	INFLATION	PV (2013)	Cummulative Cost of ARs
2013	0	£ 31,061.18	£1,242,447.04		£1,242,447.04	£ 1,242,447.04
2014	1	£ 1,333.06	£ 53,322.59	1.5%	£ 52,534.57	£ 1,294,981.61
2015	2	£ 1,390.80	£ 55,631.89	0.0%	£ 111,263.77	£ 1,406,245.38
2016	3	£ 1,333.06	£ 53,322.59	0.2%	£ 159,330.02	£ 1,565,575.41
2017	4	£ 1,548.53	£ 61,941.18	0.4%	£ 245,306.77	£ 1,810,882.18
2018	5	£ 1,333.06	£ 53,322.59	0.6%	£ 261,880.30	£ 2,072,762.49
2019	6	£ 1,390.80	£ 55,631.89	0.8%	£ 324,641.02	£ 2,397,403.50
2020	7	£ 1,333.06	£ 53,322.59	1.0%	£ 358,764.76	£ 2,756,168.26
2021	8	£ 1,548.53	£ 61,941.18	1.2%	£ 469,806.90	£ 3,225,975.16
2022	9	£ 1,333.06	£ 53,322.59	1.4%	£ 447,964.65	£ 3,673,939.81
2023	10	£ 1,390.80	£ 55,631.89	1.6%	£ 510,340.09	£ 4,184,279.90

Appendix K Full ORMIS Data Analysis Procedures

All data analysis steps following the final compilation of ORMIS data is presented here within.

Nomenclature: PT = patient, PT_0= 1st patient, PT_1= 2nd patient, DT = downtime, OL = overlap

Time Intervals Calculations

All time intervals were calculated from the ORMIS time stamps, as stated in **Table 6.7**.

Formula: (example)

> =IF(AND(ISNUMBER(E2),ISNUMBER(F2)), IF(F2>=E2,(F2-E2)*60*24,"Not Sequential"),"Missing Times")
>
> E2 = 1st sequential time stamp, F2 = 2nd sequential time stamp
>
> *Conditions:*
>
> - Time stamp must be entered or else “Missing Time”
> - E2 and F2 must be sequential times or else “Not Sequential”
> - Time interval = (Difference in time stamps)*(convert to minutes)

The location of the patient at time of the theatre entering downtime was calculated from all time stamps as follows:

Formula:
=IF(ISNUMBER(AM2),IF(G3<L2,"SUITE",IF(F3<L2,"PORTER","WARD")),"")

> AM2 = Indication of Downtime (i.e. Amount of DT, No DT, Missing Times, N/A, etc.)
>
> G3 = In Suite time of PT_1, L2 = In Recovery time of PT_0, F3 = Porter Left time of PT_1
>
> *Conditions:*
>
> - If DT is a number value (i.e. there is downtime), then determine location of PT.
> - If PT_1 is in Suite before PT_0 is in Recovery, then PT is in Suite at point of DT.
> - If the Porter Left to collect PT_1 before PT_0 is in Recovery, then PT is with porter.
> - Otherwise, PT must be in the ward.

Physician’s Assistant Flags

- Session Type PA Flag – Indicates PA is present based off Session Type data
  - =IF(AB2="PHYSICIANS ASSISTANT",1,0)

    - AB2 = Session Type field
- PA Flag based on the surname of the two PAs staffed in 2013
    - =IF(AND(OR(AE2="Surname1",AE2="Surname2",AF2="Surname2", AF2="Surname1"),OR(Y2="City Theatre 3", Y2="City Theatre 8", Y2="City Theatre 20", Y2="City Theatre 21",Y2="City Theatre 22")),1,0)
    - AE2, AF2 = 2nd, 3rd anaesthetist surname (PA cannot be 1st anaesthetist)
    - Y2 = operating theatre
    - If either of the two PAs (example: Surname1 & Surname2) are staffed in any of the 5 indicated operating theatres, then PA is present.

