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Evaluating a major innovation in hospital design: workforce implications and impact on patient and staff experiences of all single room hospital accommodation

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Phase 1 of this study (the 'before' move into all single rooms data collection- Jan 2010 Dec 2012) was funded by the Engineering and Physical Sciences Research Council (EPSRC) as a peer reviewed collaborative project within the Health and Care Infrastructure Research and Innovation Centre (HaCIRIC). Phase 1 provides in-depth research on care processes and staff and patient experiences in the existing accommodation at Pembury and Kent & Sussex hospitals during the period in the run-up to the move to the new hospital (Jan and Sept 2011) and its immediate aftermath. This proposal outlines (Phase 2) in-depth research on care processes and staff and patient experiences post move into the new hospital which has 100% single room in patient accommodation.

Evaluating a major innovation in hospital design: workforce implications and impact on patient and staff experiences of all single room hospital accommodation

1. Aims/Objectives:

The overall aim of the project is to explore the implications for the clinical workforce and patients of a move from 'traditional' facilities, comprising primarily open plan 'Nightingale' style wards, to a newly built facility in which all accommodation is in single rooms.

The research will be grounded in experiences of staff[1] and patients and issues relevant to different staff and patient groups, which are likely to vary across settings, will be allowed to surface during the research.

We will gather contextual information so that we can shed light on the process of implementing change with a move to a new facility (to enable us to give advice to others attempting similar changes later) which we also anticipate surfacing in staff and stakeholder interviews. We will make recommendations relating to (a) future workforce configuration and practices and (b) how these are likely to impact upon service effectiveness, efficiency, quality and safety (including staff and patient experiences) based on a comparative analysis of the 'before' and 'after' data.

Table 1 provides details of the specific research aims, the research questions that align with these and the principle methods that will be used to gather data to answer these.

[1] Staff in this proposal refers to the registered and unregistered nursing workforce, midwives, and Allied Health Professionals.

Table 1: Aims, research questions and methods

	Aims To identify the impact of the move to 100% single room accommodation on:	**Research question(s)**	**Methods**
1	Care delivery and working practices	How are work patterns disrupted and reconstituted, including through trial and error of new approaches (and to what extent are these successful / unsuccessful)?	CASE STUDY DATA: • Observation • Staff travel distances • Staff survey • Staff interviews (including reflexive photography) • Patient interviews • Stakeholder interviews
2	Staff experience	How are staff perceptions and experiences of the move to single rooms shaped by formal organisational and change management processes? Are there advantages and disadvantages for staff of a move to all single room accommodation? Does the move to all single room accommodation affect staff experience and wellbeing and their ability to deliver effective and high quality care?	CASE STUDY DATA: • Observation • Staff travel distances • Staff survey • Staff interviews (including reflexive photography) • Stakeholder interviews SECONDARY DATA: Routine workforce data
3	Patient experience	Are there advantages and disadvantages for patients of a move to all single room accommodation? Does the move to all single room accommodation affect patient experience and wellbeing? Does it affect diverse patient groups differently?	CASE STUDY DATA: • Observation • Patient interviews - to include some patients who experienced the *before* hospital accommodation
4	Safety outcomes (including falls and infection rates)	How does a move to a new build influence patient safety outcomes compared to remaining in standard accommodation?	**QUASI-EXPERIMENT** SECONDARY DATA: Infection rates; local incidents report (for falls)
5	Costs (including nurse staffing)	How does the move to all single room hospital accommodation impact upon: relative costs; nurse staffing and cost per nursing bed; patient contact hours per patient day?	**ECONOMIC ANALYSIS** SECONDARY DATA: • Bed occupancy; staffing; payroll; length of stay; build costs; infection rates; • + use of case study observation / interview data

2. Background:

All single room accommodation in hospitals represents a major innovation in the UK and a change to the current organisation and delivery of healthcare. Since 2001 Department of Health guidance has been that 'the proportion of single rooms in new hospital developments should aim to be 50% and must be higher than the facilities they are replacing' [1]. Increasingly new hospital design includes greater ratios of single bedded accommodation and in some cases all single in-patient rooms [2]. Wards comprising 100 per cent single rooms will require changes to the model or process for care organisation and delivery, and new organisational routines and behaviours. The research will be able to make recommendations for Trusts undergoing similar transitions, and will provide examples of good practice in relation to patient care and nursing practices in single room ward environments.

