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PATIENT SAFETY RESEARCH PORTFOLIO (PSRP)
Project No PS041

Cost-Effectiveness of Hospital Design: Options to Improve Patient Safety and Wellbeing

Final Report

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Executive Summary

1. INTRODUCTION

The Patient Safety Research Programme (PSRP) commissioned a collaborative research team from the York Health Economics Consortium (YHEC) and RKW Healthcare Strategists to conduct a review of the cost-effectiveness of various options for hospital design. The study comprised four phases.

2. PRELIMINARY CASE STUDIES

Six case study hospitals were selected from a national data base of major acute hospital PFI projects in England. The purpose of these case studies was two-fold:

- To identify design issues that were of relevance to the NHS, from which could be selected a small number that would be studied in greater detail;
- To identify issues relating to the design process.

These design issues were discussed by the Project Steering Group, who selected four. These were:

- Single rooms;
- Design issues impacting on slips, trips and falls, which included flooring choices, location and design of bathrooms and toilets and location and use of hoists, beds and rails;
- Ventilation, including positive and negative pressures in wards and theatres, and use of natural ventilation;
- Design of operating theatres, including shared facilities such as scrub, recovery and anaesthetic facilities, and use of barn theatres.

3. LITERATURE REVIEWS

Overview

The literature reviews covered the following design options:

- Single rooms;
- Operating theatres;
- Ventilation;
- Slips, trips and falls.

The main research question to address was how the design of the hospital environment contributes to both the safety and well-being of patients and thereby influences their recovery.

A systematic literature search was conducted for studies concerning each of the above four design options to which was added staff culture, in relation to the pre-specified outcomes. The search comprised a search of relevant bibliographic databases, internet and grey literature searches, reviews of papers extracted from personal libraries and hand-searches. The literature review focuses on the impact of design options on infection rates, length of stay, adverse events, medication errors, patient satisfaction and costs. The included studies were quality graded according to the NICE methodology checklists and data from the studies were recorded in a data extraction form. Studies were summarised using a narrative synthesis as this was deemed more appropriate than a meta-analysis.

Single Rooms

A total of 219 potentially relevant references were identified by the search. After applying the inclusion and exclusion criteria, 152 papers were obtained for further assessment and ultimately 28 studies were included in this review.

Twenty-eight studies quantified an effect of single-bed rooms on patient outcomes in relation to other room designs, or reported costs. The studies providing quantifiable evidence reported data on infection rates, patient satisfaction and costs; length of stay and medication errors were reported less frequently in the literature. However, there was often significant variation in the effects reported by the studies; for instance, some studies indicated that single rooms are associated with a reduced rate of infection compared to other room designs, whereas other studies reported no difference in infection, or even higher infection rates. The quality of the reviewed studies on single rooms ranged from type 2++ to type 4+.

The literature indicated that evidence relating to the effect of single rooms on the pre-specified outcomes is mixed; it is not possible to say with certainty that single-rooms reduce outcomes such as infection rates and length of stay and increase patient satisfaction. In several of the studies included in the review, it was difficult to establish whether the effect on outcomes was attributable to room design, or whether other factors may have confounded the effect. Approximately half of the included studies in this review were conducted in the US, hence highlighting the absence of UK-based single-room studies.

Design Options for Slips, Trips and Falls

A total of 196 potentially relevant references were identified by the search. After applying the inclusion and exclusion criteria, 47 papers were obtained for further assessment and ultimately 12 studies were included in this review.

There were twelve studies that quantified a before and after effect of different hospital designs on slips trips and falls. The studies providing quantifiable evidence concentrated on interventions with respect to hospital flooring, hospital bed side rails, patient transfer devices and patient furniture. The slips trips and falls outcome was reported with respect to effect on falls and effect on injuries sustained through a fall. The quality assessment of the reviewed studies on slips, trips and falls ranged from type 1 + to type 2 +.

It was difficult to establish the causal effect of the design intervention in many of the studies because of the nature of the measured before and after effect of the intervention and confounding factors. For example, there may be other factors within the patient environment such as staff perceptions, ward type and patient characteristics that gives the false appearance of an association between the design option and slips, trips and falls. The evidence highlighted that there are important tradeoffs which should be recognised with respect to the pre-specified outcomes. For example, flooring design materials have different relative tradeoffs between slips, trips and falls and infection risk.

Design Options for Ventilation

A total of 174 potentially relevant references were identified by the search. After applying the inclusion and exclusion criteria, 113 papers were obtained for further assessment and ultimately 17 studies were included in this review.

There were 17 studies that quantified an effect of hospital ventilation designs on infection, or that reported costs. Hence quantifiable evidence was only reported for one of the five pre-specified outcomes. A large proportion of the ventilation literature related to ventilation in operating theatres. Increasingly, ultra-clean ventilation (laminar air flow) is being used in operating theatres. Several studies investigated bacterial counts but the relationship between bacterial counts and infection rates has not been explicitly quantified to date, which resulted in these being excluded. The quality of the reviewed ventilation studies ranged from type 1+ to type 4+.

It is difficult to draw definite conclusions regarding the efficacy of ventilation systems in terms of infection control due to several uncontrollable variables being involved, which may also impact on the infection rate. However, overall the level of infection tended to be lower in operating theatres with vertical laminar air flow as opposed to those with conventional ventilation.

Design Options for Operating Theatres

A total of 95 potentially relevant references were identified by the search. After applying the inclusion and exclusion criteria, 70 papers were obtained for further assessment and ultimately 7 studies were included in this review.

There were seven studies that quantified an effect of different operating theatre designs on patient outcomes, or that reported costs. The studies providing quantifiable evidence reported only on infection rates, with data being absent regarding length of stay, medication errors, adverse events and patient satisfaction. The comparisons made by the studies tended to be between old and new operating theatre designs, although the designs differed between studies. In general, there were lower infection rates in the newer operating theatres, apart from one study that indicated no significant difference. The quality of the studies on operating theatres reviewed ranged from type 2++ to type 4+.

It was difficult to determine which aspect of the operating theatre design had an impact on the infection rate. This was due to the comparisons of the operating theatres under consideration often involving several changes such as ventilation system, for instance. With the exception of one study, all the included data were drawn from studies that are over a decade old, in which time practices will have changed substantially. In particular, research is needed into current operating theatre design issues such as barn theatres, operating theatres with an anaesthetic room incorporated within it, and the sharing of scrub, preparation rooms and anaesthetic facilities.

4. WILLINGNESS TO PAY PUBLIC SURVEY

The aim of this research is to evaluate the costs and benefits of a number of hospital design options to inform decisions on the future design of hospital refurbishments and new builds in the NHS. The benefits are evaluated using contingent valuation (CV) methodology. The methodology is survey based and assesses the willingness to pay of the public and staff for two of the design options: single rooms and flooring.

The contingent valuation methodology uses survey methods to present respondents with hypothetical scenarios about an option. This tool is designed to allow analysts to estimate the demand for goods/services that are not traded or only rarely traded. The method was first used in recreation planning to estimate the benefits of different recreation areas.

The respondents in the survey are required to think about the contingency of an actual market existing for the design option and are then asked to reveal the maximum they would be willing to pay for such an option. The method measures *ex ante* valuations. That is, it provides a valuation at the moment the choice is made. The approach is founded on the belief that individuals are the best judge of their own well-being.

The mean valuation for a single room versus a 4-bed room was £73 per night, a single room without an en-suite was £53 per night and a single room for five nights per night was estimated to be £35 per night. The mean valuation for the laminated wooden flooring was £18 per night compared with £23 for vinyl flooring. It should be noted the median valuation for both of the flooring options was £0 per night. The valuations were presented by a number of other factors such as length of stay, patient preferences and demographics.

The findings of the WTP exercise completed with members of the general public suggests that participants had a strong preference for single bed rooms compared to 4 bedded rooms. Furthermore, the preference for a single bed room with an en-suite bathroom was even stronger.

Responses to the willingness to pay exercise regarding flooring options showed that participants were largely indifferent to alternative flooring options in hospitals. A significant number of participants provided zero values for flooring options. This may be due to genuine indifference relating to flooring options or may reflect a relatively low level of awareness about the number of slips, trips and falls which occur in NHS hospitals and the implications in terms of morbidity and healthcare resources.

5. FINAL CASE STUDIES

The purpose of the final case studies was to identify evaluations, data and findings in respect of four design options. We also planned to undertake further WTP studies with staff and patients; however it proved too problematic to undertake the studies with patients. Five trusts were recruited for the case study visits, of which four were completed at the time of writing the final report. We obtained ethics approval to undertake these studies from North Sheffield Ethics Committee.

At each trust, between 8 - 10 staff were interviewed, using a semi structured schedule, about the four design options. Staff at three trusts also completed surveys (n=26), and at the fourth, a modified survey excluding questions on valuations. Trusts were asked to provide evaluations and reports.

Staff described the implementation and use of the design options, the issues arising from the implementation and use, and the impact of the design options on patient safety. Whilst staff described in some detail all aspects of these design options, including issues under new PFI builds, little evidence was available to support their assertions and perceived benefits.

Responding to questions on hospital issues, staff indicated that privacy was more important than interaction with other patients, and prevention of infection was the most important issue and avoidance of falls the least important. Having natural light was ranked as the most important environmental factor, whilst interior décor was ranked as the least important.

The mean valuation for a single room versus a 4-bed room was £79 per night, a single room without an en-suite was £36 per night and a single room for five nights per night was estimated to be £90 per night. The mean valuation for the carpeted flooring was £0 per night, and the mean results for vinyl compared with resin flooring was £2.50. It should be noted the median valuation for both of the flooring options was £0 per night, and a significant number of participants provided zero values for flooring options. The valuations were presented by a number of other factors such as length of stay, patient preferences and demographics.

The findings of the WTP exercise completed with staff from NHS trusts suggests that participants had a strong preference for single bed rooms compared to 4 bedded rooms. Furthermore, the preference for a single bed room with an en-suite bathroom was even stronger.

6. RECOMMENDATIONS

A series of research recommendations were made in respect of the four design options. Four recommendations were made in respect of the final case studies:

- Trusts should be encouraged to undertake audits and evaluations of patient safety design issues, to ensure cost effective solutions are chosen and implemented;
- The DH consider updating their HTMs to take more account of patient safety;
- The NPSA and the DH Estates Division promulgate good and cost effective design options;
- The trade-off between costs and patient safety is considered in more detail in PFI schemes with appropriate costs of the impact of adverse events being taken into account.

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Abbreviations

BCI	Benefit Cost Index
CBA	Cost Benefit Analysis
CUA	Cost-utility Analysis
CV	Contingent Valuation
GCSE	General Certificate Secondary Education
GNVQ	General National Vocational Qualification
HTM	Health Technical Memorandum
NHS	National Health Service
NICE	National Institute for Health and Clinical Excellence
NOAA	National Oceanic and Atmospheric Administration
NPV	Net Present Value
QA	Questions Answered Ltd
QALY	Quality Adjusted Life Year
WTP	Willingness to Pay
YHEC	York Health Economics Consortium Ltd

Section 1: Introduction to Research Project

1.1 CONTEXT

Over the next few years, the NHS will be replacing and refurbishing healthcare buildings and building 100 new acute hospitals. The design and implementation of the building work should be informed by patient and staff safety issues, and therefore NHE Estates (NHSE) and the National Patient Safety Agency (NPSA) have established a joint project, creating a Safer Built Environment (CASBE). The role of CASBE is to raise awareness of the need for safety features to be an integral part of both the process of designing a facility as well as the final product. However, whilst there is much empirical evidence about the impact of the built health care environment on staff and patients, the robustness of this evidence is not always evident, often lacking the underpinning rigour of clinical trials and economic evaluations. Therefore the Patient Safety Research Programme (PSRP) is commissioning a critique of a subset of the literature, followed by the undertaking of a series of economic evaluations for proposed environmental initiatives, for which there are unclear cost benefit analyses.

The unprecedented investment in new hospitals currently taking place within the NHS provides the opportunity for the application of what has been described as “evidence based design”. While the brief for this research project is, appropriately, to establish the evidence for key design choices it is important also to recognise how features of the briefing, design and procurement process and the wider health policy agenda may yet impede their introduction. Such features include:

- The **pace** at which the investment programme is taking place such that the opportunities to apply lessons from previous projects have, to date, been limited;
- A focus on comprehensive, **whole hospital** developments rather than incremental approaches such that extensive and complex design decisions are required early with limited opportunity for subsequent modification;
- The emphasis on investment in major hospitals when alternative care settings may, in some cases, deliver greater patient safety;
- Typically **under-developed public sector comparator designs** leaving key design issues to be resolved in haste in a competitive bidding environment;
- An NHS tendency to favour local invention over standard, albeit proven, solutions;
- An increasing private sector role in the delivery of care such that the NHS’ direct control over the quality of care settings will diminish.

Since much of the evidence currently cited for the effect of design upon patient safety and well-being is derived from the United States, it is important to recognise, and adjust for, differences in culture, clinical practice, patient expectations and design and procurement processes which may affect applicability to the UK. It is also important to recognise that the current promotion of some design options currently may be only in part associated with their contribution to patient safety (evidence based or otherwise) and in part because of other policy agendas. Thus recommendations to increase the percentage of single rooms on inpatient wards were, initially, driven as much by NHS Plan objectives for a more consumer-responsive NHS as by their contribution to reducing hospital acquired infection. Unpacking overlapping policy agendas – and identifying where these converge or conflict is necessary to establish how far evidence alone can influence design decisions.

1.2 AIMS AND OBJECTIVES OF THE RESEARCH PROGRAMME

The aim of the programme is to review the cost effectiveness of various options for hospital design, building on previous systematic reviews. The study will comprise four elements:

- To update the existing systematic reviews;
- To draw up priorities for health economic analysis;
- To assemble the knowledge of the ways in which design of buildings and the interior design of space impacts on the efficiency, safety and acceptability of patient care;
- To reconcile the costs and benefits of different design solutions.

1.3. BACKGROUND

There has been a general and growing belief from the early 1980s that the quality of the environment reinforces the quality of patient care, with improved patient satisfaction and outcomes, and improved staff and visitor satisfaction. The MARU[1] evaluation of the initial Kings Fund project *Enhancing the Healing Environment* (Francis et al 2003) states that: "there is a growing appreciation in the NHS of the impact of the hospital environment on the patient experience and staff recruitment and retention". Much of the philosophy stems from the work undertaken by Ulrich in the 1980s, following the publication of research indicating that surgical patients in rooms with an outdoor view suffered fewer complications, used less pain medication and recovered more quickly than those in rooms with internal views or none at all.

[1] King's Fund et al. Improving the patient experience: evaluation of the King's Fund's Enhancing the Healing Environment Programme. Francis S - 2003 - London: Stationery Office.

However, the literature on the evaluation of initiatives to improve physical environment indicates that, whilst there is evidence of the positive impact of environmental improvement in certain clinical areas, for example, for the elderly particularly those with dementia, and for those with mental health problems there appears to be little economic evaluation of the healthcare environment. A preliminary brief review of the literature also indicated the lack of a rigorous evaluation framework in most studies. Finally, some of the literature points to the need for a change in environment to be accompanied by a change in processes and attitudes.

Marberry[2] et al (2004) undertook a review of major areas of research in office, factory and school structural design to assess the applicability of design approaches in these environments to the design of the health care environment. Most of the review focused on the impact on productivity, satisfaction, learning and recovery, and little focused on safety. However, one interesting finding was the impact of the physiological effects of ageing on the workforce. Failing eyesight, hearing and flexibility and slower response times are among the limitations facing older workers. These issues are clearly analogous to health care situations, for example one study from the US asserted that hospital nurses are, on average, aged in their mid-40s. Therefore noisy nursing stations and inadequate lighting in pharmacy and supply cupboards may contribute to errors and missed information. Many of the studies in these environments have also highlighted built environment factors that impact on job satisfaction, and we can hypothesise that improved job satisfaction should lead to a decrease in errors as individuals feel less stressed and more comfortable. Stress can also have a psychological impact, such as anxiety, depression and anger, physiological such as impact on blood pressure (but mostly not impacting on safety) and behavioural, impacting on staff through sleeplessness, inattention to detail and the potential for substance abuse and impacting on patients through aggressive behaviour and refusal to follow instructions.

Studies on the impact of noise, for example in offices and factories, have demonstrated the health risks such as increasing rates of accident and absenteeism. The impact of air quality has also been shown to affect short-term sickness levels, and the impact of improved lighting including sunlight has been shown to reduce the impact of fatigue on workers. However, Cooper[3] (2001) in reviewing the effect of working conditions on patient safety, discussed, *inter alia*, physical environment. They reviewed the evidence on factors such as ambient noise, lighting, temperature and colours on, for example, medication errors, nosocomial infections and mortality, but they found that there was mostly insufficient evidence.

There have been several empirical approaches to the impact of design on safety. For example, approaches to designing a safe hospital were debated in the conference arranged for the design of the St Josephs Community Hospital in West Bend. The conference participants identified 10 critical design features to improve the design process. These are shown in Box 1.1

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2 Marberry S. 2004. Designing better buildings: What can be learned from offices, factories and schools. http://www.rwjf.org/files/publications/other/MarberryPaper.pdf.

3 Cooper JB. 2001. *Current Research on Patient Safety in the United States*. National Patient Safety Federation.

Box 1.1: Critical design features

- Use Failure Modes and Effects Analysis (FMEA) on current facility and at every design stage. Design process should be data driven;
- Engage a wide representation of stakeholders in the design process;
- Create an organisational process. Begin mock-ups and equipment planning from Day 1;
- Consider the human factors and environmental effects on staff, patients and families;
- Design around the vulnerable populations;
- Design for flexibility, scalability, and accessibility to adapt to changes in technology and work processes;
- Design for maximum standardisation;
- Provide accessible information systems at the point of service;
- Address known hazards to patient safety in the physical environment.

Another scheme utilising innovative design principles was the 'Fable Hospital', which included private oversized and acuity-adaptable rooms for patients, so that they could accommodate a wider range of patient conditions, needs, equipment and staffing. These, and other design features, although adding an estimated $12m to construction costs, have saved an estimated $7.8m in a year, by reducing the number of patient falls, transfers, nosocomial infections, nurse turnovers and drug costs. (Cited in Ulrich and Zimring[4], 2004)

Ulrich and Zimring have stated that evidence based design can improve hospital environments in three key ways:

- Enhancing patient safety, by reducing risk of infections, injuries from falls and medical errors;
- Eliminating environmental stress factors such as noise and poor lighting that can impact on staff performance;
- Reducing stress and promoting healing by making hospitals more pleasant and comfortable and supportive for users and staff.

Based on their review of evidence, Ulrich and Zimring made a series of recommendations summarised in Box 1.2.

[4] Ulrich R and Zimring C. 2004. The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity. Report to Tenter for Health Design for the Designing the 21st Century Hospital Project. http://www.rwjf.org/files/publications/other/RoleofthePhysicalEnvironment.pdf.

Box 1.2: Design features for safer hospitals

Recommendation	Explanation
Provide all patients with private rooms	Improve patient safety by: • Reducing patient transfers; • Reducing the risk of nosocomial infections; • Improving privacy; • Reducing stress; • Improving staff communications with patients and relatives.
Improve indoor air quality	Improving ventilation systems and using well designed air filters, in conjunction with private rooms and improved hand washing can reduce infection rates.
Increase opportunities for cleaning hands	Improved cleanliness can reduce nosocomial infections: hand washing and disinfection stations should be placed at key locations inside patient rooms and elsewhere in clinical areas.
Make hospitals quieter	Stress can be reduced for patients and staff by using sound-absorbing ceiling tiles and carpeting.
Provide better lighting and access to natural light	Exposure to daylight and natural views can improve patient outcomes by: • Reducing depression, agitation and the need for pain medications; • Encouraging improved sleep and normal circadian rest-activity rhythms; • Improving lighting to reduce likelihood of medication errors.
Create pleasant, comfortable and informative environments	Changes to layouts, colours, furniture choice and arrangements, floor coverings, and provision of information material and displays can improve moods and physiological states. Views of nature and gardens can reduce stress and alleviate pain.
Make hospitals easier places in which to navigate	Improving signage and way finding systems, providing reassurance signs for long paths, and provision of clear identification of rooms can: • Reduce stress for patients and visitors; • Reduce costs for staff providing assistance (who were not responsible for this).

A further research study, funded by the NHS Estates reviewed the links between hospital design and hospital associated infections (Noble[5] 2003). This study, however, excluded mechanical and electrical engineering services, operating theatre design and catering services. The research team undertaking the study, whilst assessing how building design affects control, such as the impact of environmental services and the facilitation of cleaning and maintenance, were unable to find research-based guidance that dealt with the interaction of the design of the built environment and infection. Most guidance merely asserted good practice. On the other hand the team interviewed a range of individuals, who identified seventeen key issues that should be addressed (although these were not necessarily evidence based). Issues of interest included: staff management and processes such as hand-washing and the management of cleaning services; design of wards and

[5] Ann Noble Architects, Health facility planning and architecture. Reduction of hospital acquired infections by design. 2003. NHS Estates Research and Development Project B (01)06.

patient areas such as bed spacing, single beds against bays (the cost implications of single rooms were highlighted), and building details such as cupboards and dados; and finally patient management processes such as the inability to clean beds and patient areas between changes in occupancy. The majority of the recommendations from this study therefore focused on guidance about working in a building rather than about the building and design itself.

In summary, the literature points to many assertions, much guidance and many empirical observations, but little by way of rigour.

1.4 METHODOLOGY ADOPTED

1.4.1 Management of the Project

The project was managed by an external steering group which also served as the external advisory group. Group members came from a wide range of backgrounds, including academics research departments, the NHS staff, the Department of Health, and the National Patient Safety Agency (NPSA). Additionally, an independent economist working for the NPSA and an economist working with the PSRP also advised the Project Team. The Group monitored progress of the project, and played a key role in the choosing of the design features for further investigation, and the development of the methodological tools, particularly the willingness to pay study.

1.4.2 Phases of the Study

The research study comprised four phases:

- **Phase one:** preliminary case studies in six trusts, out of which were identified design features that warranted further investigation;
- **Phase two:** systematic literature review on the four design features chosen by the Project Steering Group;
- **Phase three:** willingness to pay study with members of the general public;
- **Phase four:** case studies with a further group of NHS Trusts.

The detail of the methodology adopted is discussed in each of the sections discussing the phases. However, it should be noted that the methodology adopted for the final case studies had to be modified from that originally proposed given the problems that the research team encountered in trying to recruit trusts for site visits.

1.5 STRUCTURE OF REPORT

The report structure follows the phases of the study. Reports had been issued prior to completion of this final report, giving detail results of the systematic literature reviews of the four design options, and of the results from the willingness to pay studies. This report brings the results of all phases together:

- **Section 2** discusses the findings from the preliminary case studies;
- **Section 3** summarises the findings from the literature reviews of the four design options:
  - **Single rooms;**
  - **Design features impacting on slips, trips and falls;**
  - **Ventilation;**
  - **Operating theatres.**
- **Section 4** summarises the willingness to pay study;
- **Section 5** summarises the findings from the case studies undertaken with four NHS trusts, which mostly focused on the implementation of the four design options;
- **Section 6** summarises the recommendations from the previous sections.

Section 2: Preliminary Case Studies

2.1 INTRODUCTION

The purpose of the preliminary case studies was two-fold:

- To identify design issues that were of relevance to the NHS, from which could be selected a small number that would be studied in greater detail;
- To identify issues relating to the design process.

2.2 PROCESS OF CASE STUDY

Six case study hospitals were selected from a national data base of major acute hospital PFI projects in England, one of which was the pilot for the interview schedule. The projects were selected to provide a range in terms of:

- Geographical spread;
- Project stage;
- Size;
- Specialty range;
- New build-refurbishment mix.

Table 2.1 summarises the characteristics of the case study hospitals. The details of each hospital and scheme are not given, to ensure anonymity of the participants.

Table 2.1 Characteristics of case study sites

Characteristics	Summary
Value of scheme	Two schemes < £100m One scheme £100m-£300m Two schemes £300m-£400m One scheme > £400m
Number of beds	One scheme: 100 beds Two schemes: 100-500 beds Two schemes 500-1000 beds One scheme >1000 beds
Status (at time of interview)	Four operational Two under construction

Additionally, the sites covered a wide geographical spread and a wide range of specialities including regional specialties.

Interviews were undertaken with available members of the Trusts' project teams: 13 were conducted in total. The interviews were conducted over a three month period.

A structured interview schedule was used, the purpose of which was to identify the:

- Scheme details;
- Design process, including what was decided when;
- Project team, including the composition and influence;
- Design brief, and whether it was prescriptive or fluid, and the role of the public sector comparator;
- Key design choices and what factors influenced the choice.

2.3 CASE STUDY OUTPUTS

2.3.1 Design Issues

A wide range of design issues were identified by respondents as significant in their schemes. These were:

- Single rooms;
- Patient observation, and ward layout (often linked to single rooms);
- Zoning and adjacencies;
- Separation of flows;
- Wayfinding;
- Operating theatre suite configuration;
- Control of infection;
- Equipment management and storage;
- Patient movement, for example with hoists;
- Standardised layouts;
- Daylight and lighting;
- Specific requirements for children;
- Flooring;
- Integration of ICT.

These design issues were discussed by the Project Steering Group, who selected four. These were:

- Single rooms;
- Design issues impacting on slips, trips and falls, which included flooring choices, location and design of bathrooms and toilets and location and use of hoists, beds and rails;
- Ventilation, including positive and negative pressures in wards and theatres, and use of natural ventilation;
- Design of operating theatres, including shared facilities such as scrub, recovery and anaesthetic facilities, and use of barn theatres.

Additionally, the Steering Group recognised that implementation of design features were equally relevant. Implementation included staffing levels, attitudes of staff, staff culture and staff satisfaction. These features were also addressed in the case studies.

Four were selected as the maximum number that could be investigated in sufficient depth during the life of the project. The criteria for selection of these design issues included applicability and generalisability to the widest audience; the importance given to these features during the case study interviews, the likely impact of the features, and the availability of evidence on effectiveness of changing design features. The project also sought to address features that were particularly addressed in the review by Ulrich and Zimring (see Box 1.2).

2.3.2 Design Processes

A range of issues relating to the design processes were identified. Whilst these were not of particular relevance to the next phase of the project, they were of relevance to the final case study phase, where many were revisited.

The design process issues were:

- Time lags and the challenges of refreshing designs;
- Variability in the clarity of clinical models and their influence on design;
- Moving targets, for example, the introduction of and revised space standards consumerism;
- Continuity of participants and the importance for design integrity;
- The currency and relevance of design guidance in a rapidly changing health care environment;
- Differing perspectives on the status of the public sector comparator;
- The desirability of transferring experience from project to project to avoid re-invention;
- How pressures to achieve user sign off may conflict with evidence based design;
- The desirability of early assessment of design options of (properly understood) affordability.

2.3.3 Methodological Issues

Finally, the undertaking of the preliminary case studies highlighted a number of methodological issues, which the research team continued to be aware of during the life of the project, including the undertaking of the final case studies. These were:

- Variable corporate memory and team survival;
- Changing standards and targets, including expectations regarding the percentage of single rooms;
- A tendency towards post-hoc rationalisation of design choices;
- The absence of systematic post project evaluation.

Section 3: Summary of Literature Reviews

3.1 BACKGROUND

In the PSRP overview of literature, the tender specification states that it appears that different designs fall into two broad groups:

- Design options that are dominant in economic terms. These designs produce additional benefits at zero cost or reduced cost. An example of this is the substitution of natural scenes for abstract art;
- Design options that produce additional benefits at additional costs. These designs require a form of cost effectiveness index to compare design options. An example of this is the use of single-bedded rooms in place of multi-bedded rooms.

Our reviews build upon previous systematic reviews on hospital design and patient outcomes with specific emphasis on:

- Studies that have appropriate effectiveness data to populate the modelling for the two broad groups of design options stated above;
- Studies that contain the additional costs of such design options.

The main aim of the review is to critique the literature for both groups of design and to provide data for the economic appraisal of the design options. This is the first review, following the methodology of a systematic review, to the authors'' knowledge, which reviews the quality of studies with respect to the design of the hospital environment.

3.2 KEY COMPONENTS OF A SYSTEMATIC REVIEW

A systematic review provides information about the effectiveness of interventions by identifying, appraising and summarising the results of otherwise unmanageable quantities of research. They follow a replicable, scientific and transparent approach with the aim of minimising bias. They also combine information from published and unpublished studies. Studies included may be of varying study designs, but collectively should be addressing the same questions.

Our reviews follow the Centre for Review and Dissemination (CRD) guidance on performing systematic reviews[6]. The guidance suggests five main components of a systematic review (also called the review protocol) which are as follows:

1. Identification of the research question;
2. Selection of studies;
3. Study quality assessment;
4. Data extraction and monitoring progress;
5. Data synthesis.

Our review includes these five components.

3.3 SYSTEMATIC REVIEW PROTOCOL

3.3.1 Identification of the Research Question

The main research question is to address how the design of the hospital environment contributes to both the safety and well-being of patients and thereby influences their recovery. This review is the first stage in addressing this research question by identifying the effectiveness evidence, economic evidence and costs of different design options. This evidence is used in the second stage of the research by providing effectiveness and cost data for the economic model of the design options.

The main design alternatives that were generated by the interviews conducted by RKW were as follows:

- Single rooms;
- Patient observation – ward layout;
- Zoning and adjacencies;
- Separation of flows;
- Way-finding;
- Operating theatre suite configuration;
- Control of infection;
- Equipment management and storage;
- Patient movement (e.g. hoists);
- Standardised layouts;
- Daylight;
- Children's specific requirements;
- Flooring;
- Integration of ICT.

[6] CRD University of York Dissemination guidance on "Undertaking systematic reviews of research on effectiveness" CRD Report 4 2nd Edition March (2001).

Our systematic reviews have concentrated on the following design options which the Steering Group considered to be highest priority:

- Single rooms;
- Slips, trips and falls;
- Ventilation;
- Operating theatres.

We produced separate reports on our literature reviews for each of the design options, each of which includes the search methodology and the summary of the literature reviewed. These have been incorporated into the relevant sections in this final report, and into the appendices.

The first stage of the review involved identifying the main outcomes that could be affected by different designs which are as follows:

- Infection rates;
- Length of stay;
- Adverse events;
- Medication errors;
- Patient safety;
- Patient satisfaction.

3.3.2 Selection of Studies

The search strategy involved two main elements:

- Search Strategy;
- Study Selection criteria and procedures.

3.3.2.1 Search strategy

A three pronged approach was taken to source relevant literature for this review, namely:

- A search of appropriate literature databases;
- Internet and grey literatures searches;
- Review of papers extracted from personal libraries.

Table 3.1: Search status

Search	Inclusion	Conducted to date
1	General Design search	✓
2	Single rooms and Operating theatres	✓
3	Single rooms	✓
4	Flooring	✓
5	Ventilation	✓
6	Operating theatres	✓

The study design focused on literature that identified outcomes (adverse or positive) which could be affected by design and/or which included costs. The search strategies were complex: we wanted to identify material that was relevant, but not cast the net so wide that we attracted irrelevant literature, such as technical papers on infection control.

We did not seek to restrict ourselves to literature in peer reviewed journals. Firstly, we would have limited a potentially useful source of material; secondly, systematic reviews can include unpublished literature; and thirdly, much of the evidence used by Ulrich and Zimring is not published in peer reviewed journals. Our response was to rate the quality of the evidence, and where that was not possible, to take the weight of evidence for each design feature across all the evidence. Finally, it should be noted that not all of our evidence included information on costs, but also on effectiveness, which included, for example, opinions and patient and staff satisfaction.

Searches were initially undertaken to identify studies concerned with the impact of single rooms, operating theatres and hospital design on infection control. The searches used limited search terms to ensure that the number of records retrieved was manageable. The searches were also initially restricted by date range to 1996-2007. The search strategies can be found in the appendices in this report.

Further searches were undertaken which revisited the single room searches and searched additionally for studies about the impact of operating theatre design on infection control. Although still attempting to identify studies about infection control these searches were also interested in retrieving studies about hospital acquired infection in more general terms, as well as looking for the impact of design on medical and surgical errors (in the two specific settings). The new round of searches did not restrict by date range (searching from date of database inception to 2008, when the searches were being undertaken) and searched in databases beyond that of the purely health care field. The searches were however restricted to English languages studies only.

The following databases were searched:

- MEDLINE & PreMEDLINE;
- EMBASE;
- CINAHL;
- Health Management Information Consortium (HMIC);
- British Nursing Index (BNI);
- Science Citation Index/Social Science Citation Index (SCI/SSCI);
- BIOSIS;
- Database of Abstracts of Reviews of Effects (DARE);
- Health Technology Assessment (HTA);
- NHS Economic Evaluation Database (NHS EED);
- Health Economic Evaluations Database (HEED);
- Cochrane Database of Systematic Reviews (CDSR);
- Cochrane Central Register of Controlled Trials (CENTRAL);
- PsycINFO;

- Social Policy and Practice;
- EconLIT;
- Applied Social Sciences Index and Abstracts (ASSIA);
- Sociological Abstracts;
- Social Services Abstracts.

The search strategies and results of both stages of the literature search are listed below.

Terminology

The initial searches were divided into two separate search strategies: 'single rooms' and 'building design'. Inevitably there was some overlap in the records retrieved from both searches. Search terms for 'infection control' were combined separately with search terms for 'single rooms' and 'building design'.

The more recent searches revised the single rooms search strategy to include further terms for 'hospital infection', 'MRSA', 'c difficile', and 'medical/medication errors'. The searches looking at the impact of operating theatre design combined search terms for 'operating theatres/rooms' with the 'infection control' and 'hospital infection' terms used in the 'single rooms' component of the search strategy, and added terms for 'surgical errors'. As the number of records retrieved for this search was quite large it was decided to include an additional facet comprising of search terms for 'hospital design/building'.

The search terms were identified through discussion between an Information Officer and the research team, by scanning background literature, and by browsing the MEDLINE thesaurus (MeSH).

Additional Searches

Citation searches using studies identified from both the initial literature search and the more recent literature search were also undertaken. Relevant studies and prominent authors in the field were identified by the research team and details forwarded to the information officer to undertake further citation searching. The citation searches were carried out using the Science Citation Index, PubMed and the Internet. Internet searches of relevant health architectural organisation websites were also carried out. These are listed below:

- Medical Architecture Research Unit (MARU). Southbank University, London http://www.lsbu.ac.uk/maru/;
- The Center for Health Design. Texas, USA http://www.healthdesign.org/;
- Centre for Healthcare Architecture & Design (CHAD). Leedshttp://195.92.246.148/nhsestates/chad/chad_content/home/home.asp;
- School of Architecture, University of Sheffield http://www.shef.ac.uk/architecture/index.html;
- Healthcare Ergonomics and Patient Safety research Unit, Department of Human Sciences, Loughborough University http://www.lboro.ac.uk/departments/hu/groups/hepsu/.

Online library catalogues were also searched to supplement the database searches. This was an attempt to retrieve books/reports rather than journal articles. The catalogues searched were as follows:

- British Library integrated catalogue;
- US Library of Congress online catalogue;
- RIBA British Architectural Library online catalogue.

3.3.2.2 Study selection criteria and procedures

The aim of the study selection is to identify those studies that help to answer the original research questions. The inclusion and exclusion criteria can be found in Table 3.2.

The first stage involved applying the criteria presented in Table 3.2 to the citation and abstract searches. A decision was then made about whether to obtain full copies of potentially relevant references.

The inclusion and exclusion criteria were then applied so that decisions could be made about the inclusion of each full text study. In circumstances where it was unclear whether to include a study, two reviewers considered the study independently. A third reviewer was used in situations where consensus could not be reached between the two reviewers.

Table 3.2: Inclusion and exclusion criterion

Study directly relates to	AND Includes either outcome	OR includes
Single Rooms	Infection rates Length of stay	Cost data exclusive to design
Slips, trips or falls	Adverse events[7] Medication errors	Cost data exclusive to outcome
Operating theatres Ventilation	Patient safety Patient satisfaction	Cost data exclusive to both outcome and design
	Conditional on:	**Conditional on:**
	A quantifiable effectiveness measure which relates to the outcome	Costs which are applicable to the UK setting

[7] An adverse event is defined as: An event or omission arising during clinical care and causing physical or psychological injury to a patient. See, for example, *An Organisation with a Memory:* http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/Browsable/DH_4936253.

3.3.3 Study Quality Assessment

All studies that were selected for inclusion in the review were quality graded following the NICE[8] methodology checklists, developed originally by MERGE (Method for Evaluating Research and Guideline Evidence) and modified by the Scottish Intercollegiate Guidelines Network (SIGN). This section presents the methodology and process used in assessing the quality of the literature.

3.3.3.1 The quality grading taxonomy

The quality grading of articles involved, firstly classifying the article under a type of study which ranged from a classification of one to four. This is important so that the appropriate quality grading criteria can be applied to the type of study. For example, a cohort study would undergo the methodological checklist adapted from Tooth et al[9] (2005). The studies were then graded for study quality under grades ++, + or -. The classifications are explained in the next part of this section.

3.3.3.2 The study type

The study type has been classified under the following groups:

Table 3.3: Study type

Study type	Study
1	Meta-analyses, systematic reviews of Randomised Controlled Trials or Randomised Controlled Trials;
2	Systematic reviews of individual, Non-randomised Controlled Trials, Case control studies, Cohort studies, Controlled before-and-after studies (CBA), Interrupted time series studies, Correlation studies and audits;
3	Non-analytic studies;
4	Expert opinion or formal consensus.

3.3.3.3 The study quality

The study quality has been graded under the following categories.

Table 3.4: Study quality

Study quality	Evaluation
++	All or most of the criteria have been fulfilled. The criteria that have not been fulfilled are thought very unlikely to alter the conclusions;
+	Some of the criteria have been fulfilled. The criteria that have not been fulfilled or adequately described are unlikely to alter the conclusions;
-	Few or no criteria have been fulfilled. The conclusions of the study are thought likely or very likely to alter.

[8] The methodology for quality grading was adapted from NICE Methods for Development of Public Health Guidance March 2006. http://www.nice.org.uk/page.aspx?o=299970.

[9] Tooth L, Ware R, Bain C et al (2005). Quality of reporting of observational longitudinal research. Americal Journal of Epidemiology, vol 161 (3): 280-288.

Additionally, the type of study is noted via the following:

1. Systematic reviews;
2. Randomised controlled trials;
3. Case-control studies;
4. Qualitative Studies;
5. Cohort studies (adapted from Tooth et al[10] 2005);
6. Controlled Before and After studies (adapted from EPOC Cardiff University[11]);
7. Interrupted Time Series (EPOC version);
8. Economic Evaluations (Drummond et al. [12]1997).

3.3.3.4 The quality assessment process

All studies selected for inclusion were graded for quality using this methodology. This involved the completion of a Quality Grading Summary sheet, a copy of which is given at Appendix C. A summary of the quality grades for each of the papers is included at the start of each of the topic areas and is incorporated into the evidence summaries.

In order to minimise any potential bias or subjectivity in the quality grading of the literature those studies that fall between categories were independently assessed by two researchers. The results of the independent assessment were discussed at a regular internal meeting with the aim of resolving any differences. Where differences in opinion could not be resolved a third reviewer assisted in reaching an overall decision.

3.3.4 Data Extraction and Monitoring Process

The data extraction and monitoring procedure is the process by which the data that is required for data synthesis is obtained from the literature. This is conducted by the completion of a data extraction sheet. The data extraction sheet contains the following items:

- Authors and year;
- Study Type;
- Design intervention;
- Outcomes;
- Methods and patients;
- Confounders and Bias;
- Applicability to the UK;
- Quality grading.

[10] Tooth et al, op cit.
[11] Cochrane Effective Practice and Organisation of Care Review Group (EPOC).
[12] Drummond MF, O'Brien B, Stoddart GL et al (1997). Critical assessment of economic evaluation. IN Methods for the economic evaluation of health care programmes. 2nd edition. Oxford: Oxford medical Publications.

Completed data extraction sheets for the relevant studies included for each of the four design options are included at Appendix A. The comments on confounders and bias contribute, as well as design intervention and patient numbers contribute to the quality assessment ratings.

3.3.5 Data Synthesis

Data synthesis refers to collating and summarising the primary studies included within the review. It was decided that formal statistical techniques, such as meta-analyses, were not sensible to conduct, due to the heterogeneity of the data. Therefore a descriptive synthesis of the data, involving the tabulation of findings, was provided in the review. The identified data are intended for use in the economic modelling of the different design options.

3.3.6 Currency Conversion

In order to allow direct comparison of studies component valuations of the costs and benefits have been adjusted and converted from local currencies to UK £2007 prices. This was performed by a two step process:

- Firstly costs and benefits were converted to pounds sterling (GBP) using a historical conversion rate[13];
- The costs and benefits were inflated[14] to December 2007 pounds (GBP).

The costs and benefits are first reported as they appear in the original study with the conversion in pounds in brackets.

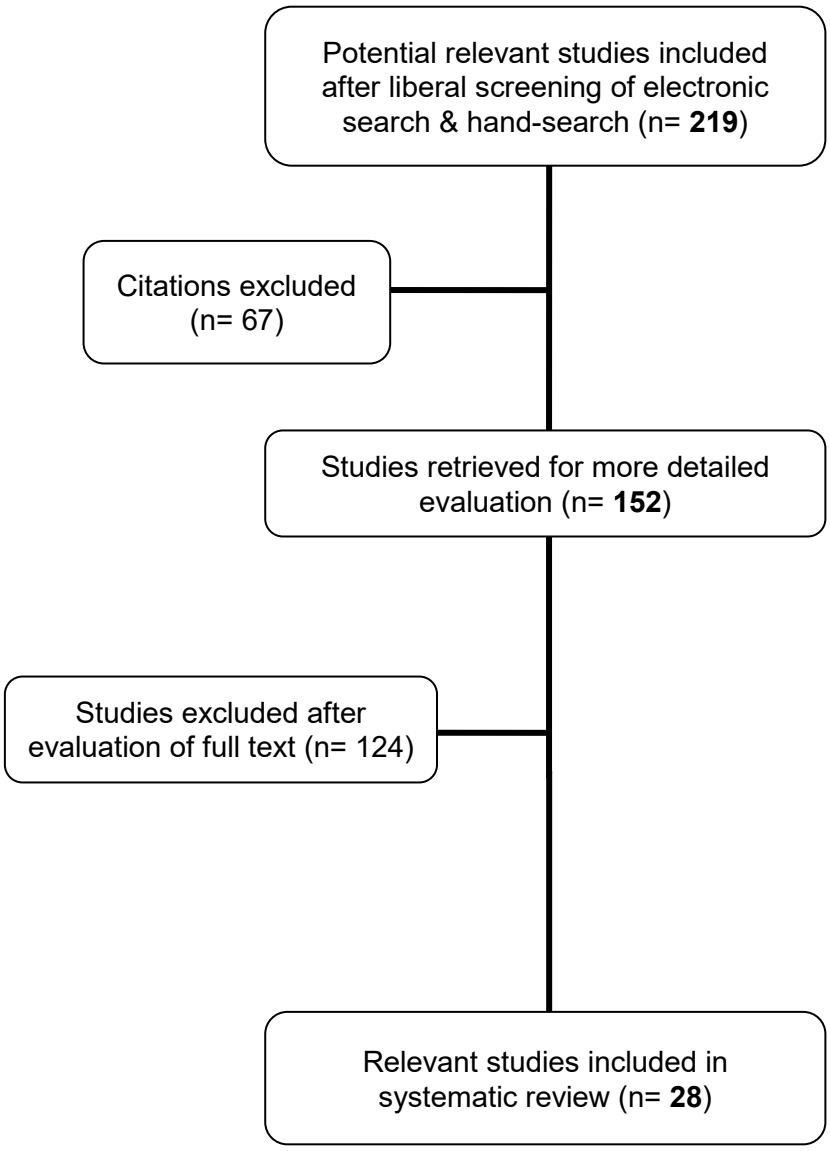
3.4 REVIEW OF LITERATURE ON SINGLE ROOMS

3.4.1 Study Selection

The study selection process is illustrated in Figure 3.2.

[13] Exchange conversion: http://www.oanda.com/convert/fxhistory
[14] Inflation Indices: http://www.statistics.gov.uk/statbase/tsdataset.asp?vlnk=229&More

Figure 3.2: Flow diagram of study selection process for single rooms



The searches relating to single rooms identified 219 potentially relevant references; 207 from screening of the electronic search and 12 from hand-searching. On the basis of reviewing the title and abstract, 152 full text papers were obtained for further assessment and 67 were excluded at this stage. After evaluation of the full text, 124 studies were excluded and 28 were included in the review.

Studies were excluded under the following circumstances:

- Where it was not possible to determine whether outcomes were influenced by the room design or by various confounding factors;
- If the isolation of patients was investigated, but this did not necessarily involve treatment in a single room, therefore the effect of room design could not be determined;
- Patients entered hospital with an infection; hence it was not possible to say whether the reported infection rates were related to the room design;
- Where the outcomes have not been clearly reported in relation to room design. For example, if outcomes were reported as an overall figure for a combination of room designs, but not broken down according to individual room designs;
- Data were provided but not according to the inclusion criteria, in particular if the data were not quantified.

The excluded studies and the associated exclusion reasons can be seen in the appendix on single rooms for the studies that were obtained in full.

3.5 SUMMARY OF LITERATURE IN RELATION TO SINGLE ROOMS

3.5.1 Introduction

Of the studies reviewed there were few that specifically related to single rooms and the impact of room design on the five pre-specified outcomes. Hence, a considerable proportion of the literature does not actually relate to design. When the studies do not relate directly to the design, this poses difficulties for the modelling of these effects. The effectiveness evidence from these studies may require assumptions, which introduces uncertainty into the economic modelling analysis. The included studies have provided data on infection rates, length of stay, medication errors, patient satisfaction and costs associated with room design.

The studies included in the literature review have been quality graded. It was not necessarily expected that grade 1 evidence, such as RCTs, would be found due to the difficulties in undertaking this type of study for the pre-specified design options. For instance, some hospitals may find it challenging to set up a study which involves randomly assigning patients between single rooms and multi-bed rooms. The majority of evidence was of grade 2; there were four 2++ studies, fifteen studies of 2+ quality, and two 2- studies. There were three 3++ studies and three were of 4+ standard. One source was not eligible for quality grading since it was only available as a presentation rather than a detailed study, and there was therefore insufficient data upon which to base an assessment of quality. However, we wished to include the evidence from this unpublished study.

3.5.2 Included Studies

3.5.2.1 Overview

The twenty-eight studies included in this review have provided data on infection rates, length of stay, medication errors, patient satisfaction and costs associated with room design. However, no data has been extracted relating to adverse events in single or multi-bed rooms. Table 3.5 shows the studies included in the review, and the outcomes which are reported in each of these studies. In addition, an extra column indicates whether the study includes cost data relating to the single rooms, and also a quality grade column. A more detailed description of each study can be found in the appendix on single rooms.

Table 3.5: Included studies

Author	Year	Quality Grade	Single Rooms					Cost
			Infection	Length of Stay	Adverse Events	Medication Errors	Patient satisfaction	
Adamson[4]	2003	2+						✓
Barlow *et al.*[5]	2002	2+	✓					
Ben-Abraham *et al.*[6]	2002	2+	✓	✓				
Bettin *et al.*[7]	1990	2-	✓	✓				
BTY Group[8]	2003	2+						✓
Chaudhury *et al.*[9]	2003	3++	✓			✓	✓	
Chaudhury *et al.*[10]	2005	2++					✓	✓
Chaudhury *et al.*[11]	2006	3++	✓			✓	✓	
Douglas &	2005	3++					✓	
Geldner *et al.*[13]	1999	2+						✓
Harris *et al.*[14]	2006	2+						✓
Harrison[15]	2005	4+	✓					✓
Herr *et al.*[16]	2003	2+						✓
Huang *et al.*[17]	2006	2+	✓					✓
Lawson *et al.*[18]	2004	2+					✓	
Maki *et al.*[19]	1982	2+	✓					
McManus *et al.*[20]	1994	2+	✓					
Mulin *et al.*[21]	1997	2+	✓					
NHS Estates[22]	2005	2+				✓	✓	✓
Parker[23]	2005	4+					✓	
Pease & Finlay[24]	2002	4+					✓	
Plowman *et al.*[25]	1999	2++						✓
Preston *et al.*[26]	1981	2-	✓					
Rosenblum[27]	2005	NA	✓	✓				
Thompson *et al.*[28]	2002	2+	✓	✓				
Vietri *et al.*[29]	2004	2++	✓					
Wilcox *et al.*[30]	1996	2++		✓				✓
Williams *et al.*[31]	1995	2+	✓	✓				✓

3.5.2.2 Infection rates

Over half of the included studies reported data regarding infection rates for different room designs. The study by Williams *et al*. (1995)[31], involving heart transplant patients in the U.S., was one of two studies to find no statistical difference in infection incidence between patients treated in private rooms and those in semi-private rooms[15]. The prospective U.S. study conducted by Maki *et al*. (1982)[19] also found an insignificant difference between the incidence of nosocomial infection in an old hospital, which comprised rooms with 2 to 8 beds[16], and the new hospital, where patients were in private rooms[17]. It should be noted that there were also differences between the old and new hospital in terms of heating, ventilation and isolation rooms.