Flagged Multi-Episode Spells

It may be that a patient who has multiple procedures within a single hospital visit will be indicated with the same HRG code multiple times, as only the highest HRG Code is indicated within a spell of multiple episodes. It was necessary to flag the duplicated episodes, as some procedures may reflect an HRG code that is not directly indicative of the tariff value of that procedure alone.

Data set sorted by:

1. Duplicated patient IDs
2. Patient ID (low to high)
3. Admittance date (oldest to newest)
4. In OR time (oldest to newest)

To order the procedures in sequential order, and listing the cases where the same patient had multiple procedures first.

> =IF(AND(NOT(ISBLANK(AB2)),C2=C3,AC2=AC3,AD2=AD3,AB2=AB3), CONCATENATE(C2,"SPELL"),IF(AND(NOT(ISBLANK(AB2)),C2=C1, AC2=AC1, AD2=AD1, AB2=AB1), CONCATENATE(C2,"SPELL"),""))

Flagging with Patient ID + “SPELL” to indicate multiple episodes within a spell (ex. 60SPELL would be shown for all spells for patient 60 in a single hospital stay). The formula only considers episodes related to the same spell if:

1. There is an HRG Code assigned / not looking at blanks
2. Patient is the same, same unique ID
3. Same admittance date and discharge date (same hospital stay)
4. Same HRG code

Overlap and Downtimes are calculated by comparing sequential cases.

Overlap Time Calculations

Overlapping time reflects the ‘doubling up’ or ‘anaesthetic overlap’ of utilising the anaesthetic room by bringing the PT_1 into the AR while the PT_0 is still in the operating theatre.

Formula:

> =IF(AND(Y1=Y2,C1=C2), IF(AND(NOT(ISBLANK(H1)), NOT(ISBLANK(H2)), NOT(ISBLANK(K1)), NOT(ISBLANK(K2))), IF(AND(H1<H2,K1<K2), IF(K1>H2, K1-H2, "No Overlap"), "Not Sequential"), "Missing Times"), "N/A")
>
> Y = Operating theatre (PT_0, PT_1), C = Operating date, H = In AR, K = Out of OR

Rules to follow:

0. Sort data in order by: (1) 'Theatre, (2) 'Operation Date', (3) 'In Operating Room'
1. 'Theatre' must be the same (Y2=Y1); else "N/A" because overlap cannot be calculated from two different theatres
2. 'Operating date' must be the same (C2=C1); else "N/A" because overlap cannot be calculated between separate dates (out of hours)
3. The 'In AR' times have to be entered, i.e. not blank (NOT(ISBLANK(H1)) and NOT(ISBLANK(H2))); else "Missing Times"
4. The 'Out OR' times have to be entered, i.e. not blank (NOT(ISBLANK(K1)) and NOT(ISBLANK(K2))); else "Missing Times"
5. Times 'In AR' must be sequential, i.e. PT_0 went through the AR before PT_1 (H1<H2; else state "Not Sequential")
6. Times 'Out OR' must be sequential, i.e. PT_0 came out of the OR before PT_1 (K1<K2; else state "Not Sequential")
7. Calculate overlap time if the 'Out OR' time is later than that of the next patient's 'In AR' time (if K1>H2, then K1-H2; else state "No Overlap")

Most instances of 'Not Sequential' despite the sort by 'In Operating Room' are due to non-sequential AR times or Out of OR times, which could be due to errors in entry. These times should not be included as overlapping times because it is not verified what process occurred.

In order to identify time errors, a macro was created to copy all cases which had an overlap time, whilst also including the 'In AR' and 'Out OR' times for the following case, and the surgery type of the following case. These could better help determine if an error occurred. A consultant anaesthetist evaluated all overlap cases of over 1 hour, as under an hour would be difficult to determine any inaccuracy in the timing. The anaesthetist identified 7 cases of questionable validity, which were removed from the final analysis.