There is little evidence from the UK on which to base decisions about moves to single rooms, including the private health sector where this model is much more prevalent. A recent review of hospital design options by the York Health Economics Consortium group (YHEC) found scant and ambiguous evidence relating to the impact of single room on patient safety and concluded that more UK based research was required [3]. Little is known about likely impacts on staff and patients. Most evidence derives from studies in the USA and Scandinavia [4-6]. This is unlikely to directly translate to the UK due to different financial, cultural and organisational systems.

Increasing the proportion of single rooms in the NHS - from the current 28% of all beds - is partly a response to the perceived public desire for such accommodation and also a response to problems arising from mixed sex wards. However the limited evidence suggests that the two issues are interrelated and does not clearly point to a preference for single bed rooms among patients, although members of the public and hospital staff showed a strong preference as assessed by willingness to pay [3]. However individual study results vary. One survey found that around 35% of the public would prefer single rooms, while around 40% preferred small (single-sex) bays [7]. In other studies patients rated privacy and personal space important but they also said that when ill they wanted nurses to be closer [8-10].

Claimed advantages of single room accommodation for patients include: increased privacy, dignity and comfort and less disruption from other patients, improved control over the environment, enhanced sleep, and improved contact with families, increased patient comfort, privacy and safety, and increased patient satisfaction [2-7]. Beneficial outcomes may include: reduced infection rates, fewer medical errors and faster patient recovery rates [4-6]. Potential disadvantages include: reduced social interaction and thus patient isolation, less surveillance by staff, increased failure to rescue and increased rates of slips, trips and falls [2, 4-6]. Claimed advantages of single room patient accommodation for staff include: potential for more personalised patient contact, potentially fewer interruptions and, with medical storage in rooms and less distraction, a decreased chance of prescribing errors [3]. Disadvantages include increased staff travel distances, the potential need for an increase in

staffing levels as a result of more single room occupancy and/or adjustments to staff skill mix [2, 5, 6]. Recent results from the York Health Economics Consortium evaluation of a pilot ward of 100% single rooms at Hillingdon Hospital suggest that while patients in single rooms were more satisfied than those in multi-bed rooms, infection rates did not decrease, while cleaning costs increased. Length of stay was unaltered. The wider evidence of the impact of single rooms on infection rates is conflicting [12, 13]. Little is known about the impact on staff efficiency, quality of care, nursing costs per occupied bed, and patient satisfaction across different age and cultural groups [14]. Clearly, the situation is complex and trade-offs may be necessary [11].

Hospitals with 100% single rooms require innovation in working practices in order to ensure that the potential for improved efficiency and productivity, quality and safety and patient experience is fully realised. Through the case study research, the project will generate evidence relating to changes in working practices (in particular, whether single room ward design leads to an increase in direct care time and nurse staffing requirements). Patient interviews will explore the impact of single rooms on patient experiences of care and identify the different ways in which single rooms contribute to, and create obstacles for, patient satisfaction. The proposed research will provide evidence on safety outcomes (through analysis of pre and post move routinely collected data) both at Maidstone & Tunbridge Wells and also for other comparator sites, and on costs.

The proposed research will contribute to improving decision making in relation to single rooms, ward layout and optimum working practices to enhance care delivery. It will be useful to staff and patients where such changes are planned as well as NHS management, policy and commissioning bodies and NHS research users.

This research seeks to add to the international evidence base through identifying the ways in which single room wards support and hinder efficiency, effectiveness, quality and safety in the NHS. It is essential that new single room hospital developments in England are fully evaluated in order to build on the findings from the Hillingdon Hospital single room pilot in relation to the advantages and disadvantages of single room ward design and implications for efficiency, quality and safety.

While the primary focus of this research is on one healthcare organisation (Maidstone & Tunbridge Wells NHS Trust), it will provide a detailed understanding of the impact of single rooms and the range of potential benefits across different clinical areas and patient groups. Four areas have been selected as case studies (maternity, elderly care, general surgery and acute assessment), and this will ensure that findings are applicable to a wide variety of settings within the acute sector. The comparator quasi-experimental element of the research provides evidence across a range of hospitals and will further enhance the generalisability of the findings and provide important evidence for other NHS organisations to use in decision making in relation to the design of new and refurbished ward buildings. This research builds both on the (limited) international evidence base, and emerging evidence from

single rooms builds in the UK. It also builds on theoretical work funded by the NIHR SDO R&D programme: the major review of the diffusion of innovations literature, the findings of which have helped shape this proposal (see Greenhalgh et al 2005, *Diffusion of Innovations in Health Service Organisations*. Oxford: Blackwell).