The mean number of infections per child (± standard deviation) was found to be lower for those treated in isolation rooms (1.87 ± 0.2) than in an open 6-bed space (3.62 ± 0.7) (Ben-Abraham *et al.*, 2002[6]). Harrison (2005)[15] reported a reduction in hospital-acquired infection of 11% when the Bronson Hospital, Michigan, moved to a new building with single rooms, as found by Ulrich. The proportion of MRSA-positive patients treated in single rooms in a military U.S. hospital was 4.9% (Vietri, 2004[29]). Barlow *et al*. (2002)[5] found that when staying in an open-bay bed, 7.5% of patients had 'alert' organisms or infections, in a point-prevalence survey of 5 acute medical and 3 surgical wards in the UK.

In a study of patients admitted to 8 intensive care units (ICUs), comprising single rooms, MRSA and vancomycin-resistant enterococci (VRE) rates were reported according to the infection status of prior room occupants (Huang *et al*., 2006[17]). For patients whose prior room occupant was MRSA positive, 3.9% acquired MRSA, whilst if the prior room occupant was MRSA negative, the proportion who acquired MRSA was 2.9%. If the prior room occupant was VRE positive or VRE negative, the proportions of patients who acquired VRE were 4.5% and 2.8%, respectively. Hence, prior room occupants were found to impact on MRSA and VRE rates in this U.S.-based study.

A study of a neonatal ICU (NICU) carried out by Rosenblum (2005)[27] in the U.S. found reductions in hospital-acquired infections when there was a move from an open design to private rooms. Before the change in design, 17.7% of newborns in the NICU encountered a hospital-acquired infection, but following the move to private rooms, this proportion fell to 5.9%. A reduction in infection was also found in a French surgical ICU (SICU) when the unit changed from comprising 7 isolation rooms and 2 open rooms[18] to a renovated unit with 15 isolation rooms, each with individual hand-washing sinks (Mulin *et al*., 1997[21]). The proportion of patients[19] who were admitted and became colonised or infected with ventilator-associated acinetobacter baumanii pneumonia reduced from 21.5% to 1.1% following the renovation.

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[15] This group of patients were treated in semi-private rooms unless they had a white blood cell count of less than 2000. This group of patients were placed in modified isolation.

[16] This was with the exception of ICUs. The old hospital had an archaic ventilation system.

[17] This was with the exception of ICUs. The new hospital building involved a modern ventilation system and improved isolation facilities for infected patients.

[18] Each with 4 beds.

[19] The patients were mechanically ventilated.

A further study, by McManus *et al*. (1994)[20], found single-bed isolation to be associated with a reduction in infection in comparison to an open ward. The U.S. study involved 2,519 burns patients who were divided into two 10-year cohorts; the incidence of gram-negative bacteremia was 31.2% in the open ward cohort as opposed to only 12.0% in the single-bed isolation cohort (P<0.001). Infection rates were also evaluated in burns patients by Thompson *et al*. (2002) before, during and after a burns isolation unit underwent renovation in a U.S. hospital. During the renovation period, where patients were treated in private rooms or in the trauma ICU, the burn wound infection rate was significantly higher at 47.1%, as opposed to 10.8% and 23.8% in the periods before and after the renovation, respectively.

The sequential intervention study carried out by Preston *et al*. (1981)[26] in a U.S. medical-surgical ICU reported the impact of moving from a 6-bed open unit design to 14 isolation rooms[20] in relation to the incidence of nosocomial infections. The effect of the move varied according to the different type of infection or organism under consideration. During the study period, infections developed at a slightly higher rate after the move to isolation rooms; 11.5% of patients in the open unit developed infections compared to 11.8% of patients in the isolation rooms. However, there were reductions in respiratory infections, urine infections, blood infections, and other infections. Wound infections were the only infection reported to increase due to the move to isolation rooms. Over-all infection rates were higher in the open unit, at 15.0%, than in the isolation rooms where the rate was 13.4%[21].

Only one study found single rooms to clearly be associated with a higher rate of infection than multi-bed rooms (Bettin *et al*., 1990)[7]. All patients admitted to a surgical ward during a period of 20 weeks were cultured for C. difficile. The acquisition of C. difficile for the 426 patients under investigation was significantly higher for those treated in single rooms, at 9.9%, as opposed to the rate for those treated in 2- or 4- bed rooms; 5.8% and 1.9% respectively.

Conversely, Chaudhury *et al*. (2003, 2006)[9][11] found perceptions of infection to indicate lower infection levels in single rooms. The results from interviews of nursing staff in four U.S. hospitals showed that 67% of respondents felt the rate of nosocomial infection was low or very low in single rooms, and found that in these rooms 11% viewed the rate to be high or very high. In contrast, for double-occupancy rooms, only 7% felt the rate of nosocomial infection was low or very low, whilst 45% considered the rate to be high or very high.

3.5.2.3 Length of stay

The findings relating to patients' length of stay differed across the six studies that reported data on this outcome. Length of stay was lower for patients who were in isolation rooms in the paediatric ICU studied by Ben-Abraham *et al.* (2002)[6]; patients stayed an average (± standard deviation) of 11 ± 2 days, whilst those in an open-space, 6-bed unit stayed for 25 ± 6 days on average. Rosenblum (2005)[27] also demonstrated that patients in NICU single rooms had a shorter length of stay of 36.2 days, as opposed to 38.3 days in the open NICU.

[20] All but 2 of the 14 isolation rooms were single rooms; the remaining 2 rooms each contained 2 beds.

[21] "Half of the infections occurring in patients with complete cultures obtained on admission were caused by organisms colonising the patient on admission to the ICU" (Preston *et al.*, 1981).

Conversely, heart transplant patients were found to have a longer stay in the cardiovascular ICU if they were treated in a private room (9.5 days) than if they were in a semi-private room (6.1 days) (Williams *et al*., 1995[31]). Bettin *et al*. (1990)[7] also found length of stay to be higher for surgical ward patients in single bed rooms, than for those in 2- and 4-bed rooms; 12.2, 9.6 and 7.6 days, respectively. Wilcox *et al*. (1996)[30] studied cases of Clostridium difficile in a geriatric multi-room ward, and found these patients had a mean stay of 46.5 days, whilst those patients who did not have Clostridium difficile stayed for almost half this time, 25.2 days on average. The length of stay for burns patients in the study by Thompson *et al*. (2002)[28] was found to be similar for the periods before, during and after the renovation of the burns isolation unit (10.6, 9.7 and 10.3 days, respectively), where the renovation period involved patients not being treated in the burns unit.

3.5.2.4 Adverse events

The studies retrieved did not report data concerning adverse events and room design.

3.5.2.5 Medication errors

Information relating to medication errors in single rooms and multi-bed rooms has been provided in the studies carried out by Chaudhury *et al*. (2003, 2006)[9][11]. Through conducting interviews with nursing and administrative hospital staff, they found that the probability of medication errors occurring was generally higher in double-occupancy rooms than single-rooms. Approximately 40% stated that the likelihood of medication errors was either high or very high in double-occupancy rooms, as opposed to only 10% for single rooms. Focussing on the other end of the scale, almost 11% of respondents felt the probability of medication errors was either low or very low in double-occupancy rooms, whereas a much higher proportion of 74% considered the probability to be low or very low in single rooms.

Research reported in NHS Estates (2005)[22] showed a 70% chance of medication errors when a patient was transferred at the Mayo Clinic in the USA, and that if transfers decline, medication errors fall, as quoted by Ulrich. NHS Estates (2005)[22] also reported that transfers fell by 90% and medication errors by 67% when the US Clarian Hospital changed its Coronary Intensive Care from 2-bed rooms to single acuity-adjustable family-centred rooms.

3.5.2.6 Patient satisfaction

Patient preferences for 49 oncology ward patients were elicited by Pease and Finlay (2002)[24]; 20% preferred a single cubicle, 68% preferred an open area and 12% stated they had no preference. Conflicting preferences were found by Chaudhury *et al*. (2003, 2006)[9][11], who reported comfort levels of patients. Patients, on the whole, were more comfortable in single rooms rather than double-occupancy rooms, with 100% of respondents feeling that the patient's comfort level was high or very high in single rooms, and 58% considering their comfort levels were low or very low in double-occupancy rooms. Market research of 1,000 members of the public, who were not necessarily familiar with health care facilities, undertaken by NHS Estates found that 52% wanted to stay in a single room and 37% preferred a shared space (Parker, 2005[23]).

A postal survey of a sample of past hospital patients found 49.5% of patients treated in single rooms were completely satisfied, in terms of the room or bay design meeting their needs, as opposed to 29.0%, 26.6% and 32.5% of patients treated in 2-4 bed bays, long open wards and small bays, respectively (Douglas & Douglas, 2005[12]). The proportion who were dissatisfied was similar across the different room designs; dissatisfaction associated with single rooms, 2-4 bed bays, long open wards and small bays was found to occur in 4.2%, 6.1%, 4.6% and 6.1% of patients, respectively. Satisfaction rates have also been collected for the Kidderminster Treatment Centre, which consists solely of single rooms; 92% of patients were satisfied with the size of rooms and the en-suite shower facilities (NHS Estates, 2005[22]).

A report by Lawson *et al*. (2004)[18] studied the effects of the architectural environment on patients in two hospitals; one general medical hospital and the other mental health. Both hospitals underwent refurbishment. Overall, of the patients surveyed, 54% preferred a multi-bed space, whilst 43% preferred single rooms. Of the patients who remained in one type of accommodation[22], 76% in multi-bed spaces stated a preference for them, whilst 93% of patients in single rooms preferred staying in single rooms. The general medicine hospital studied wards that comprised a mixture of single rooms and 4-bed rooms, but only reported findings for the wards as a whole rather than by design. Findings for the mental health ward, however, were clearly shown as there was a change from 15-bed wards to all single rooms. Larger proportions of patients gave the highest possible rating to the ward consisting of single rooms in comparison to the 15-bed ward, with regards to the architectural environment helping them feel better, appearance, overall design, and satisfaction for personal bed areas.

[22] i.e. these patients were not transferred.

The systematic review by Chaudhury *et al*. (2005)[10] identified an Austrian study (Spork, 1990[23]) which showed a link between the severity of illness and the desire for privacy. Spork found that:

> "Two thirds of the patients with less severe conditions (e.g. tonsillectomy operation) wanted single rooms and less than 40% wanted a single room after a stroke (which is a more severe condition)."

3.5.2.7 Costs

As part of a study commissioned by the Facility Guidelines Institute to the Coalition for Health Environment Research, two US studies identified costs associated with single rooms and multi-bed rooms. Adamson (2003)[4] reported the "first costs" (i.e. the cost of construction) to be $182,400 (£140,005 UK 2007) per patient for single patient room floor plans, and $122,550 (£94,066 UK 2007) per patient for mixed room floor plans. The BTY Group[8] considered the replacement of single rooms with double rooms, and found construction costs were $153,000 (£117,438 UK 2007) per bed for the single patient room option and $134,000 (£102,854 UK 2007) per bed for the double patient room option.

Costs per bed were calculated by NHS Estates (2005)[22] for various layouts of a 32-bed ward with 100% single rooms, compared to costs per bed based on the schedule of accommodation (HBN 4 V.1/04/03). The cost per bed for HBN 4 V.1/04/03 100% single rooms was £66,333 (£72,229 UK 2007), whereas the cost per bed of HBN 4 V.1/04/03 50% single rooms was £58,324 (£63,509 UK 2007). The study estimated costs per bed of the various layouts to lie between £60,203 (£65,555 UK 2007) and £67,517 (£73,519 UK 2007).

Single family rooms were found to have a higher construction cost than open-bay units, as the average cost per square foot for a single family room was $294 (£175 UK 2007) in comparison to $285 (£169 UK 2007) per square foot for open-bay (Harris, 2006[14]). Double-occupancy rooms had the highest average construction cost, at $331 (£197 UK 2007) per square foot.

Harrison (2005)[15] reported Ulrich's finding that the cost of building a hospital with single rooms, which would be 6% higher than a traditional build, could be recovered after one year. Nursing care costs were found by Williams *et al*. (1995)[31] to be higher for patients in private ($8,340; £7,647 UK 2007) than in semi-private rooms ($4,265; £3,911 UK 2007) in their study of heart transplant patients.

Following a move from a multi-bed hospital to a new private-room hospital, Bobrow and Thomas (2000)[24] found there was a substantial reduction in transfer costs (cited in Chaudhury *et al*., 2005[10]). Annually, an extra $500,000, approximately, was spent on patient transfers in the old hospital, due to infection-control issues or problems with other patients within the shared room.

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[23] Spork, C. (1990) "Patients' wishes regarding sickrooms", *Nursing Times*, 86 (20), 53.

[24] Bobrow, M., Thomas, J., (2000) "Multibed versus single-bed rooms" In R. Kobus, R.L. Skaggs, M. Bobrow, J. Thomas, & T.M. Payette (Eds), *Building type basics for healthcare facilities* (p 145-157), New York: John Wiley.

The costs associated with MRSA were reported by two of the included studies, both of which were undertaken in a German setting. The additional costs incurred by MRSA patients in an anaesthesiology ICU was found to be 3,172 DM (£1,376 UK 2007) per day of treatment, and 18,402 DM (£7,980 UK 2007) per month by Geldner *et al*. (1999)[13]. Herr *et al*. (2003)[16] identified the costs of additional hygienic measures associated with MRSA carriers on a septic surgical ward. The daily cost was found to be 371.95 Euros (£269 UK 2007) and a cost per case of 9,261.00 Euros (£6,708 UK 2007). The cost of hospital-acquired infections (HAIs) was reported in the cost-of-illness study by Plowman *et al*. (1999)[25] as being £3,154 (£3,982 UK 2007) during the in-patient phase.

3.5.2.8 Staff culture

The literature was also scanned for studies relating to the clinical adoption of single rooms; for instance, how staff have adapted to the different room design and if any training has been undertaken. Two papers reported issues that may be faced by staff when changing to single-room care. Reiling *et al*. (2003) [32] found the main resistance to the single-room neonatal intensive care unit (NICU) to be due to the perception of additional staff being required, in order to observe neonates adequately. They also pointed out the importance of the use of communication technology in reducing the perception of more staff being required.

The fears and hopes associated with a new single room infant intensive care unit were reported by Brown and Taquino (2001) [33], in addition to how the staff actually responded to the change in ward design. Before the new single-room unit was introduced, staff hoped that the single rooms would provide an optimal environment for patient care, which was ergonomically friendly with high quality technology to support care. Staff also hoped the single rooms would enhance privacy and enable the personalisation of each patient space. There were also concerns, relating to being able to see and hear their patients, whether help would be on hand if required and whether supplies they needed would be nearby. The team worked hard to ensure the areas of concern were addressed and found the move to the new unit was successful. In particular, staffing numbers were found to be unaffected by the move to single-room design and staff were very responsive to the physical environment, noting the positive effect of natural light, for instance. The involvement of staff in the adaptation process was of great importance, as this meant staff felt a sense of ownership.

3.5.3 Excluded Studies

Many of the studies reviewed tended to focus on the isolation of patients rather than the design of the room. For instance, patients may be nursed in isolation but not necessarily in a single room and therefore studies have been excluded on this basis. In studies which focussed on infection rates, several looked at the incidence of infection for patients who entered the hospital ward already having an infection, rather than the infection rates for patients who acquired infections relating to the design of the room. Consequently, these studies were excluded.

Some studies featured patients who were treated in a separate room, where this involved patients being either alone in the room or were placed with other patients in a disease- or

treatment-specific area. Although some of the effectiveness data relates to the room design, it is not possible to infer this relationship given the context of the data. These studies have therefore not been appropriate and subsequently excluded.

Other studies which have commonly been excluded are those which report overall outcomes for a ward of patients, where the ward is made up of a mixture of room designs (for instance, a combination of 4-bed rooms, 6-bed rooms and single rooms). Since the breakdown of the outcomes which arose due to certain room designs cannot be inferred from this, these types of studies have been excluded from the review.

3.5.4 Difficulties Posed by the Data

Of the studies included in the review, approximately half were conducted in the USA. When considering data provided by these studies, an issue to bear in mind is the comparability of such data to the UK. For instance, the study by Ben-Abraham *et al*. (2002)[6] was conducted in Israel, where the health care system may differ from the UK. Some studies were conducted using patients in ICUs (neonatal, paediatric and cardiovascular), hence another issue to bear in mind is the generalisability of such data to other specialties.

In addition, some studies reported patients' outcomes in open-bed bays or multi-bed bays, but did not provide the specific number of beds in the bay, which requires assumptions to be made. It is also worth noting that although the data identified by the review may at first glance appear useful, some pose difficulties in the modelling of such data.

3.5.5 Summary of Literature

Table 3.6 provides a summary of the effect of changing the design of wards from a multi-room design (base case) to a single room design for each outcome. It can be seen in the table that the outcomes with respect to changing the ward design to single rooms have an uncertain effect on outcomes.

Table 3.6: Summary of studies reviewed by outcome

Outcome	Studies	Effect in relation to base case
Infection rates	Barlow *et al*. (2002)[5] Ben-Abraham *et al.* (2002)[6] Bettin *et al*. (1990)[7] Harrison (2005)[15] Huang *et al*. (2006)[17] Maki *et al*. (1982)[19] McManus *et al*. (1994)[20] Mulin *et al*. (1997)[21] Preston *et al*. (1981)[26] Rosenblum (2005)[27] Thompson *et al*. (2002)[28] Vietri *et al.* (2004)[29] Williams *et al.* (1995)[31]	Uncertain
Length of stay	Ben-Abraham *et al.* (2002)[6] Bettin *et al*. (1990)[7] Rosenblum (2005)[27] Thompson *et al*. (2002)[28] Wilcox *et al*. (1996)[30] Williams *et al.* (1995)[31]	Uncertain
Adverse events	None.	NA
Medication errors	Chaudhury *et al.* (2003, 2006)[9][11] NHS Estates (2005)[22]	Uncertain
Patient satisfaction	Chaudhury *et al*. (2003, 2006)[9][11] Chaudhury *et al.* (2005)[10] Douglas & Douglas (2005)[12] Lawson *et al*. (2004)[18] NHS Estates (2005)[22] Pease & Finlay (2002)[24]	Uncertain

3.5.6 Further Research Recommendations

- There is a need for good quality studies relating to the impact of single room design. Although RCTs enable a robust comparison of interventions, they may be difficult to undertake due to the nature of the research areas, for logistical reasons and for ethical reasons. Therefore, alternative study designs are also required, such as controlled before-and-after studies for instance or statistical modelling (selection bias econometric techniques such as propensity score matching or instrumental variables) on observational studies that allow a quasi-experimental to be modelled.
- Although some of the included studies were UK-based, approximately two-thirds were not. There is therefore a need for future research to be carried out in the UK, for external validity reasons, in order to produce results that are generalisable. Another method to enhance external validity is to conduct research that examines different patient groups, such as those on general wards rather than ICUs for instance, which have featured in the literature review.
- Future studies must also ensure that any differences in outcome effects can be attributed to the design of the room, rather than other factors (for example, ventilation systems) that may confound the results. Methods that aim to identify the cause and effect, perhaps using statistical approaches, are advised. Ideally, the comfort levels in the rooms under comparison should be equivalent.

- An area to investigate in future research is the clinical adoption of single rooms; for instance, how nursing staff have adapted to the different ward design and if any training has been undertaken. After scanning the literature on the area of staff culture and the way in which staff adapt to the use of single rooms, some information was identified, although the literature was not plentiful on this subject.
- Work should be carried out regarding infection occurring whilst patients are in hospital, rather than focussing on patients who entered hospital already with an infection. This will allow the effect of room design on infection to be seen.
- Further investigation on the outcomes of interest would be of use due to the reasons outlined above. In order to determine patients' opinions on the current use of single rooms in the UK, further studies could be conducted regarding patient satisfaction, undertaken controlling more rigorously for patient characteristics.. We consider patient satisfaction in Section 4 of this report.

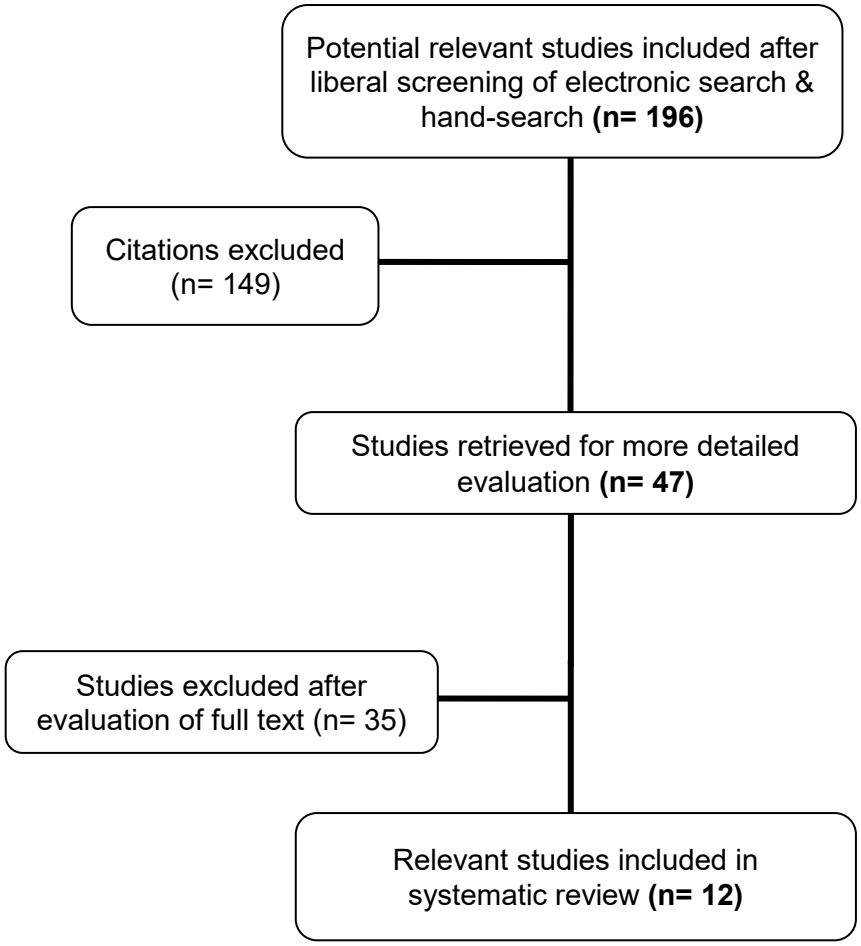
3.6 LITERATURE REVIEW OF DESIGN OPTIONS FOR SLIPS, TRIPS AND FALLS

3.6.1 Study Selection

The study selection process is illustrated in Figure 3.3. The searches relating to slips, trips and falls identified 196 potentially relevant references. On the basis of reviewing the title and abstract, 47 full text papers were obtained for further assessment and 149 were excluded at this stage. After evaluation of the full text, 37 studies were excluded and 12 were included in the review.

Studies were excluded if the data provided did not satisfy the inclusion criteria, in particular if the data were not quantified. The excluded studies and the associated exclusion reasons can be seen in the appendix on literature in relation to Slips Trips and Falls for the studies that were obtained in full.

Figure 3.3: Flow diagram of study selection process for slips, trips and falls



3.6.2 Summary of Literature in Relation to Slips Trips and Falls

Twelve studies met the study inclusion criteria. The main outcome of interest and most frequently reported outcome in this review was the fall rate for different hospital designs. A considerable proportion of the literature does not actually relate quantifiable evidence to the design. When the studies do not relate directly to the design, this poses difficulties for the modelling of these effects. The effectiveness evidence from these studies may require assumptions, which introduces uncertainty into the economic modelling analysis.

The studies selected for review were either a type 1 or type 2 study. There were two (1 +) studies on flooring and chair versus trolley usage in elderly patients. There was one (1 -) study on two recovery systems after laparoscopic surgery. There was one (2 ++) study on the use of ceiling lists. The remaining eight studies were (2 +) studies and the topics covered were different flooring materials, types of furniture and lifting devices within the patient's room.

3.6.3 Included Studies

Table 3.7 shows the slips, trips and falls literature with respect to the outcomes, costs and quality grading for each of the studies. A detailed description of the included studies can be seen in the appendix on design options for slips, trips and falls.

Table 3.7: Slips trips and falls literature

Author	Year	Topic	Quality Grade	Slips, Trips and Falls					Cost
				Infection	Length of Stay	Adverse Events	Medication Errors	Patient satisfaction	
Agodoa	2002	Patient Furniture	1 -			✓		✓	✓
Baptiste	2006	Patient Transfers	2 +			✓			
Capezuti	2007	Side Rails	2 +			✓			
Donald	2000	Flooring	1 +			✓			
Harris	2000	Flooring	2 +			✓			
Hignett	2006	Overview	2 +			✓		✓	
Hignett	2005	Side Rails	2 +			✓			
Miller	2006	Patient Transfers	2 ++			✓			
Ronald	2002	Patient Transfers	2 +			✓			
Simpson	2004	Flooring	2 +			✓			
Tan	2005	Side Rails	2 +			✓			
Wilber	2005	Patient Furniture	1 +			✓			

3.6.4 Excluded Studies

There was a relatively small body of literature on slips, trips and falls in the hospital environment. A considerable number of studies referred to slips trips and falls, but did not provide quantifiable evidence relating to the pre-specified outcomes. These studies were subsequently excluded. In total 184 studies were excluded. The exclusion reasons for these studies can be found in the appendix on literature on design options for slips, trips, and falls, and other injuries (such as pain).

3.6.5 Slips, Trips and Falls Evidence

Overview

Hignett and Masud (2006)[1] reviewed environmental hazards associated with inpatient falls. The review is structured under a number of different environmental interventions that influence the risk of falls. The environmental interventions are as follows:

- Bed rails;
- Bed height and alarms;
- Attachment to equipment;
- Footwear;
- Flooring;
- Lighting;
- Patient assessment;
- Staffing levels.

The authors reported that in a UK multicentre study of 29,998 incidents reports, 41% of the incidents were because of slips, trips and falls. This review builds upon a number of these topics where there is suitable quantifiable evidence. The authors found that there is little published research to support recommendations to reduce falls, and recommend that evidence-based design initiatives should include reduced length of stay and harm as outcome measures, incorporating risk assessment and environmental assessment tools.

Hospital Flooring

Three studies considered material usage in the design of flooring within different hospital environments. Donald *et al.* (2000)[2] investigated carpet and vinyl flooring with respect to the prevention of falls on an elderly rehabilitation ward. The study showed that the majority of falls occurred by the bedside. The study randomised 28 patients to carpet flooring and 26 patients to vinyl flooring. During the nine-month study only 15% of patients fell on average 11 times. There was no evidence from this study that carpeted bedroom areas reduced the incidence of falling and indeed in this study far more falls occurred in those allocated to carpet.

In a US study by Harris[25] (2000) [3] the author conducted monitoring of the ward environment and a number of questionnaires on the preferences and perceptions of staff and patients for different types of flooring. The author conducted a comparison between carpeted rooms and vinyl rooms. The carpet used was an 18” by 18” modular monolithic loop tile with a moisture resistant backing, antimicrobial, soil and stain protecting finish. The study found staff to be at opposition with patient’s perceptions and preferences for the flooring in hospital rooms. Sixty nine percent of those patients surveyed preferred carpet as their choice of flooring whereas over 80% of staff preferred vinyl as the choice of hospital room flooring. The patients cited that comfort, slip resistance and lower noise were their reasons for choosing carpet. In contrast staff cited colour, cleanliness and odour for their choice of vinyl flooring

[25] PhD Dissertation. Unpublished.

which may possibly reflect the importance of infection control for nursing staff. In terms of visitors the research indicated that family and friends made longer visits to rehabilitation patients in carpeted rooms, as opposed to patient rooms with hard surface flooring such as vinyl. The type of flooring did not have an effect on the amount of time staff spent with patients in their patient rooms. In contrast visitors spent significantly more time in patient rooms with carpet than in patient rooms with vinyl.

Harris (2000)[3] also found that airborne levels of bacteria were lower in carpeted rooms than vinyl rooms. The author explains that this is because carpet can act as a sink holding the bacteria and therefore keeping it out of the air. The rooms with vinyl did not have such a mechanism. The carpeted rooms can become heavily contaminated and may therefore harbour micro organisms. However, the author did not distinguish between the types of bacteria found, i.e. those that are so called 'good bacteria' and 'bad bacteria'.

Simpson *et al.* (2004)[4] considered whether the type of flooring affects the risk of hip fracture. The study considered four different options, wood sub-floor with no carpet, wood sub-floor with carpet, concrete sub-floor with no carpet and concrete sub-floor with carpet. A total of 6,641 falls were recorded during the 2 years study in 34 residential care homes and across 733 rooms. 76% of the rooms observed had carpets. Floors without carpets (whether concrete or wooden) had the highest impact force. Wooden carpeted floors were associated with the lowest number of fractures per 100 falls. The risk of fracture resulting from a fall was significantly lower compared to all other floor types. The authors calculated that the risk of breaking a hip in a fall would be reduced by 80% if carpets were laid on uncarpeted wooden floors. The study recommends that when designing safer environments for older patients, the type of floor should be chosen to minimise the risk of fracture.

Hospital Bed Side Rails

Side rails are adjustable metal or rigid plastic bars that attach to the bed and can come in an assortment of sizes, full-, three-quarter, half- quarter-, split rail configuration and alternate split rail configuration. The overall aim of side rails is to prevent patients falling out of bed, however there is evidence that side rails can lead to patient entrapment.

A before and after study by Capezuti *et al.* (2007)[5] evaluated interventions that aimed to reduce the restrictive nature of side rails in nursing homes. In the US between 1985 and 2006, 691 incidents of side rail entrapment were reported, of which 413 resulted in death of the patient. The average age of patients in this study was 84 years. The intervention group that reduced restrictive side rail use found a significant reduction in the falls rate (-0.053) whereas the group that continued to use restrictive side rails did not find a significant reduction in the fall rate. The study concluded that routine use of restrictive side rails were not supported to prevent voluntary movement that results in falls.

A second before and after study by Tan *et al.* (2005)[6] calls into question the appropriateness of using restraints (defined as bedrails and lap trays) to prevent falls in hospital patients. The authors analysed incident reports of falls for a single year for a large teaching hospital in Galway, Ireland. They found that the fall rate increased dramatically

with the age of the patient. The study found that the injuries in those patients that suffered a fall were more severe in those patients where restraints (bed rails and lap trays) were used.

In the USA in 1997 concerns were raised about the safety of hospital bed rails. Hignett and Griffiths (2005)[7] investigated whether split-side rails were more likely to be associated with entrapment and injury of patients than other bed rails types. The authors reported that since 1997 there have been 20 reported deaths from bed rail entrapment in the UK. The results of the study showed that half rails were more likely to be associated with death, full rails were more likely to be associated with injuries and split rails were more likely to be associated with near misses. The study found that split-side rail entrapments were not a common event, accounting for only 5% of incidents. However, the authors did conclude that generally there was an associated risk of entrapment from side rails which could lead to patient death.

Patient Transfer Devices

Miller *et al.* (2006)[8] conducted an evaluation of the effectiveness of portable ceiling lifts in a long-term care facility. The study considered staff preferences for different patient handling practices and the reduction in patient handling injury as a result of the introduction of ceiling lifts. The results showed that staff perceived themselves to be at significantly less risk of injury when using ceiling lifts than manual patient handling methods. The study found that introducing ceiling lifts into a long-term care facility reduced patient handling injuries and reduced the perceived risk of injury to staffing.

Ronald *et al.* (2002)[9] considered the effectiveness of replacing floor lifts with mechanical ceiling lifts. The results showed that the rates of musculoskeletal injuries (MSI) were reduced by 58% which was statistically significant. However, it was found that rates of all MSI and MSI caused by repositioning did not statistically decline.

A study by Baptiste *et al. (*2006)[10] evaluated a number of different lateral patient transfer devices by a number of outcomes in comparison to traditional draw sheet methods of patient transfer in an acute setting. The study recommended that lateral transfer devices were recommended over the traditional draw sheet method for performing lateral patient transfers. The authors reported that caregivers considered air-assisted devices as the “best in class” for overall comfort, ease of use, effectiveness in reducing injuries, time efficiency and patient safety.

Patient Furniture

Agodoa *et al.* (2002)[11] evaluated the difference in effects of a recliner chair versus a hospital bed on post-surgical diagnostic laparoscopic recovery times in a US hospital. A recliner chair allows the patient to adjust the angle to their own individual settings for comfort. The results of the study showed that patients who recovered in recliner chairs had significantly shorter recovery time (107 minutes versus 157 minutes) and experienced greater comfort levels than patients in hospital beds. The study performed a calculation of the cost saving through reduced staff time and estimated this to be US$169 (£133, £2007)[26] per patient.

[26] The cost was converted at the 2002 exchange rate and uplifted to 2007 prices. http://www.oanda.com/convert/fxhistory

Wilber *et al.* (2005)[12] conducted a study to compare reclining chairs with hospital beds in older emergency patients. The authors performed a single blinded, randomised controlled trial of the two types of furniture. The study found that for older emergency patients, recliner chairs resulted in better primary outcomes, including pain and flexibility of movement (97% versus 76%, 21% difference) and higher satisfaction (8.1 versus 6.0)[27].

3.6.5.1 Staff culture

The literature was also scanned for studies relating to the clinical adoption of hospital design relating to slips, trips and falls; for instance, how staff have adapted to the different designs and if any training has been undertaken. Studies looking at such issues did not appear to be available, however.

3.6.6 Summary of Literature

The literature considers hospital flooring, hospital bed side rails, patient transfer devices and patient furniture with respect to the pre-specified outcomes with particular consideration of the slips, trips and falls outcome. The quality of the studies on slips trips and falls reviewed ranged from type 1 + to type 2 +.

Table 3.8 presents a summary of the studies reviewed by their outcomes for falls and injuries. The third column in the table notes the comparison of the alternative and the base case for the study intervention. The effect is shown in the fourth column which either relates to falls or injuries. This can take the form of an increase, decrease or no effect of the intervention. For example, Donald *et al.* (2000) compared carpet and vinyl and found no effect upon slips, trips and falls.

Table 3.8: Summary of studies reviewed by outcome

Outcome	Studies	Alternative versus Base case	Effect in relation to base case
Hospital Flooring	Donald *et al.* (2000)[2]	Carpet versus Vinyl	No effect on falls
	Harris (2000)[3]	Carpet versus Vinyl	↓ STF
	Simpson *et al.* (2004)[4]	Carpet versus Wooden	↓ STF
Hospital Bed Side Rails	Capezuti *et al.* (2007)[5]	Side rails versus None	No effect on injuries
	Tan *et al.* (2005)[6]	Bed rails versus None	↑injuries
	Hignett and Griffiths (2005)[7]	Half rails versus Other rails	No effect on injuries
Patient Transfer Devices	Miller *et al.* (2006)[8]	Ceiling lifts versus Manual	↓ injuries
	Ronald *et al.* (2002)[9]	Ceiling lifts versus Floor lifts	↓ injuries
	Baptiste *et al.* (2006)[10]	Lateral versus Traditional	↓ injuries
Patient Furniture	Agodoa *et al.* (2002)[11]	Recliner chair versus Bed	↓ injuries and pain
	Wilber *et al.* (2005)[12]	Recliner chair versus trolley (with mattress)	↓ injuries and pain

Note: STF = Slips, Trips and Falls.
Hignett and Masud (2006) was excluded from this tale as the study provided an overview.

[27] A larger absolute value indicating a higher level of satisfaction. The author does not specify the type of scale used to measure satisfaction in the study.

It was difficult to establish the causal effect of the design intervention in many of the studies because of confounding factors and the nature of the measured before and after effect of the intervention. For example, there may be other factors within the patient environment such as staff perceptions, ward type and patient characteristics that make there appear to be an association between patient transfer devices and slips trips and falls.

There is an important trade-off to be considered between slips, trips and falls and the infection risk. For example in flooring, the evidence for carpet shows a decreased risk of slips, trips and falls but the evidence shows an ambiguous effect on infection risk. The vinyl flooring shows the opposite of a reduction in infection risk but an increase in slips, trips and falls risk.

3.6.7 Further Research Recommendations

- There is a lack of good quality before and after studies in the evidence on designs that relate to the outcome slips, trips and falls. The research team recognises that randomised controlled trials are impractical due to design and ethical issues but there is still an opportunity for well designed studies.
- The systematic review showed that nearly 60 percent of studies were conducted outside of the UK, mainly within the US. This may mean that the outcomes data for the designs are not generalisable to the UK setting. There is an opportunity for further work to be conducted within the UK hospital setting.
- A number of the studies were based in wards with biased patient groups. The differences in patient groups and design of the wards made it difficult to infer the outcomes. For example, the elderly population group are known to be more likely to fall in hospital, and design interventions which aim to reduce slips, trips and falls are more likely to be effective in this group (rather than a younger patient group). Further to this, elderly patients are likely to have a stronger preference for designs which specifically aim to reduce slips, trips and falls. It is therefore important that future research considers general wards so a representative group of patients can be studied in relation to the design options.
- It was difficult to identify a cause and effect from the studies when a new design was implemented with the aim of reducing slips, trips and falls. Many of the studies had confounding factors because of their observational nature. For example, it was not always easy to identify the causal effect of the introduction of a new flooring on infection and slips, trips and falls because of inability to control patients.
- The clinical adoption of new designs was infrequently reported within the literature. This concerns how the clinical staff use the designs and whether they would adopt the new designs. This is in particular reference to the adoption of new types of flooring or new patient transfer devices. These all require training in different aspects of the design usage, for example in terms of flooring, cleaning and in terms of patient transfer devices, effective and safe usage.

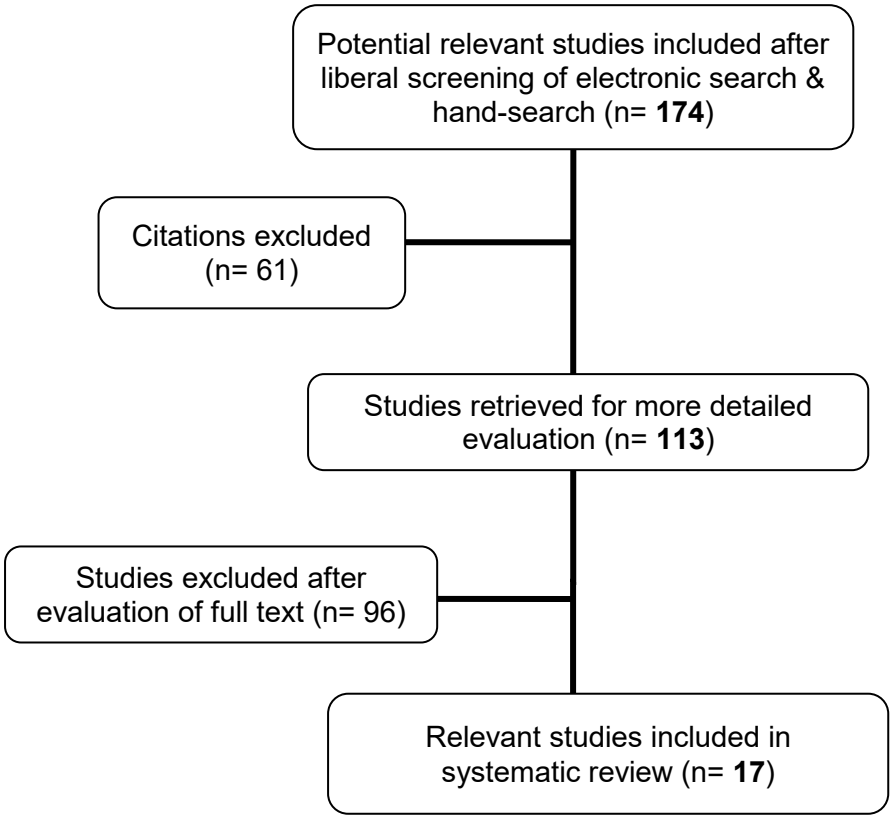
The findings of the literature review can be seen in the appendix on design options for slips, trips and falls, which provides details of the study setting, study description and the identified data for the included studies.

3.7 LITERATURE REVIEW OF DESIGN OPTIONS FOR VENTILATION

3.7.1 Study Selection

The study selection process is illustrated in Figure 3.4.

Figure 3.4: Flow diagram of study selection process for ventilation



The searches relating to ventilation identified 174 potentially relevant references; 165 from liberal screening of the electronic search and 9 from hand-searching. On the basis of reviewing the title and abstract, 113 full text papers were obtained for further assessment and 61 were excluded at this stage. After evaluation of the full text, 96 studies were excluded and 17 were included in the review.

Studies were excluded under the following circumstances:

- Where infection risk was reported as calculated by mathematical models rather than hard evidence;
- Where indicators of infection were reported, such as bacterial counts, rather than infection rates themselves. This is due to not being able to translate the indicator into infection rates;
- Where the control of infection outbreaks and use of protective isolation were investigated, but did not report the relevant evidence.

Data were provided but not according to the inclusion criteria, in particular if the data were not quantified. The excluded studies and the associated exclusion reasons in the appendix on the literature on ventilation for the studies that were obtained in full.

3.7.2 Summary of Literature in Relation to Ventilation

3.7.2.1 Overview

An a priori assumption of the literature review was that the majority of evidence on ventilation would relate to infection rates and potentially the length of stay relating to this. However, evidence on other endpoints was also sought in the literature review.

There is a significant amount of literature relating to ventilation in hospitals. A large proportion of the ventilation literature relates to ventilation in operating theatres, although few studies reported evidence regarding the impact of ventilation design on the five pre-specified outcomes. Several studies investigated bacterial counts but the relationship between bacterial counts and infection rates has not been explicitly quantified to date. Hence these studies have not been included in the review. The included studies have provided evidence regarding infection rates only; evidence on the remaining four outcomes was not quantified.

The included studies have been quality graded. It was not necessarily expected that grade 1 evidence, such as RCTs, would be found due to the difficulties in undertaking this type of study for the design options in the literature review. For example, some hospitals may find it challenging to set up a study which involves randomly assigning patients between an operating theatre with ultra-clean air and an operating theatre with conventional plenum ventilation. The quality of the evidence varied from grade 1 to 4; the review comprised one study of grade 1+, one 1- study, and one 2++ study. There were also eight studies of 2+ quality, four 2- studies, one 3- and one 4+ study included in the review.

3.7.2.2 Included studies

The seventeen studies included in the review provided only data on infection rates and costs. There was a lack of evidence in relation to adverse events, length of stay, medication errors and patient satisfaction associated with ventilation; hence no data has been extracted regarding these aspects. Table 3.9 shows the studies that have been included in the review, and the outcomes which are reported in each of these studies. In addition to this there is an extra column to indicate whether the studies included cost data relating to ventilation design, and also a quality grade column. A more detailed description of each study can be found in the appendix on literature on ventilation.

Table 3.9: Included studies

Author	Year	Quality Grade	Ventilation					Cost
			Infection	Length of Stay	Adverse Events	Medication Errors	Patient satisfaction	
Berthelot *et al*.[4]	2006	3-	✓					
Charnley[5]	1972	2+	✓					
Clark *et al*.[6]	1976	2+	✓					
Davidson *et al*.[7]	1971	2+	✓					
Drake *et al*.[8]	1977	2-	✓					
Fitzgerald[9]	1992	1+	✓					
Franco *et al*.[10]	1977	2+	✓					
Gruenberg *et al*.[11]	2004	2++	✓					
Kelly *et al*.[12]	1996	2-	✓					
Lidwell *et al*.[13]	1982	2-	✓					
Millar[14]	1979	2-	✓					
Nelson *et al*.[15]	1980	2+	✓					
Oren *et al*.[16]	2001	2+	✓					
Salvati *et al*.[17]	1982	2+	✓					
Sanderson & Bentley[18]	1976	1-	✓					
Simsek Yavuz *et al*.[19]	2006	2+	✓					
Wilson[20]	1982	4+						✓

3.7.2.3 Infection rates

Almost all of the included studies reported data relating to infection rates for different ventilation designs. Plenum (positive pressure) ventilation systems are generally recommended as the conventional system to use in most operating theatres. In certain operating theatres, such as orthopaedic theatres, it is of great importance to ensure infection rates are kept to a minimum level, due to the consequences of infection being more severe. Ultra-clean ventilation (UCV) systems, also termed laminar air flow (LAF) systems, have been used in this setting in order to reduce infection since they are "very successful in reducing contaminants at the wound site" (HTM 03-01[28]). UCV systems "relate to the operating theatre only, and rely on the provision of large quantities of filtered air introduced through a canopy positioned over the operating table and the areas immediately adjacent to it[29]". The unidirectional (laminar) air can either be in a vertical or horizontal flow. A considerable proportion of the ventilation literature refers to this topic.

[28] Health Technical Memorandum 03-01 "Specialised ventilation for healthcare premises – Part A: Design and Validation" (November 2007) Department of Health.
[29] HBN 26, Department of Health (2004).

Laminar Air Flow (LAF)

Charnley was the first to pioneer laminar flow ventilation in the 1960s and 1970s in the UK. Charnley developed an ultra-clean air system for total hip replacement, which was found to reduce the incidence of post-operative wound infection (sepsis) from 7-9% to less than 1% (Charnley, 1972[5]). However, whether this reduction could be attributed to the air system was not clear since other factors may have influenced the infection rate, such as stopping anticoagulation and the use of double gloves[30]. As a result, Charnley re-evaluated the impact of these additional factors and believed that "of all the precautions taken against infection in the operating room, the most important was clean air; but it is emphasized that this measure *alone* did not reduce the infection rate below about 1.5%" (Charnley[5]). He accordingly undertook further research, as report in his study.

The results of Charnley were assessed by Lidwell *et al*. (1982)[13], who carried out a multi-centre study which compared post-operative deep sepsis rates in patients undergoing prosthetic joint surgery in an operating theatre with an ultra-clean air system, with those in conventionally ventilated theatres[31]. The ultra-clean system[32] comprised laminar air flow and exhaust ventilated clothing. The study identified a significant reduction in sepsis from 1.5% to 0.3% when ultra-clean operating rooms were used. However, the trial was not controlled for prophylactic antibiotic administration, which is one of its limitations. Following Lidwell's work, laminar flow has been adopted in orthopaedic operating theatres.

The incidence of sternal surgical site infection (SSI) according to operating theatre ventilation design, and inner doors, was investigated for adult cardiac surgery patients; 6.7% of the patients in the plenum operating theatres[33] were identified as having sternal SSI compared to 2.0% of patients in the operating theatres with laminar air flow. Patients were given antibiotics for antimicrobial prophylaxis (Simsek Yavuz *et al*., 2006[19]).

Vertical Laminar Air Flow

All but one of the studies on vertical laminar air flow found that this type of air system was associated with a lower rate of infection. In an Italian study which retrospectively evaluated the use of ultra-clean air for 179 adult patients undergoing posterior spinal instrumentation procedures, the system was associated with a reduction in infection rates (Gruenberg *et al*., 2004[11]). The infection rate following complex spinal procedures in the conventional operating room was 12.9%, as opposed to none of the patients acquiring a wound infection in the operating room with vertical laminar air flow[34] (Gruenberg *et al*. [11]). Both groups of patients received prophylactic antibiotics.

[30] The other variables were closure of the fat layer of the surgical wound and starting adhesive plastic film on the skin.
[31] These operating theatres should involve a modern, positive-pressure air supply.
[32] Ultra-clean air was defined as air containing fewer than 10 bacteria-carrying particles per m^3.
[33] Positive pressure air supply, from clean to less clean areas, with 27 changes of high-efficiency filtered air per hour (Simsek Yavuz *et al*., 2006).
[34] The group treated in the laminar air flow operating theatre was small in comparison to the other group; 40 patients were treated in the LAF operating theatre. These patients tended to be elective cases, where a high risk of infection was considered.

Clark *et al*. (1976)[6] also looked into the effect of vertical laminar air flow, in a cardiac operating room when it was used as part of a multifaceted program which aimed to reduce infection[35]. The total wound infection rate decreased from 6.6% to 3.3% after the program was implemented, as did the deep wound infection rate (from 2.9% to 0.6%). Both of these reductions were statistically significant, although the superficial wound rate difference (3.7% to 2.7%) was not. Prosthetic valve infection rates also fell significantly, from 5.6% to 1.4%. However, it was pointed out that "no single variable or combination of variables could be isolated to account for the marked decrease in the deep wound and prosthetic valve infection rates" (Clark *et al*. [6]).

Although Sanderson and Bentley (1976)[18] reported that no infections occurred in the major joint replacement patients[36] they studied, a reduction in wound contamination was identified in the ultra-clean vertical LAF operating theatre as opposed to the conventional operating theatre[37] under consideration (mean of 1.3 colonies versus 7.3 colonies).

The only study to find no significant difference in the infection rate between operating theatres with and without laminar air flow was by Kelly *et al*. (1996)[21]. The study focussed on patients who were undergoing elective orthopaedic procedures before and after a move to new premises[38]. The operating theatre that did not have laminar air flow had a lower rate of infection than the operating theatres that did have laminar air flow, but the difference was not statistically significant. The authors noted that they believed the statistically insignificant result was due to the study's small sample size.

Horizontal Laminar Air Flow

HTM 03-01[39] specifies that "horizontal UCV air-flow systems have been shown to be less effective than vertical systems and are not the preferred solution" in operating theatres. However, several of the included studies investigate this system in operating theatres, indicating a lower infection rate, except for one that demonstrated no statistically significant difference, and another which indicated mixed results. Infection rates for patients having hip arthroplasty operations were evaluated in relation to the operating theatre design and ventilation, antibiotics[40] and previous surgery (Nelson *et al*., 1980)[15]. The two operating rooms that were investigated differed in terms of their ventilation; the 'regular operating room' had 12 air exchanges per hour and a 7.6% deep sepsis rate, whilst the 'clean room' was a horizontal flow laminar air flow room, with 480 air changes per hour and a lower deep sepsis rate of 3.0%.