Downtime Calculations

The calculation for downtime related to the time that operating room was sitting unoccupied, meaning the time between the PT_0 'Out OR' time and the PT_1 'In AR' time. Downtimes were not checked by a consultant anaesthetist as causes for downtimes are unknown in gauging validity.

Requirements for Downtime:

- No downtime can be calculated from Emergency or Urgent cases, because there is no guarantee there is a scheduled case to follow. Similarly, the following case cannot be Emergency or Urgent.
- Must be the same theatre and same date.
- Downtime is H2-K1 (i.e. difference in time between PT_0 out of OR & PT_1 in AR)

Formula:

> =IF(AND(Y1=Y2, C1=C2), IF(AND(NOT(ISBLANK(H1)), NOT(ISBLANK(H2)), NOT(ISBLANK(K1)), NOT(ISBLANK(K2))), IF(AND(H1<H2, K1<K2), IF(AND(AA1="ELECTIVE", AA2="ELECTIVE"), IF(H2>K1, H2-K1, "No Downtime"),"Not Possible"), "Not Sequential"), "Missing Times"), "N/A")
>
> Y = Operating theatre (PT_0, PT_1), C = Operating date, H = In AR, K = Out of OR
>
> AA = Operating Type (i.e. Elective, Emergency, Urgent)

The downtimes were calculated similarly to the overlap times in requiring the following:

- Theatres and operation date must be the same, else “N/A”
- All time stamps must be entered in order to determine if there was an error in times or not, else “Missing Times”
- Times must be sequential otherwise there may be an error in the entry, else “Not Sequential”
- Different from overlap time calculations, the procedure and the following procedure must both be elective procedures because an urgent or emergency case has no guarantee of there being a scheduled case to follow. Comparisons were only made for elective procedures. (AND(AA1= “ELECTIVE”, AA2= “ELECTIVE”))
- Downtime could only be calculated from same day procedures (so as to know it was not a gap between separate days, which would not be downtime), and only for cases where the “In AR” time for the 2nd procedure is after the “Out OR” time of the 1st procedure.
    - Else “No Downtime”

Procedure Durations

Formula: =IF(AND(NOT(ISBLANK(I2)), NOT(ISBLANK(K2))), K2-I2,"UNKNOWN")

> I = Anaesthetic Induction Time, K = Out of OR Time
>
> *Conditions:*

- As stated in text, procedure duration was calculated as the time between the commencement of anaesthetic induction to the time leaving the theatre (K2-I2)
- Only calculate if there is a time entered for each stamp (NOT(ISBLANK(I2)))
- If duration cannot be calculated, then "UNKNOWN".

Procedure duration times were evaluated by a consultant anaesthetist to evaluate if times were realistic for the procedures, as a falsely high time duration would result in unrealistically high staffing costs, which are calculated per hour of procedure time. All procedure durations of zero were excluded from the cost analysis. Procedures longer than 8 hours and shorter than 20 minutes were reviewed by the anaesthetist and 14 cases were removed.

Cost and Income Data

The final profit after costs needed to be calculated for each specialty. Each procedure had a given tariff (Visual Basic coding logic in **Appendix I**) and costs were calculated to provide a realistic estimate of actual costs which could be assumed per procedure.

Staff costs:

- Indicated by Session Type in ORMIS. This field is entered upon booking of the procedure (e.g. Emergency, Standard, Extra ODP, etc.)
- This was assumed to be Standard staffing level if left blank. Additionally, emergency staffing is calculated based on on-call lists at the time, so have been assumed as standard staffing levels for this analysis.
- These relate to a given pay rate per hour for staffing levels (see below). All pay rates were given in 2015/2016 GBP and were converted to 2013/2014 GBP for the analysis.

