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Your ref:
Our ref: A11060761
5 May 2015

Dear Mr Sharratt

Thank you for your letter regarding Public Petition PE1482 on single room provision in hospitals.

The Scottish Government has received an expert's opinion on the literature review of published evidence relating to single room provision in hospitals. It has concluded that from a policy perspective the decision to develop the policy of single room accommodation (allowing for exceptions in special cases) continues to be supported by the evidence. I have attached the comments received regarding the literature review.

The Committee has also asked when the Scottish Government will commence its own research on the matter and when it is likely to report these findings. The Scottish Government is now aware that the National Institute for Health Research has completed and published its research which investigates the impact of different types of hospital accommodation on patients and staff. The study titled "Evaluating a major innovation in hospital design: workforce implications and impact on patient and staff experiences of all single room hospital accommodation" is one of very few to have examined in depth the experiences of patients and staff in single room hospital accommodation in the UK and therefore it provides valuable evidence to guide policy, planning and hospital design. The Scottish Government in the first instance intends to review this study with a view to informing policy. This primary research project can be viewed at the following web address

<http://www.journalslibrary.nihr.ac.uk/hsdr/volume-3/issue-3#abstract>

In addition we intend to, through the revision of the Scottish Capital Investment Manual scheduled for completion late 2015, review and update our data collection requirements before and after completion of new hospital facilities to help more clearly identify the impact of design on wellbeing and outcomes. This will gather evidence from new hospitals such as the South Glasgow University Hospital and those planned hospitals currently being procured.

Yours sincerely

David Browning

A review of literature: Does single room accommodation have a positive effect on patient outcomes, staff outcomes and costs?

As previously indicated to the Committee during 2014 we undertook to review published evidence relating to single room provision in hospitals following the period since the report of the NHSScotland Single Room Steering Group and the issuing of CEL 48 (2008) by the then Chief Nursing Officer, Paul Martin.

The Scottish Government's initial overview of the review of published evidence found that:

- although elements of a systematic quality assessment methodology were followed, some elements required for a systematic review were not fully adhered to.
- the report does not progress the case for single room accommodation as a single factor, and although there is some evidence examining single room accommodation as a single factor, the results are both positive and negative.
- there is some evidence that as a package of interventions which include single rooms, there may be a positive effect but these were excluded from the work as it was not clear whether the impact recorded stems from the single room or another intervention.

In addition, the Scottish Government received the following comments from an expert in designing better hospitals through evidence - based design.

Despite the fact that it was conducted by a single researcher, he found the review to be quite thorough. In terms of impact of single rooms on patients and staff, he believes that it reaffirms the many positive benefits that have been described in the past and have contributed to policy decisions in 2010. He has also concluded that it is overly conservative on the impact on operating costs. It does make the important point that interventions such as single rooms are rarely done in isolation of several other design improvements, such as more natural light, lower noise levels, variable acuity and fewer transfers.

From a policy perspective there are two main points:

- The decision to develop the policy of single rooms (allowing for exceptions in special cases) continues to be supported by the evidence.
- The opening of the new Glasgow hospital provides an excellent opportunity to undertake comprehensive research on multiple levels and should not be missed.

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F +31 34 635 39 77**TNO report****TNO 2014 R11923****Does single room accommodation have a positive effect on patient outcomes, staff outcomes and costs? A review of literature.**

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Author(s)	E. Schreuder, Msc
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1 Introduction

The Dutch Centre for Health Assets (TNO) had carried out a literature search on the impact of single room accommodation on both staff and patients during June 2013. The output produced by TNO was in the form of an evidence matrix which set out the impact on patients and staff of care provided in single rooms compared with multiple bedrooms.

In Scotland current NHS Facilities guidelines on single room provision in acute healthcare services prescribe 100% single room provision for new developments. For existing accommodations which are being refurbished, a minimum of 50% single room accommodation would be allowed but as close to 100% as possible, would be expected. In new capital projects where there are clinical reasons for deviations, a clearly identified and articulated reason for deviation should be made in the appropriate business case. Each case would be subject to Scottish Government agreement as part of the business case approval process. The guidelines were published after research and expert consultation in 2010 (Scottish Government, 2010). In order to update the evidence base that partly underlies the guidelines, Scottish Government asked Health Facilities Scotland (HFS) to facilitate the expansion of the original work TNO had produced as a first step to ascertain if there was a need to expand on the original work to provide insights in the current evidence base of the effects of single bedrooms in acute healthcare facilities.

It has been indicated by the Scottish Government Health and Social Care Directorate that it would be beneficial if the matrix could be produced in the form of a report. Additionally, it was requested that the work should be complete and a draft of the report be available by October 2014. The Scottish Government Health and Social Care Directorate asked HFS to facilitate the taking forward of the preliminary piece of work that had been carried out by the Dutch Centre for Health Assets (TNO). To take the work forward it was decided to re-evaluate the quality and content of the literature contained in the evidence matrix. The key question that guided the research was:

Does single room provision have a positive effect on patient outcomes, staff outcomes and costs?

2 Methodology

2.1 Original literature search (step 1)

The literature search that was conducted in June 2013, was guided by the following research question: What is the effect of single bedrooms on:

- Patient safety.
- Patient well-being and satisfaction.
- Staff efficiency.
- Staff satisfaction.
- Operational costs/profits.

Data bases that were searched in, included: Cochrane Library, ScienceDirect, PubMed, Psycinfo and Google Scholar.

Table 1 shows the search terms used. Search terms were combined. AND was used between columns (intervention, effect and setting), OR was used within columns. E.g., single room and patient safety or satisfaction. Search terms were applied systematically in Google Scholar, Science Direct and PubMed. However, in Pschyinfo and Cochrane review a revised process was used as very few papers were returned. Relevant references were hand-searched. Literature, grey literature and expert opinions that showed an effect of single versus multiple bed rooms on one or more of the outcome measures were selected. Issue date was not a selection criteria, all papers produced before June 2013 were included. The search and paper selection was done by one researcher. Papers not selected were not documented, due to time constraints.

Table 1 Search terms used.

Intervention	Effect	Setting
Single room	Patient satisfaction	Healthcare
Single bed	Patient wellbeing	Health
Private bed	Patient safety	Hospital
Private room	Infection	Acute care
Multi-bed	Staff efficiency	Cure
Single vs Multi	Staff satisfaction	
	Costs	
	Operational costs	

The outcomes of the literature search were documented in the “Single room accommodation evidence matrix 26072013.xlsx” (referred to as evidence matrix). To take this work forward it was decided to review the quality and the content of the literature contained in the original matrix.