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35 Renovation and alteration of operating room practices included installation of a vertical, unidirectional high flow (100 room changes per hour) recirculation ventilation system with HEPA filtration, elimination of a viewing gallery, alterations to wall positioning, electrical system, removal of monitoring consoles, a separate anaesthesia induction room, a separate pump oxygenator room, isolation corridor to the suite containing pass-through cabinets, changes in apparel and draping materials (Clark *et al.*) The same antibiotics were administered to both groups.

36 Patients received prophylactic antibiotics.

37 The conventional plenum ventilated theatre filtered to 2 µ with 35 ACH; conventional cotton theatre gowns were worn.

38 Standard antibiotic prophylaxis was given in all cases of arthroplasty and rigid internal fixation.

39 Health Technical Memorandum 03-01 "Specialised ventilation for healthcare premises – Part A: Design and Validation" (November 2007) Department of Health.

40 Preventative antibiotics were either not used or were used in an unsystematic manner in the first part of the series. In the last part of the series, they were given in a standardised manner.

Horizontal laminar air flow was associated with a reduction in infection rates after total hip replacement, but with increased infection rates following total knee replacement (Salvati *et al*., 1982[22]). The large study[41] found that infection rates after total hip replacement were 0.9% in the filtered laminar air flow operating room, as opposed to 1.4% in the conventional operating rooms[42]. Conversely, a higher infection rate of 3.9% was reported in the laminar flow operating room after total knee replacement, than in the conventional rooms, where the infection rate was 1.4%. The results were statistically significant. However, the authors noted that the results were accounted for by the "position of the operating team with respect to the air flow and the wound", and that the team stands in the airflow upwind from the surgical wound during total knee replacement (Salvati *et al*. [23]). They also commented that their observations give credence to the hypothesis that "horizontal laminar air flow may produce either beneficial or adverse effects, depending on whether the surgical procedure can be performed in accordance with the theory of operation of the air-flow system".

One American study found there to be no statistically significant difference between the mean, or median, number of micro-organisms recovered per wound culture, when these were compared in a horizontal laminar air flow operating theatre and an operating theatre without laminar air flow in an orthopaedic setting (Franco *et al*., 1977[10]). Prophylactic antibiotics were not given to any of the patients.

Mixed results regarding the incidence of deep infections and the probability of deep sepsis following hip and knee operations were reported by Fitzgerald (1992)[24]. The study indicated an increased rate of deep infection during hip arthroplasties[43] and a reduced rate of deep infection during knee arthroplasties[44] when horizontal laminar air flow was used as opposed to a conventional operating room with turbulent air flow. However, these results were reversed for primary total hip and knee arthroplasties, so that there was evidence that the deep infection rate was lower for primary total hip arthroplasties under the laminar air flow conditions. The probability of deep sepsis following total hip arthroplasty was higher with laminar air flow (0.7% with laminar flow, as opposed to 0.3%), and for total knee arthroplasty the probability was found to be reduced (1.3% with laminar flow, versus 0.8%). It is worthwhile to note that none of the results were statistically significant in this study, and that all patients received prophylactic antimicrobial therapy.

41 The study used modern antiseptic conditions and antibiotic prophylaxis.

42 The two conventional operating rooms used a conventional air-conditioning system; 12-14 air changes per hour, with positive pressure relative to the pressure in the scrub rooms and corridors.

43 An increased rate of deep infection was reported during total hip arthroplasties and during revision total hip arthroplasties.

44 A reduction in deep infection rates was reported during total knee arthroplasties and during revision total knee arthroplasties.

HEPA Filters

A new surgical suite[45], involving the implementation of HEPA filters, was found by Drake *et al*. (1977)[8] to have "no perceptible effect on wound infection rates" in comparison to an older operating room[46]. The installation of HEPA filters in a haematology ward had a positive effect on the rate of invasive pulmonary aspergillosis (IPA) (Oren *et al*., 2001[16]); IPA was completely eliminated for the group staying in the HEPA ward. Since the authors found there to be "no difference in the underlying diagnosis, in neutropenia length, or in antifungal prophylaxis", the IPA elimination could be attributed solely to the HEPA filters (Oren *et al*.[16]).

Berthelot *et al*. (2006)[4] also identified HEPA filters as having a positive impact, when they were used as part of a multidisciplinary strategy[47] in the prevention of IPA. Patients staying on a haematology ward in a French hospital were investigated between 1997 and 2001. The cumulative incidence of IPA cases decreased from 0.85% before the strategy was implemented to 0.28% afterwards; this reduction was statistically significant when the 1993-1996 and 1997-2001 periods were compared.

Other Ventilation Designs

The impact of a move from an old operating theatre to a new theatre on the wound infection rate was analysed in 1,000 patients, where the operating theatres differed in terms of their ventilation systems (Davidson *et al*., 1971[7]). The old operating theatre under consideration was in a block of 2 in open communication, separated only by an area used for scrubbing up and laying trolleys. The ventilation consisted of a slow continuous exchange system which had less than 2 air exchanges per hour. The new operating theatre was in a suite of 4, and the ventilation differed by having a continuous exchange plenum system, with 10-20 air changes per hour. The overall incidence of wound infection[48] halved approximately, from 19.5% to 9.7% when there was a move to the new operating theatre for general surgical operations. However, there were several changes that occurred; hence it is difficult to determine what caused the effect.

Millar (1979)[14] also analysed the results of moving from an old operating suite which had plenum ventilation[49] to a new operating suite[50], which had a different ventilation system involving 16 ACH and a vertical piston flow system. Infection rates reduced following the move to the new operating suite, which Millar attributed to improved ventilation, adequate space and reduction of traffic, and resting of theatres between lists.

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45 The new operating room used a ventilation system that filtered air through HEPA filters, with 20 ACH; surgical traffic was controlled, multiple air screens were used.

46 The older operating room was of elementary design; window air conditioners were used, a forced air filtration system was used with minimal air filtration; a single central corridor was used for all traffic.

47 The multidisciplinary strategy was introduced during hospital building work and an air-lock chamber was installed. The control measures included healthcare workers wearing masks, gowns and disposable caps; use of plastic barriers and high-efficiency filtration masks by immunosuppressed patients when outside the protected area. Several further measures were implemented.

48 Wound infections with staphylococcus Pyogenes and intestinal organisms.

49 The old operating suite comprised 4 operating rooms that opened directly into a common corridor, with a 30-year old plenum type ventilation system.

50 This suite had a central clean area and a clean entry corridor for the 8 operating rooms, patient access was through a double barrier exchange area, staff access was through the dressing room. Filtered, humidified and temperature-controlled air was supplied.

3.7.2.4 Length of stay

The studies retrieved did not report any quantifiable data relating to length of stay and ventilation design.

3.7.2.5 Adverse events

The studies retrieved did not report any quantifiable data regarding adverse events and ventilation design.

3.7.2.6 Medication errors

The studies retrieved did not report any quantifiable data relating to medication errors and ventilation design.

3.7.2.7 Patient satisfaction

The studies retrieved did not report any quantifiable data regarding patient satisfaction and ventilation design, although this may have been expected due to patients not being informed regarding the ventilation system.

3.7.2.8 Costs

The only paper to report costs associated with hospital ventilation was an article by Wilson (1982)[20] regarding Heating, Ventilation, Air-conditioning & Cooling (HVAC) systems. Wilson stated that "complicated hospital projects have had HVAC system costs of $15 (£15.03 UK 2007) to $18 (£18.04 UK 2007) per square foot or more".

3.7.2.9 Staff culture

The literature was also scanned for studies relating to the clinical adoption of ventilation systems; for instance, how staff have adapted to the different ventilation design and if any training has been undertaken. Studies looking at such issues did not appear to be available, however.

3.7.3 Excluded Studies

There was a significant body of literature describing hospital ventilation. A considerable number of studies referred to different ventilation designs, but evidence relating to the pre-specified outcomes was generally not provided. These studies were subsequently excluded.

Several studies reported data relating to bacterial counts, colony-forming units and cultures, biological monitoring and air contamination, rather than infection rates. Although the data may appear useful, as an indicator of infection, it is not possible to translate the information into a meaningful result in terms of infection rates. Hence the data are not in a form that can be used in the economic analysis, and these studies have been excluded. Some studies

reported that a relationship exists between airborne bacteria and the infection rate (Whyte 1983[51], Lidwell *et al*., 1983[52]) but this relationship does not appear to have been quantified.

Several studies contained ventilation-related information such as the number of air changes per hour, air quality and infection risk calculated by mathematical models. However, this information did not provide useful data for the economic analysis of hospital ventilation; consequently these studies were excluded due to failing to meet the inclusion criteria. Similarly, studies concerning the control of infection outbreaks and protective isolation were excluded as they did not report the relevant evidence.

Some studies featured other types of ventilation, such as ultraviolet germicidal irradiation (UVGI), local exhaust ventilation and HVAC systems, but did not provide quantifiable evidence relating to the pre-specified outcomes.

3.7.4 Difficulties Posed by the Data

It may be difficult to draw definite conclusions regarding the efficacy of ventilation systems in terms of infection control and the other endpoints considered due to several uncontrollable variables being involved, which may impact on the infection rate. For instance, in the study by Clark *et al*.[6], the multifaceted program involving vertical laminar air flow brought about a fall in infection rates, but there was a range of factors that may have played a part in this reduction other than the ventilation design. In particular, a factor that was not controlled for in some of the studies was the use of prophylactic antibiotics. As a result, the effectiveness of laminar flow ventilation in terms of infection is often unclear. Stacey and Humphreys (2002)[53] reinforce this by pointing out that studies evaluating the direct impact of the "current structure, ventilation, layout and facilities in modern operating theatres" on post-operative infection rates are "generally absent".

The included studies were conducted in several different countries across Europe and the USA. When considering data provided by these studies, an issue to bear in mind is the comparability of such data to the UK. For instance, the study by Simsek Yavuz *et al*.[19] was conducted in Turkey, where the health care system may differ considerably from the UK. The studies focussed on settings such as orthopaedics, joint replacement (hip and knee), cardiac and spinal procedures. Another issue to bear in mind is the generalisability of such data to other specialties. A further matter to consider is that more than half of the studies were conducted in the 1970s and 1980s, since which time practices may have altered.

[51] Whyte W, Lidwell OM, Lowbury EJL, Blowers R. Suggested bacteriological standards for air in ultraclean operating theatres. *Journal of Hospital Infection* Vol. 42, 133-139 (1983).

[52] Lidwell OM, Lowbury EJL, Whyte W, Blowers R, Stanley SJ, Lowe D. Airborne contamination of wounds in joint replacement operations: the relationship to sepsis rates. *Journal of Hospital Infection*. 1983; **4**(111-131).

[53] Stacey A, Humphreys H, Hospital Infection Society Working Party on Infection C, Operating T. A UK historical perspective on operating theatre ventilation. *Journal of Hospital Infection*. 2002; **52**(2): 77-80.

In addition, some studies reported patients' outcomes in operating theatres with 'conventional' ventilation, but did not provide specific details of what this entailed, which then requires assumptions to be made. It is also worth noting that although the data identified by the review may at first glance appear useful, some may prove difficult to use in the economic analysis.

3.7.5 Summary of Literature

Table 3.10 provides a summary of the effect of changing the ventilation design in operating theatres from conventional ventilation (base case) to vertical laminar air flow for each outcome. However, since four of the five pre-specified outcomes were not reported in the literature, the effect of ventilation design could not be determined for these. The downward arrow in relation to infection rates can be interpreted as a reduction in infection rates for an operating theatre with vertical laminar air flow in comparison to a conventionally ventilated operating theatre. The a priori assumption at the outset of the research was that improved ventilation would only impact on infection and possibly length of stay, as a result of reduced infection rates.

Table 3.10: Summary of studies reviewed by outcome

Outcome	Studies	Effect in relation to base case
Infection rates	Charnley [5] Lidwell *et al*.[25]* Simsek Yavuz *et al*.[19]* Gruenberg *et al*.[11] Clark *et al*.[6] Sanderson & Bentley[18]** Nelson [15] Oren *et al* [16] Berthelot *et al* [4] Davidson *et al* [7] Millar [14] Franco [10] – no statistically significant difference Kelly *et al*.[26] - no statistically significant difference Drake[8] - no statistically significant difference Salvati[23] - mixed outcomes depending on operation Fitzgerald[24] - mixed outcomes depending on operation	↓
Length of stay	None	NA
Adverse events	None	NA
Medication errors	None	NA
Patient satisfaction	None	NA

* The type of laminar flow was not specified in the study; ** this refers to wound contamination, rather than infection rates.

3.7.6 Further Research Recommendations

- Ultra-clean ventilation (UCV) is generally accepted as the standard ventilation system to use in orthopaedic operating theatres, and is being increasingly used in other types of theatre. However, the evidence that indicates a reduction in infection from the use of UCV was conducted several years ago, where practices will have been different, and not necessarily conducted in the UK. There is therefore a need for well-designed, UK-based studies to be carried out that take account of current design considerations when exploring key outcomes such as infection, length of stay and adverse events.
- Future studies on hospital ventilation must be designed in order to control for confounding factors as much as possible. In several of the ventilation studies in the review it was not possible to isolate the determinant of the effect due to several factors playing a part, such as prophylactic antibiotics, for instance.
- To enhance external validity of studies, research should be conducted in a range of operating theatre types. In this review, studies focussed on settings such as orthopaedics, joint replacement (hip and knee), cardiac and spinal procedures, but there is a need for further data to be collected.
- When considering the type of ventilation for an operating theatre, it is useful to bear in mind that flexibility is extremely important. It is possible to install an UCV terminal which makes it possible to switch between using UCV and non-UCV depending on the situation. Having this facility enables operations to take place on a more flexible basis which will in turn reduce the time patients may wait for an UCV operating theatre to become available, hence increasing efficiency. Therefore, research into the flexible use of UCV in this way would be of value.
- The UCV terminal also allows energy to be saved, since it has the option of a set-back facility. However, the extent of staff awareness and training of this facility, and whether the system is actually set back in reality is worth investigating. In addition, it would be useful to have information on the clinical adoption of ventilation designs in general in order to determine how staff use the different designs.
- Several studies reported findings on various ventilation designs with respect to colony-forming units, bacterial counts, biological monitoring and air contamination, rather than infection rates. Work to quantify the relationship between these measures and infection rates would enable a meaningful interpretation of the data, in terms of patient outcomes.

The findings of the literature review can be seen in the appendix on ventilation, which provides details of the study setting, study description and the identified data for the 17 included studies.

3.8 SUMMARY OF LITERATURE IN RELATION TO OPERATING THEATRES

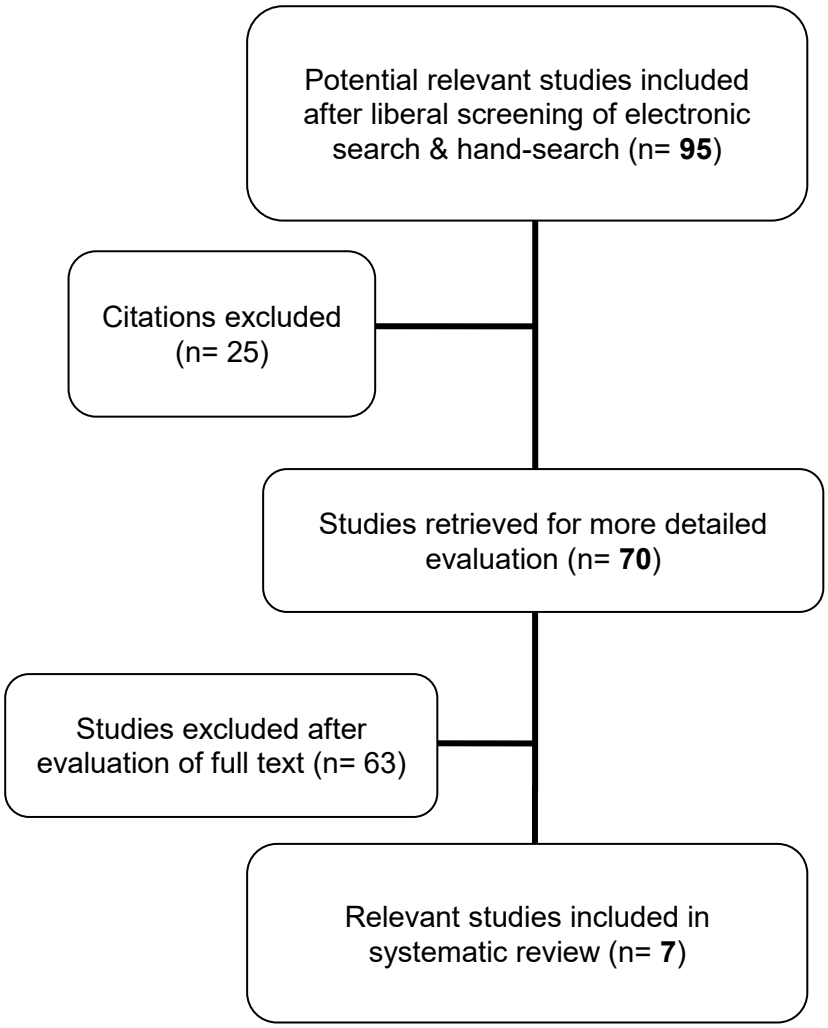
3.8.1 Selection process

The study selection process is illustrated in Figure 3.5. The searches relating to operating theatres identified 95 potentially relevant references. On the basis of reviewing the title and abstract, 70 full text papers were obtained for further assessment and 25 were excluded at this stage. After evaluation of the full text, 63 studies were excluded and 7 were included in the review.

Studies were excluded under the following circumstances:

- Where indicators of infection, such as bacterial counts, were reported rather than infection rates themselves, due to it not being possible to translate from the indicators to actual infection rates;
- Where data were provided but not according to the inclusion criteria, in particular if the data were not quantified.

Figure 3.5: Flow diagram of study selection process for operating theatres



3.8.2 Summary of Literature in Relation to Operating Theatres

The literature search identified very few studies that provided any quantifiable evidence in relation to operating theatre design and the pre-specified outcomes. In particular, of the five pre-specified outcomes, the studies included in this review only reported infection rates. The types and designs of operating theatres reported in the included literature varied quite significantly, with studies often reporting on the effects of a new operating theatre being built as opposed to an old operating theatre. In some cases, a change in operating theatre ventilation occurred as part of the design change, which raises the issue of what proportion of the reported effects can be attributed to the operating theatre design itself.

The studies included in the literature review have been quality graded. It was not necessarily expected that grade 1 evidence, such as RCTs, would be found due to the difficulties in undertaking this type of study for the pre-specified design options. For instance, some hospitals may find it challenging to set up a study which involves randomly assigning patients between operating theatres of different designs. The majority of evidence was of grade 2; one 2++ study, four studies of 2+ quality, one 2- study and one 3+ study.

3.8.3 Included Studies

The seven included operating theatre studies contained evidence relating to infection rates and costs of infection. However, data regarding operating theatre costs, length of stay, adverse events, medication errors and patient satisfaction have not been obtained, although the absence of patient satisfaction data was to be expected. Table 3.11 indicates the studies that have been included in the review, along with the outcomes that were reported in each of these studies. In addition to this there is an extra column to indicate whether the study includes cost data relating to operating theatre design, and also a quality grade column. A more detailed description of each study can be found in the full report on the literature on operating theatre design options.

Table 3.11: Included studies

Author	Year	Quality Grade	Operating Theatres					Cost
			Infection	Length of Stay	Adverse Events	Medication Errors	Patient satisfaction	
Daschner[4]	1989	3+						✓
Davidson *et al.*[5]	1971	2+	✓					
Kleinert *et al.*[6]	1997	2++	✓					
Millar[7]	1979	2-	✓					
Nelson *et al.*[8]	1980	2+	✓					
Simsek Yavuz *et al*.[9]	2006	2+	✓					
Van Griethuysen[10]	1996	2+	✓					

3.8.3.1 Infection rates

Six of the seven included studies reported evidence on infection rates in operating theatres. Several studies compared infection rates before and after a move from an old operating theatre to a new operating theatre, and tended to show a reduction in infection, in general.

Kleinert *et al*. (1997)[6] investigated the wound infection rate in a double-occupancy operating room, where the operating room[54] was designed to accommodate two separate operating teams. The study looked at elective outpatient hand operations for 2,458 patients in the USA, and found 1.5% of patients developed superficial or deep infection of the operative wound. However, the infection rate was not associated with the number of patients who were also being operated on at the same time in the same operating room, but was found to be related to the wound classification. No comparison with another operating room design was made as such; instead the focus was on the occupancy of patients.

The study by van Griethuysen *et al*. (1996)[10] compared postoperative wound infection rates before and after a move from an old operating theatre to a new site, which comprised 10 operating theatres. The old and new operating theatres differed in terms of their layout; the old hospital involved an area divided by a major corridor, with recovery rooms and staff changing rooms being separate from theatre. In the new hospital, the rooms were connected, with staff not permitted to leave the theatre area without changing from theatre dress. Patients in the study underwent either general or orthopaedic surgery in the Netherlands-based hospital. Overall there were insignificant differences between the old and new operating theatres for orthopaedic surgery (1.2% vs 1.6%) and general surgery (2.4% vs 2.2%).

The impact of a move from an old operating theatre to a new theatre on the wound infection rate was also analysed by Davidson *et al*. (1971)[5] in 1,000 patients. The old operating theatre under consideration was in a block of 2 in open communication, separated only by an area used for scrubbing up and laying trolleys. The new operating theatre was in a suite of 4 and differed in terms of its ventilation system having a greater number of air changes per hour[55]. The overall incidence of wound infection[56] halved approximately, from 19.5% to 9.7% when there was a move to the new operating theatre. However, the ventilation system may have been a potential confounder.

A further study to analyse the move from an old to a new operating theatre found a reduction in infection rates after the move (Millar, 1979[7]). The old operating suite comprised 4 operating rooms that opened directly into a common corridor, with a 30-year old plenum type ventilation system. In contrast, the new operating suite had a central clean area and a clean entry corridor for 8 (2 groups of 4) operating rooms, with patient access being through a double barrier exchange area and staff access was through the dressing room. Filtered, humidified and temperature-controlled air was supplied[57] to this operating suite. Infection

[54] Positive pressure with 20 exchanges per hour was standard in the operating room.
[55] The old operating theatre ventilation consisted of a slow continuous exchange system which had less than 2 air exchanges per hour, whereas the new operating theatre had a continuous exchange positive-pressure (plenum) system, with 10-20 air changes per hour.
[56] Wound infections with staphylococcus pyogenes and intestinal organisms.
[57] The air was supplied by a vertical piston flow system, at 16 changes per hour.

rates reduced following the move to the new operating suite, from 9% to 3% on average, which Millar attributed to "improved ventilation, adequate space and reduction of traffic and resting of theatres between lists".

The incidence of sternal surgical site infection (SSI) according to operating theatre design of ventilation and inner doors was investigated for adult cardiac surgery patients in two sites in a Turkish hospital (Simsek Yavuz *et al*., 2006[9]). There were 6 theatres in each of the sites with differing levels of infection; 6.7% of the patients in the older plenum operating theatres[58] were identified as having sternal SSI compared to 2.0% of patients in the newer operating theatres, which had laminar air flow ventilation and automatic doors that were always closed apart from movement through them. Patients were given antibiotics for antimicrobial prophylaxis (Simsek Yavuz *et al*. [9]). It is worth noting that the design of the operating theatres was not provided in detail.

Infection rates for patients having hip arthroplasty operations were evaluated in relation to the operating theatre design and ventilation, antibiotics[59] and previous surgery (Nelson *et al*., 1980[8]). The two operating rooms that were investigated differed in terms of their ventilation; the 'regular operating room' had 12 air exchanges per hour whilst the 'clean room' was a horizontal flow laminar air flow room, with 480 air changes per hour. In the 'regular operating room' doors were kept closed, personnel movement was minimised and an average of 7 people were present in the operating rooms during all operations. The 'clean room' was a regular operating theatre with a new ventilation system installed in it. Nelson *et al*.[8] found a 7.6% incidence of deep sepsis in the 'regular operating room' as opposed to a lower deep sepsis rate of 3.0% in the 'clean room'.

3.8.3.2 Length of stay

There has been no data extracted concerning length of stay and operating theatres.

3.8.3.3 Adverse events

There has been no data extracted concerning adverse events and operating theatres.

3.8.3.4 Medication errors

There has been no data extracted concerning medication errors and operating theatres.

3.8.3.5 Patient safety

There has been no data extracted concerning patient safety and operating theatres.

3.8.3.6 Patient satisfaction

There has been no data extracted concerning patient satisfaction and operating theatres.

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58 Positive pressure air supply, from clean to less clean areas, with 27 changes of high-efficiency filtered air per hour (Simsek Yavuz *et al*., 2006[9]).

59 Preventative antibiotics were either not used or were used in an unsystematic manner in the first part of the series. In the last part of the series, they were given in a standardised manner.

3.8.3.7 Costs

No data relating to the costs of different operating theatre designs has been identified. However, costs relating to nosocomial infections were reported in the study by Haley (1986)[60] (cited in Daschner (1989)[4]). This study has been included in the operating theatre literature review since it includes some operating theatre data, although the infection rate costs are not related to operating theatres as such. Haley (1986) showed that the average infection in the US costs $1,833 (£2,150 UK 2007), with the maximum cost of an infection being $41,628 (£48,838 UK 2007).

3.8.3.8 Staff culture

The literature was also scanned for studies relating to the clinical adoption of operating theatre design; for instance, how staff have adapted to the different operating theatre design and if any training has been undertaken. Studies looking at such issues did not appear to be available, however.

3.8.4 Excluded Studies

Seventy studies relating to operating theatres were excluded for a variety of reasons. Many studies looked into design aspects of operating theatres, but evidence relating the pre-specified outcomes to design was not reported in the majority of cases. Some of the studies focussed on infection control in the operating room, but again did not provide any evidence relating to the outcomes.

A few studies presented bacterial counts in certain operating theatre designs, but these were not considered to be the required outcomes since the relationship between bacterial counts and infection was not determined. Others featured recommendations and guidelines on operating theatres rather than quantifying evidence. The renovation of operating theatres and infection prevention during reconstruction were further issues covered by some of the retrieved studies.

3.8.5 Difficulties Posed by the Data

The studies that have been included in the review were set in a variety of countries, such as the USA, Turkey and The Netherlands. However, since none were conducted in the UK an issue to consider is the comparability of the included data to the UK. For example, the evidence provided by the study set in Turkey (Simsek Yavuz *et al.*[9]) may be of limited use due to factors such as the health care system being different to those of the UK.

Where comparisons have been made between operating theatres, some of the studies reported that the theatres differed in terms of their ventilation systems, and indeed other factors. It is therefore difficult to determine whether the effect on the outcome has been caused by the different design of operating theatre, or the ventilation system or other factors.

[60] Haley, R.W. (1986), "Managing hospital infection control for cost effectiveness: A strategy for reducing infectious complications", *American Hospital Publishing*, Inc.

3.8.6 Summary of Literature

Table 3.12 summarises the effect of changing the design of operating theatres from an old design to a newer design, although the design of these operating theatres differ across studies. Since evidence was not reported for four of the five pre-specified outcomes, the effect of operating theatre design could not be determined for these. The downward arrow with relation to infection rates can be interpreted as a reduction in the level of infection for a new operating theatre in comparison to an old operating theatre. For the four studies that conducted a comparison of old versus new operating theatres, three of the four indicated a reduction in infection (Davidson *et al*.[5]; Millar[7]; Simsek Yavuz *et al*.[9]), whilst one study showed no significant difference (Kleinert *et al*.[6]). When comparing a regular operating theatre to a clean room, the infection rate was found to be lower in the clean room (Nelson *et al*.[8]).

Table 3.12: Summary of studies reviewed by outcome

Outcome	Studies	Alternative versus base case	Effect in relation to base case
Infection rates	Davidson *et al*. (1971)[5] Kleinert *et al*. (1997)[6] Millar (1979)[7] Nelson *et al*. (1980)[8] Simsek Yavuz *et al*. (2006)[9] Van Griethuysen *et al*. (1996)[10]	Old OT vs new OT No design comparison Old OT vs new OT Regular OT vs Clean room Old OT vs new OT Old OT vs new OT	↓ - ↓ ↓ ↓ No effect
Length of stay	None	NA	NA
Adverse events	None	NA	NA
Medication errors	None	NA	NA
Patient safety	None	NA	NA
Patient satisfaction	None	NA	NA

3.8.7 Further Research Recommendations

- There is a need for high-quality UK-based studies of different operating theatre designs to be conducted, which have external validity in order to allow generalisability.
- Since ventilation is a potential confounder in several of the included studies, along with several other factors, future studies must aim to control for the effects of such factors. This will enable the effect of operating theatre designs to be ascertained with confidence, rather than being unsure of the cause and effect relationship.
- Operating theatre design studies that compare outcomes other than infection rates are required in order to determine the impact on important outcomes such as length of stay, medication errors, adverse events and patient satisfaction. However, infection is a key indicator of the design effect; hence good quality studies that measure this along with other outcomes are needed.
- Clinical awareness, acceptance and adoption of different operating theatre designs are areas for future investigation.

- There are several studies which report findings on operating theatre design in terms of bacterial counts and colony-forming units. Work to quantify the relationship between these measures and infection rates would enable a meaningful interpretation of the data, in terms of patient outcomes.
- The clinical adoption of different operating theatre designs is a potential area to investigate in future research. This involves the way in which staff use the designs and how they have adapted to using them, for instance whether any training has taken place. Studies looking at clinical adoption will help to inform policy makers as to how effective designs are being in practice.
- Research into the impact of different operating theatre design would be useful. Recommended designs to investigate include barn operating theatres and an operating theatre with an anaesthetic room incorporated within it as opposed to a theatre with a separate anaesthetic room. The sharing of scrub, preparation rooms and anaesthetic facilities is another potential research area.

The findings of the literature review can be seen in the appendix on the literature on operating theatre design options, which provides details of the study setting, study description and the identified data for the seven included studies.

Section 4: Willingness to Pay

4.1 VALUATION OF THE BENEFITS

> *"…Political economy has to take as the measure of utility of an object the maximum sacrifice which each consumer would be willing to make in order to acquire the object…the only real utility is that which people are willing to pay for…"*
>
> Jules Dupuit (1844)

The aim of this research is to evaluate the costs and benefits of a number of hospital design options to inform future investment decisions on hospital refurbishment and new builds in the NHS. The design options considered for evaluation are single rooms, slips, trips and falls, ventilation, operating theatres and ward layout. The benefits are evaluated using contingent valuation (CV) methodology. The methodology is survey based and assesses the willingness to pay of the public, patients and staff for each design option.

The CV method is well established in the evaluation of policies in other areas of economics such as those that relate to transport (Herzog *et al.* (1990)[1]) and the environment (Hanemann (1994)[2]). The theoretical basis for the measurement of the benefit using this technique has a solid grounding in Paretian welfare economics and in particular the concept of consumer surplus. The method allows the costs and benefits of an intervention to be compared in monetary units to determine whether the benefits outweigh the costs. This also allows interventions to be compared directly, using a 'common currency'. However, evaluating health in monetary units has often been viewed with some concern by many non-economists and as a result the use of cost-utility analysis (CUA) has prevailed.

In typical health economic evaluations such as cost-effectiveness analyses (and CUA, which is a variant of cost-effectiveness analysis), costs and outcomes are valued in different units. Often, the outcomes of cost effectiveness analysis will be valued in specific clinical terms (such as the incremental cost per unit reduction in blood pressure) which do not easily allow for comparison of alternative investment decisions. However, there has been an increased focus on developing a 'common currency' to allow for comparisons of alternative healthcare investments. For example, NICE recommends that costs are presented in monetary units whilst the recommended measure of health benefit is the quality-adjusted life year (QALY). A QALY is measured on a utility scale and represents the patient's *health*-related quality of life and the presentation of the findings of economic evaluations in the form of the incremental cost per QALY is now widely understood and recognised as a valuable input to investment decisions in healthcare.

Nevertheless, there are a number of reasons for using CV in the context of this research, one of the main arguments being the method's superiority in capturing the overall well-being of patients. The method captures both the health benefits and non-health benefits whereas the methods for eliciting health utilities for QALYs tend to focus specifically on *health-related* quality of life. In addition to this the QALY may be insensitive to small changes in well-being or short-term changes in well-being, such as those associated with improved surroundings during a hospitalisation.

The QALY approach also relies on decision makers deciding how to allocate funds by their willingness to pay (WTP) per QALY. NICE implicitly use an upper value of £30,000 per QALY for medical interventions, but there is no precedent to suggest that this value is equally applicable to new design interventions. Capital investments are typically examined by a cost-benefit analysis (CBA) or options appraisal. Whilst it could be argued that the £30k per QALY should be applicable to any health expenditure, given that it all ultimately comes from the same budget, the authors of this report are not aware of any precedent for the use of this threshold in other evaluations of capital expenditure or hospital design.

The CV approach ascertains the value of the benefits for which there is no market valuation. For example, in addition to the health benefits, single room wards may have non-health benefits that are valued by the patient such as 'privacy', 'level of comfort' or 'noise reduction' but which do not have a monetary value assigned to them and has been widely used outside of healthcare settings. The CV method aims to value all of these benefits.

This report provides a review of the literature with respect to contingent valuation methods and then presents the results from the public's willingness to pay for hospital design options. The report provides the results from the first phase of the surveys that were conducted with members of the public.

4.2 INTRODUCTION

The contingent valuation methodology uses survey methods to present respondents with hypothetical scenarios about an option. This tool is designed to allow analysts to estimate the demand for goods/services that are not traded or only rarely traded. The method was first used in recreation planning by Davis *et al.* (1963)[3] to estimate the benefits of different recreation areas.

The respondents in the survey are required to think about the contingency of an actual market existing for the option and are then asked to reveal the maximum they would be willing to pay for such an option. The method measures *ex ante* valuations. That is, it provides a valuation at the moment the choice is made. The approach is founded on the belief that individuals are the best judge of their own well-being.

The measure elicited through this type of method is a Hicksian[61] WTP measure (compensating surplus). This measure is equivalent to a change in income, coupled with a change in the good or service that leaves the respondent's utility level unchanged. This produces a compensated demand curve for the good or service.

There are a number of techniques by which a contingent valuation survey can be undertaken. The next section provides a review of the different contingent valuation methods.

4.3 CONTINGENT VALUATION LITERATURE REVIEW

A literature review was conducted to examine the advantages and disadvantages of the different methodologies that could be used in the contingent valuation survey. The searches were restricted to a handful of databases, the search terms used were kept very specific, studies were limited to English language only, and the date range was limited to 2004-2007.

The following databases were searched:

- NHS Economic Evaluation Database (NHS EED);
- Cochrane Methodology Register (CMR);
- MEDLINE & PreMEDLINE;
- EMBASE;
- EconLIT.

The searches of the literature allowed an assessment of the most suitable valuation technique for this application. A number of key recent studies were used in the evaluation of the advantages and disadvantages of each of the different survey types and techniques for conducting a contingent valuation survey. The following section provides a summary of the main techniques used within the literature.

In many early applications of the contingent valuation technique many of the studies asked a single, open-ended question to derive the individuals' valuation, such as "what would be the maximum amount of money that you would be willing to pay for a recreation area?" This type of question is limited in that respondents may not go through a process of thinking about the good/service in question and may simply just state any value. The nature of this question also means that it is fairly easy to free-ride on others responses; as respondents may answer zero in the belief that a sufficient number of other respondents will provide a positive valuation for the good.

The first version of the closed-ended question was the iterative bidding question. These questions asked the respondent a starting value for their willingness to pay and if they were to respond with 'no' the interviewer would ask an amount until the respondent answered 'yes'. This method was prone to starting bias as, for example, if you were to start at £10 the average willingness to pay amount may end up lower than if you were starting at £100.

[61] The concept is named for Sir John Hicks, an English recipient of the Nobel Prize in Economics.

A number of studies have subsequently used an alternative type of closed ended question called a dichotomous choice question. This type of CV survey asks one question and varies the starting point across different respondents. A number of improved variants of the single bound method have been introduced, since this technique only provides information on whether the respondent's willingness to pay is above or below the threshold amount stated in the question.

The first variant of this type of question is the double-bounded questions which include an additional question to the single-bounded technique. The second question allows the researcher to move closer to the individuals' actual willingness to pay rather than producing a range of values. Oscarson *et al.* (2007)[4] uses an extension of this approach to reduce the number of zero-responses. This approach uses a two step approach to elicit the individuals' WTP; firstly respondents are given a single bid and then secondly, respondents are asked for their maximum WTP.

Another variant of this approach is the multi-bounded approach. This type of survey asks the respondents questions until their willingness to pay value actually has an upper and lower value. This is the same as the iterative bidding approach but with a random starting point. The advantage of this approach is that it can even further reduce the variance of the willingness to pay estimate.

One approach of administering the questions is by a payment card method which asks an open-ended question but provides interval responses, which makes it a closed-ended approach. Respondents are provided with categories such as 'between £1 and £10', 'between £10 and £20' and so on. They are asked to indicate the range which most accurately reflects their maximum WTP. However, this approach is open to 'range bias'. Different versions of the approach include 'high-to-low', 'low-to-high' and 'random shuffle' (the latter is favoured in health care studies). The random presentation of values involves separate cards, which have separate amounts written on them, being shuffled and then shown to respondents. The shuffling aims to avoid starting point bias. Respondents are asked to choose between values they are 'sure they would pay', values they are 'sure they would not pay', values they are 'unsure if they would pay or not' and the value they feel 'most closely approximates their maximum WTP'. This approach allows respondents to indicate a range of uncertainty (their 'personal confidence interval') around their maximum WTP, hence increasing the validity of responses (Smith (2006)[5]).

Another approach, commonly adopted in mail surveys, is to use a payment scale method. The payment scale has a number of values from zero to a maximum value, where the respondent can choose whether they would be prepared to pay for each of the values. This has been the most frequently used method in paper questionnaires over the last decade (Smith (2006)[5]). This approach has shown range effects in some cases, where the stated WTP is influenced by the range of pound amounts printed on the card, though that result is not universal (Dubourg *et al*. (1997)[6]; Ready *et al*. (2006)[7]). Smith (2006)[5] states that evidence for centring bias is mixed. It is important to check for these biases in a pre-test if this method of administering the surveys is to be used.

Whitehead (2006)[8] provides a practitioner's primer on contingent valuation methods. The study provides a description of the different types of surveys and the best approaches to contingent valuation surveys. The author stresses the importance of feedback and a pre-test of the valuation survey through a number of groups such as members of the scientific community and members of the general public. The handbook also provided a summary of the recommendations of the National Oceanic and Atmospheric Administration (NOAA) committee on CV. The NOAA panel concluded the following main recommendations:

Key NOAA Recommendations:

- The choice of welfare measures should be through WTP representing compensating or equivalent variation;
- It is not recommended that WTP values, or results are adjusted for income in any way. However, it is recommended that the results are disaggregated in presentation according to income group;
- The WTP point estimates are subject to bias and they should be used more for a comparative basis;
- Summary statistics presented should be the mean which should be substantiated by a measure of precision and dispersion;
- Sample size should be sufficient to provide statistically significant estimates of WTP;
- High response rates is required and the panel set a minimum of 70%;
- The WTP values should only be used in the context of the purpose for which they were obtained;
- Specification of the size of the commodities is important;
- The presentation of WTP results should be done a NPV basis and BCI should not be used.

Arrow *et al.* (1993)[9] also stressed the importance of carefully presented questions which allow the respondent to understand what is being valued if the results are to provide useful valuations.

"…The analyst is required to decide the standard of knowledgeability of the respondents that [they] want to impose on a contingent valuation study. *It is clear* that it should be at least as high as that which the average voter brings to a real referendum..." and "if contingent surveys are to elicit useful information about willingness to pay, respondents must understand exactly what it is they are being asked to value..."

The methods in the next section build upon the multiple bounded techniques reviewed in the literature and take into account the problems and biases that occur with different methods of conducting the survey.

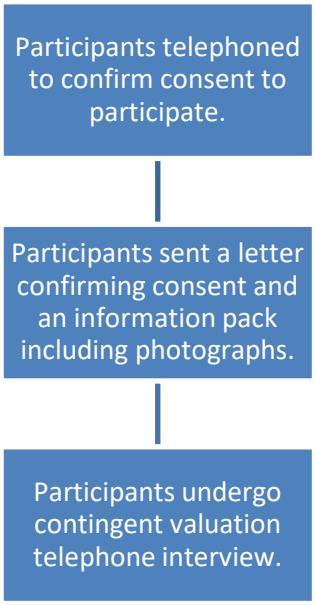
4.4 CONTINGENT VALUATION METHODOLOGY

4.4.1 Overview

This study estimates the willingness to pay for a number of design options using a multiple bounded "ping-pong" contingent valuation methodology for the public. The methods follow the recommendations of the NOAA committee on CV and the guidelines for conducting the CV analyses, Whitehead (2006)[8]. The "ping-pong" technique starts by asking respondents two questions at either end of the selected scale and then with every further question narrows the range of the responses to identify the respondent's maximum willingness to pay until it is between two defined points on the scale. (Further discussion of the methods can be found in Section 4.4.4) This process is repeated for each of the options under consideration in the research.

The approach adopted in the survey of members of the public was via a three step telephone interview process. The steps of the interview process are illustrated in Diagram 4.1.

Diagram 4.1: Three step interview process



The public telephone surveys were undertaken by QA research[62]. QA research is a specialist independent social and market research organisation. The research team provided training to the telephone interviewers who were responsible for administering the contingent valuation survey. A number of sample valuations were carried out.

4.4.2 Sample

Many CV studies use samples of convenience and in many cases results are not generalisable. This study used a sample of 200 members of the public in England that were stratified for age, sex and gender to ensure that they provided a representative sample. Telephone interviews were identified as the preferred approach for the public interviews.

4.4.3 Public Contingent Valuation Survey

The structure of the telephone interview for members of the public is shown in Table 4.1. The survey consists of five main sections:

- Section A: Attitudes towards hospitals;
- Section B: Experience of hospitals;
- Section C: Valuation question 1;
- Section D: Valuation question 2;
- Section E: Demographics section.

The survey was aimed to take on average 30 minutes dependent on the individual interview and valuation.

[62] http://www.qaresearch.co.uk/

Table 4.1: The public's contingent valuation survey description

Section of Survey	Section Purpose	Question Numbers
Section A: Attitudes towards hospitals	These questions are used to provide data to enable analysis and explanation of the results. The WTP can be presented as a function of the categories in each of these questions. These questions also provide a means of introduction to the topic and as a means of warm-up for the main valuation section questions.	1,2,3 & 4
Section B: Experience of Hospitals	This is an experience and behaviour question section which also allows the WTP results to be presented as a function of the categories in these questions.	5,6,7,8,9, 10,11 & 12
Section C: Valuation Question 1	The first valuation question in the public's version is the single room question. The participants were provided with photographs to illustrate each of the different design options to help them in the process of making an estimate of their maximum willingness to pay for the options. This section had a series of additional valuation questions which varied the following attributes of the design option: • The length of stay in the single room; • Removal of the en-suite bathroom facilities from the design option.	13,14,15, 16,17 & 18
Section D: Valuation Question 2	The second valuation question considered the public's valuation of different floorings within the hospital room that they would hypothetically be staying in. The different carpeting options compared within this valuation section were: • Laminated wooden flooring versus resin flooring; • Vinyl flooring versus resin flooring.	19, 20, 21 & 22
Section E: Demographics Questions	The demographics section provides data on individual specific characteristics for which the WTP estimates can be analysed. This allows an evaluation of how the estimates are affected by income, age and the gender of the individual. The demographics considered were with respect to: • Age; • Sex; • Race; • Education; • Income; • Marital Status.	23,24,25, 26,27 & 28

The valuation questions were supplemented with pictures of the design alternatives for:

- Single-bed room versus a four-bed room;
- Laminated wooden flooring versus resin flooring;
- Vinyl flooring versus resin flooring.

4.4.4 Valuation Questions

The method used for the valuation questions was a multi-bound "ping pong" technique. A detailed description of the "ping pong" technique is shown in Table 4.2. The interviewer filled out a valuation sheet for each of the questions. The "ping pong" technique was also supplemented by a series of rules to ensure consistency between interviews and reduce bias. Both the valuation sheet and the full details of the rules can be found in Appendix E of this report.

Table 4.2: "ping pong" technique

Step	Method
1	Starting amount: £X is randomly selected from the following 10 amounts: £0, £10, £20, £30, £40, £700, £800, £900, £1000, £1000+.
2	First valuation question: Participant is asked (example question): "Would you be prepared to pay £X for a single-bed room as opposed to a 4-bed room for one night?"
3	Second question: After the first question, the participant will be asked the valuation question again but using a different amount. The amount that will be asked in the second question will depend on the participant's answer to the first question. The second amount must be in the extreme bottom 5 amounts (£0, £10, £20, £30, £40) or the extreme top 5 amounts (£700, £800, £900, £1000, £1000+), depending on the answer to the first amount (i.e. if they said 'yes' to a low amount, or 'no' to a high amount in the first question). This is to investigate whether the participant would pay a range of amounts.
4	Following questions: Questions will continue until we find a point where the participant switches between saying 'yes' they would be prepared to pay and 'no' they would not be prepared to pay.

4.4.5 Pre-Test Pilot Feedback

The telephone survey was piloted to 20 members of the public. This involved the respondent carrying out the telephone interview and then providing feedback on the survey. Participants commented that the font and layout were easy to read, and most found the survey easy to understand. The four interviewers also provided feedback on the survey. The YHEC research team checked the valuation sheets for accuracy and consistency and comments were given to the interview team to further improve their accuracy.

The patients and staff survey was also piloted to 20 university members and useful feedback was obtained. The details of the feedback can be found in Appendix F of this report

The research team integrated feedback across both of the surveys and ensured that the valuation questions were standardised across the surveys.

Key Points:

- This study estimates the willingness to pay for a number of design options using a multiple-bounded "ping pong" contingent valuation methodology for the public;
- There are two main surveys; a public survey which was conducted by telephone and a staff survey which was completed by staff at the case study sites;
- This study used a sample of 200 members of the public in England that were stratified for age, sex and gender;
- The valuation survey consisted of five main sections; Section A: Attitudes towards hospitals; Section B: Experience of Hospitals; Section C: Valuation Question 1; Section D: Valuation Question 2 and Section E: Demographics Questions;
- The surveys were piloted to 40 members of the public.

4.5 VALUATION RESULTS

4.5.1 Overview

The results are shown for 200 members of the general public. The results for the public are presented for two of the design options, namely single rooms and flooring. The results are shown stratified by the demographics, attitudes and experience of hospitals and finally by the main valuation question for all respondents.

4.5.2 Demographics

Table 4.3 shows the demographics of the sample of 200 members of the general public in England. Approximately 42.5% of respondents were male and 57.5% were female.

Table 4.3: Sample by sex, age, ethnicity, marital status and education level

Category	Number	Percent
Sex		
Male	85	42.5
Female	115	57.5
Total	**200**	**100**
Age		
18-34	44	22
35-44	43	21.5
45-64	105	52.5
65+	8	4
Total	**200**	**100**
Ethnicity		
White	187	93.5
Black African	3	1.5
Indian	2	1
Pakistani	1	0.5
Other	7	3.5
Total	**200**	**100**
Marital Status		
Single	28	14
Married	135	67.5
Cohabiting	14	7
Divorced	15	7.5
Widowed	8	4
Total	**200**	**100**
Education Level		
Degree or higher	49	24.5
A levels	27	13.5
GCSE/GNVQ	46	23
Other qualifications	49	24.5
No qualifications	29	14.5
Total	**200**	**100**

Table 4.4: Sample by income

Income	Number	Percent
Less than or equal to £5,000	7	3.5
£5,001 - £10,000	15	7.5
£10,001 - £15,000	23	11.5
£15,001 - £20,000	19	9.5
£20,001 - £25,000	14	7
£25,001 - £30,000	26	13
£30,001 - £40,000	33	16.5
£40,001 - £60,000	41	20.5
£60,001 - £100,000	15	7.5
£100,001+	2	1
Refused	5	2.5
Total	**200**	**100**

4.5.3 Attitudes and Experience of Hospitals

The data showed that 86% of the public respondents had been into a hospital as either a patient or visitor. Only 1% of respondents had never been to hospital as a patient or visited a hospital.