	2015/2016	2013/2014
SESSION_TYPE	£/Hr	PV
STANDARD	210	£204
EMERGENCY SESSION	210	£204
WAITING LIST INITIATIVE	591	£574
PRIVATE PATIENT	591	£574
EXTRA SESSION	191	£185
PLANNED OVERRUN	210	£204
PHYSICIANS ASSISTANT	316	£307
EO PA	226	£219
Extra ODP	311	£302
No Anaesthetist	166	£161
ASSUMED STANDARD	210	£204

- Staffing costs were calculated by multiplying the hourly rate by the procedure duration.

Consumables, Overheads, Depreciation, and Non-Clinical Income:

- All expenses and non-clinical income figures were sent for months 1-12 for 2013/2014 divided by specialties, and the number of procedures done in each month per specialty were sent. This was then calculated to a cost for consumables per specialty per procedure.
- The number of procedures conducted per specialty were sent over months 1-12 and expenses and non-clinical income were calculated per specialty, per procedure.

	Consumables	Overheads Only	Overheads (No Dep)	All Overheads	Procedures
Accident & Emergency					
Acute Internal Medicine					
ADULT MENTAL ILLNESS					
Anaesthetics					
Breast Surgery	£ 113.70	£ 865.06	£ 57.56	£ 401.72	1341
BURNS	£ 108.22	£ 1,135.45	£ -	£ -	92
Cardiac Surgery	£ 234.38	£ 3,596.35	£ 1,510.76	£ 2,094.88	714
Cardiology					
Chemical Pathology					
Cleft Palate	£ 117.28	£ 540.73	£ -	£ -	351
Clinical Oncology (Previous Radiotherapy)	£ 40.89	£ 125,569.37	£ -	£ -	44
COLORECTAL	£ 107.87	£ 1,650.64	£ 333.86	£ 652.97	2049
Dental Medicine	£ 25.18	£ 243.99	£ 21.79	£ 72.44	814
Dermatology	£ 8.61	£ 10,804.58	£ -	£ -	51
ELECTIVE ORTHOPAEDICS	£ 75.49	£ 937.89	£ 440.22	£ 547.05	5900
ENT	£ 68.23	£ 958.91	£ -	£ -	3117
General Medicine					
General Surgery	£ 80.30	£ 896.93	£ 192.30	£ 301.84	2559
Genitourinary Medicine					
Geriatric Medicine					
Gynaecology	£ 68.81	£ 1,239.18	£ 213.78	£ 410.19	2666
Haematology					
HAND SURGERY	£ 66.05	£ 937.89	£ 440.22	£ 547.05	734
HPB	£ 125.88	£ 1,221.63	£ 89.11	£ 305.29	1173
Infectious Diseases					
Medical Oncology					
Nephrology					
Neurology					
Neurosurgery	£ 145.14	£ 2,001.26	£ 455.37	£ 735.90	1995
Obstetrics	£ 84.01	£ 5,412.42	£ 3,401.35	£ 3,896.49	2531

Obstetrics & Gynaecology	£ 71.32	£ 7,877.81	£ 4,223.13	£ 5,050.76	1062
Ophthalmology	£ 41.30	£ 770.03	£ 56.08	£ 180.13	6049
Oral Surgery	£ 87.42	£ 861.64	£ 67.18	£ 203.69	1463
Paediatric Gastroenterology					0
Paediatric Medical Oncology					
Paediatric Neurology					
Paediatric Surgery	£ 68.31	£ 515.00	£ -	£ -	2326
Paediatrics	£ 49.33	£ 24,514.61	£ 4,314.47	£ 8,189.94	150
Pain Management					
Palliative Medicine					
Plastic Surgery	£ 73.16	£ 770.21	£ 260.04	£ 407.28	2436
Radiology					
Renal Surgery	£ 101.87	£ 4,992.18	£ 244.24	£ 847.78	326
Rheumatology					
SPINAL SURGERY	£ 190.01	£ 1,791.14	£ -	£ 273.50	1254
Thoracic Surgery	£ 148.09	£ 1,747.13	£ -	£ 291.51	893
TRAUMA	£ 109.74	£ 2,124.44	£ 515.65	£ 835.73	2514
Trauma and Orthopaedics	£ 84.14	£ 1,263.97	£ 460.95	£ 626.38	
Urology	£ 54.80	£ 969.34	£ 181.60	£ 344.35	2761
VASCULAR SURGERY	£ 118.46	£ 1,688.33	£ -	£ 109.89	809