2.2 Quality assessment (step 2)

The papers reported in the evidence matrix were quality graded in accordance with the SIGN methodology checklists (Scottish Intercollegiate Guidelines Network, 2011). This was done by only one researcher. It first involved classifying the paper under a type of study which ranged from a classification of one to four (table 2). Accordingly, the levels 1 and 2 were graded for study quality under grades ++, + or – (table 3). Levels 3 and 4 were not quality rated as this evidence already belongs

to the lowest level of recommendation according to the SIGN grades of recommendation.

Table 2 Study types.

Study type	Study
1	Meta-analyses, systematic reviews of randomised controlled trails or randomised controlled trials
2	(Systematic reviews of) individual, non-randomized (controlled) trails, case cohort studies, (controlled) before-and-after studies, correlation studies, interrupted time series
3	Non-analytical studies such as focus groups and surveys
4	Expert opinions

Table 3 Study quality.

Study Quality	Evaluation in case of a SIGN checklist	Evaluation if no SIGN checklist existed for the type of study
++	All or most of the criteria in the SIGN checklist have been fulfilled. The criteria that have not been fulfilled are thought very unlikely to alter the conclusions.	Limited risk of biased or confounded results
+	Some of the criteria have been fulfilled. The criteria that have not been fulfilled or adequately described are unlikely to alter the conclusions.	Moderate risk of biased or confounded results
-	Few or no criteria have been fulfilled. The conclusions of the study are thought likely or very likely to alter.	High risk of biased or confounded results

Papers were excluded if, for example

- they examined the effects of single rooms in long-term care facilities,
- or if the reported effects could not be related to single rooms,
- or when data was not available to check the effects.

One exception was made with regard to individual papers included in published (systematic) review papers. All review papers have been assessed in accordance with the SIGN methodology (See Appendix B). However, to prevent double counts, only the individual papers selected in the review papers were included in the evidence matrix (see Appendix A, the column “included in review” indicates in which review the individual paper was selected). The following quality rating process was carried out:

- If a quality rating was applied to an individual paper by the reviewer, this rating was transferred to a SIGN rating (see “Explanation” column Appendix A).
- If a quality rating was not provided and the data to check the quality was not reported, the individual paper was not deleted, but downgraded to a level 4 rating.
- If the review paper was excluded (e.g., the focus was on long term care facilities) relevant individual papers that qualified the criteria (mentioned for instance in the introduction) were only downgraded if they were issued after 2006, all papers issued before 2006 were excluded. The issue date of 2006 was chosen because most included review papers included individual papers

up to 2006. As a result the individual papers issued before 2006, would have been selected in included review papers if relevant. The outcome of the assessment (reason for deletion or quality rating) was recorded in the evidence matrix "Explanation" (Appendix C and Appendix A respectively).

The original evidence matrix consisted of 157 papers. Sixty papers were deleted, because of the abovementioned reasons, which resulted in 97 appraised papers of which 7 review papers. This means the evidence base consists of 90 individual papers.

2.3 Data analysis (step 3)

After the check and grading of all resulting papers, the outcome measures reported in the papers were identified. Accordingly, a distinction was made between empirical-analytic evidence (level 1 and 2) and non-analytic evidence (level 3 and 4). From a methodological point of view evidence from empirical-analytic studies is considered stronger than evidence from non-analytical studies, even though the quality of a level 2 study may be rated as -. Thus, although the detailed quality ratings of level 1-2 are included in the evidence matrix (as indicated in Section 2.2), for presentation purposes in the report only a distinction was made between levels 1-2 and 3-4. The number of papers that reported a positive, negative, no or unclear outcome were counted and documented. Based on this analysis, it was investigated whether the outcomes of the papers in the different quality categories corroborated. Main themes and conclusions of these papers are reported in a summary of findings.

3 Results

This Chapter reports the results of the literature analysis. The Chapter is divided in a section for patient outcomes (3.1), staff outcomes (3.2) and financial outcomes (3.3).

3.1 Patient outcomes

3.1.1 Measures

From the literature assessed it can be said that the following outcomes were identified:

- Patient satisfaction. This measure includes patient satisfaction in general, but also satisfaction with specific aspects such as the care provided, noise, quality of sleep, experience of privacy, dignity, control and social support.
- Preference for a single or multiple bed room.
- Well-being, which includes health related outcomes such as length of stay, pain medication, mortality.
- Infection rates.
- Falls.

It should be noted that other adverse events such as medication - and medical errors are considered being staff outcomes.

3.1.2 Effects single room on patient outcomes

Table 4 includes results of the literature analysis for patient outcomes. The table shows the number of papers that reported positive, negative, no or unclear outcomes. A reference is made to all the papers that result in the number provided. This number corresponds with the number in the 'Article reference' column in the evidence matrix (Appendix A).

Table 4 Number of papers that reported positive, negative, no or unclear patient outcomes.

Outcome measure	Quality study	Positive impact	Negative impact	No impact / impact unclear
Satisfaction	1-2	6 (1,6, 19, 22, 67,88)		3 (55,67,88)
	3-4	31 (11,12,14,15,16,17,18, 20, 21, 24, 26, 27, 28, 30, 41, 42, 43, 44, 50, 51, 52,53, 54, 55, 65, 70, 72, 76, 77)	3 (54,61,65)	
Preference	1-2	1 (67)		
	3-4	2 (80,84)	4 (23,66, 68,80)	4 (25,47,48, 49)
Well-being	1-2	1 (2)	2 (74,87)	1 (86)
	3-4	4 (9, 85, 34, 63)		3 (45, 61, 88)
Infection	1-2	5 (2,4,58, 63,82)		5 (3,5,60, 81, 87)
	3-4	15 (8, 9,11, 12, 13, 14, 15, 16,17,18,31,39, 40, 64, 90)		3 (56,88,71)
Falls	1-2			
	3-4		3 (59, 61, 88)	

3.1.2.1 *Satisfaction*

Most evidence was found on patient satisfaction, however it should be noted that this measure includes many sub-categories (e.g., noise and privacy). Although an increase in patient satisfaction in single rooms is mainly reported by weaker evidence (level 3-4), there was also some stronger evidence (level 1-2) that showed that patients who stayed in a single room are significantly more satisfied than patients who stayed in a multiple bed room (1, 6, 19, 67, 88). This mainly includes overall satisfaction, satisfaction with care provided and privacy. Experts (and level 3 studies) worry about feelings of social isolation in single rooms, which they expect, could decrease overall satisfaction (54, 61, 65). One analytical study show that veteran patients who stayed in a single or shared bedroom (67) reported no difference in feelings of loneliness. Another analytical study found significant higher rating for many satisfaction aspects in single rooms, however also found significant lower reported satisfaction with the amount of social contact with other patients (88). This result, together with the concerns of experts show that facilitating contact with others in single rooms is a focus point.