Table 4.5: Patient preferences

Patient Preference	Number	Percent
Privacy	111	55.5
Interaction with other patients	56	28.0
No preference	26	13.0
Don't know	7	3.5
Total	**200**	**100**

Table 4.6: Patient related factors

Importance (1 = most important, 5 = least important)	Prevention of Infection (percent)	Comfort (physical comfort, emotional comfort) (percent)	Avoiding falls (percent)	Privacy (percent)	Speed of recovery (percent)
1	75	2	2.5	6	14.5
2	16.5	12	12.5	9.5	50
3	3	13.5	37.5	25.5	20.5
4	1	27	34.5	26	11.5
5	4.5	45.5	13	33	3.5
Total	**100**	**100**	**100**	**100**	**100**

Table 4.7: Patient environment

Importance (1 = most important, 5 = least important)	Control of Temperature (percent)	Interior Decoration (percent)	Reasonable noise levels (percent)	Space for family and friends (percent)	Windows (percent)
1	31.5	8	26.5	14.5	19
2	24.5	6	27	18	24.5
3	19.5	9	20.5	24.5	27
4	18	27	14.5	25	15.5
5	6.5	50	11.5	18	14
Total	**100**	**100**	**100**	**100**	**100**

Table 4.8: Hospital stay as an outpatient or inpatient

Stayed in Hospital Before	Number	Percent
Yes, in the last year	40	20
Yes, in the last 5 years	49	24.5
Yes, more than 5 years ago	91	45.5
No	20	10
Total	**200**	**100**

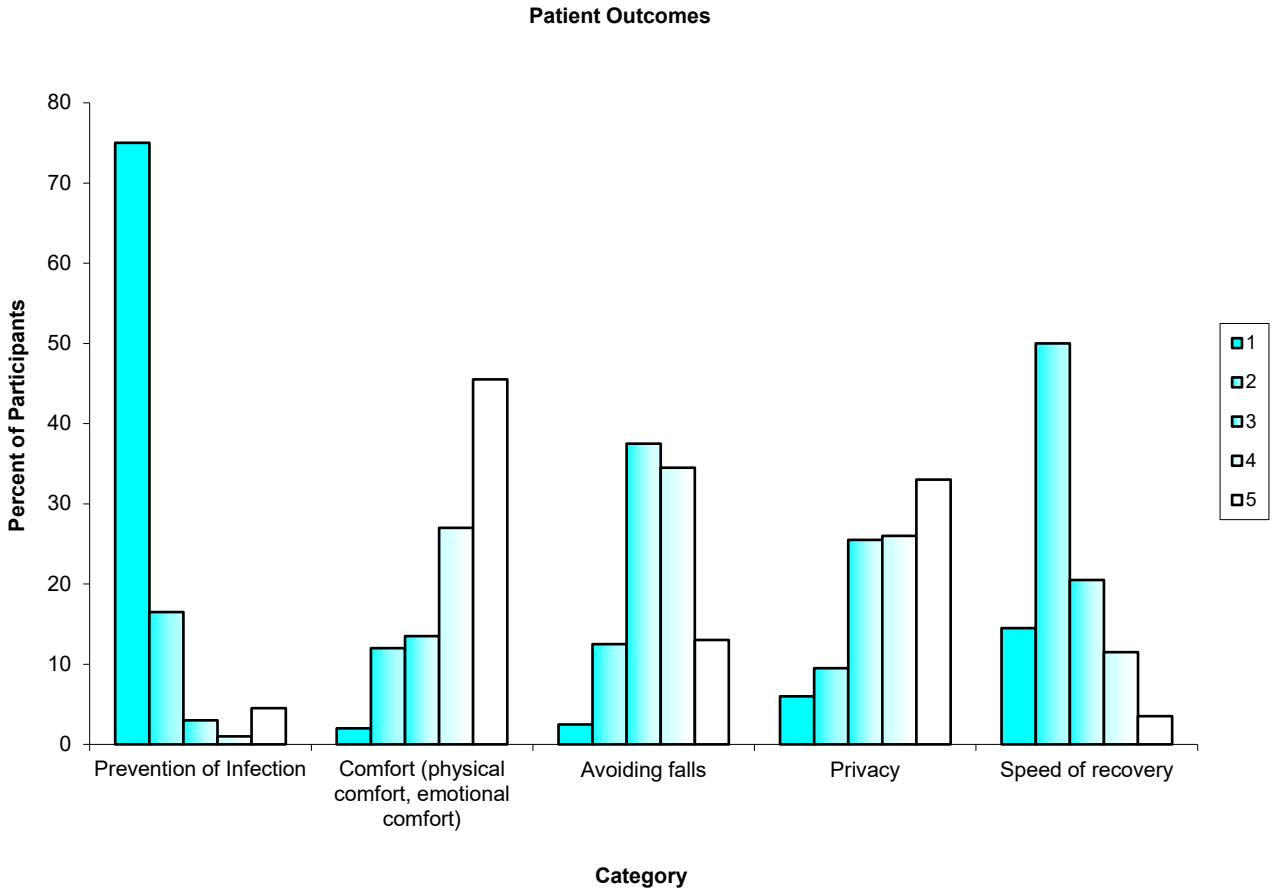
Table 4.9: Hospital stay by region

Region	Number	Percent
North West	23	11.5
North East	18	9
Yorkshire & Humber	20	10
East Midlands	19	9.5
West Midlands	20	10
East of England	11	5.5
London	12	6
South East	34	17
South West	19	9.5
Other	4	2
Not Stayed	20	10
Total	**200**	**100**

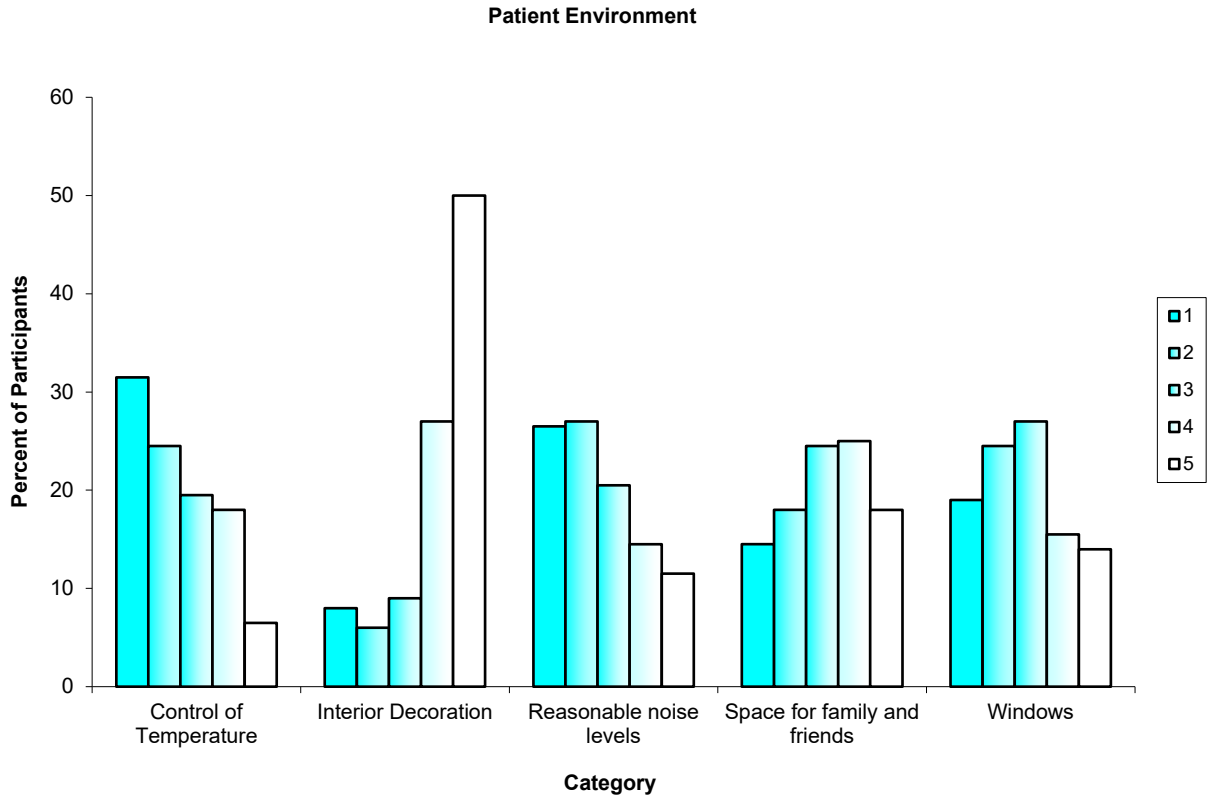
Graph 4.1 shows the respondents ranking of outcomes relating to hospital design. The category of importance was ranked on a scale of one to five (One being most important and five being least important.) The graph shows that the majority of respondents ranked prevention of infection as most important. The speed of recovery was ranked second most important by the majority of respondents. Comfort and privacy tended to be ranked in the least important categories.

Graph 4.2 shows respondents ranking of the important factors in the patient environment. The graph shows that there was more difference in the ranking of individual categories between individuals. Although for one factor, the majority of respondents did rank interior decoration as the least important patient environment factor.

Graph 4.1: Patient outcomes



Graph 4.2: Patient environment



Thus, the majority of respondents ranked prevention of infection as most important. The speed of recovery was ranked second most important by the majority of respondents. Comfort and privacy tended to be ranked in the least important categories. In the ranking of the important factors in the patient environment, there was more difference in the ranking of individual categories between individuals. Although for one factor, the majority of respondents did rank interior decoration as the least important patient environment factor.

Table 4.10: Type of room that patient stayed in

Room Type	Number	Percent
Single-bed room	26	13
2-bed room	10	5
4-bed room	40	20
Open ward	73	36.5
A combination of room types	10	5
Other	1	0.5
Visited hospital as a day patient*	20	10
Not Stayed*	20	10
Total	**200**	**100**

(*Note: respondents who visited hospital as a day patient, and did not stay on a ward.)

Table 4.11: Patient satisfaction with hospital stay

Patient Satisfaction	Number	Percent
1. Very unsatisfied	21	10.5
2. Quite unsatisfied	18	9
3. Neither unsatisfied/satisfied	10	5
4. Quite satisfied	68	34
5. Very satisfied	63	31.5
Not Stayed	20	10
Total	**200**	**100**

Table 4.12: Length of stay

	N (days)	Range (days)	Minimum (days)	Maximum (days)	Mean (days)	Std. Deviation (days)
LOS	180	89	1	90	4.51	8.07

Table 4.13: Private medical insurance

Private Medical Insurance	Number	Percent
Yes	46	23
No	154	77
Total	**200**	**100**

4.5.4 Single Room Valuation Results

Table 4.14 shows the valuations for the single room design options. The three options were as follows:

- Option 1: Single-bed room versus 4-bed room;
- Option 2: Single-bed room without en-suite facilities versus 4-bed room;
- Option 3: Single-bed room for five nights per night versus 4-bed room.

Table 4.14: Single rooms design option valuations

Option	Description	Mean	Median	Min	Max	Range	s.d.	N
Option 1	Single room versus multi-bed	£72.6	£50	0	£900	£900	99.74	200
Option 2	Without an en-suite	£52.7	£30	0	£500	£500	74.45	200
Option 3	5 night stay (WTP per night)	£34.8	£20	0	£200	£200	44.63	200

Table 4.14 presents the results of the single room valuations. The mean estimated WTP for a single room in comparison to a 4-bed room was £73 per night (£0, £900). The estimated WTP for a single room for a five night hospital stay falls to £35 per night (£0, £200). The estimated value for a single room without an en-suite was £53 per night (£0, £500). Graph 4.3 shows the estimated WTP for each of the respondents for each of the design options.

These graphs allow a visual comparison of the zero response, the range of response and the median response to the WTP valuation questions.

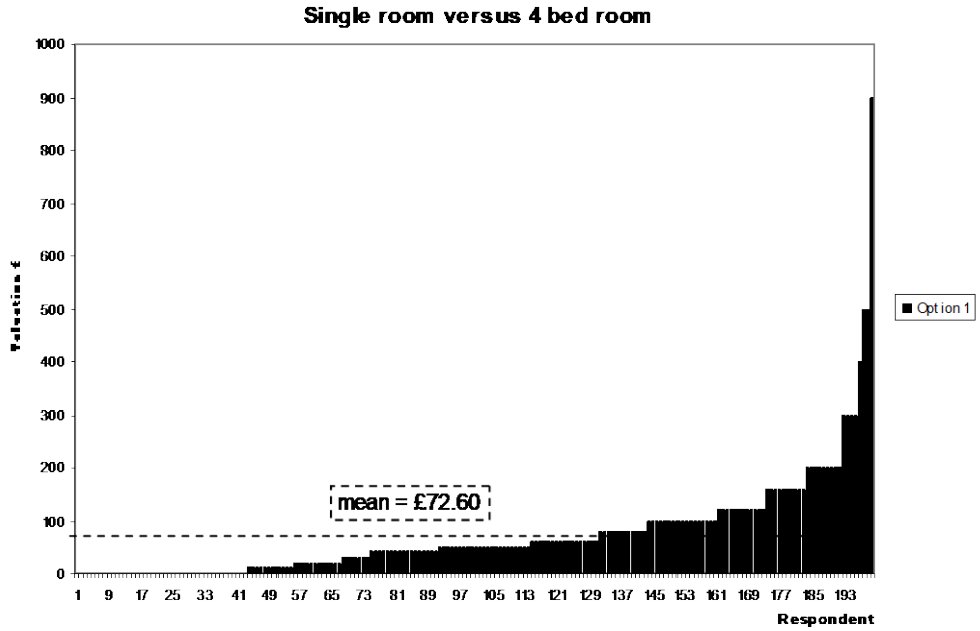
Table 4.15 shows the valuations by type of stay. Those patients that stayed overnight tended to have a lower valuation than those that visited hospital as a day patient.

Table 4.15: Valuations by type of stay

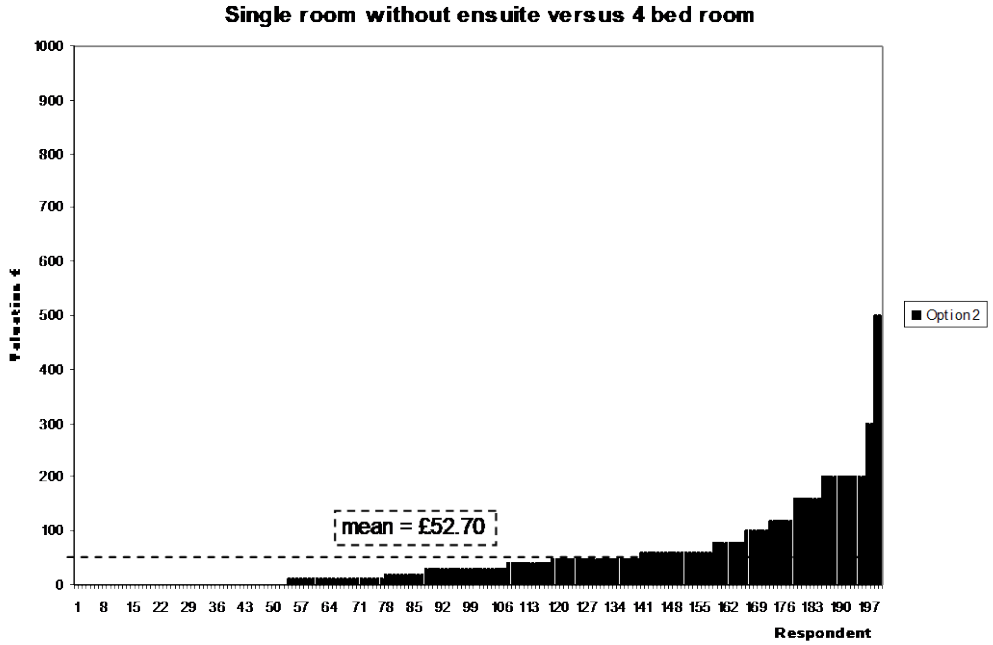
	Stay overnight		Visit hospital as a day patient	
	Mean (£)	Count	Mean (£)	Count
Option 1	£62.35	119	£96.56	61
Option 2	£47.06	119	£64.92	61
Option 3	£31.35	119	£39.34	61

Table 4.16 shows the single room design options by patient's preferences for privacy and interaction with other patients. The mean valuation of those that preferred privacy over patient interaction was higher for each of the options. For example, the valuation for the single-bed room was £87 for those that preferred privacy in comparison to £58 for those respondents that preferred interaction with other patients whilst staying in hospital.

Graphs 4.3: Single room valuations



Graphs 4.3: Single room valuations (continued)



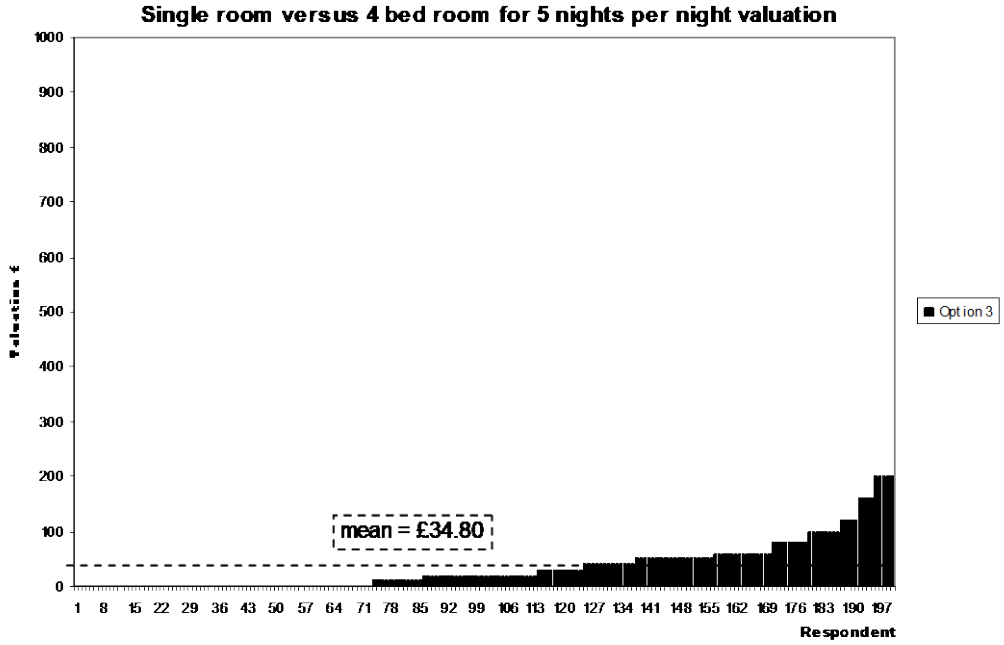


Table 4.16: Single room valuation for privacy versus interaction with other patients

	Privacy	Interaction with other patients	No preference	Don't know
	Mean (£)	Mean (£)	Mean (£)	Mean (£)
Option 1	£86.66	£58.39	£50.00	£47.14
Option 2	£70.36	£28.57	£33.08	£38.57
Option 3	£42.88	£19.11	£28.85	£54.29

The results in Table 4.17 do not show any systematic correlation between the length of stay and the valuation for each of the options. However, respondents that stayed in hospital for one day tended to place a greater value on the options than those that had a longer length of stay.

Table 4.17: Single room valuation by length of stay

	Option 1		Option 2		Option 3	
Length of stay	Mean (£)	Count	Mean (£)	Count	Mean (£)	Count
1 day	£92.40	50	£74.60	50	£40.60	50
2-5 days	£66.02	93	£43.55	93	£32.26	93
6-10 days	£70.00	28	£50.00	28	£26.79	28
11-20 days	£77.50	4	£35.00	4	£40.00	4
21 days +	£56.00	5	£48.00	5	£38.00	5

Table 4.18 presents the single rooms design options by the income of the respondents. The results show that the valuations vary by income group. For example, for option 1 the valuation for those respondents with an income less than or equal to £5,000 is £44 in comparison to a higher value of £101 for those respondents with an income between £60,001 and £100,000.

Table 4.18: Single room design options by income of respondents

Income Category	Option 1	Option 2	Option 3
	Mean (£)	Mean (£)	Mean (£)
Less than or equal to £5,000	£44.29	£40.00	£24.29
£5,001 - £10,000	£37.33	£16.67	£16.00
£10,001 - £15,000	£96.96	£45.22	£34.35
£15,001 - £20,000	£48.42	£46.84	£31.05
£20,001 - £25,000	£75.71	£57.86	£22.86
£25,001 - £30,000	£72.69	£52.69	£23.46
£30,001 - £40,000	£78.79	£65.76	£48.18
£40,001 - £60,000	£74.39	£54.88	£39.51
£60,001 - £100,000	£100.67	£83.33	£56.00
£100,001+	£30.00	£25.00	£30.00
Refused	£66.00	£36.00	£26.00

4.5.5 Slips, Trips and Falls Valuation Results

Table 4.19 presents the valuation for the different flooring options. The flooring options were as follows:

- Option 4: Laminated wooden flooring versus resin flooring;
- Option 5: Vinyl flooring versus resin flooring.

The mean results for the wooden flooring in comparison to resin flooring were £18 (£0, £300) and for vinyl flooring in comparison with resin were £23 (£0, £300). It should be noted that for both design options the median valuation was £0.

Table 4.19: Slips, trips and falls valuations

Option	Description	Mean	Median	Min	Max	Range	s.d.	N
Option 4	Wooden flooring	£17.9	£0	£0	£300	£300	41.57	200
Option 5	Vinyl flooring	£23.4	£0	£0	£300	£300	49.35	200

Table 4.20 shows that those respondents that visited hospital as a day patient on average had a slightly higher valuation than those that had stayed overnight in hospital.

Table 4.20: Valuations by type of stay

	Stay overnight		Visit hospital as a day patient	
	Mean (£)	Count	Mean (£)	Count
Option 4	£15.46	119	£20.98	61
Option 5	£20.00	119	£29.02	61

Table 4.21 shows the options by the respondents past episode length of stay in hospital. The table showed a higher valuation for both of the options for those patients that stayed for one day in comparison to those patients that had a longer length of stay.

Table 4.21: Slips, trips and falls options by length of stay

	Option 4		Option 5	
Length of stay	**Mean (£)**	**Count**	**Mean (£)**	**Count**
1 day	£21.60	50	£24.00	50
2-5 days	£16.56	93	£25.48	93
6-10 days	£15.36	28	£18.57	28
11-20 days	£15.00	4	£15.00	4
21 days +	£2.00	5	£0.00	5

Table 4.22 shows the flooring options by income category of respondents. There does not appear to be any systematic correlation between income of the respondent and the valuation estimate for the option.

Table 4.22: Slips, trips and falls valuations by income of respondents

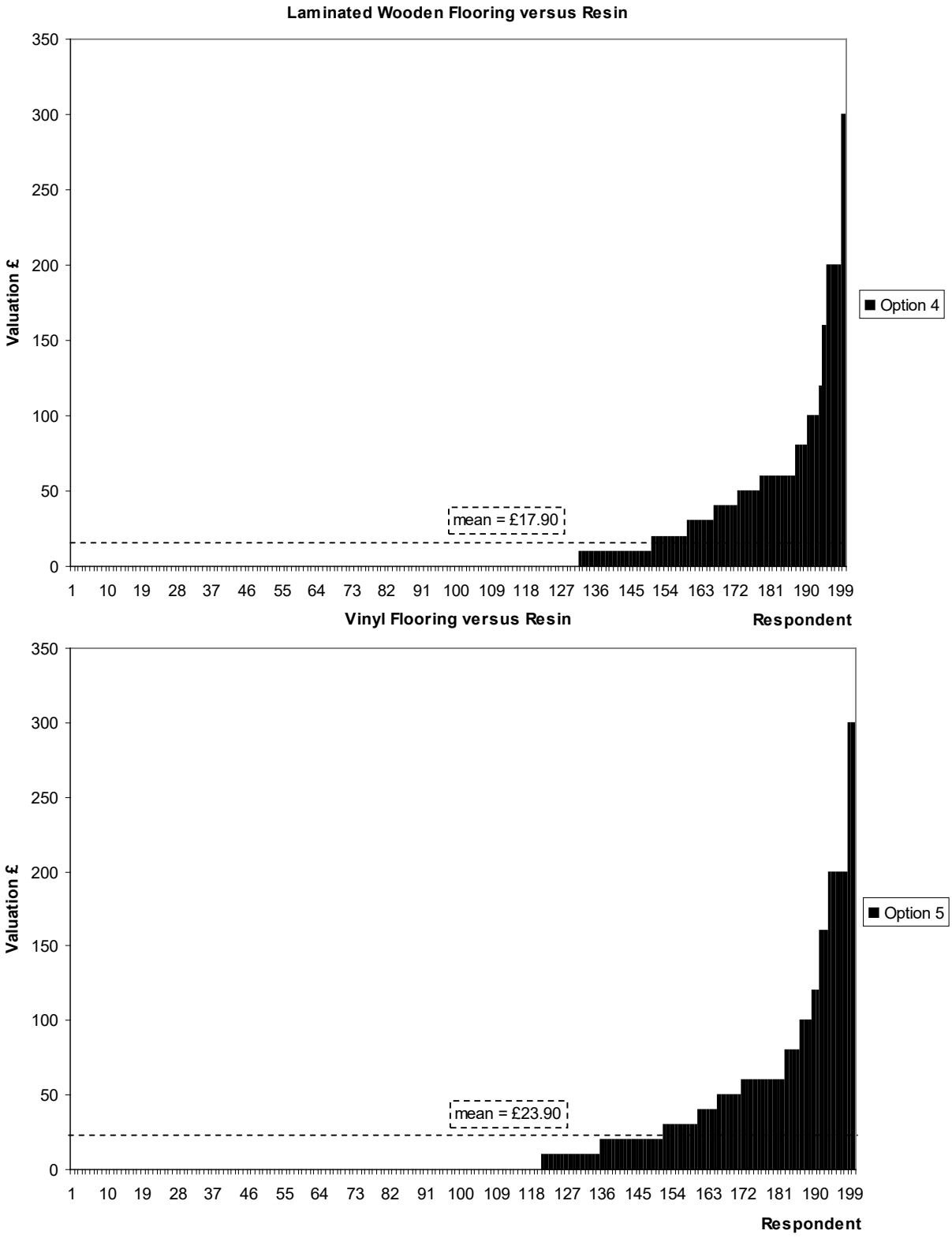
Income Category	Option 4	Option 5
	Mean (£)	Mean (£)
Less than or equal to £5,000	£40.00	£41.43
£5,001 - £10,000	£14.00	£20.67
£10,001 - £15,000	£38.70	£39.13
£15,001 - £20,000	£16.84	£28.95
£20,001 - £25,000	£15.71	£15.71
£25,001 - £30,000	£17.31	£25.38
£30,001 - £40,000	£6.06	£10.61
£40,001 - £60,000	£16.83	£24.63
£60,001 - £100,000	£21.33	£26.00
£100,001+	£0.00	£0.00
Refused	£0.00	£0.00

Graph 4.4 shows the findings in graphical format.

Key Points:

- The mean valuation for a single room versus a 4-bed room was £73 per night, a single room without an en-suite was £53 per night and a single room for five nights per night was estimated to be £35 per night;
- The mean valuation for the laminated wooden flooring was £18 per night compared with £23 for vinyl flooring. It should be noted the median valuation for both of the flooring options was £0 per night;
- The valuations were presented by a number of other factors such as length of stay, patient preferences and demographics.

Graph 4.4: Laminated wooden and vinyl flooring options



4.6 PATIENT PREFERENCES FOR HOSPITAL DESIGN

4.6.1 Overview

The results show that respondents were more alike when they ranked the patient outcomes than when they ranked the patient environment factors. The majority of patients (75%) ranked prevention of infection to be the most important patient outcome. In respect to patient environment factors there was greater variation in respondents ranking. This could possibly be explained by either; respondents being less able to distinguish between the strength of their preferences for each of the environment factor; or because respondent's preferences were markedly different for each factor.

4.6.2 Single Room Valuation

The results showed that the public placed a positive monetary value on a single room compared to a multi-bedded ward. They also showed that respondents had a relatively strong preference for the inclusion of an en-suite facility within the single room with the en-suite contributing nearly one third of the average respondent's valuation.

There were two ways in which the survey explored the relationship between length of stay and a respondent's valuation either, through the respondent's period of stay in their previous episode in hospital or by varying the length of stay in the hypothetical valuation question. This enabled a distinction and comparison between the valuations of those respondents that previously experienced hospital through being a patient and the valuations for those that had not visited hospital as a patient. The results showed for both groups that increasing length of stay resulted in decreasing valuations for each respondent.

The first possible explanation for these results is that as the length of stay increases the patient's preference for interaction with other patients strengthens. Consequentially, some patient's favour the 4-bed room option, resulting in a reduction in the mean value for the single bed room.

The second possible explanation is that respondent's considered the total cost of the stay rather than the incremental cost of each additional day. It could be that when the individual takes into account the budgetary consequences of a longer stay they reduce their subsequent per night valuations.

The results also showed that the respondents that had previously stayed overnight had on average lower valuation than those respondents that had only stayed in hospital as a day patient. One possible explanation for this could be that experiencing the environment may mean that patients are able to more accurately value the options than those that have not done so.

These are all possible explanations of the correlations between the valuations and the different factors. In order to investigate these possible relationships, further statistical analysis (regression) would be required to control for demographic factors and observable differences in respondents previous stay in hospital.

4.6.3 Flooring Valuation

The mean and median valuations for the flooring options showed that respondents had no strong preference for a particular type of flooring. There were over 120 zero responses in each of the valuation questions indicating that the individual was either indifferent or had no strong preference the flooring option.

There were, however, a small group of respondents that did express a positive WTP for the flooring options. The vinyl flooring question had fewer zero responses than the laminated wooden flooring and had a marginally higher overall mean valuation per night. In addition, the small sample of elderly members of the public may explain the high number of zero valuations as many young individuals do not appear to be so concerned with falls within hospitals. This is supported by the respondent's attitudes and experience of hospitals where only 15% of respondents ranked avoiding falls in the two most important categories (See Section 3.1.2).

The respondents found the flooring options more difficult to value than the single room designs. This is because many of the benefits associated with the outcomes are small and resulted in a tendency for individuals to report zero valuations, even when they may have believed that there was some level of benefit from the flooring option.

4.7 LIMITATIONS OF THE CONTINGENT VALUATION METHOD

4.7.1 Overview

There are a number of limitations to the contingent valuation technique which should be acknowledged when considering the results. The research team designed the surveys to minimise potential sources of bias but they may not have been completely eliminated from the estimates.

4.7.2 Respondent Based Sources of Error

Strategic behaviour is where individuals falsify the results of the CV survey by either providing an overestimate or underestimate of their actual willingness to pay in the hope to secure the provision of a good. Bateman et al. (1991)[10] highlights the case where respondents want to be seen to give sensible answers by picking up clues in the course of the interview.

However, the motivation to engage in such behaviour may be weak because there are large informational requirements for strategic behaviour; CV surveys normally convey to the respondents the impression that a large number of people will be interviewed. Therefore, there is less perceived likelihood of affecting the mean by providing over/under estimates of their willingness to pay.

4.7.3 Hypothetical Nature of CVM

A second concern relates to whether a hypothetical situation presented to a respondent can mimic that of a real market. In particular how individual's coped with the hypothetical situation that was presented to them will affect the results. The study minimised this bias by showing the respondent example hypothetical situations and a number of warm-up questions.

4.7.4 Information Bias

The degree of information that is provided to the respondent in a CV study will, along with the way in which the information is provided and interpreted by the respondent, affect the actual WTP. The respondents may have become more familiar with the questions and as a result refined their valuations. This study applied two methods to minimise the bias which were a standardised interview script and the pictures used in the valuation questions were carefully chosen to only represent the intervention change.

4.7.5 Starting Point and Range Biases

Starting point and range biases are the outcome of attempts by CV researchers to facilitate the respondent's valuation process. The nature of the questions can result in protest bids where there are lots of zero bids or unrealistically high bids given the respondents income level. This did not appear to be an issue for the single rooms design option but did appear to be a problem for the flooring option.

Key Points:

- The results showed that the public had preferences for a single room and valued the benefits. They also showed that respondents had a relatively strong preference for the inclusion of an en-suite facility within the single room with the en-suite contributing to nearly one third of the average respondent's valuation;
- The mean and median valuations for the flooring options showed that respondents had no strong preference for either types of flooring. There were over 120 zero responses in each of the valuation questions indicating that the individual was either indifferent or did not prefer the flooring option;
- There are a number of biases associated with CV surveys which are Respondent based sources of error; Hypothetical nature of CVM; Information bias and Starting Point and Range Biases.

4.8 CONCLUSION

The findings of the WTP exercise completed with members of the general public suggests that participants had a strong preference for single bed rooms compared to 4 bedded rooms. Furthermore, the preference for a single bed room with an en-suite bathroom was even stronger.

Responses to the willingness to pay exercise regarding flooring options showed that participants were largely indifferent to alternative flooring options in hospitals. A significant number of participants provided zero values for flooring options. This may be due to genuine indifference relating to flooring options or may reflect a relatively low level of awareness about the number of slips, trips and falls which occur in NHS hospitals and the implications in terms of morbidity and healthcare resources.

There was a high degree of acceptance of the CV methodology adopted in the study with the majority of participants finding it relatively easy to understand and complete the questionnaire. Findings from NHS staff are presented in Section 5.4.

Section 5: Final Case Studies

5.1 INTRODUCTION

The purpose of the final case studies was to identify evaluations, data and findings in respect of four design options. We also planned to undertake further WTP studies with staff and patients. We obtained ethics approval to undertake these studies from North Sheffield Ethics Committee.

However, when we sought to recruit case study sites, we encountered many problems:

- Trusts saw no benefits in participating, and were unwilling to commit staff time and effort;
- In exploring the logistics of patient recruitment, numerous issues were apparent:
    - We had intended to use members of the research team to recruit patients and administer surveys. We also explored options for using bank nurses at the participating trusts, who would be paid from the research project. Using the former methodology appeared to be logistically complex for trusts, and using the latter method raised ethical issues, as those recruiting were not part of the research team, and hence our ethics approval did not cover them;
    - The recruitment of consultants on a selection of wards to agree to their patients participating;
    - The selection of specialties and wards, especially when targeting those in single rooms;
    - The point in the patient pathway when patients would be recruited to the study was problematic to agree, and standardisation seemed difficult to achieve.

We therefore modified the methodology, with the permission of the funding body, and excluded patients from our case study surveys. We have assumed that the public survey will address patients' values. Our case studies have therefore only included staff.

Despite simplifying the methodology, trust recruitment still proved problematic: we were seeking trusts that were able to offer insights into design options and patient safety, and many trusts approached were unwilling to participate because of other commitments, or still saw no value in the study for themselves. Eventually, we were able to recruit five trusts, and we report here on findings from four of the trust site visits. Obtaining research governance approval in the fifth trust proved problematic, and was not obtained in time for the final report.

5.2 OVERVIEW OF CASE STUDY VISITS

The four case study sites that participated had a wide geographic spread, size and focus. Three of the trusts were teaching trusts with a range of specialties; the fourth was a medium sized DGH. Two had recently completed and commissioned PFI schemes, whilst three were in the planning and ongoing implementation phases of modifications to wards, reception areas and entrances, clinics and A&E departments. Visits were made over a six month period in early to mid 2009. The unifying factor across the participating trusts was their interest in their environment, design options, and patient safety. Two of them had participated in the Kings Fund *Enhancing the Healing Environment* Project.

At each trust, staff members were interviewed using a semi-structured interview schedule about the four design options, and were also invited to comment on other relevant design options and issues. Box 5.1 summarises the interview schedule used and box 5.2 the targeted staff groups. These staff groups were identified as those who had been involved in and had implemented design changes in respect of patient safety. The ethics approval covered these staff groups.

Box 5.1: Interview schedule

Design options	Questions
• Single rooms; • Design options for slips, trips and falls; • Ventilation; • Operating theatres; • Other design features.	In what from has [design option] been implemented?
	Describe the issues faced during implementation of [design option].
	How is/are [design option] used.
	What impact has the use of [design option] on patient safety and staff and patient well-being.

Box 5 2: Focus of interview by staff group

Staff Group being interviewed	Single Rooms	Design features impacting on slips, trips and falls	Ventilation	Operating Theatres
Director of Nursing or relevant Nurse Manager	Yes	Yes	No	No
Risk manager	Yes	Yes	Yes	Yes
Engineer or Estates/facilities Manager	Yes	Yes	Yes	Yes
Infection Control Nurse Manager	Yes	Yes	Yes	Yes
Operating Theatre Manager	Yes	No	Yes	Yes
Ward Managers	Yes	Yes	No	No

All trusts received a preliminary pre-site visit to discuss the project, research governance requirements and agree those to be interviewed. All participants received a briefing note about the project. A total of 35 staff members were interviewed across the four sites which included not only the targeted staff groups but also a chief executive, directors responsible for transformation, and project staff, for example for a productive ward project.

Staff at three of the trusts completed the survey, and at the fourth, completed a modified survey at the request of the chief executive, which excluded valuations, but included questions of preferences. Trusts were also asked to provide any evaluations or reports in respect of the impact of design options.

5.3 FINDINGS FROM INTERVIEWS

5.3.1 Single Rooms

5.3.1.1 Implementation

The number and percent of single rooms varied across the trusts, from around 10-25%, although this varied across specialties. For example ICU units tended to be single rooms, as did delivery rooms in obstetrics units and new builds tended to be 25%. The ward layouts also varied with some being integral and others being at the end of corridors. One trust currently planning a major rebuild/refurbishment believed it would achieve 40% single rooms on many wards, and another was aiming for one-third single rooms.

Not all single rooms were ensuite, for example those that were side rooms on older wards were not, whilst new single rooms were en suite.

Trusts also discussed implementation of different room designs, especially in respect of achieving single sex bays and wards, which was taxing many of them. One trust reported that they were adapting 24 bed wards to make more single sex toilets and shower rooms, and would be losing 6 beds in total. Another reported modifying 6 bed to 4 bed bays, thus creating space for single sex bathrooms in these bays whilst converting the bathrooms on corridors (which may not meet single sex accommodation guidelines) into single rooms.

5.3.1.2 Use of single rooms

All trusts reported similar use of single rooms. Most single rooms also had switchable or different ventilation systems (negative or positive) for managing patients with infections. Some single rooms also had lobbies, suitable for nursing those with infections.

Single rooms were used in some specialties, for example:

- Specialist haematology;
- Delivery suites;
- Patients with TB or infections (with negative pressure);
- Neutropenic patients (with positive pressure);
- End of life care (specifically citing that families could remain with patients).

Trusts also reported using single rooms in specific situations, including:

- For general infection control;
- For disruptive or noisy patients;
- Issues of privacy and dignity, including for prisoners who are normally hand cuffed to warders;
- Very sick patients;
- (if capacity) patient choice;
- Private patients or amenity beds.

One trust summarised their priority of allocation as:

- First is for infection control;
- Second is end of life care;
- Third is clinical priority.

5.3.1.3 Issues faced in implementation and use

The issues identified by trusts were similar, although the actual ward designs meant that the issues were more or less important, but still had to be considered.

Observation and Isolation

All trusts acknowledged that not all patients needed or wanted to be in single rooms. Despite attempts at ensuring single rooms were integral to wards, all trusts reported problems with observation of patients in single rooms. Some groups of patients were not necessarily suitable for single rooms; all trusts reported using risk assessment tools, for example, falls assessments, to ensure suitability. Trusts acknowledged that whilst particularly sick patients benefitted from nursing in single rooms, and benefitted from the one: one nature of single room nursing, observation of such patients could be problematic.

Two trusts reported trialling new alarm systems or buzzers so that patients could alert nurses when necessary.

Suitability

Interviewees stated that they preferred managing infectious patients in rooms with lobbies. However, especially in new PFI schemes, single rooms were not necessarily given lobbies (given the limitations of space), which many believed compromised their management and infection control.

Ensuite Facilities

Ideally, single rooms benefit from having en suite facilities, but trusts reported problems with bathrooms. Examples included toilets for single rooms, which were also used by patients on the main wards and single rooms without toilets. In the latter case, interviewees reported having to use commodes for patients who were infectious (acknowledged to be an unsatisfactory situation). Nonetheless, all single rooms were reported to have hand washing facilities, although one trust reported that the wash basins were not always cited close to the door or convenient for use on immediate entry to the room.

Design Features

Single rooms do not necessarily have desirable design features. Trusts reported a catalogue of problems with single rooms, including: dark rooms with poor lighting; rooms with doors too small to wheel beds through thus limiting the use of these rooms to patients who could walk, use a wheelchair or be transported on a trolley; single rooms without lobbies which limited their use for patients with infections; unsuitable ceilings which are tiled and not sealed; and limited space for nursing and for storage. Trusts also reported problems with specialist beds in single rooms, due to limitations of space, for example in resuscitating patients in some high-low beds, or larger beds.

Staffing

All trusts reported that single rooms need more observation and that management of patients in single rooms require additional nursing time. However, trusts also report that these requirements do not necessarily mean that staff numbers will increase. Trusts report having different staff allocations. For example one reported having a coordinator to ensure appropriate allocations, and a second reported moving from a two team to a three team model. Having ensuite facilities saved staffing time in escorting patients distances to the bathroom. A third reported the advantages of the new call systems being piloted, for example having different buzzers and calls. One trust reported poorly designed nursing stations such that nurses have their backs to the bays and rooms. Trusts reported having to ensure staff buy-in to the designs and a need for a change in culture towards nursing patients in single rooms. Staff experience was believed to be important.

5.3.1.4 Impact of single rooms

Trusts reported positive and negative impact. Positive impact included: infection control; flexibility for managing patients that require quarantining or would benefit from single rooms (as described earlier); ensuring a quieter and more peaceful environment for the majority when disruptive or noisy patients are moved from bays to single rooms. On the other hand, trusts reported significant negative impact including: rooms not suitable for many patients such as those likely to fall, those with visual impairment, those likely to wander or with dementia; those who are claustrophobic or unhappy if away from hustle and bustle of the ward; one trust was concerned that older people were unhappy being placed in single rooms as they "worry they are going to die"; problems with observation and visibility thus leading to increased risks of adverse incidents as well as reduced staff satisfaction; and increased costs of cleaning, particularly the deep cleaning of rooms and beds following use by infectious patients. One trust believed that it was not always easy to ensure that patients take their medications in single rooms. One interviewee reported that "currently safety is an issue due to the existing envelope but less so from falls more about reduced visibility".

5.3.1.5 Evidence

One trust reported a reduction in MRSA cases for example having no cases in the previous month, and falling infection rates (not quantified).

5.3.2 Design Features Impacting on Slips, Trips and Falls

5.3.2.1 Implementation

All trusts report using similar equipment and design features.

Flooring

Trusts ensure that the floor surfaces themselves are non-slip, for example, resin flooring in bathrooms and all wet areas, and plain vinyl and other non-slip flooring elsewhere. Trusts reported that cleaning teams do not buff floors, thus reducing slipperiness and one trust reported having a slip meter to measure the texture of flooring to assess slipperiness. To further ensure floors particularly in areas used by the public are not wet, one trust reported having large sunken mats in entrances and additional cleaning teams to mop floors in wet weather.

Beds

All trusts reported having high low and low low beds, having electric beds, and having specialist beds. Beds may have rails on bed sides, for example electrical beds. Patients were normally risk assessed to assess the most appropriate bed which would only be fitted with rails if the risk assessment indicated suitability, thus avoiding risks of accidents. Trusts reported having bed rail policies. One trust used coloured magnets above beds to indicate the risk assessment and falls category of the patient.

Patient Movement

All trusts reported having combinations of fixed, tracking and mobile hoists to aid patient lifting and moving. Hand rails were fixed in corridors; and in toilets and bathrooms. On the other hand, patients were encouraged to walk wherever possible, for example to theatre, to reduce the need for manually moving patients. One trust reported providing slippers to those patients with unsuitable footwear. Beds, including those in single rooms, have pressure pads next to them, to indicate when patients are moving around, or even have fallen from bed. One trust reported being part of a falls collaborative, and this trust also reported that the beds of those at greatest risk of falls are close to the nurses' stations.

Lighting

One trust reports having an ultra efficient lighting project, which is about the whole process of purchase, performance, cleaning and maintenance of lights. Dimmer lights at night are triggered with movement, and each bed has its own light. Of concern were dark rooms, especially single rooms lacking good natural light. Good natural light and large windows were a feature of wards and rooms in new builds (often to the detriment of privacy). One trust reported having bright yellow doors on toilets thus ensuring that confused patients or those with visual impairment were more able to see them.

5.3.2.2 Use of design features

All wet areas appear to have resin floors, regardless of which patients use them. High low and low low beds are used for patients following risk assessment, to minimise risk of falls. All single rooms in new builds have hoists, and most bays have hoists, or access to mobile hoists. Improved lighting and colour of floors especially assisted those with visual impairment. Rails were a feature of all bathrooms and toilets. One trust reported converting all bathrooms in their orthopaedic wards to wet rooms on one level, thus removing edges and lips, and minimising risks of falls.

5.3.2.3 Issues faced in implementation

The key to improved management of slips, trips and falls was seen to be staff training associated with all the equipment. Thus, trusts with new builds and a range of hoists and equipment reported running extensive training including at staff induction programmes. Training may include assessing patients, identifying risk, and ensuring a safe environment. Both trusts with new builds reported having mock-ups of patient areas to identify patient flow, visibility, and problem areas. Additionally, a large number of people, including health and safety, were involved in selecting and trying equipment such as hoists.

However, those with new PFI funded new builds reported problems with the subsequent contracts, such as the maintenance of the new beds, the replacement of slippery flooring (which according to the PFI contractor, met HTM standards), the increased number of falls at wet entrances, which again according to the PFI contractor met HTM standards. This trust reported changing their contract to increase cleaning and drying of floors. The same trust re-painted many areas to make them compliant for the visually impaired and changed signs

on toilet doors which previously were too small. One trust reported the problems in persuading their PFI contactor to implement bright yellow doors and signs on toilets, even though they believed there was good evidence on the prevention of falls.

The trade-off between preferring good natural light and issues around privacy has been problematic for one trust, for which large windows have to be frosted, to ensure that privacy inside and from outside the hospital is maintained.

Low rise beds, whilst reducing falls, can be more problematic to nurse and to clean. One example given is of a patient with a catheter whose bags may drape on the floor, thus increasing the risk of urinary tract infection.

5.3.2.4 Impact of design features

All trusts report not just reduced slips, trips and falls with improved flooring, but also reduced infections as the floors can still be cleaned thoroughly. Improved design of bathrooms and wet rooms also reduce the likelihood of falls, and improve infection control.

Light, bright wards, not only assist visual acuity of patients as they move around, but also improve the ambience of wards creating a brighter environment, appreciated by staff and patients and leading to improved satisfaction and well-being.

Another trust described an improvement in patient safety and a reduction in staff injuries since the implementation of electric beds. The trust implementing the Productive Ward initiative reported that they are monitoring slips, trips and falls as part of that project.

The trust participating in the Falls Collaborative had undertaken baseline measurements and established clear objectives and targeted areas. Examples from their project brief stated:

“Protecting patients from falls and injury and ensuring a safe environment are fundamental to providing high-quality care...immediate action [has been] taken by wards to use ‘zoning techniques’ for high risk patients and raise awareness of the need to stay with patients whilst they use the toilet”. A preliminary evaluation of the Falls Collaborative work indicated varied frequency in the use of the bed rail assessment, although staff were keen to improve this, and a high satisfaction rating for call bell usage, although recognising that bell call issues are different for different areas. Interviewees from this trust also reported that slips, trips and falls have reduced by 60%, and that the use of low beds in orthopaedics has reduced risks of persistent falls by 30%, although we saw no written evidence to support these figures.

5.3.3 Ventilation

5.3.2.2 Implementation

Trusts discussed ventilation on wards and in operating theatres.

Wards

Single rooms normally have a mix of positive and negative air flow: with negative for infections and especially TB, and positive for neutropenic patients. One trust reported having rooms with switchable pressure, for example in paediatrics. The majority of bays in wards were ventilated through natural ventilation and did not have air conditioning. Trusts reported that many clinical areas may not have natural ventilation, for example, pharmacy, and pathology, and therefore need air conditioning.

Operating Theatres

All trusts have a mixture of traditionally ventilated theatres, with laminar flow in orthopaedics and (if the specialty is delivered) neurosurgery, and positive flows in other specialties. Theatres are designed to meet the relevant HTM.

General Comments

One trust reported having a central building management system which monitored pressures and rates of air replacement.

5.3.2.3 Use of design features

There was consistency across all trusts in respect of the specialties and the rooms having positive and negative flows, and orthopaedic theatres having laminar flow. One trust reported examining an alternative laminar flow system for patients with high infection risks. Having switchable pressure was not necessarily seen as desirable, as nurses may not know which pressure was being employed. One trust reported that no training is given to staff on how to work with negative pressure rooms.

5.3.2.4 Issues faced in implementation

One trust reported having problems with the theatre ventilation, after the PFI contractor installed a ventilation system that was compliant in Europe, but only compliant in the UK if working at full capacity. There are concerns in this trust that there may be problems with this system in the future. The same trust reported having problems in getting the ventilation validated as there were discrepancies between the PFI consultants' validation and the Trust's independent engineer's validation of the exchanges per hour in the operating theatres.

Problems can arise in ensuring the correct pressure in single rooms if doors do not fit correctly, as discovered by one trust. The same trust reported problems with having a centrally managed climate control system, with complaints that parts of the building are either too hot or too cold.

All trusts with natural ventilation in wards report problems in maintaining comfortable temperatures in summer. Windows may be opened inappropriately, and where curtains are closed to prevent bright sunlight, patients may complain. Where windows are open, curtains may blow around in windy weather. One trust described having a 'hot weather policy' to which all wards are required to adhere, including ensuring windows were closed and curtains partly/completely closed. The need to manage energy consumption was balanced against problems in climate control in wards and clinical areas, adversely affecting staff and patients. Trusts reported windows that only opened a few inches, which may not ensure good ventilation, and may be problematic in single rooms where "wound are particularly malodorous". Trusts with large floor to ceiling windows reported very hot wards at higher levels.

5.3.2.5 Impact of design features

Trusts had adhered to HTM guidance, and therefore that the theatre ventilation systems delivered appropriate air quality, thus minimising risks of infections. Patients in single rooms were managed as far as possible in the appropriate environment, although one trust reported having to re-organise the management of patients with TB.

Appropriate ventilation also aided patient and staff comfort, but not always satisfactorily in wards with natural ventilation, where hot conditions were particularly problematic. One trust described the negative impact on staff when working on wards wearing plastic aprons. In trust interviews, problems with climate control and ventilation on wards were frequently voiced.

5.3.3 Operating Theatres

5.3.3.1 Implementation

Two of the trust had new theatres as part of their major PFI scheme, and one was implementing a scheme including new theatres. Again, trusts seek to meet appropriate HTM standards for theatres.