- Cost analysis was not conducted on non-surgical specialties (indicated in yellow).
- Some specialties required a weighted average and estimation of costs based on provided financial data:
    - Obstetrics & Gynaecology
        - Consumable figure available for Obstetrics & Gynaecology
        - Overheads, depreciation, and non-clinical income estimated from Obstetrics & Gynaecology figures.
    - Hand Surgery
        - Consumable figure available for Hand Surgery
        - Overheads, depreciation, and non-clinical income split from T&O – Non-trauma figures.
    - Elective Orthopaedics
        - Consumable figure available for Elective Orthopaedics
        - Overheads, depreciation, and non-clinical income split from T&O – Non-trauma figures.
    - Trauma
        - Assumed to be T&O – Trauma figures.
    - Trauma & Orthopaedics

        - All costs & non-clinical income estimated from weighted average of Elective Orthopaedics, Hand Surgery, and Trauma specialties.
- As stated in text, some non-clinical income figures far exceeded overheads and depreciation, resulting in a net negative figure of cost (so net positive income) per procedure. This was due to internal trading and false depictions of pharmacy income, so all net negative costs were set to zero cost.

Profit Calculations

Four different profit calculations were done for post-hoc use.

1. Profit – No Overheads
2. Profit – Overheads, Depreciation, and Non-clinical Income
3. Profit per Hour – No Overheads
4. Profit per Hour – All Overheads (i.e. Overheads, Depreciation, and Non-clinical Income)

Formula: (example)

=IF(AND($BG2>0,$BI2>0,$BJ2>0),$BG2-$BI2-$BJ2-$BM2,"")

BG = Tariff, BI = Staff cost,

BJ = Consumables per procedure, BM = All OH per procedure

Conditions:

- If all costs are available (greater than nothing) then profit is tariff (income) minus overheads (with non-clinical income already taken from overheads).

Profit per hour was calculated by dividing by the procedure duration.

Theatre List Utilisation Analysis

The full data set was also considered on a list level (whole day) not on an individual procedure level. The List start time was calculated as the first procedure of the day in a theatre. The List end time was calculated as the last procedure of the day in a theatre.

Formula: (List start time) =IF(C2<>C1,H2,"")

C = Operation date, H = In AR Time

Formula: (List end time) =IF(C2<>C3,K2,""), K = Out of OR Time

A macro was written to only export the list start and end times if the procedures were Elective or Urgent procedures, as the Emergency procedures could not be considered planned and therefore reflective of scheduled procedures. For example, a theatre with a procedure done at 11pm which was an emergency procedure should not be considered as having a list scheduled from the morning to through 11pm.

Fields exported from the macro were as follows:

- The total duration of the list was calculated (LISTDUR_HR)
- Total Downtime from all procedures in the list (DT_MIN)
- Total Overlap time from all procedures in the list (OL_MIN)
- Number of procedures in the list (NO_PROC)
- Start and End times
- Total Time Savings (SAVINGS_MIN & SAVINGS_HR) were calculated as the net time saved (OL-DT)

Cost Analysis

Three methods for determining financial savings due to overlap were employed:

- Profit per hour
- By procedures done
- By specialties done

Profit Per Hour

The Profit Per Hour method was the most optimistic model and considered any marginal amount of total time savings on a list (as above, Total Time Savings), even if only seconds or a few minutes.