An often reported sub-category is the satisfaction with the level of noise (27, 30, 50, 51, 55), which is assumed to be higher (less noise) in single rooms. However, noise measurements do not show a significant difference between the noise levels in single rooms compared with multiple bed rooms (55), but a trend indicating better sleep was identified. Finally, it should be noted that personal factors that are likely to influence satisfaction scores, such as (perceived) severity of the illness were not taken into account in the analyses.

3.1.2.2 *Preference*

Preferences for a single or multiple bed rooms differ. Some prefer single rooms, some shared rooms, and some do not seem to have a preference. The literature published stated that generally speaking single room preference was cited:

- where people had not been a patient previously (84);
- where patients were treated in mental health departments (80); and
- where patients were veterans (67).

Conversely shared accommodation preference was cited by patients:

- treated in an oncology ward (23,68);
- treated in care of the elderly (66).

3.1.2.3 *Well-being*

Length of stay is most often reported as measure for indicating patient well-being. There is some evidence in neonatal intensive care units that single family rooms shorten the stay of baby patients (2, 85). For adults length of stay in single rooms is reported being longer (74, 87) or having no effect (86) compared with multiple bed rooms. One trend was found indicating a shorter stay in an intensive care unit after the move to single rooms (63), but it's mainly experts that assume this effect (9, 85, 34).

3.1.2.4 *Infection*

Many papers exist on the effect of isolating policies or single rooms on infection rates, which makes it the second most popular patient outcome theme. It should be noted that papers that investigated the effect of multiple infection prevention measures, including single rooms, were excluded in this research.

In this section however we mentioned some of this research by using Harvard style references. Papers that investigated the effect of single rooms only were included in the research and are referred to by a number that corresponds with Table 4 and the evidence matrix. Papers reviewed showed conflicting results on the impact of single room accommodation on infection rates. Five stronger evidence reports show a decrease in some type of infections (63) and a decrease in infection rates for special groups such as burn patients (82) and in paediatric settings (2). In general wards or ICU's however, five stronger quality studies found no effect (3, 5, 60, 81, 87). Experts mainly assume lower infection risks often due to the fact that there are no roommates in single rooms that are a potential source of infections (8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 31, 39, 40, Ulrich et al., 2008). However, other human beings exposed to in a single room such as prior occupants, neighbours, visiting patients and staff are a potential source too (64, 71). Compliance to several infection management policies seems necessary to reduce infection risks (Bartley et al., 2010, Dettenkofer et al., 2004). Single rooms may support this, as for instance problems with isolation capacity seems less likely (90, 31) and hand washing discipline seems more likely in single room designs (Bracco et al., 2007; 65), but as a single intervention, single rooms seem not effective in decreasing the infection rate in general.

3.1.2.5 *Falls*

No well-designed studies (e.g., small sample size, recording bias) have been found that investigate the incidence of falls in single - versus multiple bed rooms. However, the research found, indicates that falls are a focus point in single rooms, as people try to walk to the bathroom themselves more often in single rooms, risking a fall, whereas in multiple bed rooms people are more often supported (59, 61, 88).

3.1.2.6 *General remarks on evidence base patient outcomes*

This field of research includes many review papers (e.g., Chaudhury et al., 2005; Glind et al., 2007; Anonymously, 2007; Ulrich et al., 2008; West et al., 2010) that remarkably often include different source papers to support the same claims and use expert opinions as sources. A general problem of the level 1-2 research in the field is the lack of adequate control conditions, and as a result alternative explanations for an effect (e.g., patient case mix, passage of time) cannot be ruled out. For example a case mix exists when more ill people are assigned to single rooms. A fair comparison between health outcomes in single versus multiple bed rooms cannot be made. A second general problem is that often multiple interventions took place, which makes it hard to relate the effects to just the design of a single factor (in this case single rooms).

3.2 **Staff outcomes**

3.2.1 *Measures*

From the literature assessed it can be said that the following outcomes were identified:

- Staff satisfaction. This measure includes satisfaction in general but also satisfaction with specific aspects such as the quality of care, supplies, equipment, noise, family interaction, communication with staff. Due to the limited number of papers found, also preference studies and studies on well-being (stress) were included in the satisfaction measure.

- Consultation, which includes staff-patient communication.
- Staff efficiency, which includes patient transfers, travel time, staff levels.
- Staff error, which includes medication error, medical error, dietary-mix ups.

3.2.2 *Effect of single rooms on staff outcomes*

In accordance with the patient outcomes section, the number of papers reported on staff outcomes are shown in Table 5.

Table 5 Number of papers that reported positive, negative, no or unclear staff outcomes.

Outcome measure	Quality study	Positive impact	Negative impact	No impact/ impact unclear
Satisfaction	1-2	1 (7)	1(62)	
	3-4	5 (8, 26, 70, 88, 89)		
Consultation	1-2	1 (69)		
	3-4	1 (65)		2 (36, 46)
Efficiency	1-2			
	3-4	2 (8, 10)	1(19)	
Staff error	1-2			
	3-4	4 (8, 9, 26, 76)		

3.2.2.1 *Satisfaction*

As table 5 shows, evidence on the effect of single rooms on staff outcomes is limited compared with evidence on patient outcomes. Effects on overall staff satisfaction is inconclusive. Staff in a maternity ward reported increased satisfaction (7), staff in a paediatric hospital showed decreased satisfaction after the move to single patient rooms (62). Based on pilot studies and expert opinion a tendency can be identified that staff can provide better patient care in a single room (8, 26, 70, 88, 89). However, patient monitoring and staff safety are not reported being more satisfying in single rooms and are a concern (88). It should be mentioned that type of staff was not explicitly taken into account in the analysis.