3. Need:

The NHS management and built environment community have expressed a need for this research and suggest the evidence generated by this study will be highly relevant and important to the needs of the NHS now and certainly the NHS of the future: In the course of our Phase 1 before study we have engaged with architects; builders; designers and NHS managers all of whom have shown great interest in our study and all of whom are keen and excited to know the outcomes of this work. Everyone we have met has suggested this is a timely and critically important study which will add considerably to the UK evidence base.

Stakeholders from these communities wish to know the impact of innovations in design and the built environment upon patients who are cared for in them, staff who work in them and more broadly upon quality outcomes and costs. The NHS estate has been identified as a key area for financial savings, for example through better asset management and space utilisation changes (HM Treasury, 2009). Estates utilisation targets and QIPP are being translated into a Premises Assurance Framework to stimulate greater productivity. There is, however, poor understanding of the relationship between care models and efficient and effective built environments. The study provides a unique opportunity to explore the economics of single rooms. Cost-effectiveness needs to be and will be examined in relation to potential cost savings arising from shorter stays, reduced hospital acquired infection compared to the additional cost (if any) of staffing and cleaning and in the comparator study we will provide evidence across a range of hospitals with varying percentages of single rooms.

There are important implications for the nursing workforce resulting from an increase in single room accommodation. Experts and nursing unions are concerned about the impact that a greater move to all single room accommodation will have on the workforce, including recruitment, retention and productivity. There is little or no UK evidence about impacts on morale, motivation and staff engagement. Staff may feel more isolated working alone in single rooms and teamwork may be impeded. A key question is whether more nurses are needed to work on wards which have single rooms. This research will provide important evidence on the impacts on the nursing workforce.

The trend towards all single room facilities is gaining pace internationally, and new builds and refurbishments in the UK must increase the number of single rooms that they replace. Single rooms are increasingly considered the minimum standard for in-patient care, and as such there is a clear need to provide evidence to keep pace with the change so that the benefits of single

room ward environments can be maximised and the disadvantages identified and minimised. The proposed research offers the first opportunity in England to understand the impact of single room accommodation on performance, quality and safety for staff and patients, and is vital in building the evidence base for future development of hospital infrastructure.

4. Methods:

a. Setting

Tunbridge Wells Hospital

In 2011 Maidstone and Tunbridge Wells NHS Trust opened a new hospital on the site of the old Pembury hospital- *Tunbridge Wells Hospital*. This is the first NHS hospital in England to have 100 per cent single in-patient rooms, including in-patient single rooms in all wards and in all high acuity areas such as critical care, high dependency, intensive care, acute stroke and acute assessment. The move occurred in two phases, with women and children's services moving into the new hospital in January 2011 and remaining services moving in September 2011. Staff and patients moved from a range of old accommodation on two main sites (Kent and Sussex and Pembury hospitals). The wards in the old hospitals predominantly comprised large bays and open Nightingale wards. This will therefore be a dramatic change for patients and staff alike and the proposed project has been designed to help us better understand the impact of the changes on care delivery and working practices, staff and patient experience, and costs.

Other Sites For Controlled Before And After-Quasi-Experimental Study

We plan to further explore the options for UK comparator sites with our contacts and continue to create a shortlist of potential comparator sites. Key to involvement will be willingness to participate but also how these hospitals vary on key dimensions – e.g. size, patient mix, location, performance, staffing levels etc. that might affect the outcomes independently of the building.

b. Design

Design and theoretical/conceptual framework

A theoretically-informed evaluation drawing on lessons from research on innovation adoption in health service organisations [15], particularly 'top down' imposed innovation taking into account four key components:

1. wider NHS/societal context
2. hospital (across different hospitals in the comparator group) and service (postnatal, elderly care; acute assessment unit; acute general surgery) context
3. new hospital design and single room patient accommodation (i.e. the innovation itself)
4. nature and quality of linkages between external stakeholders (e.g. the builders; architects; SHA; Centre for Health Design) and their relationships

with the hospital and its staff.