Both new theatres and planned new theatres will have improved equipment, such as lighting, cameras as well as a high level of finishing that can withstand deep cleaning. New theatre suites also have improved and dedicated staff changing areas, toilet facilities and lockers. One trust reported staff having to change away from the theatres, with an increased risk of infection.

New theatres aim to have improved patient and clean/dirty flows, to improve efficiency and to reduce risk of infection.

No trusts had innovative design features, and all had traditional layouts of anaesthetic and recovery rooms. One trust, in the design of their new theatres, will have shared scrub rooms. One trust also has standardised layouts, so that all aspects of the theatres including gas points are the same, and standardised equipment. This trust also described having theatres in banks, with shared recovery facilities. Interviewees described the need for appropriate adjacencies and flows between elements of the theatre suites including patient flow and flow of clean and dirty goods.

5.3.3.2 Use of operating theatres

All trusts, irrespective of the age of the theatres, had dedicated orthopaedic theatres with laminar flow ventilation. Ophthalmic theatres were also dedicated because of the equipment installed. Trusts may also have dedicated day case theatres and emergency theatres, which may be located away from the main theatre block.

5.3.3.3 Issues faced in implementation

One trust expressed concern about the potential problems in the event that orthopaedic theatres cannot be used, and therefore have business continuity plans. Another trust expressed concerns about the tiled ceilings in their new theatres, which they believe may lead to an increased risk of infections. Their Infection Control Team had recommended having a sealed ceiling, but this option was considered to be too costly. All trusts described the problems associated with upgrading or implementing new theatres, and maintenance of existing theatres, ensuring that theatre lists were not disrupted.

5.3.3.4 Impact of design features

The trusts planning for their new theatres described the anticipated benefits as: improved infection control; improved facilities for staff will give improved infection control and an improved work environment leading to increased satisfaction and possibly reduced risk of errors; improved ways of working, leading to reduced delays and improved patient management; increase in space for equipment management; and shared scrub will enable consultants to share working areas and hopefully share practices. For patients, a new reception design will benefit the patient journey. Larger theatres minimise clutter, and improve management of equipment, creating a safer environment. Reduced distances and travel time were seen as desirable to improve efficiency and reduce likelihood of adverse incidents and infections

Planned new theatres will have improved relationships of facilities and patient flow. One trust described the planned implementation of Vital Pak, which will flag up observations and calculate early warning scores, leading to improved patient safety and staff satisfaction, and the Jonah system, which will enable safer discharges. The planned wireless connections will improve communications.

5.3.3.5 Evidence

We were provided with a copy of the Report of a Working Party of the Hospital Infection Society, *Microbiological Commissioning and Monitoring of Operating Theatre Suites*, which provided the evidence for and information of how to commission conventionally ventilated and ultraclean ventilated theatres, to which all trusts, appeared to adhere.

5.3.4 Other design features

5.3.4.1 Overview

Trusts described a range of other design features which they were or had implemented, either to deliver improved safety or, as a by-product, would lead to improved patient safety. They also described a range of design problems in their new PFI scheme, which had a negative impact on patient management and safety.

5.3.4.2 Design of Corridors and Doors

One trust reported that their biggest design issue was doors! They described how none of the doors were electric, so staff and trolleys are frequently banged. The doors are heavy and need considerable force to push and keep open (measured by the trust). A survey also showed that a selection of doors did not meet standards. They now have a rolling programme to replace the doors, which the PFI company eventually agreed to fund.

5.3.4.3 Sluices and washers

One trust described the problems with their new bed pan washer. Although the Infection Control Team advised on the requirements for the new washer, the PFI contractors did not take their recommendations into account when purchasing them. The new washer failed to wash the bed pans effectively and had to be replaced, even though it met HTM guidelines. The new washers were also too large for the small sluice rooms, so that doors knocked against the machines, and therefore staff had to go into the sluice rooms backwards.

5.3.4.4 Accident and emergency department

One trust visited was particularly focusing on redeveloping their A&E department taking into account best design principles for patient safety, infection control and patient flow. The trust was clear that there is a relationship between process and design and between design and patient safety. The trust had investigated the evidence, and had made site visits to other A&E departments in the UK and USA to develop a best practice design. Their refurbishment plan would seek to increase space by reducing the overall number of rooms, although there are also requirements for additional single and more spacious rooms, for an increase in the number of medication rooms and overall workspace. The design should ensure the majority of space can be observed. One concern from those at the trust was the problems that architects may not appreciate the requirement for patient safety, and that A&E departments require specialist knowledge.

Two trusts also described problems with the curbs where ambulances deliver patients. One reported around 20 people having tripped over on the raised curbs, breaking wrists. However because the design met HTM standards, the trust did not replace the curb but painted it a bright colour.

5.3.5 Summary of Findings

Several themes emerge from the case study site visits:

- The trusts are aware of the relationships between design and patient safety;
- The trusts are implementing initiatives to impact on patient safety;
- Single rooms are not a panacea, and whilst trusts value their flexibility, they are mostly used for specific groups of patients for which infection control is a serious factor. The requirement for 50% single rooms does not appear to be justified, nor does it appear to be deliverable within costs and space constraints;
- Technical guidelines, for example the relevant HTMs, are being adhered to yet trusts report that these HTMs are frequently out of date and do not deliver standards that deliver best patient safety practice;
- Trusts reported numerous problems with PFI constructed new builds, despite design features adhering to HTM standards. Trusts report the trade-off between costs and patient-safety oriented design favouring costs, so that, for example, recommendations from Infection Control Teams on improved design may not be taken into account. It is not clear whether the problems cited are to be expected in large new builds, or whether they were exceptional. Certainly, the examples given were detrimental to patient and staff safety;
- Interviewees believe and assert that initiatives are having a positive (or negative) impact on patient and staff safety yet no trusts were able to provide evidence from their own audits and evaluations. Interviewees would cite evidence as to the beneficial effect of initiatives, but were not able to demonstrate this in their own trust.

Indeed, whilst we were given copies of trust guidance on a range of patient safety related issues, such as bed rails guidance and policy, infection control audits, and guidance in respect of wet entrance floors, we had few examples of audits of compliance against procedures, and evidence was almost non-existent. We do not believe that these trusts are atypical of trusts in the NHS.

Our original methodology envisaged collecting evidence from on-the-ground case studies, yet this has not proved possible, as trusts do not appear to evaluate the impact of patient safety design options.

5.4 STAFF SURVEY

5.4.1 Overview

During the second round site visits to trusts, staff were also invited to complete the same survey as completed by the public. One of the trusts was unhappy about their staff placing financial values on design features; therefore we modified the survey for them, taking out the questions on financial value. Surveys were given to key contacts at case study sites for onward distribution or to staff at interview. Staff completed the survey and either gave them back to the onsite project staff member or posted back to the team. Unfortunately, not all staff completed all sections of the survey, and therefore the number of respondents as indicated in our tables in following sections may vary. This is especially the case where the tables are produced from cross tabulations.

We have analysed 26 responses, of which 4 (15%) were completed by men, and 85% by women. The ethnic origin of all respondents was white. The salary of the respondents was higher than those of the public, with 80% earning over £40,000 per annum, and 89% having a degree. 44% of respondents were aged over 45, and 41% between 35 and 44 years.

5.4.2 Attitudes towards Hospital Issues

The first set of questions investigated attitudes towards hospital issues, either as a patient, or a visitor. 80% stated that privacy was the most important factor, whilst 12% stated interaction with other patients, and 8% had no preference. Respondents (n=25) were asked to rank a list of factors in order of importance (1= most important and 5 = least important).

Table 5.1: Hospital issues

Factor	Weighted ranking	Final ranking
Prevention of infection	1.76	1
Comfort (physical comfort, emotional comfort)	2.84	3
Avoiding falls	4.44.	5
Privacy	2.96	4
Speed of recovery	2.72	2

Thus staff rank prevention of infection as the most important factor and the avoidance of falls as the least important. This compares to the ranking by patients where prevention of infection is also ranked as most important, but comfort closely followed by privacy are ranked as the least important.

Respondents were also asked to rank factors relating to the surrounding and the environment in a hospital.

Table 5.2: Environmental issues

Factor	Weighted ranking	Final ranking
Control of temperature of environment	2.44	2
Interior decoration (colour of walls, pictures on walls etc)	3.92	5
Reasonable noise levels	2.6	3
Space for family and friends	3.52	4
Windows (those you can see out of and provide natural light)	2.2	1

Having natural light and being to see out of windows was ranked as the most important environmental factor, whilst interior décor was ranked as the least important. Patients rank control of temperature as most important closely followed by noise levels, whilst interior décor is also ranked as the least important.

Staff stayed in hospitals across the UK, and in a variety of specialities. On their last stay in hospital, 41% of respondents stayed in a single room, 30% in a 4-bed bay, 9% in a 2-bed room, and 9% in an open ward. 54% spent 5 days or less in hospital, and 68% had a surgical procedure. 80% had visitors every day and 33% had private health insurance. 64% were quite or very satisfied with the overall environment, 11% were quite or very unsatisfied, and 22% were neutral.

5.4.3 Single Room Valuation Results

Table 5.3 shows the valuations for the single room design options. The three options were as follows:

- Option 1: Single-bed room versus 4-bed room;
- Option 2: Single-bed room without en-suite facilities versus 4-bed room;
- Option 3: Single-bed room for five nights per night versus 4-bed room.

Table 5.3: Single rooms design option valuations

	Description	Mean	Median	Min	Max	Range	s.d.	N
Option 1	Single room versus multi-bed	£79.05	£50.00	£0	£300.00	£300.00	83.00029	21
Option 2	Without an en-suite	£36.19	£30.00	£0	£120.00	£120.00	39.93447	21
Option 3	5 night stay (WTP per night)	£90.50	£50.00	£0	£500.00	£500.00	111.61376	21

Table 5.3 presents the results of the single room valuations. The mean estimated WTP for a single room in comparison to a 4-bed room was £79 per night (£0, £300). The estimated WTP for a single room for a five night hospital stay falls to £90 per night (£0, £500). The estimated value for a single room without an en-suite was £36 per night (£0, £120).

Table 5.4 shows the valuations by type of stay. Those patients that stayed overnight tended to have a lower valuation than those that visited hospital as a day patient.

Table 5.4: Valuations by type of stay

	Stay overnight		Visit hospital as a day patient	
	Mean (£)	Count	Mean (£)	Count
Option 1	£74.00	15	£74.44	10
Option 2	£38.00	15	£34.44	10
Option 3	£118.89	15	£67.78	10

Table 5.5 shows the single room design options by patient's preferences for privacy and interaction with other patients. The mean valuation of those that preferred privacy over patient interaction was lower for each of the options. For example, the valuation for the single-bed room was £78 for those that preferred privacy in comparison to £83 for those respondents that preferred interaction with other patients whilst staying in hospital. This was different to the patient response where privacy was preferred over patient interaction.

Table 5.5: Single room valuation for privacy versus interaction with other patients

	Privacy	Interaction with other patients	No preference
	Mean (£)	Mean (£)	Mean (£)
Option 1	£78.00	£83.33	£30.00
Option 2	£37.33	£43.33	£30.00
Option 3	£62.00	£233.33	£100.00

The results in Table 5.6 do not show any systematic correlation between the length of stay and the valuation for each of the options. However, respondents that stayed in hospital for one day tended to place a lower value on the options than those that had a longer length of stay.

Table 5.6: Single room valuation by length of stay

	Option 1		Option 2		Option 3	
Length of stay	Mean (£)	Count	Mean (£)	Count	Mean (£)	Count
1 day	£56.00	7	£34.00	7	£46.00	7
2 days	£62.50	7	£25.00	7	£47.50	7
3-5 days	£85.00	8	£46.25	8	£96.25	8
5-10 days	£25.00	2	£0	2	£40.00	2
11+ days	£200.00	2	£80.00	2	£500.00	2

Table 5.7 presents the single rooms design options by the income of the respondents. There are no respondents in the lower income groups. The results show that the valuations vary by income group. For example, for option 1 the valuation for those respondents with an income of £30,001 - £40,000 is £20 in comparison to a higher value of £175 for those respondents with an income over £100,001.

Table 5.7: Single room design options by income of respondents

Income Category	Option 1	Option 2	Option 3
	Mean (£)	Mean (£)	Mean (£)
Less than or equal to £5,000			
£5,001 - £10,000			
£10,001 - £15,000			
£15,001 - £20,000			
£20,001 - £25,000	£0	£0	£0
£25,001 - £30,000			
£30,001 - £40,000	£20.00	£5	£25.00
£40,001 - £60,000	£87.50	£57.50	£80.00
£60,001 - £100,000	£87.00	£42.00	£113.33
£100,001+	£175.00	£25.00	£85.00

5.4.4 Slips, Trips and Falls Valuation Results

Table 5.8 presents the valuation for the different flooring options. The flooring options were as follows:

- Option 4: Carpeted floor versus resin flooring;
- Option 5: Vinyl flooring versus resin flooring.

Table 5.8 shows the valuation results for the flooring options. Interestingly there are no values in the carpeted flooring option at all as all staff would not want a carpeted floor at all. The mean results for vinyl flooring in comparison with resin were £2.5 (£0, £50). It should be noted that for both design options the median valuation was £0.

Table 5.8: Slips, trips and falls valuations

Option	Description	Mean	Median	Min	Max	Range	s.d.	N
Option 4	Carpeted floor	£0.00	£0	£0	£0	£0	0	20
Option 5	Vinyl flooring	£2.50	£0	£0	£50.00	£50.00	11.18034	20

Table 5.9 shows that those respondents that visited hospital as a day patient on average had a slightly higher valuation than those that had stayed overnight in hospital.

Table 5.9: Valuations by type of stay

	Stay overnight		Visit hospital as a day patient	
	Mean (£)	Count	Mean (£)	Count
Option 4	£0	15	£0	10
Option 5	£0	15	£5.56	10

Table 5.10 shows the options by the respondents past episode length of stay in hospital.

Table 5.10: Slips, trips and falls options by length of stay

	Option 4		Option 5	
Length of stay	**Mean (£)**	**Count**	**Mean (£)**	**Count**
1 day	£0	7	£0	7
2 days	£0	7	£0	7
3-5 days	£0	8	£6.25	8
5-10 days	£0	2	£0	2
11+ days	£0	2	£0	2

Table 5.11 shows the flooring options by income category of respondents. Again there are no respondents in the lower income groups and the only actual value being £5.56 for vinyl flooring in the £60,001 to £100,000 group. This indicates that staff place no value on having carpeted flooring. This result is to be expected as trusts have very few carpeted areas due to infection control, and most trusts told us that they had non-slip resin and vinyl flooring. We would not therefore expect staff to express any preference for carpeted flooring.

Table 5.11: Slips, trips and falls valuations by income of respondents

Income Category	**Option 4**	**Option 5**
	Mean (£)	**Mean (£)**
Less than or equal to £5,000		
£5,001 - £10,000		
£10,001 - £15,000		
£15,001 - £20,000		
£20,001 - £25,000	£0	£0
£25,001 - £30,000		
£30,001 - £40,000	£0	£0
£40,001 - £60,000	£0	£0
£60,001 - £100,000	£0	£5.56
£100,001+	£0	£0

We were interested, for all options across the whole valuation part of the survey, in how many staff actually ticked the box marked zero as the actual value, and how many placed crosses in all boxes with values including that marked zero. We were not sure whether those who marked crosses in all boxes disagreed with trying to place a value on a design option. Table 5.12 shows how the specific questions for the options where answered with regards to placing a value of £0 on an option, indicating that only a small number did not place a value on single rooms or beds in bays, whilst a larger number placed a zero value of flooring options.

Table 5.12 Specific response to £0 value on an option

	All values marked with cross	£0 value ticked
Option 1	2	2
Option 2	2	5
Option 3	1	2
Option 4	7	13
Option 5	7	12

Key Points:

- The mean valuation for a single room versus a 4-bed room was £79 per night, a single room without an en-suite was £90 per night and a single room for five nights per night was estimated to be £36 per night;
- The mean valuation for the carpeted flooring was £0 per night as no one wanted carpeted flooring compared with £2.5 for vinyl flooring. It should be noted the median valuation for both of the flooring options was £0 per night.

5.5 RECOMMENDATIONS

- Trusts should be encouraged to undertake audits and evaluations of patient safety design issues, to ensure cost effective solutions are chosen and implemented;
- The DH consider updating their HTMs to take more account of patient safety;
- The NPSA and the DH Estates Division promulgate good and cost effective design options;
- The trade-off between costs and patient safety be considered in more detail in PFI schemes with appropriate costs of the impact of adverse events being taken into account.

Section 6: Summary Recommendations

6.1 INTRODUCTION

This section brings together the recommendations from previous sections, including the literature reviews and the WTP study.

6.2 FURTHER RESEARCH RECOMMENDATIONS FOR SINGLE ROOMS

- There is a need for good quality studies relating to the impact of single room design. Although RCTs enable a robust comparison of interventions, they are not likely to be feasible due to the nature of the research areas and for ethical reasons. Therefore, alternative study designs are required, such as controlled before-and-after studies for instance or statistical modelling (selection bias econometric techniques such as propensity score matching or instrumental variables) on observational studies that allow a quasi-experimental to be modelled.
- Although some of the included studies were UK-based, approximately two-thirds were not. There is therefore a need for future research to be carried out in the UK, for external validity reasons, in order to produce results that are generalisable. Another method to enhance external validity is to conduct research that examines different patient groups, such as those on general wards rather than ICUs for instance, which have featured in the literature review.
- Future studies must also ensure that any differences in outcome effects can be attributed to the design of the room, rather than other factors (for example, ventilation systems) that may confound the results. Methods that aim to identify the cause and effect, perhaps using statistical approaches, are advised. Ideally, the comfort levels in the rooms under comparison should be equivalent.
- An area to investigate in future research is the clinical adoption of single rooms; for instance, how nursing staff have adapted to the different ward design and if any training has been undertaken. After scanning the literature on the area of staff culture and the way in which staff adapt to the use of single rooms, some information was identified, although the literature was not plentiful on this subject.
- Work should be carried out regarding infection occurring whilst patients are in hospital, rather than focussing on patients who entered hospital already with an infection. This will allow the effect of room design on infection to be seen.
- Further investigation on the outcomes of interest would be of use due to the reasons outlined above. In order to determine patients' opinions on the current use of single rooms in the UK, further studies could be conducted regarding patient satisfaction, undertaken in a more controlled manner. The next stage of the research for the PSRP will look at patient satisfaction.

6.3 FURTHER RESEARCH RECOMMENDATIONS FOR DESIGN OPTIONS ON SLIPS, TRIPS AND FALLS

- There is a lack of good quality before and after studies in the evidence on designs that relate to the outcome slips, trips and falls. The research team recognises that randomised controlled trials are impractical due to design and ethical issues but there is still an opportunity for well designed studies.
- The systematic review showed that nearly 60 percent of studies were conducted outside of the UK, mainly within the US. This may mean that the outcomes data for the designs are not generalisable to the UK setting. There is an opportunity for further work to be conducted within the UK hospital setting.
- A number of the studies were based in wards with biased patient groups. The differences in patient groups and design of the wards made it difficult to infer the outcomes. For example, the elderly population group are known to be more likely to fall in hospital, and design interventions which aim to reduce slips, trips and falls are more likely to be effective in this group (rather than a younger patient group). Further to this, elderly patients are likely to have a stronger preference for designs which specifically aim to reduce slips, trips and falls. It is therefore important that future research considers general wards so a representative group of patients can be studied in relation to the design options.
- It was difficult to identify a cause and effect from the studies when a new design was implemented with the aim of reducing slips, trips and falls. Many of the studies had confounding factors because of their observational nature. For example, it was not always easy to identify the causal effect of the introduction of new flooring on infection and slips, trips and falls because of inability to control patients.
- The clinical adoption of new designs was infrequently reported within the literature. This concerns how the clinical staff use the designs and whether they would adopt the new designs. This is in particular reference to the adoption of new types of flooring or new patient transfer devices. These all require training in different aspects of the design usage, for example in terms of flooring, cleaning and in terms of patient transfer devices, effective and safe usage.

6.4 FURTHER RESEARCH RECOMMENDATIONS FOR DESIGN OPTIONS ON VENTILATION

- Ultra-clean ventilation (UCV) is generally accepted as the standard ventilation system to use in orthopaedic operating theatres, and is being increasingly used in other types of theatre. However, the evidence that indicates a reduction in infection from the use of UCV was conducted several years ago, where practices will have been different, and not necessarily conducted in the UK. There is therefore a need for well-designed, UK-based studies to be carried out that take account of current design considerations when exploring key outcomes such as infection, length of stay and adverse events.
- Future studies on hospital ventilation must be designed in order to control for confounding factors as much as possible. In several of the ventilation studies in the review it was not possible to isolate the determinant of the effect due to several factors playing a part, such as prophylactic antibiotics, for instance.
- To enhance external validity of studies, research should be conducted in a range of operating theatre types. In this review, studies focussed on settings such as orthopaedics, joint replacement (hip and knee), cardiac and spinal procedures, but there is a need for further data to be collected.
- When considering the type of ventilation for an operating theatre, it is useful to bear in mind that flexibility is extremely important. It is possible to install an UCV terminal which makes it possible to switch between using UCV and non-UCV depending on the situation. Having this facility enables operations to take place on a more flexible basis which will in turn reduce the time patients may wait for an UCV operating theatre to become available, hence increasing efficiency. Therefore, research into the flexible use of UCV in this way would be of value.
- The UCV terminal also allows energy to be saved, since it has the option of a set-back facility. However, the extent of staff awareness and training of this facility, and whether the system is actually set back in reality is worth investigating. In addition, it would be useful to have information on the clinical adoption of ventilation designs in general in order to determine how staff use the different designs.
- Several studies reported findings on various ventilation designs with respect to colony-forming units, bacterial counts, biological monitoring and air contamination, rather than infection rates. Work to quantify the relationship between these measures and infection rates would enable a meaningful interpretation of the data, in terms of patient outcomes.

6.5 FURTHER RESEARCH RECOMMENDATIONS FOR DESIGN OPTIONS ON OPERATING THEATRES

- There is a need for high-quality UK-based studies of different operating theatre designs to be conducted, which have external validity in order to allow generalisability.
- Since ventilation is a potential confounder in several of the included studies, along with several other factors, future studies must aim to control for the effects of such factors. This will enable the effect of operating theatre designs to be ascertained with confidence, rather than being unsure of the cause and effect relationship.
- Operating theatre design studies that compare outcomes other than infection rates are required in order to determine the impact on important outcomes such as length of stay, medication errors, adverse events and patient satisfaction. However, infection is a key indicator of the design effect; hence good quality studies that measure this along with other outcomes are needed.
- Clinical awareness, acceptance and adoption of different operating theatre designs are areas for future investigation.
- There are several studies which report findings on operating theatre design in terms of bacterial counts and colony-forming units. Work to quantify the relationship between these measures and infection rates would enable a meaningful interpretation of the data, in terms of patient outcomes.
- The clinical adoption of different operating theatre designs is a potential area to investigate in future research. This involves the way in which staff use the designs and how they have adapted to using them, for instance whether any training has taken place. Studies looking at clinical adoption will help to inform policy makers as to how effective designs are being in practice.
- Research into the impact of different operating theatre design would be useful. Recommended designs to investigate include barn operating theatres and an operating theatre with an anaesthetic room incorporated within it as opposed to a theatre with a separate anaesthetic room. The sharing of scrub, preparation rooms and anaesthetic facilities is another potential research area.

6.6 RECOMMENDATIONS ARISING FROM CASE STUDIES

- Trusts should be encouraged to undertake audits and evaluations of patient safety design issues, to ensure cost effective solutions are chosen and implemented.
- The DH considers updating their HTMs to take more account of patient safety.
- The NPSA and the DH Estates Division promulgate good and cost effective design options.
- The trade-off between costs and patient safety is considered in more detail in PFI schemes with appropriate costs of the impact of adverse events being taken into account.

APPENDIX A

Studies and Bibliographies for the Design Options

A.1: SINGLE ROOMS

Table A.1.1: Studies included in the literature review on single rooms

Author, date, study setting	Study Description	Data	Quality Assessment
Adamson[4]* 2003 USA	This study established a cost of construction per patient for single rooms and double occupancy rooms.	"First Costs" of single versus double occupancy rooms: Single patient room floor plans: $182,400 Mixed room floor plans: $122,550	2+
Barlow *et al*.[5] 2002 UK	The study investigated whether adult isolation facilities are used optimally in an infectious diseases (ID) unit (comprising 10 isolation rooms and 12 open-bay beds).	During 1 of 3 recently performed point-prevalence surveys of 5 acute medical (including the ID unit) and 3 acute surgical wards, 7.5% (14/182) of patients were found to have 'alert' organisms or infections whilst occupying an open-bay bed.	2+
Ben-Abraham *et al*.[6] 2002 Israel	This 6-month comparative clinical study determined the effect of isolation rooms on the direct spread of nosocomial infections (NIs) due to cross-colonisation in a paediatric intensive care unit (PICU). Data from an open single-space (6-bed) unit (1992) and individual rooms (1995) were assessed.	Open single space (n=78) / Isolation rooms (n=115) LoS (days): 25 ± 6 / 11 ± 2 NI per child (mean, no.): 3.62 ± 0.7 / 1.87 ± 0.2 Type of NI Bacteremia: 9% / 7% Candidemia: 1.2% / 1.7% VAP: 22% / 8% GIT: 12.8% / 13% UTI: 9% / 3.2% Eye: 3% / 1.6%	2+

<table>
<tr>
<td>Bettin et al.[7]

1990

Setting not stated</td>
<td>426 patients admitted to a 37-bed surgical ward were cultured for C.difficile over a period of 20 weeks.</td>
<td>Patient C. difficile introduction to the ward and acquisition by room type:

<table>
<tr><th>Beds/room</th><th>#Patients</th><th>LoS (days)</th><th>C.difficile Intro/100 patients</th><th>C.D. Acq/100 patients</th></tr>
<tr><td>1</td><td>91</td><td>12.2</td><td>5.5</td><td>9.9</td></tr>
<tr><td>2</td><td>120</td><td>9.6</td><td>3.3</td><td>5.8</td></tr>
<tr><td>4</td><td>215</td><td>7.6</td><td>1.9</td><td>1.9</td></tr>
</table>
</td>
<td>2-</td>
</tr>
<tr>
<td>BTY Group[8]*

2003

USA</td>
<td>A preliminary cost study was carried out which determined the construction costs of single rooms versus two-bed rooms.</td>
<td>For replacement of single rooms with two-bed rooms:

Single patient room option: $153,000
Double patient room option: $134,000</td>
<td>2+</td>
</tr>
<tr>
<td>Chaudhury et al.[9]*

2003

USA</td>
<td>This study was a comparative assessment of patient care issues involved interviews being carried out with administrators and staff in 4 US hospitals (73 nursing staff and 4 administrative staff).</td>
<td>Data are %:

<table>
<tr><th></th><th>Helpful</th><th>Somewhat Helpful</th><th>Somewhat Problematic</th><th>Problematic</th></tr>
<tr><td>Layout:</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Single room (n=68)</td><td>46.6</td><td>23.3</td><td>16.4</td><td>4.1</td></tr>
<tr><td>Double room (n=64)</td><td>9.6</td><td>26.0</td><td>43.8</td><td>6.8</td></tr>
</table>

<table>
<tr><th></th><th>Very high</th><th>High</th><th>Moderate</th><th>Low</th><th>Very low</th><th>NA</th></tr>
<tr><td>Probability of medication errors:</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Single room (n=73)</td><td>6.8</td><td>2.7</td><td>13.7</td><td>42.5</td><td>31.5</td><td>2.7</td></tr>
<tr><td>Double room (n=71)</td><td>11.0</td><td>28.8</td><td>39.7</td><td>8.2</td><td>2.7</td><td>6.8</td></tr>
<tr><td>Rate of nosocomial infection:</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Single room (n=69)</td><td>6.8</td><td>4.1</td><td>13.7</td><td>47.9</td><td>19.2</td><td>2.7</td></tr>
<tr><td>Double room (n=66)</td><td>9.6</td><td>35.6</td><td>30.1</td><td>5.5</td><td>1.4</td><td>8.2</td></tr>
<tr><td>Falls incidence:</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Single room (n=67)</td><td>4.1</td><td>5.5</td><td>47.9</td><td>21.9</td><td>2.7</td><td>9.6</td></tr>
<tr><td>Double room (n=65)</td><td>0.0</td><td>12.3</td><td>47.9</td><td>17.8</td><td>1.4</td><td>9.6</td></tr>
</table>
</td>
<td>3++</td>
</tr>
</table>

		Patient's comfort level: Single room (n=73) 68.5 31.5 0.0 0.0 0.0 0.0 Double room (n=71) 0.0 1.4 34.2 38.4 19.2 4.1	
Chaudhury *et al*.[10] 2005 Combination of settings	This systematic review analyses the existing literature relating to the advantages and disadvantages of single- versus multiple-occupancy hospital rooms.	• Bobrow & Thomas (2000): There was a reduction in transfer costs in Bronson Methodist Hospital's new 348 private-room facility compared to the older multi-bed facility. The old hospital spent an extra $500,000 (approximately) per year in patient transfers due to problems with room-mates or infection-control issues. • Rich (2002): Falls reduced by 60% when the cardiac wing of the Methodist Hospital in Indianapolis was redesigned to contain acuity-adaptable rooms. • Reizenstein & Grant (1991), as cited in Carpman & Grant (1993): If cost was not an issue, 45% of patients would choose private rooms, 48% would choose semi-private rooms and 7% would choose multi-bed rooms. • Spork (1990), Austria: The desire for privacy was related to the severity of illness – 2/3 of patients with less severe conditions such as tonsillectomy operations, wanted single rooms, whilst less than 40% wanted a single room after having a stroke (i.e. a more severe condition).	2++
Chaudhury *et al*.[11] 2006 USA	This pilot study investigated nurses' perceptions of the advantages and disadvantages of single-occupancy versus multi-occupancy patient rooms in the medical-surgical units of 4 hospitals.	Nurses' perceptions of (data are %): Very high High Moderate Low Very low NA Probability of medication errors: Single room (n=73) 7 3 14 43 32 3 Double room (n=71) 11 29 40 8 3 7 Rate of nosocomial infection: Single room (n=69) 7 4 14 48 19 3 Double room (n=66) 10 36 30 6 1 8 Falls incidence: Single room (n=67) 4 6 48 22 3 10 Double room (n=65) 0 12 48 18 1 10 Patient's comfort level: Single room (n=73) 69 32 0 0 0 0 Double room (n=71) 0 1 34 38 19 4	3++

Douglas & Douglas[12] 2005 UK	The research explores patients' perceptions of health care built environments by using both qualitative and quantitative methodologies. A questionnaire survey of a representative sample of past patients was conducted.	The quantitative postal survey results relating to room design are in terms of %: Level of Satisfaction / Single room / 2-4 bed bay / Long, open ward / Small bay Completely satisfied: 49.5 / 29.0 / 26.6 / 32.5 Very satisfied: 18.9 / 22.9 / 25.2 / 27.6 Fairly satisfied: 23.2 / 32.3 / 33.5 / 25.8 Neither satisfied nor dissatisfied: 4.2 / 6.1 / 4.6 / 6.1 Fairly dissatisfied: 1.1 / 5.7 / 6.4 / 3.7 Very dissatisfied: 3.2 / 1.8 / 1.8 / 3.1 Completely dissatisfied: - / 1.1 / 0.9 / 0.6 Cannot say: - / - / 0.5 / - Total number of patients: 95 / 276 / 217 / 162	3++
Geldner *et al*.[13] 1999 Germany	A cost analysis of MRSA-infected patients was conducted in an ICU in the anaesthesiology department. The study notes that the costs can only be documented approximately.	Extra costs incurred by MRSA patients (costs have been converted and inflated from German DM): Cost per day of treatment (£) / Cost per month (£) Fixed portion of costs (due to lost days of treatment): 780 / 4,522 Expenditure on cleaning, decontamination etc.: 212 / 1,228 Expenditure on microbiological examinations: 84 / 488 Specific MRSA medication: 244 / 1,413 Total extra costs per month: **1,319*** / **7,651** * The total is 1,319 rather than £1,320 due to rounding. Patients had an average of 5.8 days of treatment for MRSA.	2+
Harris *et al*.[14] 2006 USA	The study looks at the impact of the single family room (SFR) in neonatal ICUs (NICUs) on construction costs, staff perceptions, family experience and neonate outcomes.	The following are average costs per square foot (2005 prices): Single family room $294 Double-occupancy room $331 Open-bay $285	2+

Harrison[15] 2005 UK	This article investigates the potential benefits of single rooms.	HAI reduced by 11% when the Bronson Hospital, Michigan, moved to a new building with single rooms (Ulrich). Building a hospital with single rooms would cost 6% more than a traditional build, but the costs could be recovered after a year (Ulrich).	4+
Herr *et al*.[16] 2003 Germany	The study retrospectively identified the additional costs associated with MRSA carriers on a septic surgical ward of a German university hospital, and potential cost-reduction strategies.	Additional costs of hygienic measures implemented for MRSA carriers included costs for protective measures, disinfection and cleaning measures, isolation, training, microbiological screening, eradication measures and transportation of patients. Total cost (Euros) of additional hygienic measures related to MRSA management — Daily Cost*: 371.95; Cost per Case**: 9,261.00† * Estimated from a total of 498 hospital-days assessed in patients carrying MRSA; ** estimated from 20 cases on the ward during the 1-year study period; † this was calculated by dividing total costs by the number of MRSA carriers, and included costs for bed closures. Due to the retrospective nature of the study, "certain routine measures that were not usually documented in the medical charts of the patients were included in the calculation for each hospital-day."	2+
Huang *et al*.[17] 2006 USA	This was a 20-month retrospective cohort study of patients admitted to 8 ICUs (in single rooms, rather than cohorts) to investigate whether MRSA and Vancomycin-Resistant Enterococci (VRE) rates are affected by prior room occupants.	Among patients whose prior room occupant was: MRSA positive, 3.9% acquired MRSA; MRSA negative, 2.9% acquired MRSA; VRE positive, 4.5% acquired VRE; VRE negative, 2.8% acquired VRE.	2+

Lawson *et al*.[18] 2004 UK	The report presents findings from a study of two NHS hospitals, one general medical and the other mental health, concerning the effects of the architectural environment on the lives of patients and staff. Both hospitals underwent refurbishment, involving a change in ward design.	- Poole general medicine hospital was refurbished from a hospital with six 4-bed bays and six 1-bed bays to sixteen single bedrooms and three 4-bed bays. - Brighton accommodation for the mentally ill changed from 15-bed wards to all single rooms. Many of the results are presented for the old and new hospitals as a whole rather than for each room design. However, the following were reported for Brighton (which had a clear change in ward design): - Appearance: 41% of patients on new wards gave them the highest possible rating in terms of appearance, as opposed to 20% on the old wards. - Design: 65% gave the highest possible rating to new wards, compared to 35% on old wards when asked about the overall design. - Satisfaction for personal bed area: 51% gave their personal bed area the highest rating on new wards, as opposed to 16% on old wards. - Architectural environment: 68% on the newer ward felt the environment helped them feel better, compared to 39% in the old wards. - Treatment times: patients showed a reduction of 14% in treatment times. Poole General Hospital (patients in single rooms and multi-bed (4-bed) rooms: - Bed area/private space: 71% of the single-room accommodation group gave the highest rating in terms of their bed area or private space, compared with 33% in multi-bed spaces. Overall: - 54% preferred multiple-bed space, whilst 43% preferred single rooms. Of patients who stayed in one type of accommodation (i.e. were not transferred): - 76% of patients in multi-bed spaces preferred them, and 93% of patients in single-bed spaces said they preferred them.	2+

<table>
<tr>
<td>Maki et al.[19]

1982

USA</td>
<td>The study prospectively examined the relationship between environmental contamination and endemic nosocomial infection when a hospital moved from an old building to a new building.</td>
<td>Before: In old hospital, rooms had 2 – 8 beds, with the exception of ICUs; archaic ventilation system.
After: In new hospital, patients were in private rooms, apart from ICU; modern ventilation system; improved isolation facilities for infected patients.
[Note: there were also differences relating to heating and isolation rooms]

The incidence and profile of nosocomial infection in patients was not statistically significantly different between periods:
<table><tr><th></th><th>Old hospital</th><th>New hospital (after 2 months)</th><th>New hospital (after 12 months)</th></tr><tr><td>Nosocomial infection rate (%)</td><td>6.9</td><td>6.9</td><td>7.5</td></tr></table>
[A breakdown of the infection types is provided in the study]</td>
<td>2+</td>
</tr>
<tr>
<td>McManus et al.[20]

1994

USA</td>
<td>The retrospective cohort study compared the incidence of gram-negative bacteremia and mortality in patients with large burns treated in either single-bed isolation rooms or an open ward in an ICU.</td>
<td>The study involved 2,519 burns patients who were divided into two 10-year cohorts. The first cohort patients were treated under open ward conditions, the second in a single-bed isolation environment.

Incidence of infection (%):
<table><tr><th></th><th>Open-ward (n=1,605)</th><th>Single rooms (n=914)</th><th>P</th></tr><tr><td>Gram-negative</td><td>31.2</td><td>12.0</td><td>0.001</td></tr><tr><td>Gram-positive</td><td>31.8</td><td>20.0</td><td>0.001</td></tr><tr><td>Yeast</td><td>6.7</td><td>5.4</td><td>NS</td></tr><tr><td>Pseudomonas aeruginosa†</td><td>17.8</td><td>3.4</td><td>0.0001*</td></tr><tr><td>Klebsiella pneumoniae†</td><td>12.0</td><td>4.0</td><td>0.0001*</td></tr><tr><td>Enterobacter cloacae†</td><td>6.2</td><td>2.0</td><td>0.0001*</td></tr><tr><td>Escherichia coli†</td><td>4.7</td><td>2.8</td><td>0.0206*</td></tr><tr><td>Providencia stuartii†</td><td>4.1</td><td>0.1</td><td>0.0001*</td></tr><tr><td>Candidemia†</td><td>6.7</td><td>5.4</td><td></td></tr></table>
NS not significant; * comparisons are between cohort years; † patients had burns of 20% or more of body surface.</td>
<td>2+</td>
</tr>
</table>

<table>
<tr>
<td>Mulin et al.[21]

1997

France</td>
<td>A before-and-after study compared ventilator-associated acinetobacter baumanii pneumonia in mechanically-ventilated patients treated in a surgical ICU in a French university hospital, according to the design of the physical environment. The surgical ICU was converted from enclosed isolation rooms and open rooms to single rooms only.</td>
<td>Period A: 135 patients were treated in the unit, which comprised seven enclosed isolation rooms and 2 open rooms (each with 4 beds)

Period B: 179 patients were treated in a renovated unit with 15 enclosed isolation rooms, each with individual handwashing sink.

<table>
<tr><th></th><th>Period A</th><th>Period B</th></tr>
<tr><td>Proportion of patients admitted that became colonized or infected with A baumanii:</td><td>21.5%</td><td>1.1%</td></tr>
<tr><td>The rate of SICU-acquired bronchopulmonary (BP) colonisation with A baumanii (per 1,000 days of mechanical ventilation during period):</td><td>9.07</td><td>0.46</td></tr>
<tr><td>Rate of colonisation</td><td>28.1%</td><td>5.0%</td></tr>
</table>
During the two 6-month periods before period A, the rate of clinical colonisation, detected by clinical cultures alone, were 8.8% and 12.2%. The rates for the two 6-month periods after period B were 3.8% and 3.1%.</td>
<td>2+</td>
</tr>
<tr>
<td>NHS Estates[22]

2005

UK</td>
<td>This 3-year study presents the findings of a programme of research into the advantages of establishing single beds within acute hospital care facilities. It also investigates the amount of space around a hospital bed.</td>
<td>Costs per bed for various ward layouts in a 32-bed unit with 100% single rooms compared to costs per bed based on the schedule of accommodation (HBN 4 V.1/04/03). (Figures are based on the MIPS index of 395):

<table>
<tr><th>Ward type 32-Bed unit 100% Single rooms</th><th>Total m^2</th><th>Cost per bed (£)</th></tr>
<tr><td>F</td><td>1283.00</td><td>67,517</td></tr>
<tr><td>G</td><td>1144.00</td><td>60,203</td></tr>
<tr><td>H</td><td>1231.00</td><td>64,781</td></tr>
<tr><td>I</td><td>1230.00</td><td>64,728</td></tr>
<tr><td>J</td><td>1199.00</td><td>63,097</td></tr>
<tr><td>K</td><td>1148.00</td><td>60,413</td></tr>
<tr><td>HBN 4 V.1/04/03 100% SRs</td><td>1260.50</td><td>66,333</td></tr>
<tr><td>HBN 4 V.1/04/03 100% SRs*</td><td>1213.00</td><td>63,834</td></tr>
<tr><td>HBN 4 V.1/04/03 50% SRs</td><td>1183.50</td><td>58,324</td></tr>
</table>
* modified.</td>
<td>2+</td>
</tr>
</table>

		Adverse clinical incidents decrease with single-bed rooms. In multi-occupancy rooms in the USA, incompatibility of patients causes many patient transfers. - At the Mayo Clinic (USA), research indicated there to be a 70% chance of medication errors when a patient was transferred. Medication errors fall if transfers decline (Ulrich, quoted in NHS Estates, 2003). - When Clarian Hospital (USA) moved from two-bed rooms in Coronary Intensive Care to single acuity-adjustable family-centred rooms, transfers declined 90% and medication errors dropped 67%. The 100% single rooms provision at Kidderminster Treatment Centre has generated, in general, "positive feedback from patients, indicating 92% satisfaction rates with size of rooms and en-suite shower facilities." (Project Manager)	
Parker[23] 2005 UK	The article reports on the Transforming the Environment conference, held by NHS Estates.	L Jones (NHS Estates clinical director) presented market research, undertaken for NHS Estates, of 1,000 members of the public who had not necessarily had experience of health care facilities. - 52% wanted to stay in a single room; - 37% preferred a shared space. Ulrich said that "researchers in the US have been collating data since 1980 on 'millions' of patients in the US, and these have to date shown that 93% prefer single rooms."	4+
Pease & Finlay[24] 2002 Wales	Questionnaires relating to patient preferences for those treated in the oncology ward were completed - 49 patients participated.	20% preferred a single cubicle; 68% preferred an open area; 12% stated no preference.	4+
Plowman *et al*.[25] 1999	The cost-of-illness study investigates the burden of hospital-acquired infections in terms of the costs to the	The additional mean cost incurred due to a hospital-acquired infection during the in-patient phase = £3,154. The additional mean cost of consumables incurred due to a hospital-acquired infection during the in-patient phase = £315.	2++

UK	public sector, patients, their families and society.	The additional mean cost of nursing care = £1,336. Costs are also split according to admission type, specialty, site of infection etc.	
Preston *et al.*[26] 1981 USA	This sequential intervention study looks at the effects of converting a medical-surgical ICU from a 6-bed open unit design to 14 isolation rooms[a] on colonisation and infection, staff handwashing behaviour and numbers of persons in the vicinity of individual patients.	Effect of ICU Design on Nosocomial ICU Infections during the study period (Rate per 100 Discharges): Open Unit* / Isolation rooms** Infections 11.5 / 11.8 Site: Respiratory 6.1 / 3.7 Urine 3.9 / 3.4 Wound 2.0 / 3.4 Blood 1.5 / 1.2 Other 1.5 / 1.2 Total 15.0 / 13.4 Organism: Esch. Coli 3.2 / 3.0 Staph. Aureus 1.5 / 1.7 Pseudomonas 2.0 / 3.6 Acinetobacter 1.5 / 1.2 Klebsiella 0.5 / 2.1 Serriatia 0.7 / 0.7 Nonstudy 0.3 / 6.3 * 410 admissions; ** 1,022 admissions. [a] The 14 isolation rooms consisted of single rooms apart from 2 which contained 2 beds in each. Note: - 55% and 54% of nosocomial infections were caused by study organisms colonising the patient at the time of admission to the ICU for the open unit and isolation rooms, respectively. - Handwashing facilities were altered by the design of the rooms.	2-

Rosenblum[27] 2005 USA	This presentation gives details of the before-and-after study carried out on single family room care in a NICU.	The old NICU had 12 beds in an open room. The new NICU had 22 private rooms. Developmental care was enhanced (Newborn Individualized Developmental Care and Assessment Program (NIDCAP)). Open NIDCAP Private Hospital-acquired infections (% of newborns) 17.7 10.5 5.9 (P=0.008) Length of stay (days) 38.3 36.0 36.2	NA (Since the study was in presentation format).
Thompson *et al*.[28] 2002 USA	The effectiveness of a burn isolation unit was evaluated retrospectively by comparing infection rates when the burn unit was in use, before and after a renovation, to the rate during the renovation when patients were treated in private rooms or in the ICU.	Group A (n = 37): patients treated in burn unit (isolation rooms for each patient) during the 5 months before renovation. Group B (n = 17): patients treated in private rooms or in the trauma ICU during renovation period (lasted approximately one month). Group C (n = 21): patients treated in burn unit during 2 months after renovations were completed. Burn care management practices and infection control practices remained the same across groups. The use of single patient rooms was continued. The number of patients with burn wound infections was significantly higher during the renovation period when the burn unit was not in use. Length of stay was similar across groups: Group A (Old unit) Group B (No unit) Group C (New unit) Infection incidence (%) 10.8 47.1 23.8 Mean length of stay (days) 10.6 9.7 10.3	2+
Vietri *et al*.[29] 2004 USA	This study compared the prevalence of MRSA before and after a move from an old hospital facility with open bay wards to a new facility, which was made up mostly of single or double rooms with optimised hand-washing facilities.	4 of the MRSA-positive samples in the new hospital occurred in single rooms, at a rate of 4.9% (4/81). All other infection data was reported for the new and old hospitals as a whole, rather than separating out the infection rates according to the room design.	2++

Wilcox *et al*.[30] 1996 UK	This study related to the financial burden associated with hospital-acquired Clostridium difficile. 50 consecutive cases of C. difficile (the development of diarrhoea due to C. difficile infection at least 48 hours after admission) and 92 control patients (in the same geriatric wards) were prospectively followed.	Cases stayed longer in hospital (mean of 21.3 days longer) (P<0.001), 14.2 days of which involved nursing in a side room: Cases Controls Total Length of Stay (mean, days) 46.5 25.2 Length of Stay in a side room (mean, days) 14.2 0.2 Approximate additional cost of the average patient with C. difficile compared with a control was £4,107.	2++
Williams *et al*.[31] 1995 USA	The retrospective study looked at the impact of discontinuing isolation in a cardiovascular (CV) ICU after heart transplantation (i.e. moving patients from the CV ICU). Group 1: 33 heart transplant patients in modified isolation in private rooms. Group 2: 38 heart transplant patients with no isolation, placed in semi-private rooms.), some in private rooms (since some of this group were placed in modified isolation if certain specifications were not met (white blood cell count etc.)).	There was no statistical difference in the incidence of infection: 2 infections in group 1 (private rooms); 4 infections in group 2 (semi-private rooms). Length of Stay was statistically different: Private rooms: 9.5 days; Semi-private rooms: 6.1 days. Mean nursing care costs: Private rooms: $8,340; Semi-private rooms: $4,265.	2+

* Note: Adamson, BTY Group and Chaudhury (2003) were part of the study commissioned by Facility Guidelines Institute to the Coalition for Health Environments Research: “The use of single patient rooms versus multiple occupancy rooms in acute care environments”.

A.1.2: Reference List for Single Rooms

1. Whitehead SJ, Bending MW, Trueman P, Saxby RC, Duffy S, York Health Economics Consortium. *Cost-Effectiveness of Hospital Design: Options to Improve Patient Safety and Wellbeing. Systematic Literature Review of Ventilation in Relation to Infection.* 2008.

2. Whitehead SJ, Bending MW, Trueman P, Saxby RC, Duffy S, York Health Economics Consortium. *Cost-Effectiveness of Hospital Design: Options to Imrove Patient Safety and Wellbeing. Systematic Literature Review of Operating Theatres in Relation to Infection.* 2008.

3. Bending MW, Whitehead SJ, Trueman P, Saxby RC, Duffy S, York Health Economics Consortium. *Cost-Effectiveness of Hospital Design: Options to Imrove Patient Safety and Wellbeing. Systematic Literature Review of Slips, Trips and Falls in Relation to Infection.* 2008.

4. Adamson DL. Comparative first cost assessment of single and multiple occupancy patient rooms. Submitted to the Coalition for Health Environments Research and developed by Davis Langdon Adamson, Construction Cost Planning and Management, November 20, 2003 in *The use of single patient rooms vs. multiple occupancy rooms in acute care environments*. Edition Simon Fraser University, Vancouver, BC, Canada, 2003.

5. Barlow G, Sachdev N, Nathwani D. The use of adult isolation facilities in a UK infectious diseases unit. *Journal of Hospital Infection*. 2002; 50 (2): 127-32.

6. Ben-Abraham R, Keller N, Szold O, Vardi A, Weinberg M, Barzilay Z, Paret G. Do isolation rooms reduce the rate of nosocomial infections in the pediatric intensive care unit? *Journal of Critical Care*. 2002; 17 (3): 176-80.