DAY	% of year	N	Mean	**Prof/Hr (No OH)**	**Prof/Hr (All OH)**	**N**	**Total**	**% Specialty**	**Savings (No OH)**	**Savings (All OH)**
Monday	85%	44	8.98	£ 1,532.91	£ 1,405.01	109	111	98%	£ 229.36	£ 210.22
Tuesday	79%	41	1.49	£ 1,120.94	£ 925.14	136	138	99%	£ 167.72	£ 138.42
Wednesday	79%	41	19.54	£ 1,501.23	£ 1,352.55	107	114	94%	£ 224.62	£ 202.37
Thursday	79%	41	11.83	£ 1,395.83	£ 1,247.27	140	148	95%	£ 208.85	£ 186.62
Monday	83%	43	.12	£ 1,126.61	£ 849.94	142	142	100%	£ 168.56	£ 127.17
Tuesday	77%	40	16.38	£ 1,343.99	£ 1,198.70	94	116	81%	£ 201.09	£ 179.35

- As only some lists were included (elective or urgent only), some lists were not part of the calculation. Theatre lists which did not capture the mean time savings for over 50% of the year were excluded.
- Only lists with net positive mean time savings could provide additional profit.
- Mean Profit/Hr was calculated per Theatre, Day, & Specialty combination.
- The Profit/Hr was selected for the dominant specialty within the list was selected, with the total number of cases done of the specialty, compared to the total number of cases done on the list, in order to determine the percentage of the specialty.
    - For example, the Monday list shown consists of 109 thoracic surgery cases out of a total of 111, which is 98% of the work done on the list.
- For any dominant specialties (over 80% of the work on the list), the estimate of Profit/Hr of the list was sufficient as an estimate for profit rates on the list, calculated by Profit/Hr times the Mean |Time Savings (converted to hours).

- For any mixed theatres (no dominant specialty of over 80%), the largest proportions of work were aggregated with a weighted average until over 80% of the work was aggregated into the estimated Profit/Hr, as shown for the Monday list in orange.

This process was undertaken again with all net positive time savings, excluding downtime, which increased the number of lists with gains. This optimistic time savings was compared against the actual time savings (including downtime), to see the impact of DT.

By Procedures Done

This estimate looked at mean durations of procedures which had been done within the theatre achieving time savings. All possible procedures which had been done in that theatre before, which were of mean time duration less than or equal to the mean time savings were compiled.

The total count of the procedures done on the list were determined in order to select the procedure with highest count (i.e. selecting not based on highest profit, but on realistic assumption that the procedure was done multiple times in that theatre -not a one off).

The mean profit per procedure was then used for calculation for the whole procedure which would fit in the mean time savings on a list.

All procedures selected were verified by the consultant anaesthetist to determine the plausibility of having the selected procedure waiting to be done (i.e. plausibility of up-scheduling a case).

Most time savings were too small per list to fit an entire procedure.

By Specialties Done

Similarly as above, the same strategy was undertaken, except for all possible procedures conducted in specialties which were done in the theatre list. This assumed theatres might only be able to do work for certain specialties; however, any procedures of that specialty done across the Trust could be done. This opened up assumptions compared to the *By Procedures Done* model and is more optimistic.

All weekly total potential profits were summed and extrapolated to a 52 week year to estimate total profits for across the Trust annually.

Present Value Cost-Benefit

The total cost for purchasing, maintaining, and equipping the anaesthetic rooms were shown in **Appendix J**. The three profit models of annual profits (made from time savings) were forecasted out to the maximum lifetime of the anaesthetic machines (10 years) and calculated to present value (2013 GBP) using the UK Gilt 10 Year Yield estimates. The cumulative profit curves were compared against the anaesthetic room cumulative costs to gauge cost-benefit.