The four components exist in dynamic relation to the system as a whole and our research is designed to capture these interactions as we explore how and why the process of implementation of all single rooms differs in the four case study services at Tunbridge Wells Hospital, and how this impacts upon each of the six domains listed below:

1. **Care delivery and working practices** (e.g. increased direct care time; more staff walking time; less surveillance)
2. **Staff experience** (e.g. enhanced satisfaction; diminished team working; fewer interruptions; changed workforce deployment; challenges of change management)
3. **Patient experience** (e.g. increased isolation; increased privacy; increased environment control; less disruption; enhanced sleep; improved family contact)
4. **Costs** including nurse staffing (e.g. costs and savings that are potentially attributable to or consequent from single rooms will be identified)
5. **Safety outcomes** (e.g. reduced infection; faster patient recovery; increased patient falls)

Design and Sampling

1. Case Study Design

Using a longitudinal mixed method case study design, we propose a realist evaluation[2] with four cases (postnatal ward; acute assessment unit; acute general surgery ward and elderly care ward) within one organisation (new Tunbridge Wells Hospital) to assess impacts of the move to single room hospital accommodation.

We already have 'before' data from these four nested case study areas in the old accommodation and propose to collect the same data following the move into the new hospital for these same four services. We also have 'before' data on this whole organisation (from routinely collected data and stakeholder interviews) and propose collecting comparative data 'after' the move (further stakeholder interviews and analysis of routinely collected data). We additionally propose to use the before and after data to understand the costs and savings resultant from the single room hospital design.

This approach allows consideration of the impact of single rooms on the

[2] The realist evaluation approach seeks to get beyond a simple question 'do single rooms 'work'? It seeks to understand better what works, for whom – which staff; which patients; in what circumstances. This top down innovation of 100% single in-patient rooms is being introduced into multiple contexts, even in the single hospital trust, Tunbridge Wells Hospital, and we seek to find out under what conditions this change will produce its impacts. In some cases and perhaps on some wards, some of the effects may be unwanted, in other cases wanted and more likely they will be a mixture of wanted and unwanted effects. Realistic evaluation is simply an application of this insight to the examination of new programmes and innovations. Its concern with understanding causal mechanisms and the conditions under which they are activated to produce specific outcomes is highly relevant for this study.

hospital as a whole, while also facilitating a detailed understanding of the single room environment for different clinical areas and patient groups. As outlined above, four areas have been selected as case studies to ensure that findings are applicable to a wide variety of settings and patient groups within the acute sector.

The research in the four cases will focus on the practice and experience of registered midwives, nurses and nursing assistants in each case study area and these staff will be invited to participate in a range of quantitative and qualitative data collection activities. Staff will be selected to take part using a purposive sampling approach to in order to include staff across a range of grades, responsibilities and time working in the Trust.

Patient experience will be captured through qualitative in-depth interviews. Patients over the age of 18 who have received care in the four case study areas during a specified period and who can independently give informed consent will be invited to participate in the patient interviews. Invitation letters will be sent to patients two to six weeks after they have been discharged and interviews will be conducted in their own homes or other preferred location. Patients who are unwilling or unable to give informed consent will be excluded (including for example patients with dementia or learning disabilities) as will any patients under the age of 18. Patients will be selected to take part using a purposive sampling approach. We hope and anticipate that we will be able to include some patients across the four case study areas that have experienced the old hospital accommodation as well as the new. These will be an important sub-group. Sample sizes for the different elements are provided in the section on data collection below.

Key stakeholder interviews will be carried out with a range of key stakeholders[3] to establish early challenges and experiences across the Trust relating to transition to all single room ward accommodation and to give contextual insight into processes and mechanisms which may account for the experiences of staff and patients.

2. Quasi-Experimental Study Design

In addition we propose studying outcomes of care and resource use / staffing costs in a quasi-experimental study. The study will be a controlled before and after study with non-equivalent controls [16]. This will examine before and after secondary data (ward staffing levels / costs, staff and patient survey results, hospital acquired infection rates, slips trips and falls and data from local score cards where possible (e.g.

[3] To include medical staff (consultant, registrar and senior house officer grades); the trust lead for allied health professionals and a physiotherapist and occupational therapist working on the case study wards; the PFI equipment manager; and the estates and facilities Director and a member of the domestic staff and catering staff; at least one member of the ward administrative staff who work on the case study wards as well as senior nurses. We plan to keep the sample for these interviews under review and add other key stakeholders as necessary.

ward based reports of incident pressure ulcers) in two control hospitals, one where there is no new build (steady state control) and one which experiences a significant new build which is not primarily single rooms (new build control). These will be matched as closely as possible to the 'intervention' hospital in terms of size, type of hospital and baseline staffing levels.