3.2.2.2 *Consultation*

With regard to patient communication a nicely controlled pilot study (allocation of patients to a single or multiple bedroom by randomization to control for case-mix differences) was conducted that showed better staff-patient communication in single vs multiple bed rooms (69). Other reports of weaker quality were inconclusive (36, 46).

3.2.2.3 *Efficiency*

Very limited research was found on the effect of single rooms on staff efficiency. Experts report increased efficiency due to less patients transfers (8) and easier cleaning (decontamination) of the room (no need to transfer other patients) (10), but others claim a decrease due to inefficient monitoring (19). Also see health provision costs for the assumed cost related to staff efficiency. Further research is needed to draw conclusions on the effect on staff efficiency.

3.2.2.4 *Staff error*

There are several expert opinions that report less medication errors or dietary mix-ups in single rooms, but strong evidence was not found (8, 9, 26, 76).

3.2.2.5 *General remarks on evidence base*

Limited evidence was found on staff outcomes. A Cochrane review by Dijkstra and Pieterse (2011) on the psychological effects of the built healthcare environment on healthcare staff, excluded the single room evidence due to methodological shortcomings (e.g., lack of a control group, confounded with policy changes). The evidence that is reported in this review is mostly based on focus groups or surveys with small sample sizes or expert opinion. Thus, as Dijkstra and Pieterse already concluded in 2011, more research in this area is needed.

3.3 Financial outcomes

3.3.1 *Measures*

From the literature assessed it can be said that the following outcomes were identified:

- Construction costs, which includes cost for land and construction.
- Operating costs, which includes healthcare provision costs (travel costs, nursing costs, medication costs) and operating & housekeeping costs (energy, cleaning).
- Maintenance costs, which includes updating and refurbishing.
- Financial benefits, which includes occupancy rates (turnover), premium price.

It should be noted that costs related to medications errors or travel time also could be interpreted as staff outcomes. It was decided to only report the papers ones and assign the papers to the main outcome under investigation to prevent double counts.

3.3.2 *Effect of single rooms on financial outcomes*

In accordance with the patient outcomes section, the number of papers reported on financial outcomes are shown in Table 6.

Table 6 Number of papers that reported positive, negative, no or unclear financial outcomes.

Outcome measure	Quality study	Positive impact	Negative impact	No impact/ impact unclear
Costs				
Construction	1-2		4 (73, 75, 78, 83)	
	3-4	29	4 (17, 32, 33, 79)	
Operation	1-2		1 (87)	
	3-4	7 (32,34,35,36,37,38,56)	3 (32, 33, 88, 56)	1 (88)
Maintenance	1-2			
	3-4		1 (56)	
Benefits				
Occupancy	1-2			
	3-4		4 (32, 33, 57, 65)	
Premium	1-2			
	3-4		1 (56)	

3.3.2.1 *Construction costs*

Evidence in both quality categories agrees on increased construction costs when comparing single rooms to multiple bed rooms, due to increased floor area needed (17, 32, 33, 79, 73, 75, 78, 83). In these papers construction costs are calculated per bed. It should be noted that total construction cost levels also depend on the total number of single rooms. It is assumed that at 100% single room provision, single rooms may become multi-purpose. This eliminates the need for separate ancillary spaces such as day-rooms, and treatment rooms. Due to the flexible use of single rooms a reduction of space and related costs are expected. However, the costs are not expected to drop below the costs when single room provision is only 50% (29).

3.3.2.2 *Operating costs*

Operating costs include many sub-categories and as a result seem conflicting in table 6. Costs related to the floor area, such as cleaning and energy costs are assumed to increase (56, 88). Considering the health provision costs, some experts assume that nursing and physician costs increase mainly due to increased travel time (56, 32, 33). Others assume health provision costs to decrease mainly due to reduced patient transfers (56, 36 and also see 6, 8, 9 which are reported as patient outcomes), but less medication errors (37, 38 and also see 26, 76 which are reported as staff outcomes) or less staff (35) needed is also reported. A recent pilot study found no effect on medication costs or staff levels needed (88). More quality research is required to draw conclusions on the effect of single rooms on operating costs.

3.3.2.3 *Maintenance*

Only one study mentioned maintenance cost and relate this to construction costs (56). As a result these costs are assumed to be higher for single rooms.

3.3.2.4 *Occupancy rates*

Experts agree that single rooms improve occupancy rates due to the reduction of transfers, which results in higher turnover (32, 33, 57, 65).

3.3.2.5 *Premium price*

Not much research has been done on financial benefits, besides assumed better occupancy rates, because the assumed benefits such as increased patient satisfaction, are difficult to value. One study conducted a cost-benefit analysis for private versus semi-private rooms (56). The study indicated increased overall costs, but a net social benefit of +70K US dollars for a bed in a private room compared to a semi-private room. This included an premium that people are willing to pay for private rooms. The results are assumed, as strong evidence on the financial benefits of single rooms is lacking. More quality research is required to draw conclusions on the effect of single rooms on financial benefits.

3.3.2.6 *General remarks on evidence base*

There is limited evidence on the (operational) costs and financial benefits of single room provision. Most evidence are assumptions based on the increased number of square meters needed or other assumed (patient and staff) outcomes. There were very few (no) papers reviewed which included comparative data.

It should be noted that cost-benefit calculations are hard to generalize due to different cost levels and healthcare systems in different countries and regions. In general more quality research is needed to draw conclusion.

4 Discussion

Based on the literature review and analysis of the benefits of single room accommodation it was found that single rooms:

- increase overall patient satisfaction, but attention should be paid to isolation, falls and monitoring;
- are preferred by patients in general, however certain groups may prefer shared rooms;
- may support in infection management policies, but as single intervention there is no convincing evidence for reduced infections;
- have unclear staff outcomes. There is an indication for better patient-staff communication, but there is a need for more quality research on all outcome measures;
- increase construction costs and floor area related costs; impact on long-term operational costs are unclear. There is a need for more quality research.

These results show a potential for single rooms to have better patient and staff outcomes than multiple bed rooms, however strong evidence is lacking. This observation should encourage researchers to improve their research designs in order to be able to draw conclusions on this subject, on all outcome measures. It should be noted however, that designing a hospital is about many design decisions and trade off's. The effect of the hospital building on patients, staff and costs is determined by many factors of which having single or multiple bed rooms is just one. In this light the practical value of knowing the effects of this single design factor can be questioned as it is never implemented on its own. Perhaps a better question is, what building and care concept together achieve the best results with regard to patient -, staff - and financial outcomes.