End of	Year	Potential Profit Per Hour	UK Gilt 10 Year Yield	PV (2013)	Cumulative Profit
2013	0				0
2014	1	£ 224,044.13	2.6%	£218,433.66	£ 218,433.66
2015	2	£ 224,044.13	1.9%	£435,613.30	£ 654,046.97
2016	3	£ 224,044.13	2.2%	£643,297.01	£ 1,297,343.98
2017	4	£ 224,044.13	2.5%	£841,902.96	£ 2,139,246.94
2018	5	£ 224,044.13	2.9%	£1,029,926.29	£ 3,169,173.23
2019	6	£ 224,044.13	3.2%	£1,206,083.89	£ 4,375,257.12
2020	7	£ 224,044.13	3.5%	£1,369,329.74	£ 5,744,586.86
2021	8	£ 224,044.13	3.8%	£1,518,863.37	£ 7,263,450.23
2022	9	£ 224,044.13	4.2%	£1,654,131.29	£ 8,917,581.52
2023	10	£ 224,044.13	4.5%	£1,774,822.03	£ 10,692,403.55

End of	Year	Potential Profit By Procedures	UK Gilt 10 Year Yield	PV (2013)	Cumulative Profit
2013	0				0
2014	1	£ 5,452.63	2.6%	£5,316.09	£ 5,316.09
2015	2	£ 5,452.63	1.9%	£10,601.65	£ 15,917.74
2016	3	£ 5,452.63	2.2%	£15,656.11	£ 31,573.85
2017	4	£ 5,452.63	2.5%	£20,489.64	£ 52,063.49
2018	5	£ 5,452.63	2.9%	£25,065.63	£ 77,129.12
2019	6	£ 5,452.63	3.2%	£29,352.83	£ 106,481.95
2020	7	£ 5,452.63	3.5%	£33,325.79	£ 139,807.73
2021	8	£ 5,452.63	3.8%	£36,965.03	£ 176,772.77
2022	9	£ 5,452.63	4.2%	£40,257.09	£ 217,029.86
2023	10	£ 5,452.63	4.5%	£43,194.38	£ 260,224.23

End of	Year	Potential Profit By Specialty	UK Gilt 10 Year Yield	PV (2013)	Cumulative Profit
2013	0				0
2014	1	£ 69,427.63	2.6%	£67,689.04	£ 67,689.04
2015	2	£ 69,427.63	1.9%	£134,989.48	£ 202,678.52
2016	3	£ 69,427.63	2.2%	£199,347.28	£ 402,025.80
2017	4	£ 69,427.63	2.5%	£260,892.03	£ 662,917.83
2018	5	£ 69,427.63	2.9%	£319,157.40	£ 982,075.23
2019	6	£ 69,427.63	3.2%	£373,745.78	£ 1,355,821.01
2020	7	£ 69,427.63	3.5%	£424,333.01	£ 1,780,154.02
2021	8	£ 69,427.63	3.8%	£470,671.05	£ 2,250,825.08
2022	9	£ 69,427.63	4.2%	£512,588.38	£ 2,763,413.46
2023	10	£ 69,427.63	4.5%	£549,988.48	£ 3,313,401.93

The same analysis was conducted with overheads included and without. Additionally, the specific lists known to employ physician's assistants were analysed in the same fashion to compare against costs of additional PA staff.

Appendix L 3-Part Patient Experience Survey

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Patient Experience Survey Part 1 of 3: *Pre-surgical Check*

Date & Time of Survey Completion: ____ /____ /____ @ _____ : _____

Age: _____ **years**

Gender: Male ☐ Female ☐

Expectations & Pre-surgical Anxiety (please tick one box for each question 1-5)

1. How long have you been resident in the UK?

Less than a year☐ 1-10 years☐ 11-20 years☐ 21-50 years☐ More than 50 years☐

2. Number of Previous Operations: 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5+ ☐

3. If given the choice, where would you choose to go to sleep for your surgery?

Anaesthetic Room ☐ Operating Theatre ☐

Wherever the Anaesthetist Chooses ☐ I Do Not Know☐

4. Do you know what the *anaesthetic room* is? Yes ☐ No ☐ I'm not sure ☐

5. If yes, where did you first hear about one?

Surgeon/Anaesthetist ☐ Family/Friend ☐ Your own experience ☐
Television show/Movie ☐ News/BBC ☐ Internet ☐
I don't know ☐ Other ☐ *Please explain below:*