The study will allow us to:

(1) Compare the before and after outcomes / resource use in Kent and Sussex and Pembury / Tunbridge Wells hospitals with before and after outcomes / resource use in similar hospitals
(2) Compare changes over time in the Kent and Sussex and Pembury / Tunbridge Wells hospitals with changes in the 2 control hospitals.
(3) Examine the plausibility of the hypotheses that any changes in Kent and Sussex and Pembury / Tunbridge Wells hospitals are specifically associated with the move to all single rooms as opposed to the provision of modernised accommodation or secular trends (for example staffing changes due to finance pressures)

At the TRUST level data on infections (MRSA bloodstream infections, C diff) are reported in a standardised form to national bodies (HPA), as are falls and serious pressure ulcers (NPSA NRLS) although the latter are entirely dependent upon incident reporting as opposed to standardised surveillance. At the WARD level we already have access to the following from Kent and Sussex and Pembury / Tunbridge Wells hospitals from the 'before' period: Ward staffing (establishment, grade and cost) by month. Ward level reports of MRSA / Cdiff infections, falls, staff sickness / absence, ward based nurse staffing / costs.

c. Data collection

1. Case Study Element
1.1. Overall hospital case study (*Tunbridge Wells Hospital*)

(i) Key stakeholder interviews (n=15-20) to include medical staff (consultant, registrar and senior house officer grades); the trust lead for allied health professionals and a physiotherapist and occupational therapist working on the case study wards; the PFI equipment manager; and the estates and facilities Director and a member of the domestic staff and catering staff; at least one member of the ward administrative staff who work on the case study wards as well as senior nurses. These interviews are to further understand early challenges and experiences across the Trust, context, embedding, and issues of implementation relating to transition to all single room ward accommodation.

(ii) ***Routinely collected Trust data***: Analysis of secondary data sources relating to workforce and patient and safety outcomes[4]

1.2. Four nested case studies in four clinical areas: postnatal ward; acute assessment unit; acute general surgery ward and elderly care ward

Quantitative and qualitative data collection involving patients and nursing staff in four nested case study areas within the overall case study of Tunbridge Wells Hospital will be collected. A range of data collection methods will be used to understand patient experience and outcomes, working practices and staff experience in the all single room ward environments. This approach will ensure a holistic and detailed exploration of the impact of single rooms from all perspectives. Data will be collected as follows:

(i) ***Observation of practice:*** Observation will be undertaken over 30 hours in each case study area (120 hours total). Observation will involve shadowing individual nursing staff members (both registered and assistant staff) for between four and six hours using a structured time-motion data collection tool. Time-stamped data is collected using a hand-held computer relating to task/activity, location, and with whom. Additional detail is collected in relation to two activity categories (direct care and professional communication) which are predicted to change most in the all single room ward environment. The tool includes a 'Twitter' feature which allows the observer to note down any other important detail relating to working practices and effectiveness, particularly where the physical environment impacts positively or negatively on these.

(ii) ***Staffs travel distance*** data will be captured using pedometers distributed to staff during observation periods.

(iii) ***Review of ward floor plans and staffing*** to understand built / working environments.

(iv) ***Staff survey:*** distributed to all ward nursing staff in each case study area (n= approx 25-40 in each of four case study areas to complete the survey - total 100-160). The survey will capture staff views relating to the new all single room ward environment and incorporates a validated measure relating to team working,

[4] Total number of hospital acquired MRSA infections; number of MRSA confirmed bacteraemia; new C Diff episodes; number of medication errors; numbers of high dependency patients; numbers of patients requiring feeding; number of falls and fall risk assessments completed; missing or absconding patients; number of falls and fall resulting in injury; number of patients admitted to hospital with a pressure ulcer; and number who acquired a pressure ulcer in hospital (grade 2 or above); number of violent of aggressive incidents between patients and visitors; number of patient or relative complaints; sharps related injuries for staff; staff sickness absence; bank and agency staff use; planned and actual ward staffing per shift; bed occupancy rates per shift.

communication and patient safety, the 22 item version of the Teamwork and Safety Climate Survey [17].

(v) Staff interviews: In-depth interviews with nursing staff (registered and assistant staff). A total of 24 interviews will be conducted (6 per case study area). Half these interviews (n=12, or 3 per case study area) will additionally involve reflexive photography [18]. This has been popular and successful with staff during pre move (phase 1) data collection. Reflexive photography is a type of photo-interviewing or photo-elicitation technique which entails research participants themselves taking photographs that serve as the main focus of 'reflective' discussion during a subsequent interview. The approach allows the research participant to talk about the significance and meaning of photographs which represent their perspective on the topic in question [19]. Reflexive photography used in this research will both generate a visual record of the work environments, and also encourage research participants to critically analyse the ward layout, environment and facilities. It will prompt deeper consideration of positive and negative aspects of the work environment, and encourage participants to 'view' the environment in a new way or light, reassessing those aspects that are taken for granted [20,21], and consider the impact of the all single room ward environment on practice and communication [22].