Finally, some limitations with regard to the review method used should be mentioned. Only one researcher was involved in the search and assessment of the quality of the literature. The resulting report and evidence matrix was reviewed by a second TNO researcher. Although a systematic quality assessment methodology was followed, due to time constraints, some rules were adapted that might have biased the results, such as that possible higher quality research was downgraded. Furthermore, results were analyzed in terms of setting (e.g., ICU, general ward, pediatric ward), however other contextual factors such as culture were not taken into account.

5 References

References related to evidence base. Numbering in accordance with Evidence Matrix.

- 1) Nguyen Thi, P.L., Briancon, S., Empereur, F., Guillemin, F. (2002). Factors determining inpatient satisfaction with care. *Social Science & Medicine* 54 (2002) 493–504.
- 2) Ben-Abraham, R., Keller, N., Szold, O., Vardi, A., Weinberg, M., Barzilay, Z., et al. (2002). Do isolation rooms reduce the rate of nosocomial infections in the pediatric intensive care unit? *Journal of Critical Care*, 17(3), 176-180.
- 3) Preston, G. A., Larson, E. L., & Stamm, W. E. (1981). The effect of private isolation rooms on patient-care practices, colonization and infection in an intensive-care unit. *American Journal of Medicine*, 70(3), 641–645.
- 4) Mulin, B., Rouget, C., Clement, C., Bailly, P., Julliot, M. C., Viel, J. F. et al. (1997). Association of private isolation rooms with ventilator-associated *Acinetobacter baumannii* pneumonia in a surgical intensive-care unit. *Infection Control and Hospital Epidemiology*, 18(7), 499–503.
- 5) Martiny H, von Stempel A, Rden H. Zwei Intensivpflegestationen mit Einbett- und Vierbettzimmern-baulich-funktionelle und hygienische Untersuchungen. *Hygiene & Medizin* 1982;7:524-529.
- 6) Janssen PA, Klein MC, Harris SJ, Soolsma J, Seymour LC. Single room maternity care and client satisfaction. *Birth* 2000;27(4):235–43.
- 7) Janssen, P.A., Harris, S.J., Soolsma, J., Klein, M.C., Seymour L.C. (2001). Single room maternity care: The nursing response. *Birth* 2001 28(3):173-179.
- 8) Page, A. (Ed.). (2004). *Work and workspace design to prevent and mitigate errors*. In *Keeping patients safe: Transforming the work environment of nurses* (pp. 226-285). Washington, DC: The National Academies Press.
- 9) Anonymous. (2000). Hospitals discover cost efficiency of private rooms. *Executive Solutions for Healthcare Management*, 3, 7-8.
- 10) Ulrich, R. S & Wilson, P. (2006). Evidence-based design for reducing infections. *Public Service Review: Health (UK)* 8, 24–25.
- 11) Romano M. 2004. Going solo. Private-rooms-only provision for new hospital construction stirs controversy. *Modern Healthcare* 2004;34(48). p. 36, 38.
- 12) Sandrick K. 2003. A higher goal. Evidence-based design raises the bar for new construction. *Health Facility Management* 2003;16(9):16–21.
- 13) Marshall N. 2005. Tuning in to the way ahead. *Health Estate* 2005;59(10):50–1.
- 14) Mader B.(2002) Private hospital rooms the new norm. In *Depth: Health Care* 2002.
- 15) Hamilton DK. 2000 Design for patient units. In *healing by design:building for health care in the 21st century: September 20–21 Montreal 2000*.
- 16) Coile Jr RC. 2002. Competing by design. *Physician Exercise*; 28(4):12–6.
- 17) Berry, L. L., Parker, D., Coile, R. C., Hamilton, D. K., O'Neill, D. D., & Sadler, B. L. (2004). The business case for better buildings. *Frontiers of health services management*, 21, 3-24.
- 18) Landro L. 2006. New standards for hospitals call for patients to get private room. In *The Wall Street Journal*. New York; 2006: A1.

- 19) Barlas D, Sama AE, Ward MF, Lesser ML. 2001. Comparison of the auditory and visual privacy of emergency department treatment areas with curtains versus those with solid walls. *Annual Emerging Medicine* 2001;38(2):135–9.
- 20) Jolley S. (2005) Single rooms and patient choice. *Nursing Standard*, 20(9):41–8.
- 21) Lawson B, Phiri M. Hospital design. 2000. Room for improvement. *Health Services Journal* 2000;110(5688):24–6.
- 22) Kaldenberg DO. 1999. The influence of having a roommate on patient satisfaction. *The Satisfaction Monitor* 1999.
- 23) Pease NJ, Finlay IG. Do patients and their relatives prefer single cubicles or shared wards? *Palliative Medicine* 2002;16(5): 445–6.
- 24) Dolson J, Hesla L, Krewson C, Parimu J. Around the patient: hospital room equipment. *Program Archives* 1976;57: 54–7.
- 25) Miller NO, Friedman SB, Coupey SM. 1998. Adolescent preferences for rooming during hospitalization. *Journal of Adolescent Health* 1998;23(2):89–93.
- 26) Chaudhury, H., Mahmood, A., Valente, M. 2006. Nurses' perception of single-occupancy versus multioccupancy in acute care environments: An exploratory comparative assessment. *Applied Nursing Research* 2006;19:118-125.
- 27) Hilton, B. A. (1985). Noise in acute patient care areas. *Research in Nursing & Health*, 8(3), 283-291.
- 28) Press Ganey, Inc. (2003). National satisfaction data for 2003 comparing patients with versus without a roommate. (Provided by Press Ganey, Inc., for this research report at the request of Ulrich et al., 2008.
- 29) Dowdeswell, B., Erskine, J., & Heasman, M. (2004). Hospital ward configuration determinants influencing single room provision. A Report for NHS Estates, England. European Health Property Network: Stockton-on-Tees.
- 30) Duffin, C. 2002. Private Rooms in Hospital 'Would Hasten Recovery'. *Nursing Standard*, 2002. 16(37): p. 8.
- 31) Mears, A., White, A., Cookson, B., Devine, M., Sedgwick, J., Phillips, E., & Bardsley, M. (2009). Healthcare-associated infection in acute hospitals: which interventions are effective?. *Journal of hospital infection*, 71(4), 307-313.
- 32) Bobrow, M., & Thomas, J. (2000). *Multibed versus single-bed rooms. Building type basics for healthcare facilities* New York: John Wiley & Sons, 145-57.
- 33) Delon, G. L., & Smalley, H. E. (1970). Applications of the nursing unit methodology. *Quantitative methods for evaluating hospital design*, 49-83.
- 34) Hill-Rom. (2002). *The patient room of the future*. Batesville, IN: Author.
- 35) Drake, E. (2001) Hospital design can help make the bottom line better. *Washington Business Journal*. Retrieved March 10, 2003, from <http://Washington.bizjournal.com/Washington/stories/2001/09/03/focus4.html>
- 36) Ulrich, R.S. (2003). Creating a healing environment with evidence-based design. Paper presented at the American Institute to Architects Academy of Architecture for Health Virtual Seminar Healing Environments.
- 37) Bilchuk, G.S. (2002). A better place to heal. *Health Forum Journal*, 45(4), 10-15.
- 38) Morrissey, J. (1994). Cooperative care acutely less costly. *Modern Healthcare*, 24(38), 32-35.