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A.1.3: Excluded Studies Single Rooms

Study	Exclusion Reason
American Institute of Architects (2006)	This study is a guideline and does not have any data that relates the outcomes to design.
Anderson *et al.* (2000)	This focuses on infection in long-term care facilities, but does not give infection rates according to the design of the room, only overall rates.
Anderson *et al*. (2002)	This looks at an outbreak of MRSA rather than MRSA arising from design and there is no reference to single rooms in the ICU.
Anonymous (2005)	The brief description of a review relating to single rooms and isolation wards is provided, but no quantifiable evidence.
Ayliffe *et al.* (1979)	This study focuses on isolation procedures, rather than on design.
Ayliffe *et al. (*1992)	These are only guidelines; no quantifiable evidence is specified.
Baker (1996)	The design guide does not report any quantifiable evidence relating to the pre-specified outcomes.
Barlow *et al.* (2006)	This does not report outcomes in relation to design.
Beauchemin & Hayes (1998)	The effect of sunshine on patients in a 10-bed cardiac ICU is investigated; but the required designs are not featured.
Beaujean *et al*. (2001)	This looks at isolation of patients with communicable diseases to begin with; isolation does not always involve a single room.
Berild *et al*. (2003)	Infection rates are not reported in relation to the design.
Bouchard *et al*. (1999)	This analysis looks at patients infected with multi-resistant bacteria when entering hospital; hence infection was not acquired due to design.
Brady (2005)	This looks at infections in NICUs, but not in relation to design.
Bravo & Munarriz (2007)	This protocol outlines how isolation strategies affect hepatitis C infection in haemodialysis units, but there is no specific reference to the required design features.
Brown & Taquino (2001)	This is in relation to single rooms but there is no specific data contained within the study.
Caetano (1983)	There is no quantifiable data that relates to any of the required designs.
Cepeda *et al*. (2005)	The study investigates the impact of isolation on the incidence of MRSA colonisation in ICUs, but isolation involved single rooms and cohorting. Hence, the effects of single rooms on MRSA cannot be determined.
Chant *et al*. (1993)	There is no quantifiable evidence that relates to the design of a hospital in this study.
Cheng *et al.* (1999)	This looks at the physical design space of haemodialysis units but does not report any of the required outcomes in relation to design.
Cohen (1984)	This is a discussion of economic methodology. There are no costs included within the study.
Conly & Johnston (2006)	This article presents issues concerning hospital-acquired infections, but the reported outcomes on reductions in infection due to a move to a different ward design does not specify what the design was to begin with.

Cooper *et al.* (2004)	Information is provided relating to MRSA rates and isolation policies, but does not report rates related to the room design specifically. A few studies refer to single rooms, but MRSA rates are not quantified for the phases with and without single rooms.
Corrado *et al*. (1990)	This looks at the presence of C. difficile on a ward, but this is made up of 2 sections, one for up to 15 patients and the other for up to 12 patients; hence the ward designs are of no use.
Cox *et al*. (1995)	An MRSA outbreak is investigated, but outcomes are not reported in relation to room design specifically.
Cunney *et al.* (2006)	The survey of infection control resources in acute hospitals does not provide any of the required outcomes in relation to design. It reports on hand washing in hospitals.
Dettenkofer *et al*. (2004)	This does not provide any quantifiable evidence.
Djordjevic *et al.* (2000)	This study is not in relation to a single-room design.
Douglas *et al.* (2002)	The research provides indicators for hospital developments, but no quantifiable evidence is reported.
Duckworth *et al*. (1988)	An outbreak of MRSA is described, and the measures that were taken to control it. However, it is not specified that the isolation wards comprised only single rooms; cohorting took place on one of the wards.
Eveillard *et al*. (2001)	This investigates isolation, which did not necessarily involve single rooms.
Fazal *et al*. (1996)	This study looks at the impact of an isolation policy on MRSA rates, but this policy involved features other than simply the room design; hence it was not possible to evaluate the effects of design.
Ford-Jones *et al.* (1990)	This looks at nosocomial diarrhoea in a paediatric hospital, but the wards comprised rooms of different designs. Hence the effect of single rooms could not be determined.
Fryklund *et al*. (1997)	The single room patients included both patients who were nursed in separate rooms and those who were together with patients without a catheter.
Gammon (1998)	This looks at the psychological effects of isolating patients because of an infection, but does not refer to design.
Garner (1996)	Guidelines for isolation precautions in hospitals are provided, but no quantifiable evidence.
Gastmeier *et al*. (2004)	This did not focus on single rooms only, but included cohorted patients too.
Geditz *et al.* (2005)	This focuses on isolation practices in long-term care facilities for multidrug-resistant organisms. However, infection rates are not related to design; instead the isolation policy for patients infected or colonised with MRSA or VRE is looked at.
Gould (2005a)	There is no quantifiable evidence related to the required design issues reported.
Hannan *et al*. (2000)	Looks at hospital infection control (including ventilation) but does not report any quantifiable evidence.
Hardy *et al.* (2006)	This looks at patient acquisition of MRSA but investigates a 9-bed open unit ICU; therefore the data is of no use.
Harmankaya *et al.* (2002)	This investigates the impact of patient isolation on Hepatitis C Virus transmission; but infection rates are given for the patients as a whole rather for those that are in isolation rooms.

Harstein *et al*. (1997)	In this study, MRSA patients were admitted to single rooms, but infection related to being in the single rooms was not reported since patients were already colonised before being placed in a single room. There is no comparison with another room design.
Humphreys & Moriarty (2006)	This looks at design issues in ICUs but does not report any quantifiable outcomes.
Hurst (2004)	None of the required quantifiable outcomes are reported.
Hurst (2006)	None of the required quantifiable outcomes are reported.
Jepsen (1980)	This letter features the role of an isolation unit in controlling hospital infection, but does not refer to the required design issues.
Johnston *et al.* (2005)	This looks at the effect of pre-admission screening and patient segregation on MRSA. Although the MRSA rates on the control wards may have been of use, the ward design is not specified; hence the impact of ward design cannot be determined.
Karkar *et al*. (2006)	The impact of isolation on viral transmission in HD units is investigated; but the number of patients that were treated in separate rooms is not stated.
Kibbler *et al.* (1998)	The effect of increasing the number of beds from 4 to 5 in acute medical wards is analysed, but the wards were made up of a combination of single rooms and multiple-bed rooms. Therefore the impact of room design cannot be determined.
Kim *et al.* (1987)	This is about the prevalence of isolation usage in a paediatric hospital and does not relate to how the design affects outcomes.
Knowles (1993)	This study looked into patients' views of single rooms, but does not provide any quantifiable evidence.
Koay & Fock (1998)	The design and planning of a hospital is discussed, but no outcomes are reported.
Kunaratanapruk & Silpapojakul (1998)	Unnecessary hospital infection control practices are reported, but there is no reference to the required design features.
Kuschel & Roy (2005)	This survey provides information on neonatal unit design, but none of the required outcomes are reported in relation to design.
Langley & Hanakowski (2000)	Chickenpox transmission rates are given but not in relation to design.
Langley *et al.* (1994)	This looks at isolation bed use in relation to infection, but does not report any outcomes specifically related to single rooms.
Langley *et al*. (1997)	Isolation of patients was not strictly by use of single rooms (also cohorting); so evidence relating to room design was not provided.
Lawton (1997)	This is concerned with hospice rooms, but does not refer to the required designs or outcomes.
Lemmen *et al.* (2004)	Only patients with infection were included in study – the infection acquired in relation to design was not shown.
Lessing *et al.* (2005)	This article questions the study by Cepeda *et al*. but does not provide any quantifiable evidence in relation to design.
Lewis *et al.* (1999)	This is mainly guidance and does not report the pre-specified outcomes.
Li *et al.* (1996)	Only a proportion of the patients were in single rooms; hence the outcomes are not directly related to design.
Macartney *et al.* (2007)	Outcomes are not reported in relation to design.
Marshall *et al.* (1998)	There is no reference to design.

Mathur (2004)	This argues the need for a NICU with single rooms, but no quantifiable evidence is reported.
McConkey *et al.* (1999)	This looks at the impact of an infection control program on the incidence of surgical-site infections; none of the required quantifiable outcomes are reported.
McFarland (1995)	Only overall infection rates are given, for private and semi-private rooms combined.
McGowan (1981)	There is no quantifiable evidence that relates to the design of a hospital.
McKeever *et al*. (2002)	The mothering of severely ill patients in isolation is investigated, but none of the required outcomes are presented.
McKendrick & Emond (1976)	This looks at cross-infection in isolation wards that vary in design, but the wards are made up of a mixture of room designs; hence the infection rates cannot be specifically related to single rooms etc.
Miller *et al*. (1995)	No quantifiable evidence in relation to design is specified.
Mintz (1994)	This does not have any data relating to the design feature upon any outcome.
Mohan *et al.* (2007)	This is the protocol for a Cochrane Review on patient isolation measures, so as yet has no quantifiable evidence.
Murray-Leisure *et al*. (1990)	The study looks at the spread of MRSA and the efforts to control this; isolation measures are featured but isolation is not clearly defined.
Nardell (1996)	None of the required quantifiable outcomes are reported.
National Audit Office (2000)	The management and surveillance of HAI and infection control is looked into, but there is no quantifiable evidence relating to design.
Noble (2004)	This investigates the architecture of infection control, but does not provide any quantifiable evidence.
Nystrom (1983)	None of the required quantifiable outcomes are reported.
Oelrich (2003)	This looks at single-bed neonatal ICUs but does not quantify the outcomes.
Onesko *et al*. (1987)	This study compares infection across different hand-washing techniques, and although isolation is referred to, there is no reference to the room design.
Papia *et al*. (1999)	The study concerns screening and infection control measures; patients with MRSA were placed in single rooms, but outcomes are not related to the design of the room (since the patients had MRSA and were then placed in a single room).
Peel *et al.* (1982)	This study does not specifically relate to design.
Pfaller *et al*. (1991)	The impact of infection control and surveillance procedures on the transmission of MRSA is investigated. However, patients were not necessarily in single rooms only, as cohorting was mentioned.
Pick *et al*. (1994)	The MRSA rates are not reported in relation to design.
Rahman (1985)	The number of infection outbreaks in an infectious diseases unit is reported, but the unit did not solely comprise single rooms. Hence the effect of single rooms on infection cannot be determined.
Rao (2004)	Guidance on infection control is provided, but no quantifiable evidence.
Rashid (2006)	This looks into the physical design characteristics of adult ICUs, but does not provide any quantifiable evidence.

Richet *et al.* (1996)	The MRSA rates featured in the paper are not related to design.
Richet *et al.* (2003)	There is no reference to design.
Robert *et al.* (2006)	There is no reference to design.
Rohr *et al*. (2003)	A decolonisation regime of patients with MRSA is investigated. Once MRSA carriage was confirmed, patients were placed in single rooms; however, the MRSA reported was not acquired during hospital stay in single room.
Selkon *et al*. (1980)	The effect of using isolation facilities on the rate of MRSA is investigated. However, the isolation unit comprised 8 single cubicles and 2 double rooms, but the MRSA rates are not reported according to this.
Sexton *et al.* (1993)	This does not directly relate to the design of a hospital. Instead the study considers predictors of hospital infection.
Shanson *et al.* (1985)	This investigates an outbreak of MRSA, but does not report outcomes in relation to design.
Shirani *et al.* (1986)	This study compares infection rates between patients in an open unit ICU and those in a renovated unit containing single rooms. However, the renovated unit does not solely consist of single rooms.
Smith *et al*. (1974)	The study looks at postoperative wound infection on a "Nightingale" type ward and a "race track" ward, but does not focus on the required design.
Smylie *et al.* (1971)	The study looks at postoperative wound infection on wards of different designs, where one comprises single rooms and multi-bed rooms. The only evidence relating solely to single rooms is given in terms of bacterial particle counts.
Stone *et al.* (1998)	Patients with infection were isolated in side rooms; therefore infection was not related to design.
Stone (1997)	No outcomes directly related to single rooms are reported.
Stroud *et al.* (1995)	This looks at patients being admitted to single rooms if they have TB; thus the reported infection rates are not related to the design of the room.
Struelens *et al*. (1994)	Questionnaires were completed relating to infection control measures in Belgian hospitals, but none of the required design features are referred to.
Struelens *et al.* (1996)	This focuses on infection control measures, including the isolation of patients in single rooms, but no outcomes linked to design were reported.
Talon (1999)	This investigates the hospital environment in relation to multi-resistant bacteria, but does not refer to the required designs.
Taskapan *et al*. (2001)	Infection rates are featured for patients in HD units, but are not split according to whether patients were in separate rooms or in the same room.
Taylor (1994)	The article looks at the risk of TB and the evidence required for control programs, but does not feature design in relation to TB.
Theaker *et al*. (2001)	MRSA rates in an ICU are analysed; there is no reference to room design.
Thompson (2004)	MRSA in a general ICU (made up of different room designs) is reported, but not according to the room design.
Tokars *et al.* (2001)	This looks at TB rates, but these are not related to design.
Ulrich & Zimring (2004)	The report looks at several hospital design issues, but the pre-specified outcomes are not quantified in relation to single rooms.

Valls *et al*. (1994)	The infection rates are not given according to the room design; instead an infection control program was assessed.
Vandenbroucke-Grauis (1996)	There is no information on the baseline levels of infection and further to this the study does not relate to design.
Verity *et al.* (2001)	The infection rates are not directly related to the room design.
Vonberg & Gastmeier (2005)	This is guidance regarding isolation, with no reference to design.
Walsh *et al.* (1989)	This trial looks at the impact of protective isolation on infection incidence, where this involved the wearing of hats, masks, sterile gowns and hand-washing procedures.
Ward *et al*. (1981)	The possible causes of an MRSA outbreak are investigated; infection control measures for MRSA patients are described (including cohorting of MRSA patients and isolation) but infection rates associated with the room design cannot be determined.
Warren & Kollef (2005)	This looks into the prevention of hospital infection, but does not present any quantifiable evidence relating to the required designs.
White (2003)	The case for and against NICUs having individual rooms is evaluated, but no quantifiable evidence.
Wicker (1991)	Infection control policies are provided but there is no reference to design.
Wigglesworth (2003)	Protective isolation guidance is given, but no quantifiable evidence.
Wigglesworth & Wilcox (2006)	The failure to isolate is looked at, but no quantifiable evidence is provided.
Wilcox *et al.* (1997)	There is no reference to design.
Williams (1996)	This is with respect to precautions to prevent infection rather than by design.
Yang (2003)	The dialysis patients in this study were not in single rooms.
Yoshida *et al. (*1995)	This study investigates the impact of the order of ward rounds on nosocomial infections, but does not feature any outcomes specifically related to design.

A.2: HOSPITAL DESIGN FEATURES IMPACTING ON SLIPS TRIPS AND FALLS

A.2.1 Literature Relating to Hospital Design Features Impacting on Slips Trips and Falls

Author, date, study setting	Study Description	Data	Quality Grade
Agodoa[11] *et al.* 2002 US	This study was a randomised comparative study evaluating two different methods of recovery positioning for post surgical diagnostic laparoscopy patients. 130 patients were recruited into the trial.	The average ages of bed and chair patients were 31 and 32, respectively. The chair users were lighter, with a BMI of 26 and the bed participants had a BMI of 28. The study considered home readiness scores. Those recovering in recliner chairs had significantly higher scores at each point in time. The recliner chair and traditional hospital bed at times 1, 2 and 3 were 11.5 and 11.08, 12.81 and 12.06 and 13.53 and 12.53, respectively. The mean difference between the two groups was 50.51 minutes. The cost differences between the groups based on a crude estimate between the two was US$523.00 for traditional hospital trolleys and US$354.81 for recliner chair patients. With 2,000 diagnostic laparoscopy procedures carried out in this hospital alone, there is potential for US$337,600 saving.	1 -
Baptiste[10] *et al.* 2006 US	This study aimed to assess the performance of lateral transfer devices compared with traditional draw sheet method in acute care settings through subjective feedback of caregivers actually using the devices. The assistive devices were randomly assigned to different centres over the period of the study.	179 transfers were performed using eight different devices. The devices were placed in a rank order based on their overall performance. The study results showed AIRPAL, the HoverMatt, and the Resident Transfer Assist to be the top three devices. The draw sheet and Maxi Trans had the lowest rating. Overall performance ratings were: ▪ Airpal: 46.00 ▪ HoverMatt: 45.00 ▪ The Slipp: 36.38 ▪ Flat Sheet Set: 32.73 ▪ Draw sheet: 27.67 ▪ Resident Transfer Assit: 39.00 ▪ Maxi Slide: 37.64 ▪ Maxi Trans: 21.27 Performance consists of a 10 point scale for comfort, ease of use, injury reduction, time efficiency and safety.	2 +

Capezuti[5] *et al.* 2007 US	This study had two objectives. The first was to explore the effect of an advanced practice nurse (APN) intervention on restrictive side rail usage in four nursing homes with a sample of 251 residents. The second objective was to explore the association between restrictive side rail reduction and bed-related falls.	One of four nursing homes had significantly reduced restrictive side rail use. For the group that reduced restrictive side rails, there was a significantly reduced fall rate (-0.053), whereas the group that continued restrictive side rails did not demonstrate a significantly reduced fall rate. The average age of patients was 83 for the discontinued restrictive use and 84 for continued restrictive side rail use. The mean estimates were: ▪ Discontinued restrictive side rails (n=130): -0.053 (P value: 0.003); ▪ Continued restrictive side rails (n=121): -0.013 (P value: 0.47); ▪ The APN intervention reduced bed related injuries from 9 (3.68%) to 5 (1.99%).	2 +
Donald[2] *et al.* 2000 UK	The objective of this study was to compare two flooring types; carpet and vinyl in the bed areas and two modes of physiotherapy; conventional therapy and additional leg strengthening exercises to avoid falls.	Carpet: Flotex versus Latex Vinyl. A fall was defined as "an accidental collapse to the ground which led to the completion of an accident report". During the period of the study (nine-months) 15% of patients fell 11 times. ▪ Relative risk of Carpet (Flotex) versus Vinyl = 8.3 (95CI: 0.95-73); ▪ 7 out of 28 fell in Carpet (25%) in comparison with 1/26 in Vinyl room's (approx 4%); ▪ LOS: 22.7 days for carpet versus 36.1 days for vinyl. The evidence is contrary to the belief that carpeted bedrooms reduce the risk of falling. In this study far more falls occurred in carpeted rooms.	1 +
Harris[3] 2000 US	The purpose of the study was to investigate the impact of finish materials on the human response and qualitative experience of an interior environment. 36 patients participated in the study.	The primary outcomes of the study were to measure the physical characteristics of the flooring finish to develop an Environmental Quality Index (EQI) and to examine the index in relation to patient and staff perceptions, preferences, comfort and biological response to the environment. The study identified two environmental factors relating to falls, the season and the patient having three or more patient transfers. The carpet used was an 18" by 18" modular monolithic loop tile with a moisture resistant backing, antimicrobial, soil and stain protecting finish. The carpet cost $3.28 per sq.ft. The typical patient room was 275 sq.ft.	2 +

		Sixty-nine percent of patient's surveyed preferred carpet as their flooring choice for their patient rooms. The reasons for selecting carpet as their preference were comfort, slip resistance and lower noise levels. Those that cited vinyl as their choice of flooring provided cleanliness as the reason for this choice. Staff rated the patient rooms with vinyl to be better than carpet for colour, cleanliness and odour. (more than 80% of staff). The carpeted rooms were perceived to be quieter, both with regards to noise within the room and the noise from the corridor. Staff perceptions appeared to be contrary to patient's perceptions and preferences for the flooring in hospital rooms. The type of flooring did not affect the amount of time that staff spent with patients in their rooms.	
Hignett[7] *et al.* 2005 UK	The study investigates the concerns that have been raised about the safety of split-side bed rails for patients in the UK. The objective of the study was to examine whether split-side rails were more likely to be associated with entrapment and injury of patients than other bed rail types.	Side bed rail incidents accounted for 5% of the reports. A total of 3,466 reports were retrieved. There have been 20 reported deaths from bed rail entrapment in the UK since 1997. Half rails are associated with the most serious outcomes. Patients were often found: ▪ Heads between the rails; ▪ Found on the floor following the collapse; ▪ Only 5% of patients were found between the split sides. In relation to the rails a significant relationship was found $p<0.001$ that: ▪ Half rails (n=105) were more likely to be associated with death; ▪ Full rails (n=37) were more likely to be associated with injuries; and ▪ Spilt rails (n=199) had more near misses reported. The area of the body that was damaged was: ▪ Head/face/neck entrapments/injuries; ▪ Pelvis/chest entrapment/injuries; ▪ Upper/Lower limb entrapment/injuries.	2 +
Hignett[7][1] *et al.* 2006 UK	This study was a narrative review of the slips, trips and falls literature.	Slips, trips and falls present the greatest risk to in-patients in terms of exposure but only present a low severity risk in terms of mortality. Those patients that undergo an incident can lead to prolonged hospital stays. The review reports a multi-centre trial that found that in 28,998 incidents, 41% were due to slips, trips and falls and that 66.5% of the incidents occurred in a hospital ward.	2 +

		In terms of lighting, in 43% of falls, the patients lacked eye glasses and in 18% poor lighting was present. The study found that airborne levels of bacteria were lower in carpeted rooms than vinyl rooms. The authors explain this by the fact that the carpet can act as a sink holding the bacteria and therefore keeping it out of the air. The rooms with vinyl did not have such a mechanism. However the carpeted rooms can become heavily contaminated which may harbour micro organisms.	
Miller[8] *et al.* 2006 Canada	Researchers and health and safety practitioners have advocated replacing manual patient handling techniques with ceiling lifts in long-term care. This study was a pre-post intervention assessing the effectiveness of portable ceiling lifts in a new multi-level care facility on the risk of patient handling injuries where the ratio of ceiling lifts to resident beds is one to six.	The results showed that staff had perceived that they were at significantly ($P<0.05$) less risk of injury when using ceiling lifts compared to manual methods. The study shows that incorporating ceiling lifts into design of a new multi-level care facility reduced patient handling injuries and decreased the perceived risk of injury among care staff. The staff ages were similar and the majority of staff were female. There were more injuries associated with manual lifting: ▪ Neck manual versus lift injuries were 5.65 and 2.82*, respectively; ▪ Shoulder manual versus lift injuries were 6.65 and 3.35*, respectively; ▪ Low back manual versus lift injuries were 7.18 and 3.19*, respectively; ▪ Arm manual versus lift injuries were 6.88 and 3.63*, respectively. (* denotes statistically significant at the 1% level.) Beds were quoted to cost around US$3,500 per bed in addition to the facility needing to purchase the actual ceiling lift and tracks motors. There are potential construction problems in older buildings.	2 ++
Ronald[9] *et al.* 2002 US	This study evaluates the effectiveness of installing overhead ceiling lifts in the extended care unit of a British Columbia hospital. This involved installing 65v ceiling lifts.	The rate of MSI caused by lifting/transferring patients was significantly reduced (58% reduction $p=0.011$) after installation, but rates of all MSI and MSI caused by repositioning did not statistically decline. ▪ The age category of workers was similar pre and post intervention; ▪ 237 MSI's were documented in the 5 year period. The results of the evaluation showed that the installation of ceiling lifts in combination with a training programme is effective in reducing the number of MSI's (musculoskeletal injuries) of nurses and LTCA's (long-term care aides) during lifting or transferring patients in an ECU.	2 +

Simpson[4] *et al.* 2004 UK	The aim of this study was to determine whether the type of flooring affects the risk of hip fracture. The study included 34 residential homes in the United Kingdom.	The number of hip fractures worldwide is estimated to be 1.7 million. A total of 6,641 falls and 222 fractures were recorded. Wooden carpeted floors were associated with the lowest number of fractures per 100 falls. The floor types were classified into four groups: 1. Wood sub-floor with no carpet: 3.1 falls per room (2.31 fractures per 100 falls); 2. Wood sub-floor with carpet: 5.3 falls per room (4.14 fractures per 100 falls); 3. Concrete sub-floor with no carpet: 8.6 falls per room (4.36 fractures per 100 falls); 4. Concrete sub-floor with carpet: 13.5 falls per room (2.44 fractures per 100 falls). Falls per room relative risks: 1. Wood uncarpeted RR 1.00; 2. Concrete uncarpeted RR 1.69; 3. Wood carpeted RR 2.74; 4. Concrete uncarpeted RR 4.3. ▪ The risk of falling was significantly lower compared with all other floor types (odds ratio: 1.78, 95% CI 1.22-2.35); ▪ The mean impact force was significantly lower on wooden carpeted floors 11.9 kilonewton (kN) compared to other floor types. The study concludes that changes to the flooring in residential homes could reduce the number of hip fractures.	2 +
Tan[6] *et al.* 2005 Ireland	The aim of this study was to determine the frequency of falls and fall-related injuries and the contribution of restraints in a hospital in Ireland. The incident reports for a single year from a large teaching hospital were	The fall rate per 10,000 patients days was 13.2 (95%CI 11.6-14.8) ▪ Fall rate increased dramatically with increased age; ▪ Eighty two (30.7%) falls resulted in injury of which: o 6 (7.3%) were serious; ▪ Injuries occurred in 71/247 (29%) unrestrained falls and in 11/20 (55%) falls in patients who were restrained; ▪ Injuries were more severe in falls with restraints in place ($p<0.0001$). Patient falls are the largest single category of reported incidents in hospitals. The	2 +

	analysed.	consequences for patients include physical effects such as discomfort, injury, increased morbidity, reduced independence and death. Fall rates were given by age: ▪ 18-34 years: 5.97 per 10,000 patient days; ▪ 35-49 years: 7.10 per 10,000 patient days; ▪ 50-69 years: 7.94 per 10,000 patient days; ▪ 70-84 years: 19.90 per 10,000 patient days; ▪ 85+years: 25.88 per 10,000 patient days; ▪ All ages: 13.20 per 10,000 patient days.	
Wilber[12] *et al.* 2005 US	This study was a randomised single blind controlled trial comparing different chair types conducted in the US. The patients were randomised either to stay on a reclining chair or a trolley.	66 patients in each group were enrolled. There was no difference in demographics between the groups, but the chair patients were more likely to have pain at the start of the study than the trolley patients. ▪ The patients had similar demographic information; ▪ Chair patient had more successful outcomes than trolley patients (97% versus 76%, 25% difference, 95% CI 10-32%; ▪ The mean satisfaction score was higher in the chair group than the trolley group (8.1 versus 6.0, 2.1 difference, 95%CI 1.4% to 2.8%).	1 +

A.2.2: References for hospital design features impacting on slips trips and falls

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A.2.3: Excluded literature for hospital design features impacting on slips trips and falls

Study	Exclusion reason
Akridge (2004)	This study contained no specific quantifiable data.
Alexander (2000)	This refers to bed mobility rather than the effect of design with relation to slips trips and falls.
Ali (2000)	This study discusses recommendations with regards to cot sides in the patient setting.
Alkridge (2005)	This does not specifically relate to slips trips and falls in the context of hospital design.
Allen (2002)	This study is with respect to transferring patients safely and does not address design aspects upon outcomes.
Allen (2002)	The information in this study does not contain data which is specific to the design or the outcomes.
Anonymous (1997)	This does not directly relate to design.
Anonymous (2001)	This is recommendations on staff activity within the hospital.
Anonymous (2002)	This discusses patient fatality with respect to bed rail-related entrapment.
Anonymous (2004)	This study discusses bed exit alarms and does not refer to the design directly.
Anonymous (2006)	This is a one page study on the risk of entrapment in hospital beds.
Bain *et al.* (2003)	This does not directly relate to the design of the hospital with respect to the outcomes under consideration.
Ballek (1997)	This does not directly relate to the design of the hospital with respect to the outcomes under consideration.
Baptiste (2002)	This does not directly relate to the design of the hospital with respect to the outcomes under consideration.
Barnett *et al.* (1999)	This is an audit of manual handling equipment and therefore does not directly relate to the design features of a hospital.
Barry (2006)	This study evaluates a HoverMatt system for patient transfer.
Bartley (2001)	This study considers infection control but does not relate this to the design of a hospital.
Beebe (2002)	This study recommends how morbidly obese patients should be handled in the hospital setting.
Belkin (2005)	This is an author reply to a study called “What about the floor?”
Beyer (2000)	This study is with respect to fungal contamination of outpatient examination rooms.
Biant *et al.* (2004)	This study examines eradication of MRSA but does not relate directly to the design of a hospital.

Block (2004)	This study discusses infection control but does not appear to relate to the design of a hospital.
Boden (1999)	This study discusses infection control with respect to the moving and handling of patients.
Boocock *et al.* (2006)	The data contained within this study is about forces applied by different bedside safety rails. The data does not specifically relate the design to the outcomes that are required.
Bracco *et al.* (2007)	This is with respect to infection control and does not relate specifically to the design.
Brezovich *et al.* (1997)	This study discusses a quality assurance system that can correct errors that affect patients. This does not specifically relate to design features.
Brienza (2000)	This study appears to explain support surface technologies within hospitals.
Brienza (2005)	This study appears to explain support surface technologies within hospitals.
Bunterngchit *et al.* (2000)	This study does not contain any quantifiable data relating the design to the study outcomes.
Caboor *et al.* (2000)	The study considers the implications of adjustable bed height. This does not relate the design to the specific outcomes.
Capezuti (2001)	This study considers the legal aspects of hospital side rail use.
Casalena *et al.* (1998)	The study discusses the technical aspects of falls on the femur.
Casalena *et al.* (1998)	This study considers design parameters associated with walking deflections.
Catalano *et al.* (1999)	The study considers the different bacterial levels on bed rails during a sporadic outbreak.
Chang (2004)	Slips and falls in liquid contaminated surfaces.
Chang *et al.* (2001)	This does not relate to the criteria as the study examines the role of surface roughness in the measurement of slipperiness.
Chang *et al.* (2001)	This does not relate to the criteria as the study examines the role of surface roughness in the measurement of slipperiness.
Cheung (2004)	The study solely relates to MRSA infection levels.
Chipman *et al.* (2006)	This study does not relate directly to the design of the hospital as it discusses different types of bed.
Christensen (1997)	This study does not relate to the design of the hospital.
Cogswell (2005)	This study addresses the use of carpets in hospitals.
Collins (2004)	This study relates to the design of equipment within hospitals.
Corbett *et al.* (1992)	The intervention under evaluation in this study is a quality improvement tool and does not relate directly to hospital design.
Danschutter (2005)	This does not relate to hospital design or outcomes.

Das *et al.* (2002)	This study does not contain any quantifiable data relating the design to the study outcomes.
Datta *et al.* (2005)	This relates to infection rates but does not consider different design options.
De Andrade *et al.* (2000)	This study examines the bacteriology of hospital beds after they are cleaned with phenolic disinfectant.
De Lorenzi (2006)	This study considers different floor cleaning methods.
Dettenkofer (2004)	This study considers different floor cleaning methods.
Dinsdale (2000)	This study reports an audit of bacterial levels in hospital beds.
Dyson (1996)	This study discusses the nursing implications in modern critical care unit design.
Eagle *et al.* (2004)	This study does not contain any quantifiable data relating the design to the study outcomes.
Evans *et al.* (2000)	This study conducts a clinical evaluation of a pressure mattress replacement system.
Flaaten (2007)	This study does not relate specifically to the design outcomes.
Fogg (1999)	This study refers to equipment and does not relate to design.
Fogg (2001)	This study refers to equipment and does not relate to design.
Fogg (2004)	This study examines different cleaning techniques within hospitals.
Fowler (2003)	This study relates to patient comfort and does not link different designs with the selected outcomes.
Galliangh (2001)	This study considers relatives perception of hand rail usage in hospitals.
Galliangh (2001)	This study considers an assessment of hand rail use by elderly patients.
Gamble (2005)	This study is a guideline on hospital cleaning.
Govier (2000)	This research considers cot sides and reports the results of an audit. This does not refer directly to the hospital design with respect to the outcomes.
Griffiths (2006)	This study considers the assessment of manual handling risk.
Gronqvist (2001)	This discusses a portable testing device that assesses floor slipperiness and therefore does not refer directly to the design of a hospital.
Gronqvist (2003)	This discusses a portable testing device that assesses floor slipperiness and therefore does not refer directly to the design of a hospital.
Gyntelberg (2006)	This discusses the quality of hospital care and does not relate hospital design to the outcomes.
Hall (2002)	This study discusses the use of hoist and slings for patient transfer.
Hammond *et al.* (1999)	This study does not contain any quantifiable data relating the design to the study outcomes.

Hampton (1997)	This is an evaluation of a new type of therapy system. This does not relate to the design.
Hardy (2004)	This does not relate to hospital design with respect to the selected outcomes.
Harrell *et al.* (2004)	This study does not contain any quantifiable data relating the design to the study outcomes.
Harris (2004)	The article discusses whether anaesthetic rooms are necessary and does not appear to contain any quantifiable evidence.
Hignett (1999)	This study discusses an ergonomic approach to manual lifting. This does not address different hospital design with respect to the outcomes under consideration.
Hignett *et al.* (2003)	This study is not relevant as it presents information on equipment maintenance.
Hospital Bed Safety Workgroup (2003)	This study presents clinical guidance for the assessment and implementation of bed rails in hospitals.
Jastrenski (2002)	This study is not relevant as it discusses pressure relief bedding to prevent ulcer development in critical care.
JCAHO (2002)	This is an article warning of bedrail-related entrapment. The article does not refer to any specific data.
Jepson (2003)	This study does not fulfil the criteria as it discusses using equipment to solve residents' bathing problems.
Jepson (2004)	This study does not fulfil the criteria as it discusses using equipment to solve residents' bathing problems.
Jepson (2005)	This study does not fulfil the criteria as it is a practical guide to using mobile hoists.
Kao *et al.* (2006)	This study does not link the outcome (infection rates) to the design features.
Kendzior *et al.* (2002)	This study does not contain any quantifiable data relating the design to the study outcomes.
Kent (2004)	This study does not fulfil the criteria as it discusses bed design.
Kernohan et al (1999)	The data contained within this study is not specific to the outcomes of interest.
Kibbler *et al.* (1998)	This study does not fulfil the criteria as it solely considers the effects of increased bed numbers on MRSA infection rates.
Kings Fund (1997)	This study describes a Centenary Bed Project and does not refer directly to the effect of design on the outcomes.
Knowles (1999)	This study is a clinical evaluation of a electronic pressure-relieving mattress.
Koay (1998)	This study discusses the planning and design of a surgical intensive care unit but appears not to relate to the outcomes.
Kunaratanapruk (1998)	This study does not fulfil the criteria as it discusses unnecessary infection control practices in Thailand.
Lankford *et al.* (2006)	This study does not contain any quantifiable data relating the design to the study outcomes.

Lawrence (2006)	This study does not fulfil the criteria as it is with respect to hospital beds by design.
Leighty (2003)	This study does not relate different designs to the outcomes.
Love (1996)	This does not fulfil the criteria as it discusses the ergonomic considerations when choosing a hoist or a sling.
Matern *et al.* (2001)	This does not fulfil the criteria as it discusses the adjustment height for laparoscopic surgery without relating this to the outcomes.
Maxwell (1997)	This study recommends how to use hospital beds.
McFadden (1997)	This study recommends healthcare fabrics and there impact on the effectiveness of support services.
McGuire *et al.* (1996)	This study evaluates mechanical aids and does not relate to the design of the hospital or the outcomes.
Mendez-Eastman (2006)	This study recommends support surfaces for the prevention and treatment of pressure ulcers.
Mercer (2001)	This study is with respect to the design of a nursing home and does not discuss outcomes.
Milburn (1999)	This is solely in relation to the production of hospital beds.
Miles (1998)	This is pictures of fatal bedrail entrapment.
Miles (2002)	This study considers deaths between bedrails and air pressure mattresses.
Minns (2004)	This study did not contain any specific quantifiable evidence relating to slips, trips and falls.
Morrison *et al.* (2005)	The data contained in this study is not in the correct context.
Mullette (2004)	This study considers bedrails in relation to restraints or enablers. This therefore does not fulfil the study criterion.
Muncey (1996)	This study does not appear to have any quantifiable evidence on the outcomes with respect to different designs.
O'Connell (2000)	This study provides recommendations on the ICU design and environmental factors in the acquisition of infection.
O'Connell (2006)	This study provides an insight into patient care and the way patients are positioned. Therefore it does not relate directly to hospital design.
O'Connor (2000)	This study considers cleaning rather than the design of mattresses.
O'Keeffe (2004)	This study does not contain any quantifiable data relating the design to the study outcomes.
O'Meara (2006)	This study does not appear to include any quantifiable evidence with respect to the different design options.
Panagea *et al.* (2005)	This study has no direct relation to the design of a hospital.

Parker *et al.* (1997)	This study presented data on the breakdown of the type of deaths by bedrails. The study did not report baseline incidence or alternative designs and the incidence of entrapment.
Parry *et al.* (2005)	This does not include evidence on the number of infections but instead provides bacterial level counts.
Patel (2005)	This study discusses ways in which to minimise cross-infection risks associated with beds and mattresses.
Perkins *et al.* (2006)	This study relates to resuscitation with respect to aspects of bed design.
Petzall *et al.* (1996)	This study is an example of how beds are used in a university hospital. This study does not appear to include any quantifiable evidence.
Petzall *et al.* (2003)	This study considers the transportation of hospital beds.
Poulos (1997)	This relates to a bed design which prevents pneumonia but does not relate the design directly to the outcome.
Powell-Cope *et al.* (2005)	This study discusses the modification of bed systems to reduce the risk if hospital-bed entrapment.
Purvis (2005)	This study discusses the use of electric profiling beds in the reduction and prevalence of pressure ulcers.
Ralph (2002)	This study discusses ways of minimising the risk of transmitting infection.
Redfern *et al.* (2001)	This study discusses the biomechanics of slips and falls.
Redman (2000)	The use of portable cushioned operating table side rails. However the study did not include an alternative design option to make a comparison.
Richards (1998)	This study does not relate to design options with respect to the outcomes.
Rollins (2006)	This study discusses the safety issues surrounding the use of bedrails and therefore does not appear to have any quantifiable evidence.
Ruden (2002)	This study is in relation to the cleaning of floors with disinfectant.
Rush (2004)	This study presents an overview of equipment for moving and handling tasks.
Russell *et al.* (2001)	This study evaluated a medical centre's experience with managing specialty bed usage.
Shaw *et al. (2005)*	This study does not contain any quantifiable data relating the design to the study outcomes.
Shiomori *et al.* (2001)	The significance of airborne transmission of MRSA in a head and neck surgery unit. This therefore does not relate to the design with respect to the outcomes.
Shiomori *et al.* (2002)	The study evaluates bed making related airborne surface MRSA contamination. This does not relate to the design of a hospital.

Silverwood *et al.* (2006)	This study does not contain extractable quantifiable evidence.
Smith *et al.* (2002)	This study is a clinical examination of ceiling lifts.
Smy (2004)	This study discusses making beds better.
Spiegel *et al.* (2002)	This discusses the implementation of a resident lifting system in an extended care hospital.
Steffes *et al.* (1997)	This study relates to concepts in OR design and does not appear to contain quantifiable evidence.
Swayze (1999)	This study is with relation to labor and delivery beds.
Thompson (2006)	This study does not fulfil the criteria as it discusses soft form premier active mattresses.
Todd (2002)	This study discusses safety with respect to hospital beds.
Todd *et al.* (1997)	This study reports on injury and death associated with side rails.
Van der Mee Marquet *et al.* (2006)	This study reports a bacterial outbreak in a hospital but does not relate this to design alternatives.
Walls (2001)	This study relates to staff safety with respect to the choice of bed.
Werner (2003)	This study discusses products and services for within the hospital.
White (1997)	This study does not fulfil the criteria as it discusses bed choices for the physically vulnerable patients.
Williams (2000)	This study is a product focus on alternative sectional bedding systems.
Williams (2000)	This is a framework for evaluating patient hoists.
Wilson (1999)	The study discusses the future of hospitals and does not refer directly to design.
Wolski (2006)	This study does not directly refer to design with respect to the outcomes.
Yarme (1999)	This study discusses floor coverings as a safety factor but does not appear to contain quantifiable evidence with respect to this.
Yonezawa *et al.* (2005)	This study discusses a new intelligent bed care system for hospital and home patients.
Young *et al.* (2005)	This study discusses microbial contamination of hospital bed handsets and therefore does not fulfil the criteria.
Zehetner *et al.* (2006)	This study discusses screen height as an ergonomic factor in laparoscopic surgery. This does not relate design directly to the outcomes.
148 Exclusion reasons	

A.3: HOSPITAL DESIGN FEATURES ON VENTILATION

A.3.1: Literature on Ventilation

Author, date, study setting	Study Description	Data	Quality Assessment
Berthelot *et al*.[4] 2006 France	The study evaluated the efficacy of a multidisciplinary strategy in the prevention of invasive pulmonary aspergillosis (IPA) in adult patients staying in a haematology ward between 1995 and 2001, when construction work was near hospital wards.	The multidisciplinary strategy included: - The installation of a ventilation system that included HEPA filters that are 99.97% efficient for removing 0.3µm particles, with directed room airflow; - An air lock chamber maintained the air pressure at a higher level than the surroundings; - Ensuring that staff in this ward, wore gowns, masks and disposable caps. The incidence (incidence density*) of IPA cases decreased from 0.85% (1.19/1000 patient-days) in 1993 to 0.28% (0.21/1000 patient days) in 2001. This reduction was statistically significant (p 0.02) when the 1993-1996 and 1997-2001 periods were compared. * Incidence density was calculated by dividing the number of IPA cases by the cumulative number of patient days spend in the haematology wards.	3-
Charnley[5] 1972 UK	The progress of a continuing study of an ultra-clean air system and its impact on post-operative sepsis rates for total hip replacement patients was reported.	The infection rate was at the 7-9% level in 1960, whilst in 1970 it was less than 1%. However, whether this reduction could be attributed to the air system was not clear since other factors may have influenced the infection rate. These included stopping anticoagulation, starting adhesive plastic film on the skin, and the use of double gloves and closure of the fat layer of the superficial wound.	2+

		Charnley therefore re-evaluated the impact of these factors and believed that “of all the precautions taken against infection in the operating room, the most important was clean air; but it is emphasized that this measure *alone* did not reduce the infection rate below about 1.5%”.	
Clark *et al*.[6] 1976 USA	A four-year multifaceted program to reduce infection in the cardiac operating room was evaluated, where the program involved a change in the ventilation system.	Renovation and alteration of operating room practices included installation of a vertical, unidirectional high flow (100 room changes per hour) recirculation ventilation system with HEPA filtration, elimination of a viewing gallery, alterations to wall positioning, electrical system, removal of monitoring consoles, a separate anaesthesia induction room, a separate pump oxygenator room, isolation corridor to the suite containing pass-through cabinets, changes in apparel and draping materials. Wound infection rates: No. at risk* / Superficial rate (%) / Deep rate (%) / Total wound rate (%) 1966 to 1970: 350 / 3.7 / 2.9 / 6.6 1970 to 1974: 826 / 2.7 / 0.6 / 3.3 * ≥ 1 week after operation. For the 2 time periods, there were significant differences between the deep ($p<0.01$) and total ($p<0.02$) infection rates, but not the superficial rates. Prosthetic valve infection rates: No. of valve patients at risk / No. with infected valves (%) 1966 to 1970: 162 / 9 (5.6) 1970 to 1974: 279 / 4 (1.4) P<0.02. Bacterial concentration data were provided – airborne bacteria concentrations decreased.	2+

		It was noted that "no single variable or combination of variables could be isolated to account for the marked decrease in the deep wound and prosthetic valve infection rates."	
Davidson *et al*. [7] 1971 Setting not stated.	The impact of a move from an old OT to a new OT on wound infection rates was investigated in more than 1,070 patients.	- Old OT: 1 in a block of 2 in open communication, separated only by an area used for scrubbing up and laying trolleys. Ventilation involved a slow continuous exchange system with <2 air exchanges per hour. - New OT: 1 of a suite of 4, ventilation by continuous exchange positive-pressure (plenum) system, 10-20 air changes per hour. Old OT / New OT Incidence of wound infections* 19.5 / 9.7 Incidence of wound infection after clean operations 9.2 / 5.4 Incidence of wound inf'n after potentially dirty ops 37.4 / 19.7 All data are %; * wound infection with staph. Pyogenes and intestinal organisms.	2+
Drake *et al*.[8] 1977 USA	The study evaluated the origin and spread of airborne micro-organisms causing surgical infections during two phases. Places, persons and environmental air were monitored.	Phase 1: Old physical plant – operating room of elementary design (window air conditioners were used, a forced air filtration system was employed with minimal air filtration). Single central corridor used for all traffic. Phase 2: Surgical suite used a ventilation system that filtered air through HEPA type filters (20 air exchanges per room per hour). Surgical traffic was controlled, multiple air screens. No. of wound Infections (%) / No. of infections in: Clean wounds / Clean-contaminated / Dirty Phase 1: 6 (7.23) / 2 / 2 (3.5%) / 2 Phase 2: 3 (4.11) / 3 / 0 (5.7%) / 0	2-

		The authors noted that the new surgical suite, with a sophisticated ventilation system, had “no perceptible effect on wound infection rates”.	
Fitzgerald[27] 1992 USA	As part of this review of the prevention and diagnosis of sepsis, the author describes a prospective RCT that was carried out in 1981. The incidence of deep sepsis following total hip and knee arthroplasty in a conventional operating room was compared to that in a horizontal clean room.	3,762 procedures were performed in the operating rooms with conventional air flow, compared to 3,543 with in operating rooms with horizontal clean air flow. All of the following refer to deep wound infections: Conventional OR: Hip / Knee — Laminar flow OR: Hip / Knee Total arthroplasty 0.26% 0.90% 0.49% 0.69% Revision total Arthroplasty 0.34% 4.4% 1.82% 2.07% Primary total Arthroplasty 0.23% 0.31% 0.06% 0.69% Due to range of follow-up examinations (from eight years to less than one year) the data were analysed with Kaplan Meier probability analysis: - The probability of deep sepsis following total hip arthroplasty was 0.3% without the unidirectional system and 0.7% with the unidirectional air flow system functioning ($p<0.05\%$); - The probability of deep sepsis following total knee arthroplasty was 1.3% without the unidirectional system and 0.8% with the unidirectional air flow system functioning ($p>0.05\%$). Note: none of the results were statistically significant in this study.	1+

Franco *et al*.[10] 1977 USA	The impact of horizontal laminar air flow systems and aspiration suits on wound contamination was evaluated. Correlation analysis between airborne contamination and quantitative contamination of the surgical wound is also presented.	Group 1: 37 patients - surgery was performed using laminar air flow and aspiration suits were worn. Group 2: 41 patients – laminar air flow, but no aspiration suits. Group 3: 30 patients - surgery was conducted in a plexiglass enclosure, but without laminar air flow or aspiration suits (designated “control”). Note: patients were not assigned to groups randomly. Microbial wound contamination: Group 1 / Group 2 / Group 3 (Control) Number of cases: 37 / 40 / 30 Mean bacteria per wound culture in the average case ± SD: 77 ± 304 / 187 ± 359 / 15 ± 34 Median bacteria per wound culture in the average case: 0 / 0 / 0 Range of medians: 0-1800 / 0-5000 / 0-23 The differences between the groups were not statistically significant.	2+
Gruenberg *et al*.[11] 2004 Italy	The retrospective study compared infection rates after patients had posterior spinal instrumentation procedures performed in a conventional operating room versus those performed in an ultra-clean air (vertical laminar flow) operating room.	179 adult patients were divided into two groups: Group 1: 139 patients undergoing operations in a conventional operating room. Group 2: 40 patients in a vertical exponential laminar flow operating room, in which the surgical team wore total body exhaust gowns. - 18 wound infections* were diagnosed in group 1 (12.9%) - 0 wound infections* were diagnosed in group 2.	2++