6. If you are feeling at all anxious, please explain what may be causing it.

Please explain below ***OR*** *leave blank and select →* I'm not feeling anxious at all☐

7. Please mark with a vertical line to indicate your current level of anxiety

No Anxiety |——————————| Extremely Anxious

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Unique Code _____

Patient Experience Survey Part 2 of 3: *Time of Induction*

Part 2 of 3 must be completed by the patient

To be completed by the patient just prior to provision of primary anaesthetic

Please mark with a vertical line to indicate your current level of anxiety

No Anxiety |——————————| Extremely Anxious

Please send to co-investigator, Jeena Velzen

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Unique Code _____

Patient Experience Survey Part 2 of 3: *Time of Induction*

Part 2 of 3 must be completed by the anaesthetist

***Surgical Severity:**
Minor: e.g. carpal tunnel, MUA, arthroscopy: procedure generally lasts <30 min
Intermediate: e.g. hernias, ACL reconstruction, varicose veins: procedure generally lasts <1 hour
Major: e.g. lap cholecystectomy, primary joint replacement
Complex: e.g. open cavity surgery, major laparoscopic surgery, organ resections, bilateral or revision joint replacements

*See above for definitions for questions marked**

Date: ____ /____ /____ **Theatre Number:** _____

Time Entering Surgical Suite (AR or OT): _____ : _____

Operation Name: _____

ASA Grade: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Surgical Severity*: Minor ☐ Intermediate ☐ Major ☐ Complex ☐

Where did induction take place? Anaesthetic Room ☐ Operating Theatre ☐

Anaesthetic induced by (*please tick all that apply*)**:**

Consultant ☐ | Trainee/Trust grade junior ☐ | Non-consultant grade senior ☐ | Physician's Assistant (A) ☐

Induction of GA: Inhalational ☐ Intravenous ☐ Not GA (i.e. regional) ☐

Maximum number of people present during induction: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7+ ☐

Time Sleeping Agent or Regional Anaesthetic is Administered: _____ : _____

Was an anxiolytic administered prior to measuring patient anxiety?

Yes ☐ No ☐

Patient Experience with Surgical Anaesthesia
Patient Experience Survey Part 1 & 2
Final Version 3.0 Date 8/4/16

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Patient Experience Survey Part 3 of 3: *Post-Surgery*

Please mark a vertical line on the scale, or tick the box, for each question 1-7

How satisfied were you with…

1. … the information you were given by the anaesthetist before your operation?
Very Dissatisfied |—————————————| Very Satisfied I don't recall ☐

2. … the level of noise before you fell asleep?
Very Dissatisfied |—————————————| Very Satisfied I don't recall ☐

3. … the number of people around you before you fell asleep?
Very Dissatisfied |—————————————| Very Satisfied I don't recall ☐

4. … what you witnessed happening around you before you fell asleep?
Very Dissatisfied |—————————————| Very Satisfied I don't recall ☐

5. … your level of privacy before you fell asleep?
Very Dissatisfied |—————————————| Very Satisfied I don't recall ☐

6. … the specific room in which you were located while you fell asleep?
Very Dissatisfied |—————————————| Very Satisfied I don't recall ☐

7. … your overall anaesthetic care?
Very Dissatisfied |—————————————| Very Satisfied

8. What factors do you feel were helpful in relieving your anxiety? *Please tick all that apply*

The amount of explanation by doctors and staff ☐
Being given an opportunity to ask questions ☐
Education about anaesthesia (e.g. pamphlet/video) ☐
Family member accompanying you to theatre ☐
The amount of reassurance from the anaesthetist ☐
Having been put to sleep in the location you were ☐
I was not anxious at all ☐
Nothing helped my anxiety ☐
Other ☐
Please explain:

9. If applicable, please list anything that you would have changed about your experience that you believe would have made you less anxious or nervous.