- 39) O'Connell, N.H., & Humphreys, H. (200). Intensive care unit design and environmental factors in the acquisition of infection. *Journal of Hospital Infection*, 45(4),255-262
- 40) Silini,E.,Locasciulli, A., Santoleri,L., Gargantini., L., Pinzello, G., Montillo, M., et al. (2002). Hepatitis C virus infection in a hematology ward : Evidence for nosocomial transmission and impact on hematologic disease outcome. *Haematologica*, 87(11), 1200-1208.
- 41) Bobrow, M., & Thomas, J. (1994) Hospitals 'prosperity should be by design. *Modern Healthcare*, 24(47), 54
- 42) Burden, B (1998) Privacy or help? The use of curtain positioning strategies within the maternity ward environment as a means of achieving and maintaining privacy, or as a form of signaling to peers and professionals in an attempt to seek information or support. *Journal of Advanced Nursing*, 27(1), 15-23.
- 43) Clipson, C.W., & Wehrer, J.A. (1973). Planning for cardiac care: A guide to the planning and design of cardiac care facilities. Ann Arbor, MI: Health Administration.
- 44) Solovy,A.(2002). "Home" improvement. *H&HN:Hospitals and Health Networks*, 76(12), 28.
- 45) Dolce, J.J., Doley,D.M. Raczynski, J., M & Crocker, M.F (1985). Narcotic utilization for back pain patients housed in private and semi-private. *Addictive Behavior*, 10, 91-95.
- 46) Rich, M. (2002, November 27). Healthy hospital designs: Improving décor can have impact on care; fewer fractures and infections. *The Wall Street Journal*, p. B1.
- 47) Douglas, C., Steele, A., Todd, S., & Douglas, M. (2002) Primary care trusts. A room with a view. *Source Health Service Journal*, 112(5827), 28-29.
- 48) Kirk, S. (2002) Patient preferences for a single or shared room in a hospice. *Nursing Times*, 98(50), 39-41.
- 49) Reid, E.A., & Feeley, E.M. (1973). Roommates. *American Journal of Nursing*, 73(1), 104-107.
- 50) Baker, C., Garvin, B.J., Kennedy, C.W., & Polivka, B.J. (1993). The effect of environmental sound and communication on CCU patients' heart rate and blood pressure. *Research in Nursing & Health*, 26, 415-421.
- 51) Hosking, S., & Haggard, L. (1999). Patient wards. In S. Hosking & L. Haggard (Eds.), *Healing the hospital environment: Design, management and maintenance of healthcare premises* (pp.70-73). London: Routledge.
- 52) Shumaker, S.A., & Reizenstein, J.E.(1982). Environmental factors affecting inpatient stress in acute care hospitals. In G. Evans (ED), *Environmental stress* (pp.179-223). Cambridge, UK: Cambridge University Press.
- 53) Willimans, M. (2001). Critical care unit design: A nursing perspective. *Critical Care Nursing Quarterly*, 24(3), 35-42.
- 54) Persson, E., Määttä, S.(2012) To provide care and be cared for in a multiple-bed hospital room. *Scandinavian Journal of Caring Sciences: Empirical studies*. Doi:10.1111/j.1471-6712.2012.00976
- 55) Tegnstedt, C., Günther, A., Reichard., A., Bjurström, R., Alvarsson, J., Martling C.-R., Sackey. P. (2013) Levels and sources of sound in the intensive care unit- an observational study of three room types. *Acta Anesthesiologica Scandinavica*. Doi: 10.1111/ aas.12138.

- 56) Boardman, A.E., Forbes, D. (2011) A benefit-Cost Analysis of Private and Semi-Private Hospital Rooms. *Journal of benefit-cost analysis* Vol 2, 2011. Doi: 10.2202/2152-2812.1050
- 57) Gregory, R., Astly, P. (2009) Single rooms: The case for change. *Proceedings HacCIRIC International Conference 2009*, p.145-156.
- 58) BloemendaalAL, FluitAC, JansenWJM, VriensMR, Ferry T, Argaud L, et al. (2009). Acquisition and cross-transmission of *Staphylococcus aureus* in European intensive care units. *Infect Control Hosp Epidemiol* 2009;30:117-24.
- 59) Lorenz, S.G. (2009). Hospital Room Design and Health Outcomes of the Aging Adult. A Thesis Submitted to the Faculty of Drexel University in partial fulfillment of the requirements for the degree of Doctor of Nursing Practice May 2009.
- 60) Vietri, N. J., Dooley, D. P., Davis Jr, C. E., Longfield, J. N., Meier, P. A., & Whelen, A. C. (2004). The effect of moving to a new hospital facility on the prevalence of methicillin-resistant *Staphylococcus aureus*. *American journal of infection control*, 32(5), 262-267.
- 61) Stelfox, H. T., Bates, D. W., & Redelmeier, D. A. (2003). Safety of patients isolated for infection control. *Jama*, 290(14), 1899-1905.
- 62) Maguire., D.J., Burger, K.J., O'Donnell, P.A., Parnell L.P. (2013). Clinician perceptions of a changing hospital environment. *HERD* 2013, Vol 6 nr 3, p. 69
- 63) Teltsch, D. Y., Hanley, J., Loo, V., Goldberg, P., Gursahaney, A., & Buckeridge, D. L. (2011). Infection acquisition following intensive care unit room privatization. *Archives of internal medicine*, 171(1), 32-38.
- 64) Hamel, M., Zoutman, D., & O'Callaghan, C. (2010). Exposure to hospital roommates as a risk factor for health care-associated infection. *American journal of infection control*, 38(3), 173-181.
- 65) Baillie, J. "Benefits of a single-minded approach." *Health estate* 66.6 (2012): 44-48.
- 66) Florey, L., R. Flynn, and C. Isles. "Patient preferences for single rooms or shared accommodation in a district general hospital." *Scottish medical journal* 54.2 (2009): 5-8.
- 67) Ehrlander, W., Ali, F., & Chretien, K. C. (2009). Multioccupancy hospital rooms: Veterans' experiences and preferences. *Journal of Hospital Medicine*, 4(8), E22-E27.
- 68) Søndergaard Larsen, L., Hedegaard Larsen, B., & Birkelund R. (2013) A companionship between strangers – the hospital environment as a challenge in patient–patient interaction in oncology wards. *Journal of Advanced Nursing*, June 2013
- 69) van de Glind, I., van Dulmen, S., & Goossensen, A. (2008). Physician–patient communication in single-bedded versus four-bedded hospital rooms. *Patient education and counseling*, 73(2), 215-219.
- 70) Cone, S. K., Short, S., & Gutcher, G. (2010). From “baby barn” to the “single family room designed NICU”: a report of staff perceptions one year post occupancy. *Newborn and Infant Nursing Reviews*, 10(2), 97-103.
- 71) Huang, S. S., Datta, R., & Platt, R. (2006). Risk of acquiring antibiotic-resistant bacteria from prior room occupants. *Archives of internal medicine*, 166(18), 1945-1951.
- 72) Paikada, G. (2010). Study on the impacts of hospital design on patient safety and staff performance. Dissertation submitted to the Rajiv Gandhi University