		* Any wound considered infected, either deep or superficial, under any protocol was included. The difference was found to be statistically significant (P<0.017).	
Kelly *et al.*[28] 1996 UK	The study compared the infection rates of patients undergoing elective orthopaedic procedures before and after a move to new premises. Laminar air flow was only available three of the four theatres in the new premises.	Theatre / Air flow / No. of Procedures / Infection Rate 1 / LAF / 340 / 10.0% (11 major and 23 minor) 2 / LAF / 258 / 7.0% (2 major and 16 minor) 3 / No LAF / 143 / 4.2% (0 major and 6 minor) 4 / LAF / 253 / 7.9% (4 major and 8 minor) The incidence of total infection was lowest in the theatre without laminar air flow; however this was not statistically significant. The authors feel that this result may be due to the small sample size.	2-
Lidwell *et al.*[13] 1982 UK (Participating hospitals were in England, Scotland and Sweden).	The multi-centre study looks at the incidence of sepsis in patients who underwent total hip or knee replacement, where operations were randomised between control and ultra-clean air operating rooms.	Sepsis in relation to operating room conditions: Hospital group (no. of hospitals) / % septic* -Control / % septic* -Ultra-clean / Conditions in ultra-clean air series 1 (n=6) / 2.2 / 1.0 / Conventional-pattern clothing 2a (n=3) / 1.0 / 0.1 / Body-exhaust suits (BES) 2b (n=3) / 2.2 / 0.9 / Trexler isolator 2a+2b (n=6) / 1.2 / 0.3 / 3 (n=4) / 1.4 / 0.2 / Conventional-pattern clothing, BES 4 (n=3) / - / - / 1+3 (n=10) / 2.0 / 1.0 / Conventional-pattern clothing 2+3 (n=10) / 1.3 / 0.3 / BES or isolator All groups (n=19) / 1.5 / 0.6 / *Sepsis (category 3) confirmed after re-operation on joint. - Ultra-clean air was defined as air containing fewer than 10 bacteria-carrying particles/m^3. - It was also found that prophylactic antibiotic use was related to a lower	2-

		sepsis incidence: 0.6% in patients who received prophylactic antibiotics as opposed to 2.3% in patients who did receive them. Note: this test was not controlled.	
Millar[14] 1979 Germany	The opening of a new operating suite, with 2 groups of 4 theatres, was investigated in relation to a continuing infection control programme. More than 3,000 operations were studied per annum.	- The old operating suite comprised 4 ORs opening directly into a common corridor, with a 30-year old plenum type ventilation system. - The new operating suite had a central clean area and a clean entry corridor for the 8 ORs. Patient access was through a double barrier exchange area. Staff access was through the dressing room, after changing to theatre garb with trouser suits and overboots. Filtered, humidified and temperature-controlled air is supplied by a vertical piston flow system, 16 changes per hour. Before / After Average infection rate 9%* / 3%** Average major infection rate in clean surgery 5% / 0.8%† Class A (clean) infection rate 5.5% / 1.7% Class B (potential contamination) infection rate 26.5% / 7.6% * over the previous 3 years; ** for the 18 months in the new area; † over 12 months. Note: The authors believe the following factors have operated: improved ventilation; adequate space and reduced traffic; resting of theatres between lists.	2-
Nelson *et al*.[15] 1980 Setting not stated	The incidence of deep postoperative infection for patients having hip arthroplasty operations, in relation to the operating environment, antibiotics and	No. of patients / Type of OR / % of infections 131 / Regular* / 7.6 135 / Clean room** / 3.0 In both OR's, there were regular garments, and either irregular or no antibiotics.	2+

	previous surgery was reviewed.	* This OR was constructed in 1966 and had 12 air exchanges per hour. Doors were kept closed, personnel movement was minimised, an average of 7 people were present in the OR during all operations; ** This OR was a Class 100 horizontal-flow laminar-flow module installed in an existing regular OR, with 480 hourly exchanges.	
Oren *et al*.[16] 2001 Israel	During 1993 to 1998 patients with acute leukaemia were treated with intensive chemotherapy. The study was broken down into three study periods. The aim was to investigate the impact of air ventilation on the incidence of invasive pulmonary aspergillosis (IPA).	Period 1 (Sept 1993 - Dec 1993): patients were housed on a regular ward without any aspergillus prophylaxis. Period 2 (Jan 1994 - June 1995): patients were housed on a regular ward and received chemoprophylaxis. Period 3 (July 1995 - June 1998): patients were housed in a ward that had HEPA filters. During this period some patients were treated on a regular ward (3a) and some on the new ward (3b). Bone marrow transplantation patients were treated on the new ward (3c). In total 31 patients developed IPA: 6/12 (50%) of patients in period 1; 12/28 (43%) of patients in period 2; 13/45 (29%*) of patients in period 3a; 0/26 (0%) in period 3b; and 0/26 (0%) in period 3c. *this is lower than previous years due to the fact that in period 3 some patients were moved into or out of the HEPA ward. The HEPA ward led to a complete elimination of IPA, as there was no difference between the underlying diagnoses, neutropenia length or in antifungal prophylaxis, this result is entirely due to the HEPA filters.	2+

Salvati *et al.*[29] 1982 USA	The cohort study investigated differences in infection rates between operating rooms that were ventilated using conventional air conditioning units compared to those that were ventilated using horizontal unidirectional filtered laminar air flow.	Total knee and total hip replacement surgery were performed in all operating rooms: Room 1: ventilated using horizontal unidirectional filtered air-flow (1,828 patients). Rooms 2 and 3: ventilated using conventional air-conditioning (1,334 patients). The filtered ventilation led to a reduction in the infection rate found after total hip replacement (from 1.4% to 0.9%). It led to an increased infection rate after total knee replacement (from 3.9% to 1.4%). These results were statistically significant. The authors believe that the results were due to the "positions of the operating team and of the wound with respect to air flow". During the hip replacements the operating team were correctly positioned within the air-flow stream, however during the knee replacements the operating team were required to periodically stand up wind from the wound and in the air flow.	2+
Sanderson and Bentley[18] 1976 UK	Patients undergoing a major joint replacement were randomly allocated to one of the two theatres; further study details were not provided.	Theatre 1: vertical laminar flow, where the operating team used non-porous gowns and body exhaust systems. Theatre 2: conventional plenum ventilated system, where conventional cotton gowns were worn. 306 patients were included in the study. Operating Theatre / Total no. of wash-outs / No. of colonies (mean) / No. of sterile wash-outs Conventional / 15 / 0-20 (7.3) / 4 Laminar flow / 27 / 0-9 (1.3) / 18 Wound contamination was lower in the 'ultra-clean' operating theatre compared to the conventional theatre.	1-

Simsek Yavuz *et al*.[19] 2006 Turkey	This study reports the incidence of sternal surgical site infection (SSI) and identifies risk factors associated with SSI.	Adult patients who underwent cardiac surgery with sternotomy who survived at least 4 days after surgery were included in the study. The OTs varied in terms of their ventilation systems and inner doors: - Older OTs had plenum ventilation from clean to less clean areas, with 27 changes of high-efficiency filtered air per hour. - Newer OTs had laminar-flow ventilation systems, with automatic doors that were always closed apart from movement through them. Plenum Ventilation — Laminar flow Sternal SI Rate — 6.74% — 2.01% The overall SSI rate was 4.1%; but this comprises both old and new OTs (6 of each), n=991.	2+
Wilson[30] 1982 USA	The article describes the concept of central HVAC (Heating, Ventilation, Air-conditioning & Cooling) systems and surrounding issues.	Complicated hospital projects have had HVAC system costs of $15 (£15.03 UK 2007) to $18 (£18.04 UK2007) per square foot or more.	4+

A.3.2: Reference List Hospital Design Features Impacting on Ventilation

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A.3.3: Excluded Literature for Hospital Design Features Impacting on Ventilation

Anonymous (1968)	The brief article features laminar air flow but does not report any of the pre-specified outcomes.
Anonymous (1969)	The article reports on hospital air but does not provide any quantifiable evidence.
Arrowsmith (1986)	Information regarding ultra clean ventilation systems is provided but evidence relating to the required outcomes is not reported.
Ayliffe (1991)	This study focuses on the impact of the environment of the operating room on surgical wound infection. However, quantifiable outcomes such as infection rates are not reported although bacterial counts are.
Ayliffe (1992)	The practical handbook does not report any evidence that has not already been included in the review.
Ayliffe (1994)	This does not report any quantifiable evidence that has not already been included in the review.
Babb *et al*. (1995)	A barn operating theatre is reported; bacterial counts are provided, but the pre-specified outcomes are not.
Bagshawe *et al*. (1978)	This looks at the design and construction of isolation accommodation, including ventilation. No quantifiable evidence is reported.
Balaras *et al*. (2007)	The paper provides guidelines for HVAC systems and reports findings from an investigation into indoor thermal conditions in operating rooms (temperature and air changes per hour) but no evidence relating to the required outcomes.
Bechtol (1971)	This reports the author's experience of operating in a vertical flow clean operating room enclosure, but none of the pre-specified outcomes are reported.
Bechtol (1979)	This study collected data on vertical laminar flow and compared it against a previous study of horizontal flow. However, details of this study are not provided, and data are not in terms of infection rates, but are in terms of colony-forming units and cultures.
Beggs *et al*. (2000)	Advanced ventilation techniques, HEPA filters and UVGI in hospitals are discussed, but no evidence relating to the pre-specified outcomes is presented.
Birnbaum (1990)	The article discusses aerobiology and hospital design but does not present any evidence.
Blowers *et al*. (1963)	This letter addresses points made by other authors regarding ventilation in operating rooms, but does not provide any evidence relating to the pre-specified outcomes.
Bodey & Gewertz (1969)	Results of biological monitoring in a laminar flow unit during patient occupancy are given, but infection rates are not.
Buemi *et al*. (2000)	Environmental air pollution in an ICU is reported, but there is no reference to infection rates.
Cacciari *et al*. (2004)	Information and guidelines regarding ventilation systems in isolation rooms are presented. However, none of the pre-specified outcomes are quantified.
Chau *et al*. (2006)	A mathematical CFD model of a local exhaust ventilation system is presented, with particle distributions reported. The pre-specified outcomes are not covered.
Chow & Yang (2002)	The laminar air flow study uses CFD analysis for a standard operating theatre, but none of the outcomes are reported.

Chow & Yang (2004)	This looks at ventilation in operating theatres but does not report any evidence that has not already been included in the review.
Clark (1972)	Laminar flow in an operating room is investigated; particle counts are provided, but the required outcomes are not.
Clarke *et al*. (2004)	The guidance on minimising air pollution in hospitals does not report any quantifiable evidence.
Crimi *et al*. (2006)	Data relating to bacterial charge in hospitals with HEPA filters are presented, but infection rates are not reported.
Decker (1995)	Tracer gas analysis was used to identify air change rates, air mixing and dissemination of contaminated air to non-contaminated areas. However, no outcomes are reported.
Dettenkofer *et al*. (2003)	The study reports particle counts in an operating theatre when ventilation system was switched off and re-started, but does not report any outcomes.
Dharan & Pittet (2002)	Ventilation in conventionally ventilated operating theatres and laminar flow systems are discussed, with reference to bacterial air counts. However, patient outcomes are not featured.
Escombe *et al*. (2007)	A comparison between naturally ventilated and mechanically ventilated rooms for infectious patients is made; infection risk is estimated using a mathematical model, but infection is not reported as such.
Fenelon (1995)	Issues surrounding protective isolation are presented, but quantifiable evidence is not reported.
Fennelly & Nardell (1998)	A model of airborne transmission of disease is featured, using various room ventilation rates and classes of respirators, but no patient outcomes are reported.
Friberg *et al.* (1999)	The relationship between air and surface counts of bacteria is investigated, but patient outcomes are not reported.
Friberg *et al*. (2002)	A mobile screen producing ultra-clean LAF is evaluated. Bacteria-carrying particles, air counts and air contamination at the wound site are reported, but there is no reference to outcomes such as infection rates.
Gosden *et al*. (1998)	This looks at issues related to infection in orthopaedic implant surgery, but does not report evidence regarding the outcomes.
Hahn *et al*. (2002)	The cause of an infection outbreak is investigated. However, infection rates are not reported in direct relation to the HEPA filters.
Hayden *et al*. (1998)	Air volume migration using tracer gas is presented, but none of the pre-specified outcomes are reported.
Holton & Ridgway (1993)	This focuses on operating theatre issues such as assessment of air quality and standards, but does not provide any additional quantifiable evidence that has not already been identified in the search.
Howorth (1987)	This looks at prevention of airborne infections in operating rooms, but does not report any quantifiable evidence.
Humphreys (2004)	This reports on ventilation issues and summarises evidence related to protective isolation; it is not easy to identify infection rates associated with control and intervention groups, and the ventilation is not in an operating theatre or acute hospital setting.
Jacobsen *et al*. (1993)	The letter reports on air-fluidised beds and negative pressure isolation rooms, but does not provide any quantifiable evidence relating to the required outcomes.

Jiang *et al*. (2003)	This looks at preventing SARS outbreaks, but the reported designs are not the options under consideration.
Jowitt & Morris (2005)	This article shows air changes per hour, air pressure gradients and counts of particles in the operating theatre, but does not describe the operating theatre design or report any required outcomes.
Kao & Yang (2006)	The letter addresses the topic of safe zones in isolation rooms but does not report any of the pre-specified outcomes.
Kao & Yang (2006)	Models are used to simulate virus diffusion within an isolation room, but no outcomes are reported.
Kelkar *et al*. (2005)	Bacteria carrying particles are reported for air conditioning units in operating theatres, but no outcomes.
Kingston *et al*. (1962)	This looks at the incidence of the common cold in offices, but not in a hospital setting.
Leung & Chan (2006)	Indoor air quality guidelines are presented, but none of the pre-specified outcomes are featured. Air change rates and particle concentrations are provided.
Li *et al*. (2004)	The air distribution study looks at a SARS outbreak but does not provide outcomes in relation to ventilation designs.
Lidwell *et al*. (1975)	Hospital airborne infection is investigated; air counts of particles are reported, but infection rates are not given.
Lidwell *et al*. (1983)	This study reports findings that are already included in the review; it investigates the relationship between air contamination and the infection rate.
Lutz *et al*. (2003)	Particle counts are used as surrogate markers for aspergilluscondidia, but infection rates themselves are not reported.
Madeo (1996)	The role of air sampling and ventilation is evaluated, but no outcomes relating to ventilation are reported.
Managan *et al*. (1998)	This looks at the implementation of CDC guidelines in US hospitals, but does not report the pre-specified outcomes in relation to ventilation design.
Manzo (1977)	HVAC systems are investigated, but no quantifiable evidence is presented in relation to outcomes.
Marier & Nelson (1993)	Respiratory isolation issues are reported, and particle counts are given. However, the pre-specified outcomes are not reported.
Marshall *et al*. (1996)	Ventilation efficiency and room air exchange rate in an isolation room is modelled, but outcomes are not reported.
McLarnon *et al*. (2006)	The effectiveness and efficiency of an air filtration system in a double-occupancy ward is reported, in terms of microbial counts. Colonies were checked for MRSA (4 were clearly MSSA positive, none were MRSA positive). Note: M**S**SA – sensitive.
Menzies *et al*. (2000)	The risk of tuberculin conversion associated with ventilation and air exchanges per hour is investigated. However, tuberculin conversion was not given in relation to different ventilation designs.
Minns *et al*. (1979)	A plenum chamber type ventilation system is evaluated in terms of air velocity and bacteriological sampling. None of the pre-specified outcomes are reported.
Moran *et al*. (1995)	This looks at TB in hospital emergency departments (EDs), shows how many EDs have negative pressure, HEPA filtration etc. but the required outcomes are not reported.

Nardell (1993)	Recommendations concerning the environmental approaches towards airborne TB are presented. The pre-specified outcomes are not reported.
Nevins *et al*. (1971)	Issues relating to environmental control of health care facilities are presented, but no quantifiable evidence regarding the pre-specified outcomes is provided.
Nicas *et al*. (1993)	This looks at isolation rooms for TB control, but does not provide any evidence in relation to design.
O'Connel & Humphreys (2000)	Infection in the ICU is investigated, but outcomes relating to design are not provided.
O'Marberry (2006)	The book covers several hospital design issues but did not provide quantifiable evidence.
Passweg *et al*. (1998)	The impact of protective isolation on outcomes of bone marrow transplantation is reported. Relative risks are provided, but no patient outcomes.
Pavelchak *et al*. (2000)	Airflow characteristics of isolation rooms are investigated, but no outcomes are quantified in relation to design.
Pavelchak *et al*. (2001)	The short article summarises a survey carried out regarding negative pressure monitoring of TB in isolation rooms, but outcomes are not reported.
Pegues *et al*. (1996)	The study evaluates an algorithm for isolation of suspected TB patients. Outcomes are not reported in relation to design.
Persson & van der Linden (2004)	Ultra-clean air ventilation was simulated in a surgical wound model; air counts are reported but evidence is not quantified.
Pittet & Ducel (1994)	Some information on operating theatre ventilation and wound infection rates is provided, but infection rates are not quantified in relation to different ventilation designs.
Pizzo (1981)	This features ventilation used in isolation rooms, but does not report quantifiable evidence.
Queensland Health (1997)	The paper summarises the evidence surrounding laminar air flow, although the references cited are already in the literature search.
Rebbman (2005)	Guidelines and an algorithm for infection control are provided. The study looks at a portable filtration unit (costs of which are reported) and negative pressure rooms. Quantifiable evidence relating to the pre-specified outcomes is not reported.
Reichert (1990)	Air flow patterns are featured but there is no reference to the pre-specified outcomes.
Ritter *et al*. (1976)	Contamination of instruments used in operating theatres with and without laminar air flow is reported.
Rutuala *et al*. (1995)	The ability of portable filtration units to reduce aerosolised particles is evaluated, and particle counts are given. However, none of the pre-specified outcomes are reported.
Scherrer (2003)	This study suggests the levels of bacteria within different types of operating theatre. It does not quantify the outcome in relation to the design of the operating theatre.
Sinkowitz *et al*. (1996)	Tuberculosis infection control programs are investigated; negative pressure rooms are referred to. However, infection rates related to ventilation design are not reported.
Smyth et al. (2005)	This survey focuses on OT ventilation systems, including a breakdown of the OT ventilation used for certain surgery types, but does not report any of the required outcomes.

Srinivasan *et al*. (2002)	Aspergillus counts are recorded in this study of hospital ventilation systems, but no patient outcomes.
Stacey et al. (2002)	This study describes the evidence surrounding operating theatre ventilation; there is no additional evidence that has not already been identified by the review.
Strawser & Gregory (1993)	Design considerations for HVAC systems in critical care units are presented; the pre-specified outcomes are not reported.
Streifel (2002)	Issues relating to air in health care facilities are presented, but none of the pre-specified outcomes are reported.
Sutton *et al*. (2000)	Control measures for TB isolation are evaluated, but no evidence is given in relation to the ventilation design of the room.
Tablan *et al*. (2004)	The guidelines for preventing health-care-associated pneumonia briefly mention ventilation but do not provide outcomes.
Tang *et al*. (2005)	A case of hospital-acquired chicken pox in an ICU with negative pressure is described and an experimental model is featured. No evidence relating to design is reported.
Thio *et al*. (2000)	This looks at controlling an outbreak of aspergillus, but outcomes are not reported in relation to design.
Van Drunen *et al*. (1996)	Ventilation patterns of TB isolation rooms are reported, but no outcomes are reported in relation to these.
Verkkala et al. (1998)	Bacterial air contamination during cardiac surgery was assessed according to different garments worn by staff and bacteriological and particulate matter control. None of the required outcomes in relation to design are reported.
Vokes-Air (2005)	Air handling systems are explored, but no relevant quantifiable evidence is reported.
Whyte & Carson (1970)	This letter gives annual costs of electricity and fuel for the use of laminar flow operating theatres, but the costs are considered to be no longer relevant.
Whyte *et al*. (1970)	The letter provides the cost of an air conditioning plant; however this is not relevant to the review.
Whyte *et al*. (1971)	An experimental laminar flow operating room is described; none of the pre-specified outcomes are quantified.
Whyte *et al*. (1973)	Airborne bacteria rates are reported in laminar flow operating rooms, but not infection rates.
Whyte & Shaw (1974)	This looks at ventilation systems in operating rooms; bacterial counts at the wound site are reported, but not infection rates.
Whyte (1984)	The paper investigates the importance of airborne contamination and ventilation of pharmaceutical manufacturing areas; particle counts and concentrations are reported, but not in a hospital setting.
Wilson (2007)	The article looks at using natural ventilation as a tool for airborne TB prevention, but does not provide any quantifiable evidence regarding the pre-specified outcomes.

A.4: HOSPITAL DESIGN FEATURES IMPACTING ON OPERATING THEATRES

A.4.1: Literature on Operating Theatres

Author, date, study setting	Study Description	Data	Quality Assessment
Daschner[4] 1989 Combination of settings.	Various hospital design issues were reported, including operating theatres.	Average and maximum costs per nosocomial infection ($): Pneumonia: Average 4,947; Maximum 41,628 Septicaemia: Average 3,061; Maximum 9,027 Wound Infection: Average 2,734; Maximum 26,019 Urinary tract infection: Average 593; Maximum 8,280 All nosocomial infections: Average 1,833; Maximum 41,628 *Source: Haley (1986)*	3+
Davidson *et al*.[5] 1971 Setting not stated.	The impact of a move from an old OT to a new OT on wound infection rates was analysed in 1,000 patients.	- Old OT: 1 in a block of 2 in open communication, separated only by an area used for scrubbing up and laying trolleys. Ventilation involved a slow continuous exchange system with <2 air exchanges per hour. - New OT: 1 of a suite of 4, ventilation by continuous exchange positive-pressure (plenum) system, 10-20 air changes per hour. Incidence of infection (all data are %): Wound infections: Old OT 19.5; New OT 9.7 Wound infection after clean operations: Old OT 9.2; New OT 5.4 Wound inf'n after potentially dirty ops: Old OT 37.4; New OT 19.7 Staphylococcus pyogenes infection (all): Old OT 8.5; New OT 4.9 Intestinal organism infection (all): Old OT 11.0; New OT 4.7	2+

Kleinert *et al.*[6] 1997 USA.	This study investigates infection rates in a double-occupancy operating room (OR) for elective outpatient operations (on the hand), and the factors affecting the infection rate.	(Positive-pressure airflow with 20 exchanges per hour is standard in the double-occupancy operating room). Of the 2,458 patients: • 1.5% (1.1-2.1%)* developed superficial or deep infection of the operative wound. • Infections were identified at a median of 11 days (range: 1-30 days). • Overall, 0.3% had a deep infection. No. of other patients in the OR: Infection Rate (%) 0 2.2 1 1.3 >1** 1.9 Classification of wound: Clean (did not have a drain) 1.3 Clean-contaminated (with drain) 4.8 * 95% confidence interval; ** these patients were treated at different times during the procedure. Infection rates were also reported according to factors including surgeon, anaesthesia class, and antibiotics.	2++

Millar[7] 1979 Germany.	The opening of a new operating suite, with 2 groups of 4 theatres, was investigated in relation to a continuing infection control programme. More than 3,000 operations were studied per annum.	- The old operating suite comprised 4 ORs opening directly into a common corridor, with a 30-year old plenum type ventilation system. - The new operating suite had a central clean area and a clean entry corridor for the 8 ORs. Patient access was through a double barrier exchange area. Staff access was through the dressing room, after changing to theatre garb with trouser suits and overboots. Filtered, humidified and temperature-controlled air is supplied by a vertical piston flow system, 16 changes per hour. Before / After Average infection rate 9%* / 3%** Average major infection rate in clean surgery 5% / 0.8%† Class A (clean) infection rate 5.5% / 1.7% Class B (potential contamination) infection rate 26.5% / 7.6% * over the previous 3 years; ** for the 18 months in the new area; † over 12 months. Note: The authors believe the following factors have operated: improved ventilation; adequate space and reduced traffic; resting of theatres between lists.	2-
Nelson *et al*.[8] 1980 Setting not stated.	The incidence of deep postoperative infection for patients having hip arthroplasty operations, in relation to the operating environment, antibiotics and previous surgery was reviewed.	No. of hips / Type of OR / % of infections 131 / Regular* / 7.6 135 / Clean room** / 3.0 In both ORs, there were regular garments, and either irregular or no antibiotics. * This OR was constructed in 1966 and had 12 air exchanges per hour. Doors were kept closed, personnel movement was minimised, an average of 7 people were present in the OR during all operations; ** This OR was a Class 100 horizontal-flow laminar-flow module installed in an existing regular OR, with 480 hourly exchanges.	2+

Simsek Yavuz *et al*.[9] 2006 Turkey.	This study reports the incidence of sternal surgical site infection (SSI) and identifies risk factors associated with SSI.	Adult patients who underwent cardiac surgery with sternotomy who survived at least 4 days after surgery were included in the study. The overall SSI rate was 4.1%; but this comprises both old and new OTs (6 of each), n=991. The OTs varied in terms of their ventilation systems and inner doors: - Older OTs had plenum ventilation (positive pressure air supply from clean to less clean areas, with 27 changes of high-efficiency filtered air per hour. - Newer OTs had laminar-flow ventilation systems, with automatic doors that were always closed apart from movement through them. Sternal SI Rate: Old OT 6.74%; New OT 2.01% The design of the OT was not detailed.	2+
Van Griethuysen *et al*.[10] 1996 The Netherlands.	Postoperative wound infection rates were compared before and after a move from an old OT to a new site (with 10 OTs in each).	Patients who underwent general or orthopaedic surgery in: - the old hospital, where the area was divided by a major hospital corridor. Coffee-room and changing rooms for staff and recovery rooms for patients were separate from the theatre. - The new hospital, all these rooms were connected, and staff were not allowed to leave the theatre area without changing from theatre-dress. Comparison of postoperative wound infections (%) in the old and new theatres: General surgery: Old OT / New OT Clean: 1.5 / 1.9 Clean-contaminated: 4.1 / 2.9 Contaminated: 5.7 / 3.6 Dirty: 3.3 / 1.7 Total: 2.4* / 2.2*	2+

		Orthopaedic surgery Clean 1.2 1.6 Other - - Total 1.2* 1.6* * No significant differences (P>0.05)	

A.4.2: HOSPITAL DESIGN FEATURES IMPACTING ON OPERATING THEATRES

Reference List

1. Whitehead SJ, Bending MW, Trueman P, Saxby RC, Duffy S, York Health Economics Consortium. *Cost-Effectiveness of Hospital Design: Options to Imrove Patient Safety and Wellbeing. Systematic Literature Review of Single Rooms in Relation to Infection.* 2008.

2. Whitehead SJ, Bending MW, Trueman P, Saxby RC, Duffy S, York Health Economics Consortium. *Cost-Effectiveness of Hospital Design: Options to Improve Patient Safety and Wellbeing. Systematic Literature Review of Ventilation in Relation to Infection.* 2008.

3. Bending MW, Whitehead SJ, Trueman P, Saxby RC, Duffy S, York Health Economics Consortium. *Cost-Effectiveness of Hospital Design: Options to Imrove Patient Safety and Wellbeing. Systematic Literature Review of Slips, Trips and Falls in Relation to Infection.* 2008.

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9. Simsek Yavuz S, Bicer Y, Yapici N, Kalaca S, Aydin OO, Camur G, Kocak F, Aykac Z. Analysis of risk factors for sternal surgical site infection: emphasizing the appropriate ventilation of the operating theaters. *Infection Control & Hospital Epidemiology*. 2006; **27**(9): 958-63.

10. van Griethuysen AJ, Spies-van Rooijen NH, Hoogenboom-Verdegaal AM. Surveillance of wound infections and a new theatre: unexpected lack of improvement. *Journal of Hospital Infection*. 1996; **34**(2): 99-106.

A.4.3: Excluded Literature on Hospital Design Features Impacting on Operating Theatres

Study	Exclusion reason
Author not stated (1981)	The study evaluates the provision and utilisation of operating theatres, but does not report any evidence relating to the required outcomes.
Adams & Fry (1984)	This concerns the renovation of an operating theatre, but there is no quantifiable evidence.
Agnew (1969)	This looks at design aspects of the operating area but does not report any quantifiable evidence.
Allen & Reynolds (1978)	This does not contain any quantifiable data.
Allen & Josephson (1995)	This concerns meeting the standards for infection control in an operating theatre.
Allo & Tedesco (2005)	This refers to the design of operating theatres but does not have any specific data relating to the outcomes.
Anonymous (2000)	This looks at infection control during remodel, but does not report any outcomes in relation to the required design issues.
Aorn, Journal (1989)	Recommended practices in the surgical suite are presented, but there is no quantifiable evidence.
Aorn, Journal (1992)	Recommended practices in the surgical suite are presented, but there is no quantifiable evidence.
Aorn, Journal (1993)	Practices for traffic patterns in the perioperative setting are recommended, but no quantifiable evidence is provided.
Berquer *et al*. (2001)	The study investigates the impact of operating table height on surgeons' muscles but does not report the pre-specified outcomes.
Chow *et al*. (2006)	This study considers differing air pressures in the operating theatre but does not relate these to the outcomes.
Essex-Lopresti (1999)	This study discusses operating theatre design.
Fleming (1981)	A review of operating department practice rather than relating the design to the required outcomes.
Fogg (1991)	This study presents questions and answers concerning the cleaning of an operating theatre and therefore does not relate quantifiable data for the outcomes to the design.
Fortney (2001)	This study contains no quantifiable evidence.
Fox (1997)	There is no quantifiable data specific to operating theatres and outcomes in this study.
Gadalla & Fong (1990)	This is a note to the editor which contains no data on outcomes in relation to operating theatres.
Gates (2005)	This is a short article on barn theatres which contains no quantifiable data.
Gehrki (2002)	This considers the best approaches to renovating operating theatres. This therefore does not relate to the design impact upon outcomes.
Greene (2006)	Information on preventing infection during OR reconstruction is provided but it does not report the required quantifiable outcomes.
Gregory (1989)	This discusses the need for substerile rooms depending on the design of the operating room.
Hill (2003)	This includes a qualitative discussion on infection control issues and the operating room construction.
Holton *et al.* (1990)	This reports bacteria carrying particles in an operating theatre but not patient infection rates.
Hughes (1993)	This study does not contain any baseline data.
Humphreys *et al*. (1991)	This is a short editorial comment. This does not contain any quantifiable data on operating theatre design and the outcomes.
Humphreys (1993)	This relates to best practice for designing operating rooms. The best practice suggested is not directly supported by data.

Humphreys *et al*. (1995)	This is a survey of the different types of operating theatres by the theatre design.
Humphreys (1999)	Infection control in the operating room is discussed but quantifiable data for the outcome is not reported.
Johnston & Hunter (1984)	This book does not report any quantifiable evidence in relation to the required design features.
Karanfil *et al.* (2005)	This discusses risk assessment tools for a patient safe environment. This is not directly in relation to design. For example the study discusses misidentification of patients.
Laufman (1974)	This looks at architectural and engineering aspects of the operating room, but doe not report any evidence relating to the required outcomes.
Laurence (1984)	Infection rates in operating theatres are reported, but they are related to the surgeon rather than design.
Mangram *et al.* (1999)	This is a guideline and contains no quantifiable data.
Marcon *et al.* (2003)	The study does not relate to hospital design.
Matern (2004)	This looks at the laparoscopic surgeon's posture and table heights. Outcomes are not reported.
McDonald *et al.* (2006)	This is a qualitative assessment of staff views on safety in the operating room.
Moss & Xiao (2004)	The study relates to staff behaviour within the operating theatre and does not relate directly to the design.
Noskova *et al*. (2003)	The study does not directly relate to the design features.
Patkin (2003)	Surgeons views are investigated, but evidence relating to the required outcomes is not quantified.
Polk *et al.* (1977)	This does not contain any quantifiable evidence that relates to the design and outcomes.
Polk (1979a)	This has no data that relates to the operating theatre design.
Polk & Finn (1979b)	Only surgical wound infections in relation to antibiotic use are reported.
Pryor & Messmer (1998)	This reports different risk factors for surgical site infections but does not provide details of operating theatre design.
Quebbeman & Telford (1993)	This looks at the risk of infection transmission in the operating room, but does not report the required outcomes associated with design.
Ritter (1999)	The study reports contamination rates (for different ventilation designs) in the operating room. However, it is not possible to infer the linkage between contamination and infection rates.
Rosin *et al.* (1999)	This book considers the design of the future operating theatre of 2010. It does not however include any quantifiable data.
Sanchez & Hernandez (1999)	An infection control program during operating room construction is investigated, but no quantifiable evidence is provided.
Saunders (2004)	This study suggests best practice for nursing stuff with respect to conduct in the operating theatre.
Schultz (1979a)	There is no quantifiable evidence that relates to the design of the hospital in this study.
Schultz (1979b)	There is no quantifiable evidence that relates to the design of the hospital in this study.
Schurr *et al.* (1995)	This study does not contain any quantifiable data.
Seagull & Sanderson (2004)	Focuses on anaesthesia in the operating room, but does not report the required outcomes in relation to design.
Shani (1988)	The article looks into the ideal operating environment, but does not report evidence.
Shaw *et al*. (1974)	This study does not report any quantifiable evidence that relates directly to design.
Silen-Lipponen *et al.* (2005)	This study is a qualitative discussion of nursing errors and team work in the operating theatre environment.

Taylor (1993)	This study considers universal precautions in the operating department but does not include any quantifiable data with respect to the design.
Taylor & Quick (1994)	MRSA in the operating theatre is discussed. The study contains no quantifiable data.
Ulrich (2002)	There is no quantifiable evidence that relates to the design of a hospital in this study.
Unerman (1994)	Infection control in the operating department is the issue reported, but there is no quantifiable evidence.
Ward (1986)	This paper focuses on disinfection procedures in operating theatres, but does not provide any quantifiable evidence.
Webster & Cao (2006)	This relates to staff behaviour and is not directly with respect to the design of operating theatres and outcomes.
Weist & Ruden (1991)	The paper is in German.

A.5: REFERENCES ON WILLINGNESS TO PAY

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3. Davis R. Recreation planning as an economic problem. *Natural Resources Journal*. 1963; **3** 239-249.

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APPENDIX B

Search Strategies

B.1: SEARCH STRATEGY FOR LITERATURE ON SINGLE ROOMS AND OPERATING THEATRES

MEDLINE & PreMEDLINE (Ovid Gateway). 1996-2006/Mar week 4. 5th April 2006.

Single rooms:

152 records were retrieved in MEDLINE and 4 records were retrieved in PreMEDLINE.

1. Patients' Rooms/
2. (single adj2 room$).ti,ab.
3. ((private or isolat$ or separate) adj2 room$).ti,ab.
4. or/1-3
5. exp Infection Control/
6. (infection adj2 control$).ti,ab.
7. 5 or 6
8. 4 and 7

Building design:

124 records were retrieved in MEDLINE and 2 records were retrieved in PreMEDLINE.

1. "Facility Design and Construction"/
2. "Hospital Design and Construction"/
3. (building adj2 design).ti,ab.
4. or/1-3
5. exp Infection Control/
6. (infection adj2 control$).ti,ab.
7. 5 or 6
8. 4 and 7

EMBASE (Ovid Gateway). 1996-2006/week 13. 5th April 2006.

Single rooms:

86 records were retrieved.

1. (single adj2 room$).ti,ab.
2. ((private or isolat$ or separate) adj2 room$).ti,ab.
3. or/1-2
4. infection control/
5. (infection adj2 control$).ti,ab.
6. 4 or 5
7. 3 and 6

Building design:

41 records were retrieved.

1. hospital building/ or hospital design/
2. (building adj2 design).ti,ab.
3. 1 or 2
4. infection control/
5. (infection adj2 control$).ti,ab.
6. 4 or 5
7. 3 and 6

CINAHL (Ovid Gateway). 1996-2006/Mar week 5. 5th April 2006.

Single rooms:

126 records were retrieved.

1. Patients' Rooms/
2. (single adj3 room$).ti,ab.
3. ((private or isolat$ or separate) adj3 room$).ti,ab.
4. or/1-3
5. exp Infection Control/
6 (infection adj3 control$).ti,ab.
7. 5 or 6
8. 4 and 7

Building design:

100 records were retrieved.

1. "facility design and construction"/ or "hospital design and construction"/
2. (building adj3 design).ti,ab.
3. 1 or 2
4. Infection Control/
5. (infection adj2 control$).ti,ab.
6. 4 or 5
7. 3 and 6

HMIC (Ovid Gateway). 1996-2006/March. 5th April 2006.

Single rooms:

14 records were retrieved.

1. exp SINGLE ROOMS/
2. (single adj3 room$).ti,ab.
3. ((private or isolat$ or separate) adj3 room$).ti,ab.
4. or/1-3
5. exp INFECTION CONTROL/
6. (infection adj3 control$).ti,ab.
7. 5 or 6
8. 4 and 7

Building design:

32 records were retrieved.

1. building design/
2. (building adj3 design).ti,ab.
3. 1 or 2
4. exp INFECTION CONTROL/
5. (infection adj2 control$).ti,ab.
6. 4 or 5
7. 3 and 6

BNI (Ovid Gateway). 1996-2006/March. 5th April 2006.

Single rooms:

21 records were retrieved.

1. (single adj3 room$).ti,ab.
2. ((private or isolat$ or separate) adj3 room$).ti,ab.
3. (patient$ adj1 isolat$).ti,ab.
4. or/1-3
5. infection control/
6. (infection adj3 control$).ti,ab.
7. 5 or 6
8. 4 and 7

Building design:

13 records were retrieved.

1. "hospital planning and design"/
2. (building adj3 design).ti,ab.
3. 1 or 2
4. Infection Control/
5. (infection adj2 control$).ti,ab.
6. 4 or 5
7. 3 and 6

SCI/SSCI (Web of Science). 1996-2006/March. 5th April 2006.

Single rooms:

7 records were retrieved from both databases combined.

TS=(single room) or TS=(single rooms)
TS=(infection control)
#1 and #2

Building design:

5 records were retrieved from both databases combined.

TS=(building SAME design)
TS=(infection control)
#1 and #2

BIOSIS (Edina). 1996-2006/March. 5th April 2006.

Single rooms:

4 records were retrieved.

(al: “infection control”) and (al: “single room” or “single rooms”)

Building design:

0 records were retrieved.

(al: “infection control”) and (al:building w3 design)

B.2: FURTHER SEARCHES FOR SINGLE ROOMS AND OPERATING THEATRE DESIGN

MEDLINE (Ovid Gateway). 1950-2007/Feb week 2. 23rd February 2007.

Single rooms: 439 records were retrieved

Operating theatres: 330 records were retrieved

1. Patients' Rooms/
2. (single adj2 room$).ti,ab.
3. (single adj2 bed$).ti,ab.
4. (side adj2 (room$ or bed$)).ti,ab.
5. ((private or isolat$ or separate) adj2 room$).ti,ab.
6. or/1-5
7. Operating Rooms/
8. ((operating or surgical or surgery) adj2 (room$ or suite$ or theatre$ or theater$)).ti,ab.
9. 7 or 8
10. exp Infection Control/
11. (infection adj2 control$).ti,ab.
12. Cross Infection/
13. (hospital adj2 infect$).ti,ab.
14. (healthcare adj2 infect$).ti,ab.
15. (nosocomial adj2 infect$).ti,ab.
16. (cross adj2 infect$).ti,ab.
17. (mrsa or emrsa).ti,ab.
18. (exp Staphylococcal Infections/ or Staphylococcus aureus/) and Methicillin Resistance/
19. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).ti,ab.
20. Clostridium difficile/
21. (clostridium difficile or c difficle).ti,ab.
22. Medication Errors/
23. Medical Errors/

24. ((medication or medical) adj2 (error$ or mistake$)).ti,ab.
25. ((surgical or operative) adj2 (error$ or mistake$)).ti,ab.
26. ((anaesthetic or anesthetic) adj2 (error$ or mistake$)).ti,ab.
27. Surgical Wound Infection/
28. ((surgical or operative) adj2 infect$).ti,ab.
29. ((postsurgical or postoperative) adj2 infect$).ti,ab.
30. (wrong adj2 site).ti,ab.
31. or/10-30
32. exp "Facility Design and Construction"/
33. "Hospital Design and Construction"/
34. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
35. or/32-34
36. Animals/
37. Humans/
38. 36 not (36 and 37)
39. 6 and 31
40. 9 and 31 and 35
41. 39 or 40
42. 41 not 38
43. limit 42 to english language

EMBASE (Ovid Gateway). 1980-2007/week 7. 23rd February 2007.

Single rooms: 184 records were retrieved

Operating theatres: 131 records were retrieved

1. (single adj2 room$).ti,ab.
2. (single adj2 bed$).ti,ab.
3. (side adj2 (room$ or bed$)).ti,ab.
4. ((private or isolat$ or separate) adj2 room$).ti,ab.
5. or/1-4
6. Operating Room/
7. ((operating or surgical or surgery) adj2 (room$ or suite$ or theatre$ or theater$)).ti,ab.
8. 6 or 7
9. infection control/
10. (infection adj2 control$).ti,ab.
11. Hospital Infection/
12. (hospital adj2 infect$).ti,ab.
13. (healthcare adj2 infect$).ti,ab.
14. (nosocomial adj2 infect$).ti,ab.
15. (cross adj2 infect$).ti,ab.
16. methicillin resistant staphylococcus aureus/
17. (mrsa or emrsa).ti,ab.
18. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).ti,ab.
19. Clostridium Difficile/
20. (clostridium difficile or c difficle).ti,ab.
21. Medication Error/
22. Medical Error/
23. Surgical Error/
24. ((medication or medical) adj2 (error$ or mistake$)).ti,ab.
25. ((surgical or operative) adj2 (error$ or mistake$)).ti,ab.
26. ((anaesthetic or anesthetic) adj2 (error$ or mistake$)).ti,ab.
27. Surgical Infection/
28. ((surgical or operative) adj2 infect$).ti,ab.

29. ((postsurgical or postoperative) adj2 infect$).ti,ab.
30. (wrong adj2 site).ti,ab.
31. or/9-30
32. hospital building/ or hospital design/
33. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
34. 32 or 33
35. exp animal/
36. Nonhuman/
37. (rat or rats or mouse or mice or murine or rodent or rodents or hamster or hamsters or pig or pigs or porcine or rabbit or rabbits or animal or animals or dogs or dog or cats or cow or bovine or sheep or ovine or monkey or monkeys).ti,ab,sh.
38. exp human/
39. or/35-37
40. 39 not (39 and 38)
41. 5 and 31
42. 8 and 31 and 34
43. 41 or 42
44. 43 not 40
45. limit 44 to english language

CINAHL (Ovid Gateway). 1982-2007/Feb week 3. 23rd February 2007.

Single rooms: 153 records were retrieved

Operating theatres: 102 records were retrieved

1. Patients' Rooms/
2. (single adj3 room$).ti,ab.
3. (single adj3 bed$).ti,ab.
4. (side adj3 (room$ or bed$)).ti,ab.
5. ((private or isolat$ or separate) adj3 room$).ti,ab.
6. or/1-5
7. Operating Rooms/
8. ((operating or surgical or surgery) adj3 (room$ or suite$ or theatre$ or theater$)).ti,ab.
9. 7 or 8
10. Infection Control/
11. (infection adj2 control$).ti,ab.
12. Cross Infection/
13. (hospital adj2 infect$).ti,ab.
14. (healthcare adj2 infect$).ti,ab.
15. (nosocomial adj2 infect$).ti,ab.
16. (cross adj2 infect$).ti,ab.
17. (exp Staphylococcal Infections/ or Staphylococcus aureus/) and Methicillin Resistance/
18. (mrsa or emrsa).ti,ab.
19. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).ti,ab.
20. Clostridium Difficile/
21. (clostridium difficile or c difficle).ti,ab.
22. Medication Errors/
23. Treatment Errors/
24. ((medication or medical) adj2 (error$ or mistake$)).ti,ab.
25. ((surgical or operative) adj2 (error$ or mistake$)).ti,ab.
26. ((anaesthetic or anesthetic) adj2 (error$ or mistake$)).ti,ab.
27. Surgical Wound Infection/
28. ((surgical or operative) adj2 infect$).ti,ab.
29. ((postsurgical or postoperative) adj2 infect$).ti,ab.

30. (wrong adj3 site).ti,ab.
31. or/10-30
32. "facility design and construction"/ or "hospital design and construction"/
33. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
34. 32 or 33
35. 6 and 31
36. 9 and 31 and 34
37. 35 or 36
38. limit 37 to english

HMIC (Ovid Gateway). January 2007. 23rd February 2007.

Single rooms: 24 records were retrieved

Operating theatres: 16 records were retrieved

1. exp SINGLE ROOMS/
2. (single adj3 room$).ti,ab.
3. (single adj3 bed$).ti,ab.
4. (side adj3 (room$ or bed$)).ti,ab.
5. ((private or isolat$ or separate) adj3 room$).ti,ab.
6. or/1-5
7. exp OPERATING THEATRES/
8. ((operating or surgical or surgery) adj3 (room$ or suite$ or theatre$ or theater$)).ti,ab.
9. 7 or 8
10. exp INFECTION CONTROL/
11. (infection adj3 control$).ti,ab.
12. exp HOSPITAL ACQUIRED INFECTION/
13. (hospital adj3 infect$).ti,ab.
14. (healthcare adj3 infect$).ti,ab.
15. (nosocomial adj3 infect$).ti,ab.
16. (cross adj3 infect$).ti,ab.
17. STAPHYLOCOCCAL INFECTIONS/ and METHICILLIN/
18. (mrsa or emrsa).ti,ab.
19. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).ti,ab.
20. exp CLOSTRIDIUM INFECTIONS/
21. (clostridium difficile or c difficle).ti,ab.
22. exp MEDICATION ERRORS/
23. ((medication or medical) adj2 (error$ or mistake$)).ti,ab.
24. ((surgical or operative) adj2 (error$ or mistake$)).ti,ab.
25. ((anaesthetic or anesthetic) adj2 (error$ or mistake$)).ti,ab.
26. ((surgical or operative) adj2 infect$).ti,ab.
27. ((postsurgical or postoperative) adj2 infect$).ti,ab.
28. (wrong adj3 site).ti,ab.
29. or/10-28
30. building design/
31. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
32. 30 or 31
33. 6 and 29
34. 9 and 29 and 32
35. 33 or 34

BNI (Ovid Gateway). 1985-2007/Feb. 23rd February 2007.

Single rooms: 7 records were retrieved

Operating theatres: 9 records were retrieved

1. (single adj3 room$).mp.
2. (single adj3 bed$).mp.
3. (side adj3 (room$ or bed$)).mp.
4. ((private or isolat$ or separate) adj3 room$).mp.
5. or/1-4
6. ((operating or surgical or surgery) adj3 (room$ or suite$ or theatre$ or theater$)).mp.
7. (infection adj3 control$).mp.
8. (hospital adj3 infect$).mp.
9. (healthcare adj3 infect$).mp.
10. (nosocomial adj3 infect$).mp.
11. (cross adj3 infect$).mp.
12. (mrsa or emrsa).mp.
13. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).mp.
14. (clostridium difficile or c difficle).mp.
15. ((medication or medical) adj3 (error$ or mistake$)).mp.
16. ((surgical or operative) adj3 (error$ or mistake$)).mp.
17. ((anaesthetic or anesthetic) adj3 (error$ or mistake$)).mp.
18. ((surgical or operative) adj3 infect$).mp.
19. ((postsurgical or postoperative) adj3 infect$).mp.
20. (wrong adj3 site).mp.
21. or/7-20
22. "hospital planning and design"/
23. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
24. 22 or 23
25. 5 and 21
26. 6 and 21 and 24
27. 25 or 26

SCI/SSCI (Web of Science). 1996-2007/Feb. 23rd February 2007.

Single rooms: 238 records were retrieved

Operating theatres: 70 records were retrieved

TS=(single SAME room*) or TS=(single SAME bed*)
TS=(private SAME room*) or TS=(private SAME bed*) or TS=(isolat* SAME room*) or TS=(isolat* SAME bed*) or TS=(separate SAME room*) or TS=(separate SAME bed*) OR TS=(side SAME room*) or TS=(side SAME bed*)
#1 OR #2
TS=("operating room*") or TS=("surgical room*") or TS=("surgery room*") or TS=("operating suite*") or TS=("surgical suite*") or TS=("surgery suite*") or TS=("operating theatre*") or TS=("surgical theatre*") or TS=("surgery theatre*") or TS=("operating theater*") or TS=("surgical theater*") or TS=("surgery theater*")
TS=("infection control")
TS=("hospital infect*")
TS=("healthcare infect*")
TS=("nosocomial infect*")
TS=("cross infect*")
TS=(mrsa or emrsa)

TS=(staphylococc* SAME infect*) or TS=(staphylococc* SAME aureus)
TS=(methicillin SAME resistan*)
#11 AND #12
TS=("clostridium difficile") or TS=("c difficle")
TS=("medication error*") or TS=("medical error*") or TS=("medication mistake*") or TS=("medical mistake*") or TS=("surgical error*") or TS=("operative error*") or TS=("surgical mistake*") or TS=("operative mistake*")
TS=("surgical infect*") or TS=("operative infect*") or TS=("postsurgical infect*") or TS=("postoperative infect*") or TS=("post-surgical infect*") or TS=("post-operative infect*")
TS=("wrong site")
#17 OR #16 OR #15 OR #14 OR #13 OR #10 OR #9 OR #8 OR #7 OR #6 OR #5
TS=(design* or construct* or build* or built or renovat* or architect* or traffic or size)
#3 and #18
#4 and #18 and #19
#20 or #21
DocType=All document types; Language=English

DARE (CRD databases). 1994-2007/Jan. 23rd February 2007.

Single rooms: 5 records were retrieved

Operating theatres: 10 records were retrieved

s single(w3)(room$ or bed$)
s (private or isolat$ or separate or side)(w3)(room$ or bed$)
s s1 or s2
s (operating or surgical or surgery)(w)(room$ or suite$ or theatre$ or theater$)
s infection(w3)control$
s hospital(w3)infect$
s healthcare(w3)infect$
s nosocomial(w3)infect$
s cross(w3)infect$
s mrsa or emrsa
s staphylococc$(w2)(infect$ or aureus) and methicillin(w2)resistan$
s clostridium(w)difficile or c(w)difficle
s (medication or medical)(w3)(error$ or mistake$)
s (surgical or operative)(w3)(error$ or mistake$)
s (anaesthetic or anesthetic)(w3)(error$ or mistake$)
s (surgical or operative)(w3)infect$
s (postsurgical or postoperative)(w3)infect$
s wrong(w3)site
s s5 or s6 or s7 or s8 or s9 or s10 or s11 or s12 or s13 or s14 or s15 or s16 or s17 or s18
s design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size
s s3 and s19
s s4 and s19 and s20
s s21 or s22

NHS EED (CRD databases). 1994-2007/Jan. 23rd February 2007.

Single rooms: 15 records were retrieved

Operating theatres: 19 records were retrieved

s single(w3)(room$ or bed$)
s (private or isolat$ or separate or side)(w3)(room$ or bed$)
s s1 or s2
s (operating or surgical or surgery)(w)(room$ or suite$ or theatre$ or theater$)
s infection(w3)control$
s hospital(w3)infect$
s healthcare(w3)infect$
s nosocomial(w3)infect$
s cross(w3)infect$
s mrsa or emrsa
s staphylococc$(w2)(infect$ or aureus) and methicillin(w2)resistan$
s clostridium(w)difficile or c(w)difficle
s (medication or medical)(w3)(error$ or mistake$)
s (surgical or operative)(w3)(error$ or mistake$)
s (anaesthetic or anesthetic)(w3)(error$ or mistake$)
s (surgical or operative)(w3)infect$
s (postsurgical or postoperative)(w3)infect$
s wrong(w3)site
s s5 or s6 or s7 or s8 or s9 or s10 or s11 or s12 or s13 or s14 or s15 or s16 or s17 or s18
s design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size
s s3 and s19
s s4 and s19 and s20
s s21 or s22

HTA Database (CRD databases). 1994-2007/Jan. 23rd February 2007.