(vi) Patient interviews: In-depth interviews with recently discharged patients. A minimum of 32 patient interviews will be conducted (between 8 and 10 patients per case study area) (n=32-40). Where possible these will include some patients who experienced the previous '*before* the move' accommodation at Kent and Sussex or Pembury hospitals.

2. Economic Analysis Elements

2.1 Nurse staffing costs: For each of the case study wards we will compare ward establishments per bed (planned staffing) before and after the move to identify planned changes in nurse staffing levels. As ward establishments may not closely reflect actual staffing we will also calculate nursing / midwifery hours per patient day by summing the nursing hours worked (including bank and agency staff) over monthly periods and dividing by days in the month, adjusting for bed occupancy. We will use data from our observations to adjust this figure for the proportion of unproductive time and to identify patient contact hours per patient day. We will also estimate nursing/midwifery payroll costs per-patient per day by using salary expenditure data provided by the Trust (including bank and agency staff, sick leave but not other forms of authorised absence). [Data from 'before' has already been secured].

2.2 Overall costs: Data will be collected to identify the costs associated with the two hospital designs (before and after) e.g. costs associated with construction and the estimated costs of the nearest equivalent design with 50% single rooms; nursing costs per occupied bed. We will model the cost implications of changes in care processes and outcomes that might be attributed to single rooms, with scenarios based around the observed before and after comparisons (e.g. changes in length of stay, costs associated with outcomes hospital-acquired infection treatments potential, accidents due to lack of surveillance (e.g. falls); length of stay; staff training and staff turnover (or additional staff required to increase surveillance). We will explore with ward and hospital managers any other costs that are directly attributable to single rooms as opposed to the new build per se.

3. Quasi-Experiment In Comparator Hospitals:

3.1 Routinely collected Trust data at unit (ward) level: ward staffing levels / costs, staff and patient survey results , hospital acquired infection rates, slips trips and falls and data from local score cards where possible These data have been secured for Kent and Sussex and Pembury / Tunbridge Wells hospitals from the 'before' period . The selection of control Trusts will ensure that trusts are able to supply comparable information, where possible to ward level by month for at least 24 months prior to an index date which will be either the date of the moves in the intervention hospital or, for the new build control, the date of occupation of their own new build.

3.2 Routinely collected NHS data We will access routinely collected NHS Trust level data (e.g. staff survey, falls, hospital acquired infection rates) from national sources (NHS IC, NPSA, HPA or successors). Where available and possible we will access data by month or by quarter over a period of at least 2 years prior to the index date.

d. Data analysis

1. ***Case Study Elements***: The wider theoretical framework [16] will be used to identify general lessons about implementation of the innovation. Interviews will be digitally recorded and transcribed verbatim in preparation for analysis using a framework approach, a method which involves the systematic analysis of verbatim interview data within a thematic matrix using a framework approach [23]. The key topics and issues emerging from the interviews will be identified through familiarisation with interview transcripts as well as reference to the original objectives and the topic guides used to conduct the interviews. A series of thematic charts will be developed and data from each transcript will be summarised under each theme. This will facilitate detailed exploration of the charted data, in order to map and understand the range of views and experiences in different themes and allowing comparison across cases and groups of cases.

Qualitative data, including associated reflexive photographs taken by staff, will be managed in NVivo, a computer assisted qualitative data analysis software package. Photographs will be coded for setting and issues identified such as staff experience, patient experience, care delivery and associated categories.

Time-motion data will be exported from the hand-held computers to Excel for analysis. Staff survey data will be entered and analysed in SPSS. Time-motion data, that describes the way care is delivered (e.g. activities, types of direct care, location, staff interaction), and staff survey data will be summarised and compared statistically between case study wards and 'before' and 'after' and using appropriate univariate and multivariate methods (e.g. t-test, ANCOVA). Survey and time motion data collected on the same member of staff on two occasions will allow causal relationships between variables to be explored using statistical models. Most of the analyses will be performed in IBM SPSS or SAS but other specialised software (e.g. MPLUS v6) will be used, for example to model latent variables or to fit a number of different inter-connected models simultaneously (structural equation models). The pattern of missing data will be assessed and adjustments for bias incorporated into the modelling (e.g. full maximum likelihood).
We will analyse all data alongside the phase 1 (before move) data – providing a total of 240 hrs observation, 48 staff interviews, a minimum of 64 patient interviews and approximately 30 key stakeholder interviews. This will allow direct comparison with the previous built environment, with the proposed business case and with the design plans to examine the extent to which these have been implemented and anticipated benefits realised.