- of Health Sciences, Karnataka, Bangalore in partial fulfillment of the requirements for the degree of Masters in hospital administration.
- 73) Adamson D.L. 2003. 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. The use of single patient rooms vs multiple occupancy rooms in acute care environments. Vancouver: Simon Fraser University; 2003.
 - 74) Bettin K.M., Kolb S, Clabots C, Gerding D.N.(1990) Frequency of Introduction and Acquisition of Clostridium-Difficile (Cd) by Patients in Private Versus Multibed Rooms. *Clinical Research*. 1990;38(3):A870-.
 - 75) BTY Group. Preliminary comparative cost study: One-bed room versus two-bed room cost comparison. BTY Group. 2003.
 - 76) Chaudhury H, Mahmood A, Valente M 2003. Pilot study on comparative assessment of patient care issues in single and multiple occupancy patient rooms. Submitted to the Coalition for Health Environments Research. The use of single patient rooms vs multiple occupancy rooms in acute care environments. Vancouver: Simon Fraser University; 2003.
 - 77) Douglas CH, Douglas MR. (2005) Patient-centred improvements in health-care built environments: Perspectives and design indicators. *Health Expectations: An International Journal of Public Participation in Health Care & Health Policy* 8(3):264-76.
 - 78) Harris DD, Shepley MM, White RD, Kolberg KJS, Harrell JW.(2006) The impact of single family room design on patients and caregivers: executive summary. *Perinatology*; 26(Suppl S3):S38-48.
 - 79) Harrison S.(2005). Single rooms boost morale. *Nursing Standard* 19(31):5-.
 - 80) Lawson B, Phiri M, Wells-Thorpe J, Estates N. The architectural healthcare environment and its effects on patient health outcomes a report on an NHS Estates funded research project (Reprinted January 2004). London: Edition Stationery Office; 2004.
 - 81) Maki DG, Alvarado CJ, Hassemen CA, Zilz MA.(1982). Relation of the inanimate environment to endemic nosocomial infection. *The New England Journal of Medicine*:1562-66.
 - 82) McManus AT, A D Mason J, McManus WF, B A Pruitt BA J. A decade of reduced gram-negative infections and mortality associated with improved isolation of burned patients. *Archives of Surgery*. 1994;129(12):1306-09.
 - 83) NHS Estates, Health Do. (2005) Ward layouts with single rooms and space for flexibility. London: Edition The Stationery Office; 2005.
 - 84) Parker J. (2005).Singular visions. *Hospital Development*, 36(4):11-2.
 - 85) Rosenblum D. (2005).Single family room care: before and after data.
 - 86) Thompson JT, Meredith JW, Molnar JA. The effect of burn nursing units on burn wound infections. *Journal of Burn Care & Rehabilitation*. 2002;23(4):281-86.
 - 87) Williams BA, Rago KA, Gamberg P. (1995) Impact of discontinuing isolation after heart transplantation. *Journal of Transplant Coordination*, 5(1):31-4.
 - 88) West, P., McDonagh, S., Burke, M., Trueman, P. (2010). Evaluation of single room ward at Hillingdon Hospital: Final Report. York Health Economics Consortium.
 - 89) Chaudhury, H., Mahmood, A., Valente, M.,(2009) The Effect of Environmental Design on Reducing Nursing Errors and Increasing Efficiency

- in Acute Care Settings: A Review and Analysis of the Literature. *Environment and Behavior* 2009; 41; 755. DOI: 10.1177/0013916508330392.
- 90) Wigglesworth, N., & Wilcox, M. H. (2006). Prospective evaluation of hospital isolation room capacity. *Journal of Hospital Infection*, 63(2), 156-161.

Other references (including review papers that were used to identify individual papers):