Single rooms: 2 records were retrieved

Operating theatres: 1 record was retrieved

s single(w3)(room$ or bed$)
s (private or isolat$ or separate or side)(w3)(room$ or bed$)
s s1 or s2
s (operating or surgical or surgery)(w)(room$ or suite$ or theatre$ or theater$)
s infection(w3)control$
s hospital(w3)infect$
s healthcare(w3)infect$
s nosocomial(w3)infect$
s cross(w3)infect$
s mrsa or emrsa
s staphylococc$(w2)(infect$ or aureus) and methicillin(w2)resistan$
s clostridium(w)difficile or c(w)difficle
s (medication or medical)(w3)(error$ or mistake$)
s (surgical or operative)(w3)(error$ or mistake$)
s (anaesthetic or anesthetic)(w3)(error$ or mistake$)
s (surgical or operative)(w3)infect$
s (postsurgical or postoperative)(w3)infect$
s wrong(w3)site
s s5 or s6 or s7 or s8 or s9 or s10 or s11 or s12 or s13 or s14 or s15 or s16 or s17 or s18

s design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size
s s3 and s19
s s4 and s19 and s20
s s21 or s22

HEED (CD-ROM). February 2007. 23rd February 2007.

Single rooms: 0 records were retrieved

Operating theatres: 4 records was retrieved

AX=(single room) or (single rooms) or (single bed) or (single beds) or (single bedroom) or (single bedrooms)
AX=(private room) or (private rooms) or (isolation room) or (isolation rooms) or (separate room) or (separate rooms) or (side room) or (side rooms) or (private bed) or (private beds) or (private bedroom) pr (private bedrooms) or (separate bed) or (separate beds) or (separate bedroom) pr (separate bedrooms)
CS=1 or 2
AX=(operating room) or (operating rooms) or (surgical room) or (surgical rooms) or (surgery room) or (surgery rooms) or (operating suite) or (operating suites) or (surgical suite) or (surgical suites) or (surgery suite) or (surgery suites) or (operating theatre) or (operating theatres) or (surgical theatre) or (surgical theatres) or (surgery theatre) or (surgery theatres) or (operating theater) or (operating theaters) or (surgical theater) or (surgical theaters) or (surgery theater) or (surgery theaters)
AX='infection control' within 3
AX='hospital infect' within 3 OR 'hospital infection' within 3 OR 'hospital infections' within 3
AX='healthcare infect' within 3 OR 'healthcare infection' within 3 OR 'healthcare infections' within 3
AX='nosocomial infect' within 3 OR 'nosocomial infection' within 3 OR 'nosocomial infections' within 3
AX='cross infect' within 3 OR 'cross infection' within 3 OR 'cross infections' within 3
AX=mrsa or emrsa
AX=(Meticillin Resistant Staphylococcus Aureus)
AX=(clostridium difficile) or (c difficle)
AX=(medication error) or (medication errors) or (medication mistake) or (medication mistakes) or (medical error) or (medical errors) or (medical mistake) or (medical mistakes)
AX=(surgical error) or (surgical errors) or (surgical mistake) or (surgical mistakes) or (operative error) or (operative errors) or (operative mistake) or (operative mistakes)
AX=(anaesthetic error) or (anaesthetic errors) or (anaesthetic mistake) or (anaesthetic mistakes) or (anesthetic error) or (anesthetic errors) or (anesthetic mistake) or (anesthetic mistakes)
AX='surgical infect' within 3 OR 'surgical infection' within 3 OR 'surgical infections' within 3 OR 'operative infect' within 3 OR 'operative infection' within 3 OR 'operative infections' within 3
AX='postsurgical infect' within 3 OR 'postsurgical infection' within 3 OR 'postsurgical infections' within 3 OR 'postoperative infect' within 3 OR 'postoperative infection' within 3 OR 'postoperative infections' within 3 OR 'post-surgical infect' within 3 OR 'post-surgical infection' within 3 OR 'post-surgical infections' within 3 OR 'post-operative infect' within 3 OR 'post-operative infection' within 3 OR 'post-operative infections' within 3
AX=(wrong site)
CS=5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18
AX=design or designed or designs or designer or construct or construction or constructed or build or building or buildings or built or renovate or renovation or renovated or architect or architects or architecture or traffic or size
CS=3 and 19

CS=4 and 19 and 20
CS=21 or 22

CDSR and CENTRAL (Cochrane Library. Issue 1:2007. 23rd February 2007.

CDSR.

3 records were retrieved in total

CENTRAL.

Single rooms: 17 records were retrieved

Operating theatres: 35 records was retrieved

#1 MeSH descriptor Patients' Rooms explode all trees
#2 (single NEAR/2 room*)
#3 (single NEAR/2 bed*)
#4 (side NEAR/2 room*)
#5 (private or isolat* or separate) NEAR/2 room*
#6 (#1 OR #2 OR #3 OR #4 OR #5)
#7 MeSH descriptor Operating Rooms explode all trees
#8 (operating or surgical or surgery) NEAR/2 (room* or suite* or theatre* or theater*)
#9 (#7 OR #8)
#10 MeSH descriptor Infection Control explode all trees
#11 (infection NEAR/2 control*)
#12 MeSH descriptor Cross Infection explode all trees
#13 (hospital or healthcare or nosocomial or cross) NEAR/ infect*
#14 (mrsa or emrsa)
#15 MeSH descriptor Staphylococcal Infections explode all trees
#16 MeSH descriptor Staphylococcus aureus explode all trees
#17 MeSH descriptor Methicillin Resistance explode all trees
#18 ((#15 OR #16) AND #17)
#19 staphylococc* NEAR/2 infect*
#20 staphylococc* NEAR/2 aureus
#21 methicillin NEAR/2 resistan*
#22 ((#19 OR #20) AND #21)
#23 MeSH descriptor Clostridium difficile explode all trees
#24 "clostridium difficile" or "c difficle"
#25 MeSH descriptor Medication Errors explode all trees
#26 MeSH descriptor Medical Errors explode all trees
#27 (medication or medical) NEAR/2 (error* or mistake*)
#28 (surgical or operative) NEAR/2 (error* or mistake*)
#29 (anaesthetic or anesthetic) NEAR/2 (error* or mistake*)
#30 MeSH descriptor Surgical Wound Infection explode all trees
#31 (surgical or operative) NEAR/2 infect*
#32 (postsurgical or postoperative) NEAR/2 infect*
#33 (post-surgical or post-operative) NEAR/2 infect*
#34 (wrong NEAR/2 site)
#35 (#10 OR #11 OR #12 OR #13 OR #14 OR #18 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34)
#36 MeSH descriptor Facility Design and Construction explode all trees
#37 MeSH descriptor Hospital Design and Construction explode all trees
#38 (design* or construct* or build* or built or renovat* or architect* or traffic)
#39 (#36 OR #37 OR #38)

#40 (#6 AND #35)
#41 (#9 AND #35 AND #39)
#42 (#40 OR #41)

PsycINFO (Ovid Gateway). 1985-2007. 2nd March 2007.

92 records were retrieved

1. architecture/ or interior design/
2. environmental planning/
3. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
4. or/1-3
5. (single adj3 (room$ or bed$)).ti,ab.
6. (side adj3 (room$ or bed$)).ti,ab.
7. ((private or isolat$ or separate) adj3 room$).ti,ab.
8. or/5-7
9. ((operating or surgical or surgery) adj3 (room$ or suite$ or theatre$ or theater$)).ti,ab.
10. exp Infectious Disorders/
11. (infection adj3 control$).ti,ab.
12. ((hospital or healthcare or nosocomial or cross) adj3 infect$).ti,ab.
13. (mrsa or emrsa).ti,ab.
14. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).ti,ab.
15. (clostridium difficile or c difficle).ti,ab.
16. exp Errors/
17. ((medication or medical or surgical or operative or anaesthetic or anesthetic) adj3 (error$ or mistake$)).ti,ab.
18. ((surgical or operative or postsurgical or postoperative) adj3 infect$).ti,ab.
19. or/10-18
20. 8 and (4 or 19)
21. 9 and (4 or 19)
22. 20 or 21
23. limit 22 to english language

Social Policy and Practice (Ovid WebSPIRS). 2007/01. 2nd March 2007.

23 records were retrieved

#1 design* or construct* or build* or built or renovat* or architect* or traffic or size
#2 single near3 (room* or bed*)
#3 (side near3 (room* or bed*))
#4 (private or isolat* or separate) near3 room*
#5 (operating or surgical or surgery) near3 (room* or suite* or theatre* or theater*)
#6 (mrsa or emrsa)
#7 (staphylococc* adj2 (infect* or aureus)) and (methicillin adj2 resistan*)
#8 clostridium difficile or c difficle
#9 (medication or medical or surgical or operative or anaesthetic or anesthetic) near3 (error* or mistake*)
#10 (surgical or operative or postsurgical or postoperative) near3 infect*
#11 #2 or #3 or #4
#12 #6 or #7 or #8 or #9 or #10
#13 #11 and (#1 or #12)
#14 #5 and (#1 or #12)
#15 #13 or #14

EconLIT (Ovid WebSPIRS). 1969-2007/1. 2nd March 2007.

5 records were retrieved

#1 design* or construct* or build* or built or renovat* or architect* or traffic or size
#2 single near3 (room* or bed*)
#3 (side near3 (room* or bed*))
#4 (private or isolat* or separate) near3 room*
#5 (operating or surgical or surgery) near3 (room* or suite* or theatre* or theater*)
#6 (mrsa or emrsa)
#7 (staphylococc* adj2 (infect* or aureus)) and (methicillin adj2 resistan*)
#8 clostridium difficile or c difficle
#9 (medication or medical or surgical or operative or anaesthetic or anesthetic) near3 (error* or mistake*)
#10 (surgical or operative or postsurgical or postoperative) near3 infect*
#11 #2 or #3 or #4
#12 #6 or #7 or #8 or #9 or #10
#13 #11 and (#1 or #12)
#14 #5 and (#1 or #12)
#15 #13 or #14

ASSIA (CSA Ilumina). 1987-2007/1. 6th March 2007.

43 records were retrieved

((KW=((single WITHIN 3 (room* or bed*)) or (side WITHIN 3 (room* or bed*)) or ((private or isolat* or separate) WITHIN 3 room*))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or build* or built or renovat* or architect* or traffic or size)) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*)))))) or ((DE=(Operating theatres) or KW=((operating or surgical or surgery) WITHIN 3 (room* or suite* or theatre* or theater*))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or build* or built or renovat* or architect* or traffic or size)) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*))))))

Sociological Abstracts (CSA Ilumina). 1952-2007/1. 6th March 2007.

29 records were retrieved

((KW=((single WITHIN 3 (room* or bed*)) or (side WITHIN 3 (room* or bed*)) or ((private or isolat* or separate) WITHIN 3 room*))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or build* or built or renovat* or architect* or traffic or size)) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*)))))) or ((DE=(Operating theatres) or KW=((operating or surgical or surgery) WITHIN 3 (room* or suite* or theatre* or theater*))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or build* or built or renovat* or architect* or traffic or size)) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*)))))

Social Services Abstracts (CSA Ilumina). 1979-2007/1. 6th March 2007.

29 records were retrieved

((KW=((single WITHIN 3 (room* or bed*)) or (side WITHIN 3 (room* or bed*)) or ((private or isolat* or separate) WITHIN 3 room*))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or build* or built or renovat* or architect* or traffic or size)) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*)))))) or ((DE=(Operating theatres) or KW=((operating or surgical or surgery) WITHIN 3 (room* or suite* or theatre* or theater*))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or build* or built or renovat* or architect* or traffic or size)) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*)))))

Citation searches

Citation searches were undertaken using the Science Citation Index, PubMed and a cross-database search using Ovid gateway. Searches for studies by potentially relevant authors were undertaken and then papers citing the identified studies were retrieved.

The authors searched for were as follows:

Lawson B, Phiri M, Glanville R, Ulrich R, Chaudhury H, Dettenkofer M and Hignett S.

Internet searches. Organisation websites.

Medical Architecture Research Unit (MARU). Southbank University, London
http://www.lsbu.ac.uk/maru/

The Center for Health Design. Texas, USA
http://www.healthdesign.org/

Centre for Healthcare Architecture & Design (CHAD). Leeds
http://195.92.246.148/nhsestates/chad/chad_content/home/home.asp

School of Architecture, University of Sheffield
http://www.shef.ac.uk/architecture/index.html

Healthcare Ergonomics and Patient Safety research Unit, Department of Human Sciences, Loughborough University
http://www.lboro.ac.uk/departments/hu/groups/hepsu/

B.3: SEARCH STRATEGY FOR LITERATURE ON VENTILATION AND SLIPS, TRIPS AND FALLS

Searches were undertaken to identify studies about the impact of ventilation and falls.

The following databases were searched:

- MEDLINE & PreMEDLINE
- EMBASE
- CINAHL
- Health Management Information Consortium (HMIC)
- British Nursing Index (BNI)
- Science Citation Index/Social Science Citation Index (SCI/SSCI)
- BIOSIS
- Database of Abstracts of Reviews of Effects (DARE)
- Health Technology Assessment (HTA)
- NHS Economic Evaluation Database (NHS EED)
- Health Economic Evaluations Database (HEED)
- Cochrane Database of Systematic Reviews (CDSR)
- Cochrane Central Register of Controlled Trials (CENTRAL)
- PsycINFO
- Social Policy and Practice
- EconLIT
- Applied Social Sciences Index and Abstracts (ASSIA)
- Sociological Abstracts
- Social Services Abstracts

Search Results for ventilation and Slips, Trips and Falls

MEDLINE (Ovid Gateway). 1950-2007/Apr week 2. 19th April 2007.

Ventilation: 457 records were retrieved

Falls: 475 records were retrieved

1. Ventilation/
2. ventilation.ti,ab.
3. (air condition$ or aircondition$).ti,ab.
4. (air contamination or air quality).ti,ab.
5. or/1-4
6. Accidental Falls/
7. (fall or falls or falling or faller).ti,ab.
8. (slip or slips or slipped or trip or trips or tripped).ti,ab.
9. stumble$.ti,ab.
10. or/6-9
11. exp Infection Control/
12. (infection adj2 control$).ti,ab.
13. Cross Infection/
14. (hospital adj2 infect$).ti,ab.
15. (healthcare adj2 infect$).ti,ab.
16. (nosocomial adj2 infect$).ti,ab.
17. (cross adj2 infect$).ti,ab.
18. (mrsa or emrsa).ti,ab.
19. (exp Staphylococcal Infections/ or Staphylococcus aureus/) and Methicillin Resistance/
20. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).ti,ab.
21. Clostridium difficile/
22. (clostridium difficile or c difficle).ti,ab.
23. Medication Errors/
24. Medical Errors/
25. ((medication or medical) adj2 (error$ or mistake$)).ti,ab.
26. ((surgical or operative) adj2 (error$ or mistake$)).ti,ab.
27. ((anaesthetic or anesthetic) adj2 (error$ or mistake$)).ti,ab.
28. Surgical Wound Infection/
29. ((surgical or operative) adj2 infect$).ti,ab.
30. ((postsurgical or postoperative) adj2 infect$).ti,ab.
31. (wrong adj2 site).ti,ab.
32. or/11-31
33. exp "Facility Design and Construction"/
34. "Hospital Design and Construction"/
35. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
36. or/33-35
37. Animals/
38. Humans/
39. 37 not (37 and 38)
40. 5 and 32 and 36
41. 40 not 39
42. limit 41 to english language
43. 10 and 32
44. 43 not 39
45. limit 44 to english language

EMBASE (Ovid Gateway). 1980-2007/week 15. 19th April 2007.

Ventilation: 279 records were retrieved
Falls: 334 records were retrieved

1. Air Conditioning/
2. ventilation.ti,ab.
3. (air condition$ or aircondition$).ti,ab.
4. (air contamination or air quality).ti,ab.
5. or/1-4
6. Falling/
7. (fall or falls or falling or faller).ti,ab.
8. (slip or slips or slipped or trip or trips or tripped).ti,ab.
9. stumble$.ti,ab.
10. or/6-9
11. infection control/
12. (infection adj2 control$).ti,ab.
13. Hospital Infection/
14. (hospital adj2 infect$).ti,ab.
15. (healthcare adj2 infect$).ti,ab.
16. (nosocomial adj2 infect$).ti,ab.
17. (cross adj2 infect$).ti,ab.
18. methicillin resistant staphylococcus aureus/
19. (mrsa or emrsa).ti,ab.
20. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).ti,ab.
21. Clostridium Difficile/
22. (clostridium difficile or c difficle).ti,ab.
23. Medication Error/
24. Medical Error/
25. Surgical Error/
26. ((medication or medical) adj2 (error$ or mistake$)).ti,ab.
27. ((surgical or operative) adj2 (error$ or mistake$)).ti,ab.
28. ((anaesthetic or anesthetic) adj2 (error$ or mistake$)).ti,ab.
29. Surgical Infection/
30. ((surgical or operative) adj2 infect$).ti,ab.
31. ((postsurgical or postoperative) adj2 infect$).ti,ab.
32. (wrong adj2 site).ti,ab.
33. or/11-32
34. hospital building/ or hospital design/
35. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
36. 34 or 35
37. exp animal/
38. Nonhuman/
39. (rat or rats or mouse or mice or murine or rodent or rodents or hamster or hamsters or pig or pigs or porcine or rabbit or rabbits or animal or animals or dogs or dog or cats or cow or bovine or sheep or ovine or monkey or monkeys).ti,ab,sh.
40. exp human/
41. or/37-39
42. 41 not (41 and 40)
43. 5 and 33 and 36
44. 43 not 42
45. limit 44 to english language
46. 10 and 33
47. 46 not 42
48. limit 47 to english language

CINAHL (Ovid Gateway). 1982-2007/Apr week 2. 19th April 2007.

Ventilation: 140 records were retrieved

Falls: 224 records were retrieved

1. VENTILATION/
2. ventilation.ti,ab.
3. (air condition$ or aircondition$).ti,ab.
4. (air contamination or air quality).ti,ab.
5. or/1-4
6. ACCIDENTAL FALLS/
7. (fall or falls or falling or faller).ti,ab.
8. (slip or slips or slipped or trip or trips or tripped).ti,ab.
9. stumble$.ti,ab.
10. or/6-9
11. Infection Control/
12. (infection adj2 control$).ti,ab.
13. Cross Infection/
14. (hospital adj2 infect$).ti,ab.
15. (healthcare adj2 infect$).ti,ab.
16. (nosocomial adj2 infect$).ti,ab.
17. (cross adj2 infect$).ti,ab.
18. (exp Staphylococcal Infections/ or Staphylococcus aureus/) and Methicillin Resistance/
19. (mrsa or emrsa).ti,ab.
20. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).ti,ab.
21. Clostridium Difficile/
22. (clostridium difficile or c difficle).ti,ab.
23. Medication Errors/
24. Treatment Errors/
25. ((medication or medical) adj2 (error$ or mistake$)).ti,ab.
26. ((surgical or operative) adj2 (error$ or mistake$)).ti,ab.
27. ((anaesthetic or anesthetic) adj2 (error$ or mistake$)).ti,ab.
28. Surgical Wound Infection/
29. ((surgical or operative) adj2 infect$).ti,ab.
30. ((postsurgical or postoperative) adj2 infect$).ti,ab.
31. (wrong adj3 site).ti,ab.
32. or/11-31
33. "facility design and construction"/ or "hospital design and construction"/
34. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
35. 33 or 34
36. 5 and 32 and 35
37. limit 36 to english
38. 10 and 32
39. limit 38 to english

HMIC (Ovid Gateway). 2007/March. 19th April 2007.

Ventilation: 12 records were retrieved

Falls: 26 records were retrieved

1. ventilation equipment/ or air conditioning equipment/ or ventilation systems/
2. ventilation.ti,ab.
3. (air condition$ or aircondition$).ti,ab.
4. (air contamination or air quality).ti,ab.
5. or/1-4
6. exp FALLING/
7. (fall or falls or falling or faller).ti,ab.
8. (slip or slips or slipped or trip or trips or tripped).ti,ab.
9. stumble$.ti,ab.
10. or/6-9
11. Infection Control/
12. (infection adj2 control$).ti,ab.
13. Cross Infection/
14. (hospital adj2 infect$).ti,ab.
15. (healthcare adj2 infect$).ti,ab.
16. (nosocomial adj2 infect$).ti,ab.
17. (cross adj2 infect$).ti,ab.
18. (exp Staphylococcal Infections/ or Staphylococcus aureus/) and Methicillin Resistance/
19. (mrsa or emrsa).ti,ab.
20. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).ti,ab.
21. Clostridium Difficile/
22. (clostridium difficile or c difficle).ti,ab.
23. Medication Errors/
24. Treatment Errors/
25. ((medication or medical) adj2 (error$ or mistake$)).ti,ab.
26. ((surgical or operative) adj2 (error$ or mistake$)).ti,ab.
27. ((anaesthetic or anesthetic) adj2 (error$ or mistake$)).ti,ab.
28. Surgical Wound Infection/
29. ((surgical or operative) adj2 infect$).ti,ab.
30. ((postsurgical or postoperative) adj2 infect$).ti,ab.
31. (wrong adj3 site).ti,ab.
32. or/11-31
33. "facility design and construction"/ or "hospital design and construction"/
34. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
35. 33 or 34
36. 5 and 32 and 35
37. 10 and 32

BNI (Ovid Gateway). 1985-2007/March. 19th April 2007.

Ventilation: 2 records were retrieved

Falls: 10 records were retrieved

1. ventilation.mp.
2. (air condition$ or aircondition$).mp.
3. (air contamination or air quality).mp.
4. or/1-3
5. (fall or falls or falling or faller).mp.
6. (slip or slips or slipped or trip or trips or tripped).mp.
7. stumble$.mp.
8. or/5-7
9. (infection adj3 control$).mp.
10. (hospital adj3 infect$).mp.
11. (healthcare adj3 infect$).mp.
12. (nosocomial adj3 infect$).mp.
13. (cross adj3 infect$).mp.
14. (mrsa or emrsa).mp.
15. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).mp.
16. (clostridium difficile or c difficle).mp.
17. ((medication or medical) adj3 (error$ or mistake$)).mp.
18. ((surgical or operative) adj3 (error$ or mistake$)).mp.
19. ((anaesthetic or anesthetic) adj3 (error$ or mistake$)).mp.
20. ((surgical or operative) adj3 infect$).mp.
21. ((postsurgical or postoperative) adj3 infect$).mp.
22. (wrong adj3 site).mp.
23. or/9-22
24. "hospital planning and design"/
25. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
26. 24 or 25
27. 4 and 23 and 26
28. 8 and 23

SCI/SSCI (Web of Science). 1900-2007/April. 19th April 2007.

Ventilation: 218 records were retrieved
Falls: 141 records were retrieved

TS=(ventilation) or TS=("air condition*") or TS=("aircondition*") or TS=("air contamination") or TS=("air quality")
TS=(fall or falls or falling or faller)
TS=(slip or slips or slipped or trip or trips or tripped or stumble*)
#2 or #3
TS=("infection control")
TS=("hospital infect*")
TS=("healthcare infect*")
TS=("nosocomial infect*")
TS=("cross infect*")
TS=(mrsa or emrsa)
TS=(staphylococc* SAME infect*) or TS=(staphylococc* SAME aureus)
TS=(methicillin SAME resistan*)
#11 AND #12
TS=("clostridium difficile") or TS=("c difficle")

TS=("medication error*") or TS=("medical error*") or TS=("medication mistake*") or TS=("medical mistake*") or TS=("surgical error*") or TS=("operative error*") or TS=("surgical mistake*") or TS=("operative mistake*")
TS=("surgical infect*") or TS=("operative infect*") or TS=("postsurgical infect*") or TS=("postoperative infect*") or TS=("post-surgical infect*") or TS=("post-operative infect*")
TS=("wrong site")
#17 OR #16 OR #15 OR #14 OR #13 OR #10 OR #9 OR #8 OR #7 OR #6 OR #5
TS=(design* or construct* or build* or built or renovat* or architect* or traffic or size)
#1 and #18 and #19
#4 and #18
DocType=All document types; Language=English

DARE (CRD databases). 1994-2007/Mar. 19th April 2007.

Ventilation: 7 records were retrieved

Falls: 3 records were retrieved

s ventilation or air(w)condition$ or aircondition$ or air(w)contamination or air(w)quality
s fall or falls or falling or slip or slips or slipped or trip or trips or tripped or stumble$
s infection(w3)control$
s hospital(w3)infect$
s healthcare(w3)infect$
s nosocomial(w3)infect$
s cross(w3)infect$
s mrsa or emrsa
s staphylococc$(w2)(infect$ or aureus) and methicillin(w2)resistan$
s clostridium(w)difficile or c(w)difficle
s (medication or medical)(w3)(error$ or mistake$)
s (surgical or operative)(w3)(error$ or mistake$)
s (anaesthetic or anesthetic)(w3)(error$ or mistake$)
s (surgical or operative)(w3)infect$
s (postsurgical or postoperative)(w3)infect$
s wrong(w3)site
s s3 or s4 or s5 or s6 or s7 or s8 or s9 or s10 or s11 or s12 or s13 or s14 or s15 or s16
s design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size
s s1 and s17 and s18
s s2 and s17

NHS EED (CRD databases). 1994-2007/Mar. 19th April 2007.

Ventilation: 9 records were retrieved

Falls: 8 records were retrieved

s ventilation or air(w)condition$ or aircondition$ or air(w)contamination or air(w)quality
s fall or falls or falling or slip or slips or slipped or trip or trips or tripped or stumble$
s infection(w3)control$
s hospital(w3)infect$
s healthcare(w3)infect$
s nosocomial(w3)infect$
s cross(w3)infect$
s mrsa or emrsa
s staphylococc$(w2)(infect$ or aureus) and methicillin(w2)resistan$
s clostridium(w)difficile or c(w)difficle

s (medication or medical)(w3)(error$ or mistake$)
s (surgical or operative)(w3)(error$ or mistake$)
s (anaesthetic or anesthetic)(w3)(error$ or mistake$)
s (surgical or operative)(w3)infect$
s (postsurgical or postoperative)(w3)infect$
s wrong(w3)site
s s3 or s4 or s5 or s6 or s7 or s8 or s9 or s10 or s11 or s12 or s13 or s14 or s15 or s16
s design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size
s s1 and s17 and s18
s s2 and s17

HTA (CRD databases). 1994-2007/Mar. 19th April 2007.

Ventilation: 1 records were retrieved

Falls: 4 records were retrieved

s ventilation or air(w)condition$ or aircondition$ or air(w)contamination or air(w)quality
s fall or falls or falling or slip or slips or slipped or trip or trips or tripped or stumble$
s infection(w3)control$
s hospital(w3)infect$
s healthcare(w3)infect$
s nosocomial(w3)infect$
s cross(w3)infect$
s mrsa or emrsa
s staphylococc$(w2)(infect$ or aureus) and methicillin(w2)resistan$
s clostridium(w)difficile or c(w)difficle
s (medication or medical)(w3)(error$ or mistake$)
s (surgical or operative)(w3)(error$ or mistake$)
s (anaesthetic or anesthetic)(w3)(error$ or mistake$)
s (surgical or operative)(w3)infect$
s (postsurgical or postoperative)(w3)infect$
s wrong(w3)site
s s3 or s4 or s5 or s6 or s7 or s8 or s9 or s10 or s11 or s12 or s13 or s14 or s15 or s16
s design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size
s s1 and s17 and s18
s s2 and s17

HEED (CD-ROM). 2007/April. 19th April 2007.

Ventilation: 9 records were retrieved

Falls: 8 records were retrieved

AX=ventilation
AX=(air conditioning) or (air condition) or (air conditioned) or (airconditioning) or (airconditioned) or (aircondition) or (air contamination) or (air quality)
CS=1 or 2
AX=(fall or falls or falling or slip or slips or slipped or trip or trips or tripped or stumble)
AX='infection control' within 3
AX='hospital infect' within 3 OR 'hospital infection' within 3 OR 'hospital infections' within 3
AX='healthcare infect' within 3 OR 'healthcare infection' within 3 OR 'healthcare infections' within 3
AX='nosocomial infect' within 3 OR 'nosocomial infection' within 3 OR 'nosocomial infections' within 3

AX='cross infect' within 3 OR 'cross infection' within 3 OR 'cross infections' within 3
AX=mrsa or emrsa
AX=(Meticillin Resistant Staphylococcus Aureus)
AX=(clostridium difficile) or (c difficle)
AX=(medication error) or (medication errors) or (medication mistake) or (medication mistakes) or (medical error) or (medical errors) or (medical mistake) or (medical mistakes)
AX=(surgical error) or (surgical errors) or (surgical mistake) or (surgical mistakes) or (operative error) or (operative errors) or (operative mistake) or (operative mistakes)
AX=(anaesthetic error) or (anaesthetic errors) or (anaesthetic mistake) or (anaesthetic mistakes) or (anesthetic error) or (anesthetic errors) or (anesthetic mistake) or (anesthetic mistakes)
AX='surgical infect' within 3 OR 'surgical infection' within 3 OR 'surgical infections' within 3 OR 'operative infect' within 3 OR 'operative infection' within 3 OR 'operative infections' within 3
AX='postsurgical infect' within 3 OR 'postsurgical infection' within 3 OR 'postsurgical infections' within 3 OR 'postoperative infect' within 3 OR 'postoperative infection' within 3 OR 'postoperative infections' within 3 OR 'post-surgical infect' within 3 OR 'post-surgical infection' within 3 OR 'post-surgical infections' within 3 OR 'post-operative infect' within 3 OR 'post-operative infection' within 3 OR 'post-operative infections' within 3
AX=(wrong site)
CS=5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18
AX=design or designed or designs or designer or construct or construction or constructed or build or building or buildings or built or renovate or renovation or renovated or architect or architects or architecture or traffic or size
CS=3 and 19 and 20
CS=4 and 19

CDSR and CENTRAL (Cochrane Library. Issue 2:2007. 19th April 2007.

CDSR.

0 records were retrieved in total

CENTRAL.

Ventilation: 2 records were retrieved

Falls: 0 records were retrieved

#1 MeSH descriptor Ventilation
#2 "ventilation"
#3 "air condition*" or aircondition*
#4 "air contamination" or "air quality"
#5 (#1 OR #2 OR #3 OR #4)
#6 MeSH descriptor Accidental Falls
#7 "fall" or "falls" or "falling" or "faller"
#8 "slip" or "slips" or "slipped" or "trip" or "trips" or "tripped" or stumble*
#9 (#7 OR #8)
#10 MeSH descriptor Infection Control explode all trees
#11 (infection NEAR/2 control*)
#12 MeSH descriptor Cross Infection explode all trees
#13 (hospital or healthcare or nosocomial or cross) NEAR/ infect*
#14 (mrsa or emrsa)
#15 MeSH descriptor Staphylococcal Infections explode all trees
#16 MeSH descriptor Staphylococcus aureus explode all trees

#17 MeSH descriptor Methicillin Resistance explode all trees
#18 ((#15 OR #16) AND #17)
#19 staphylococc* NEAR/2 infect*
#20 staphylococc* NEAR/2 aureus
#21 methicillin NEAR/2 resistan*
#22 ((#19 OR #20) AND #21)
#23 MeSH descriptor Clostridium difficile explode all trees
#24 "clostridium difficile" or "c difficile"
#25 MeSH descriptor Medication Errors explode all trees
#26 MeSH descriptor Medical Errors explode all trees
#27 (medication or medical) NEAR/2 (error* or mistake*)
#28 (surgical or operative) NEAR/2 (error* or mistake*)
#29 (anaesthetic or anesthetic) NEAR/2 (error* or mistake*)
#30 MeSH descriptor Surgical Wound Infection explode all trees
#31 (surgical or operative) NEAR/2 infect*
#32 (postsurgical or postoperative) NEAR/2 infect*
#33 (post-surgical or post-operative) NEAR/2 infect*
#34 (wrong NEAR/2 site)
#35 (#10 OR #11 OR #12 OR #13 OR #14 OR #18 OR #22 OR #23 OR #24 OR #25 OR #26 OR #27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34)
#36 MeSH descriptor Facility Design and Construction explode all trees
#37 MeSH descriptor Hospital Design and Construction explode all trees
#38 (design* or construct* or build* or built or renovat* or architect* or traffic)
#39 (#36 OR #37 OR #38)
#40 (#5 AND #35 AND #39)
#41 (#9 AND #35)

PsycINFO (Ovid Gateway). 1985-2007/April week 1. 19th April 2007.

Ventilation: 3 records were retrieved

Falls: 49 records were retrieved

1. architecture/ or interior design/
2. environmental planning/
3. (design$ or construct$ or build$ or built or renovat$ or architect$ or traffic or size).ti,ab.
4. or/1-3
5. ventilation.ti,ab.
6. (air condition$ or aircondition$ or air contamination or air quality).ti,ab.
7. or/5-6
8. exp Falls/
9. (fall or falls or falling or slip or slips or slipped or trip or trips or tripped or stumble$.ti,ab.
10. exp Infectious Disorders/
11. (infection adj3 control$).ti,ab.
12. ((hospital or healthcare or nosocomial or cross) adj3 infect$).ti,ab.
13. (mrsa or emrsa).ti,ab.
14. ((staphylococc$ adj2 (infect$ or aureus)) and (methicillin adj2 resistan$)).ti,ab.
15. (clostridium difficile or c difficile).ti,ab.
16. exp Errors/
17. ((medication or medical or surgical or operative or anaesthetic or anesthetic) adj3 (error$ or mistake$)).ti,ab.
18. ((surgical or operative or postsurgical or postoperative) adj3 infect$).ti,ab.
19. or/10-18
20. 8 and (4 or 19)
21. 9 and (4 or 19)

22. 20 or 21
23. limit 22 to english language

Social Policy & Practice (Ovid WebSPIRS). 2007/03. 19th April 2007.

Ventilation: 0 records were retrieved

Falls: 2 records were retrieved

#1 design* or construct* or build* or built or renovat* or architect* or traffic or size
#2 ventilation
#3 (air condition*) or aircondition*
#4 (air contamination or air quality)
#5 (fall or falls or falling or slip or slips or slipped or trip or trips or tripped or stumble*)
#6 (mrsa or emrsa)
#7 (staphylococc* adj2 (infect* or aureus)) and (methicillin adj2 resistan*)
#8 clostridium difficile or c difficle
#9 (medication or medical or surgical or operative or anaesthetic or anesthetic) near3 (error* or mistake*)
#10 (surgical or operative or postsurgical or postoperative) near3 infect*
#11 #2 or #3 or #4
#12 #6 or #7 or #8 or #9 or #10
#13 #11 and (#1 or #12)
#14 #5 and (#1 or #12)
#15 #13 or #14

EconLIT (Ovid WebSPIRS). 1969-2007/3. 19th April 2007.

Ventilation: 0 records were retrieved

Falls: 0 records were retrieved

#1 design* or construct* or build* or built or renovat* or architect* or traffic or size
#2 ventilation
#3 (air condition*) or aircondition*
#4 (air contamination or air quality)
#5 (fall or falls or falling or slip or slips or slipped or trip or trips or tripped or stumble*)
#6 (mrsa or emrsa)
#7 (staphylococc* adj2 (infect* or aureus)) and (methicillin adj2 resistan*)
#8 clostridium difficile or c difficle
#9 (medication or medical or surgical or operative or anaesthetic or anesthetic) near3 (error* or mistake*)
#10 (surgical or operative or postsurgical or postoperative) near3 infect*
#11 #6 or #7 or #8 or #9 or #10
#13 #1 and (#2 or #3 or #4) and #11
#14 #5 and #11

ASSIA (CSA Ilumina). 1987-2007/4. 19th April 2007.

Ventilation: 0 records were retrieved

Falls: 0 records were retrieved

((KW=(ventilation or (air condition*) or aircondition*) or KW=((air contamination) or (air quality))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or (build* or renovat* or architect* or traffic or size))) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*))))))) or (((falls) or (DE=falls or KW=((fall or falls or falling) or (slip or slips or slipped or trip or trips or tripped) or stumble*))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or (build* or renovat* or architect* or traffic or size))) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*)))))))

Sociological Abstracts (CSA Ilumina). 1952-2007/4. 19th April 2007.

Ventilation: 0 records were retrieved

Falls: 0 records were retrieved

((KW=(ventilation or (air condition*) or aircondition*) or KW=((air contamination) or (air quality))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or (build* or renovat* or architect* or traffic or size))) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*))))))) or (((falls) or (DE=falls or KW=((fall or falls or falling) or (slip or slips or slipped or trip or trips or tripped) or stumble*))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or (build* or renovat* or architect* or traffic or size))) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*)))))))

Social Services Abstracts (CSA Ilumina). 1979-2007/4. 19th April 2007.

Ventilation: 0 records were retrieved

Falls: 0 records were retrieved

((KW=(ventilation or (air condition*) or aircondition*) or KW=((air contamination) or (air quality))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or (build* or renovat* or architect* or traffic or size))) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*))))))) or (((falls) or (DE=falls or KW=((fall or falls or falling) or (slip or slips or slipped or trip or trips or tripped) or stumble*))) and ((DE=(architecture or (interior design)) or KW=(design* or construct* or (build* or renovat* or architect* or traffic or size))) or ((DE=(Infectious diseases) or KW=((infection WITHIN 3 control*) or ((hospital or healthcare or nosocomial or cross) WITHIN 3 infect*) or (mrsa or emrsa))) or (DE=errors or KW=(((medication or medical or surgical or operative or anaesthetic or anesthetic) WITHIN 3 (error* or mistake*)) or ((surgical or operative or postsurgical or postoperative) WITHIN 3 infect*)))))))

Citation Searches

Citation searches were undertaken using the Science Citation Index, PubMed and a cross-database search using Ovid gateway. Searches for studies by potentially relevant authors were undertaken and then papers citing the identified studies were retrieved.

The authors searched for were as follows:

Lawson B, Phiri M, Glanville R, Ulrich R, Chaudhury H, Dettenkofer M and Hignett S.

APPENDIX C

Quality Grading Summary Sheet

Quality Grading Summary: Hospital Design Systematic Literature Review

GRADE

Grade	Study Quality
	++ All or most of the criteria have been fulfilled. Where they have not been fulfilled the conclusions are thought very unlikely to alter.
	+ Some of the criteria have been fulfilled. Those criteria that have not been fulfilled or not adequately described are thought unlikely to alter the conclusions.
	- Few or no criteria have been fulfilled. The conclusions of the study are thought likely or very likely to alter.

Grade	Study Type
	1 - Meta-analyses, systematic reviews of RCTs or RCTs (including cluster RCTs).
	2 - Systematic reviews of, or individual, non-randomised controlled trials, case-control studies, cohort studies, controlled before-and-after (CBA) studies, interrupted time series studies and correlation studies.
	3 - Non-analytic studies (for example case reports, case series studies).
	4 - Expert opinion, formal consensus.

Comments:
Name of Assessor:
Date:

APPENDIX D

Summary of Quality Appraisals

Taken from:

Methods for the Development of NICE Public Health Guidance

Study type	Quality assessment methodology
Before and after (BA) studies	• BA studies have lower internal validity than study designs in which outcomes in the intervention (exposed) group are compared with outcomes in a concurrent (unexposed) control group; • Is there any evidence for a prevailing 'temporal trend' (that may confound study findings; • Is any indication of selection bias; • A good quality BA study will demonstrate clear and consistent inclusion and exclusion criteria in subject selection; • Causality between intervention and outcome will often be strengthened when observed changes are significant and occur soon after the intervention.
Case control (CC) studies	• CC studies have lower internal validity than study designs in which outcomes in the intervention (exposed) group are compared with outcomes in a concurrent (unexposed) control group; • Is there is any indication of potential confounding factors; • Is any indication of selection bias; • Is there significant recall bias.
Cluster randomised controlled trial	• Is the method of randomisation truly random (compared to pseudo-randomisation procedures); • Has the allocation of clusters to either intervention or control been influenced by the person doing the allocation; • Is the trial externally valid: i.e. the extent to which the findings of a study are applicable or generalisable beyond the confines of the study itself; • Were appropriate analyses conducted.
Cohort studies	• These are considered to be the most reliable observational study design and are particularly useful for examining the effects of harmful exposures; • Is there any indication of selection bias or confounding; in the case of retrospective cohort studies; • Is there significant recall bias; • In the case of prospective cohort studies, is there significant withdrawal bias.
Correlational study	• Are there any potential confounding factors; • Are there significant sources of measurement bias.
Cross sectional study	• Are there any potential confounding factors; • Are there significant sources of measurement bias.
Interrupted time series	• Were outcomes assessed before and after an intervention was delivered; • Is it clear precisely when an intervention took place; • Is there any evidence for a prevailing 'temporal trend' that may confound study findings.
Non-randomised controlled trials (NRCT)	• NRCT's are generally considered to be less reliable than randomised controlled trials; • Non-randomisation of participants makes selection participant and observer biases much more likely and confounding factors may exist; • Is there significant baseline differences between groups.
Randomised controlled trials (RCT)	• RCTs are generally considered to be the most rigorous experimental study design as the randomisation of participants helps to minimise confounding and other sources of bias; • Is the method of randomisation is truly random; • Could the allocation of participants to either intervention or control have been influenced by the person doing the allocation; • Is the trial externally valid –it is not unusual for an RCT to have strong internal validity, but poor external validity.

APPENDIX E

Supplementary Information from the Willingness to Pay Study

VALUATION SHEET RULES

1. The first 2 amounts are asked fully so that the participant gets used to the way the question works, i.e. "Would you be prepared to pay £X for a single-bed room as opposed to a 4-bed room for one night?"

- After the first 2 amounts, you don't necessarily have to repeat the whole phrase using the different amounts instead you can say "how about £60?" or "would you pay £80?" etc. if you feel the participant is understanding the question;
- After using the short questions for 3 or 4 amounts, ask them the next amount using the full phrase again, to remind them of what they're being asked.

2. Make sure you ask a minimum of 8 amounts.

3. The second amount must be in the extreme bottom 5 amounts (£0, £10, £20, £30, £40) or the extreme top 5 amounts (£700, £800, £900, £1000, £1000+), depending on the answer to the first amount.

4. If they answer 'yes' they would be prepared to pay → ask a higher amount.

5. If they answer 'no' they would not be prepared to pay → ask a lower amount.

6. At the end of each question, confirm that "the maximum amount that you would be prepared to pay is ……" (the maximum amount is shown by the highest amount that the participant said 'yes' to).

7. There must be 2 yes's and 2 no's (yynn) in order to show the point where the participant switches from saying yes to no (see examples).

8. If answer 'yes' to £1000+, ask them, "how much you would be prepared to pay?" (so that they specify an actual amount).

9. If the participant gives an inconsistent answer (i.e. the pattern does not flow from yes's to no's (yyyynnnnn), but instead has yyynynnn for example) ask the participant ALL amounts.

10. When asking £0 → use the phrase, "If it were no extra cost, would you prefer a single-bed room as opposed to a 4-bed room?"

- If 'yes': proceed as normal (i.e. make sure a minimum of 8 questions have been asked);
- If 'no': still ask a minimum of 8 questions. If participant said no to all amounts, do not need to confirm the maximum they would be prepared to pay (since they are not willing to pay at all);
- The 2 yes's and 2 no's are not required in this situation, since the participant is expected to answer all 'no's to the questions (if they are consistent).

Valuation Sheet

- Complete using y and n for ‘yes’ and ‘no’;
- For each valuation question, make sure that the question sequence is recorded in the column on the right (i.e. an order 1, 2, 3… showing which amount was asked first, second, third etc.)

Would you be prepared to pay:	Question 13		Question 14		Question 15		Question 18		Question 19	
£1,000+										
£1,000										
£900										
£800										
£700										
£600										
£500										
£400										
£300										
£200										
£160										
£120										
£100										
£80										
£60										
£50										
£40										
£30										
£20										
£10										
£0										

Interviewer Name: _____

ID Check (please record the ID that appears on computer screen): _____

Participant ID:
00X

APPENDIX F

Pilot Survey Feedback

F.1: PILOT POSTAL SURVEY FEEDBACK

Pilot Results: 21st August 2007

Sarah Whitehead and Matthew Bending.

F.2: OVERALL UNDERSTANDING

The survey was piloted to 20 members of the University of York on the 14th, 15th and 16th August 2007. Participants commented that the font and layout were easy to read, and most found the survey easy to understand. Ninety percent of participants rated the survey very easy or easy to complete and understand.

F.2.1: Information Sheet

- Found this very clear;
- One participant suggested altering the wording of "survey methodology" to something less confusing;
- Participants said that the survey did not make them think that they would be charged for the options now or in the future.

F.2.2: Section A: Attitudes towards Hospitals

- This section appeared to be straight-forward for participants to fill out;
- The ranking of the aspects in Q3 and Q4 generated confusion in the majority of participants. Most people instinctively expected to rank the aspects by 1 indicating the most important aspect and 5 the least important. The survey asked for the ranking to be done using 5 as the most important. The ranking has been altered;
- Some participants noted that there were aspects other than those they had been asked to rank that were important to them;
- The order of the aspects presented in Q3 and Q4 could possibly be randomised. A check was made to see if participants displayed a tendency towards picking the aspect at the top of the list and this was found not to be the case.

F.2.3: Section B: Experience of Hospitals

- One participant had been a day patient and therefore had some experience of hospitals, but due to the set-up of the survey, was unable to provide information relating to this → in Q5 'overnight' was removed to encompass patients that also stayed in hospital as in patients and outpatients;
- An extra question was added after Q5 (and the command to move to Q12) asking if on their last visit to hospital they stayed overnight or visited hospital as a day patient (i.e. did not stay overnight). Then throughout the remainder of the survey it will be apparent what type of patient they were on the visit they described;
- Q6: Add in extra category for 'other, please specify' or 'treated outside England';
- Q8: All categories appear to have been covered. Alter wording to "please specify ward size as far as you can (i.e. number of beds) below";
- Q9: Provide space for comments on why were satisfied/unsatisfied.

F.2.4: Section C: Valuation Question – Single Rooms

Valuation Example

- Most found the valuation example useful in understanding the valuation questions that were to follow. One participant suggested re-wording the explanation and reducing the emphasis on the reference items.

Reference Items

- Many participants said they found the reference points useful in indicating the relative price of other goods/services. Others noted that they were useful but that they personally did not use them, whilst some did not find them useful in making their valuations. One found them confusing initially and said they did not need them. Most people tended to have stopped using them after the first questions as they noticed they were the same throughout. One said that the reference points were not relevant to her situation, so did not use them for this reason;
- In the description of the situation, it may be useful to emphasise that the 4-bed room will involve sharing with 3 other patients, and the 2-bed room with 1 other patient;
- Make the italics/bold/underlined formatting consistent across questions – to highlight the important parts (i.e. one night, single-bed room etc.);
- Make sure per night is highlighted/different colour in all questions, since some participants thought about the total cost rather than per night cost in Q14 & Q15 where the stay was for 5 nights;
- Clarify what the £0 box means (indifference/would not pay/ would pay not to have the design) as several participants were confused by this;
- The use of the bullet points showing different things that may be important to consider when making valuations were found to be useful reminders/indicators to participants, although not everyone used these to aid their valuations. The ordering of the bullet points did not appear to affect participant's valuations when asked about this;
- One suggestion for a further bullet point was for the amount of space visitors/size of area in the room. Another was for the inclusion of a category relating to lighting;
- Making the bullet points more concise was a further suggestion, as the participant noted that the bullet points in the flooring valuation section were good due to them being shorter;
- Q17 & Q18: Add in for a single-bed room with en-suite:
    - Staff presence was suggested as a further option that is important here;
    - Adding in space to provide another reason that was important to the participants was suggested, as it was difficult to choose just one reason for some participants.
- In making their valuations, many had the cost of a hotel room in mind;
- When deciding on their valuations, most worked from the top of the scale downwards, with others deciding on a specific amount and then ticking/crossing the remaining boxes accordingly. A couple worked from the bottom upwards;

- The majority of participants did not expect to have to pay for the options now or in the future – they noted that this had been clearly explained in the information sheet and survey;
- A couple of participants pointed out that they found the bullet points for the single room section harder to read than the more concise points in the flooring section;
- Several participants noted that some of the aspects such as noise levels and comfort are interlinked;
- It was suggested that the scale should have more values around, say, the £150 amount. One participant stated that they had chosen £100 since it was a nice round figure. Two separate scales were used in the survey to consider whether the scale influenced the participant's response. The results of the bias testing did not find the scale to influence participant's responses.

F.2.5: Section D: Valuation Question – Flooring

- Underline the sentence which says the rooms will be exactly the same apart from the flooring;
- Many participants were not willing to pay for carpet; with some saying it was an unreasonable question to ask. A few participants did prefer carpet to resin, some of which were not prepared to pay for it however;
- An additional sentence describing vinyl (and for wooden flooring, to be consistent) would have been considered helpful by many participants;
- Some participants noted that the colour of the flooring influenced their answers;
- Some only noticed the colour of the floor;
- Some would be prepared to pay for wooden flooring, when they were asked about this;
- Q17 and Q18 need to be altered to allow for people being indifferent etc. (as participant 017 was);
- Zero value: discuss whether should explain this in valuation example or whether will bias about this amount (i.e. ticking £0 implies have a preference for it, may not necessarily pay for it; crossing £0 implies would not pay for it).

F.2.6: Section E: Demographics

- There were no major problems or concerns about this section;
- One suggestion was to add a category in the income question for 'prefer not to specify'. Also, a category to allow for participants being students may be an option to incorporate;
- Another participant pointed out that you may be unaware of your ethnic background.