2. ***Economic and Quasi-Experiment Elements*:** Primary analysis for all quantitative data will use appropriate univariate and multivariate tests for difference to make comparisons between "before" and "after". Where we can assemble sufficient data from routine sources (e.g. infection rates) we will explore the feasibility of a time series based analysis of counts using a Poisson (e.g. counts per month with number of patients as the denominator (offset)) or negative binomial regression could be considered. We will use information from the hospital's administrative data systems to make simple case mix adjustments including factors such as major diagnostic categories and patient age and comorbidities. As it seems likely that there will not be sufficient data for such analyses (especially "after") the intervention we will use statistical process control methods (U-Chart, P-Chart) to explore evidence of change before during and after the move. Control limits will be established during the 'before' period for each Trust. Standard rules for detecting 'special cause' variation over the index period and beyond will be used to determine evidence of change as opposed to random variation. Change in the intervention trust will be compared to that in control trusts to determine if differences can plausibly attributed to factors specific to that trust (including single

rooms) or may reflect system wide trends or a move to a new hospital per se. All statistical analysis will be conducted with IBM SPSS and / or R statistical software or an equivalent package.

The implications of single rooms for cost and cost effectiveness will be modelled by developing a number of scenarios for differential costs and outcomes (e.g. changes in infection rates) which are plausibly associated with single rooms based on data from other aspects of the study. We will take a limited perspective on our economic analysis to consider additional costs of changes in ward based workforce, additional costs of provision of accommodation and (if evidence suggests different outcomes) average additional treatment costs of adverse outcomes. Additional costs of the single room build will be averaged over the expected life of the hospital, with future costs discounted using standard approaches. Cost comparisons before and after will be based on nursing costs per patient per day (monthly nursing costs divided by patient bed days) and accommodation costs per patient per day. We will also estimate differences in costs of factors identified by ward managers as changing due to the single room layout (e.g. cleaning or supplies).

Our primary analysis will be a cost minimisation analysis, with sensitivity analysis used to assess the impact of assumptions made and to explore the potential for achieving different results. For example, if there is an increase in costs associated with the single rooms we would assess the necessary changes in length of stay or rates of adverse outcomes to reduce net inpatient costs. If there is evidence of differences in outcome we will calculate incremental cost effectiveness ratios for differences.

5. Contribution of existing research:

We will draw extensively on the literature and from our data from Phase I of the study- the Phase 1 data which provides data from 'before' move into all single rooms. This data was collected Jan 2010 – September 2012 with the final report being completed for this stage of the study in Dec 2012. The work - funded by the Engineering and Physical Sciences Research Council (EPSRC) as a peer reviewed collaborative project within the Health and Care Infrastructure Research and Innovation Centre (HaCIRIC) - provides in-depth research on care processes and staff and patient experiences in the existing accommodation at Pembury and Kent & Sussex hospitals during the period in the run-up to the move to the new hospital (Jan and Sept 2011) and its immediate aftermath. Thus we will have extensive in –depth data from before the move to compare with data collected in this protocol after the move. We will analyse Phase II data alongside the phase 1 (before move) data – providing a total of 240 hrs observation, 48 staff interviews, a minimum of 64 patient interviews and approximately 30 key stakeholder interviews. This will allow direct comparison with the previous built environment, with the proposed business case and with the design plans to examine the

extent to which these have been implemented and anticipated benefits realised.

6. Plan of Investigation:

Jan - Apr 2012

- Project management - recruit patient representatives to Project Advisory Group (PAG); PAG meeting (April 2012)
- Case study research - revise / develop case study data collection tools
- Economic analysis - develop data request; access available data and develop analysis plan
- Quasi-experiment - recruit trusts; initiate R&D / additional ethics approvals if required

May - Jul 2012

- Project management - progress report to SDO (June 2012)
- Case study research - key stakeholder organisational context interviews; pilot and finalise case study data collection tools; agree case study fieldwork schedule with ward managers
- Economic analysis - call for data (activity, costs and staffing)
- Quasi-experiment - gain approvals; call for data (historical safety and other outcomes data); data cleaning / follow up with providers

Aug 2012 - Mar 2013

- Project management - PAG meeting (Oct 2012); progress report to SDO (Jan 2013)
- Case study research - post move data collection
- Economic analysis - gathering additional cost / activity data
- Quasi-experiment - continue data cleaning / follow up with providers; ongoing (prospective) data submissions
- Project management - PAG meeting (Apr 2013)

Apr - Aug 2013

- Project management - progress report to SDO (June 2013); plan research findings dissemination activities
- Case study research - data analysis; comparative analysis and synthesis of pre and post move case study data
- Economic analysis - analysis of costs data; analysis of activity / staffing data
- Quasi-experiment - assemble final data set; pass outcomes data to EA team; data analysis

Sept - Dec 2013

- Project management - PAG meeting (Oct 2013); dissemination of research findings; agree report structure, finalise and submit to SDO
- Case study research - write up
- Economic analysis - economic model building; write up
- Quasi-experiment - write up
- Synthesis of all aspects of the study

- Delivery of final report to NIHR SDO.

7. Project Management:

The project will be managed by Professor Jill Maben who will co-ordinate the efforts of the research team, direct fieldwork and analysis of the data and be responsible for delivery of the project and final report on time and to budget.

Professor Jill Maben (National Nursing Research Unit, King's College London) is responsible for the overall case study of the Tunbridge Wells Hospital and the four nested case studies. Professor Peter Griffiths (University of Southampton) is responsible for the delivery of the quasi-experimental study and will also work with Professor James Barlow (Imperial College London) to lead and manage the costs comparison aspects of the study. Professor Glenn Robert (National Nursing Research Unit, King's College London) will be responsible for methodological and theoretical support to the project and take the lead on the interpretation of the study results – particularly for the organisational case study in the context of the diffusion of innovation theoretical framework. Dr Janet Anderson (Patient Safety and Service Quality Research Centre, King's College London) will provide human factors theoretical input and interpretation. Sally Brearley (National Nursing Research Unit, King's College London) will lead the user involvement aspects of the study and will be responsible for recruiting the two user members of the project advisory groups.

A wider advisory reference group which was formed for the EPSRC *'before'* aspects of the study will continue. This represents the wide variety of stakeholders including the core project team and will provide advice and support to the 'core' team in its oversight of the project (see service users/public involvement section below for membership details).

8. Service users/public involvement:

The new hospital was designed in collaboration with patients and staff, key participants in our proposed study, and we have access to records of their input to the design process. We have also discussed user input during key stakeholder interviewers conducted at the beginning of the project.

Our project design was informed by input from patients on a visit to the single room accommodation pilot ward (Bevan) at Hillingdon Hospital in 2009. This helped us gain clarity into the potential issues for patients which, in turn, informed development of our patient experience data collection tool (depth interview topic guide for patients). Key topic areas include feeling comfortable, feeling safe, interaction with staff, and interaction with visitors. We have also drawn upon patient issues identified by staff and discussed at the Trust's Single Room Working Group monthly meetings, which researchers attended as invited observers.

Patient experience is a key variable in our proposed study.

In terms of user involvement as the study progresses, we have staff members of the Trust and Hillingdon hospital as part of the team and on the advisory group and one of the co-applicants is an experienced patient representative and researcher, with extensive connections with patient organisations and public engagement mechanisms. She is a lay member on the National Quality Board and its Patient Experience Sub-Group.

The main means of actively involving patients during the study is through their recruitment to and membership of the Project Advisory Group (PAG). We will recruit two patients to the PAG and, alongside other group members, they will be asked to advise on data collection, comment upon and help us interpret the findings emerging from the research, and help us with dissemination through links with their local networks. The PAG meets biannually and current membership includes representatives from Maidstone & Tunbridge Wells Trust, NHS South East Coast, the Department of Health, Laing O'Rourke, HCP Social Infrastructure (UK) Ltd. Patient members of the PAG will be offered support for their role, payment of out-of-pocket expenses and a day-rate for attendance at meetings (in accordance with good practice as recommended by INVOLVE). We would expect these stakeholders to advice on data collection, to comment upon and help us interpret the findings emerging from the research, and to help us link with relevant networks to disseminate the findings. We would also be delighted to feedback to the patients and public in the local area.

As the study progresses, we will also link with regional and national patient organisations and public engagement networks (for example, National Voices, Local Involvement Networks/Local Health Watch, and where possible patient groups involved in work concerning the healthcare built environment and the healing environment) to share emerging findings, obtain feedback and seek help with dissemination. We will do this through the organisations' membership mailings and by offering to attend and speak at events. This method has proved very effective for other studies we have conducted.

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