- Anonymus, (2007). *Review of international literature on the use of single versus multiple bedrooms in acute care facilities*. Queensland Department of Health in collaboration with Centre for Health Assets Australia.
- Bartley, J.M., Olmsted, R.N., Haas, J. (2010). Current views of health care design and construction: Practical implications for safer, cleaner environments. *Am J Infect Control* 2010;38:S1-12.
- Bracco, D., Dubois, M. J., Bouali, R., & Eggimann, P. (2007). Single rooms may help to prevent nosocomial bloodstream infection and cross-transmission of methicillin-resistant *Staphylococcus aureus* in intensive care units. *Intensive care medicine*, 33(5), 836-840.
- Chaudhury, H., Mahmood, A., & Valente, M. (2005). Advantages and disadvantages of single-versus multiple-occupancy rooms in acute care environments—A review and analysis of the literature. *Environment and Behavior*, 37(6), 760–786.
- Scottish Government, 2010. Provision of single room accommodation and bed spacing. *Cel* 27, 20 July 2010
- Detsky, M. E., & Etchells, E. (2008). Single-patient rooms for safe patient-centered hospitals. *JAMA*, 300(8), 954-956.
- Dettenkofer M, Seegers S, Antes G, Motschall E, Schumacher M, Daschner FD. Does the architecture of hospital facilities influence nosocomial infection rates? A systematic review. *Infection Controlled Hospital Epidemiology* 2004;25(1):21–5.
- Glind, van der I., Roode, de S., Goossensen, A. (2007). Do patients in hospitals benefit from single rooms? A literature review. *Health Policy* 84 (2007) 153–161.
- Huisman, E. R. C. M., Morales, E., van Hoof, J., & Kort, H. S. M. (2012). Healing environment: A review of the impact of physical environmental factors on users. *Building and Environment*, 58, 70-80.
- Joseph, A., & Quan, X. (2011). A Glossary of Healthcare Built Environment Terms and Measures. *Development of Tools for Healthcare Environments Research and Practice*.
- Scottish Intercollegiate Guidelines Network. (2011) *SIGN 50 A guideline developer's handbook*. Scottish Intercollegiate Guidelines Network, Edinburgh
- Tanja-Dijkstra, K., & Pieterse, M. E. (2011). The psychological effects of the physical healthcare environment on healthcare personnel. *Cochrane Database Syst Rev*, 1.
- West, P., McDonagh, S., Burke, M., Trueman, P. (2010). *Evaluation of single room ward at Hillingdon Hospital: Literature Review*. York Health Economics Consortium.
- Zimring, C. M., Ulrich, R. S., Zhu, X., DuBose, J. R., Seo, H. B., Choi, Y. S., ... & Joseph, A. (2008). A review of the research literature on evidence-based healthcare design.

A Evidence Base Matrix

The below table shows the evidence base matrix. The “Article reference” column shows the reference number that is used in the results tables in chapter 3 and reference list in chapter 5. From left to right the matrix indicates: the “Individual study” showing the author (s) and issue date of the selected paper; “Included in review” showing the review paper (s) if the paper was selected in that review; the “Intervention” of the study if relevant; the “Type of study” if reported; “N” showing the number and type of participants if reported; the “Setting” in which the research was conducted; the reported “Results”; “Risk confounding or bias” indicating for level 1-2 research if no quality grading was provided by others, if the risk was low, moderate or high (see table 3), the explanation of this assessment is provided in “Explanation”; “Other rating” showing the rating of other reviewers, how this rating was transferred into a SIGN rating is provided in “Explanation”; “SIGN rating” showing the rating that was used for interpretation, “Remarks” showing remarks of any kind with regard to the paper.

Table 7 Evidence Base Matrix

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
Nguyen Thi et al., 2002	CHD, 2011	No intervention, survey to investigate factors contributing to patient satisfaction.	Survey. Identification of factors contributing to patient satisfaction by regression.	533	Hospital inpatients France	Patient in private bedroom scored higher on patient satisfaction (Odd ratio 1.8-2.0) than 2-3 bedroom.	Moderate		2+	Not clear if people in single rooms differed from people in 2/3 bedroom on other characteristics.	Interesting that article was not included (or excluded) in West, 2010 or Glind, 2007).	1
Ben-Abraham et al., 2002	CHD, 2011; Calkins and Cassella, 2007; West et al., 2010	Comparison single room vs multibedroom nosocomial infections paediatric ICU.	Compare data set of 1992 (open unit) vs 1995 (single rooms); no control, just indication.	78 children hospitalized for more than 48 hours in 1992 and 115 children hospitalized for more than 48 hours in 1995 in a six-bed PICU	Paediatric Intensive Care	Nosocomial infection frequency was much lower in a single-bed paediatric intensive care unit (PICU) than multibedrooms. Shorter stay.		2+ West et al., 2010	2+	Rating based on West et al., 2010)		2
Preston, Larson, and Stamm's, 1981	West et al., 2010; Ulrich, 2008; Glind, 2007; Dettenkofer, 2004	Effect on nosocomial infection rate single vs multibedroom	before after studies (improvement isolation capacity with 100% single rooms)		ICU	No effect on nosocomial infection rates.		2- (West et al.,2010)	2-	Rating based on West et al., 2010)	See Preston, Mulin, Martiny.	3
Mulin et al, 1997	West et al.,2010	Effect on nosocomial infection rate single vs multibedroom	before after studies (improvement isolation capacity with 100% single rooms)			Reduction nosocomial infection rates.		2+	2+	Rating based on West et al., 2010)	See Preston, Mulin, Martiny.	4
Preston, 1981 (3) Mulin, 1997 (4) Martiny, 1982 (5)	Dettenkofer et al., 2004; Review 1975-2001	Review 3 studies on intervention move to single beds only (+ others) on effect nosocomial infection.	before after studies (improvement isolation capacity with 100% single rooms).		ICU	Mixed results: 2: no difference (Preston, 1981; Martiny, 1982); 1: reduction (Mullin, 1997).		Preston 2- (West et al., 2010: review excluded no quantifiable evidence), Glind +++.	2+/-	Rating based on West et al., 2010)	3 articles included as they were mentioned by West, 2010 and or Glind, 2007. Quality of articles 2+/- due to risk of confounding factors (sanitary was also changed next to single rooms).	(3,4) 5

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
Janssen, Klein, Harris, Soolsma, & Seymour, 2000 (and 2001) Client (6) (and Staff (7))	Chaudhury et al., 2009; Client: Glind, 2007; Staff: Dijkstra et al, 2011; Dowdeswell, 2004.	Effect single room vs multibed on staff and patients (renovation maternity ward).	Staff: before after study, survey. Clients: Comparative study with historical and concurrent comparison groups.	72 staff; 205 client women in single-room maternity care (study group); 221 women in historical comparison group; 104 women in concurrent comparison group.	maternity ward	Staff: In single rooms equipment and supplies were easier to access, privacy was greater and noise levels were reduced, and quality of care was also perceived as being greater because nurses were better able to respond to the emotional and physical needs of the patients. Client: Single room maternity care was associated with a significant improvement in client satisfaction because of many factors, including the physical setting itself, avoidance of transfers, and improved continuity of nursing care.		Client: Glind +++, Staff: Dijkstra, 2011 excluded: confounded with changes in nursing education.	Client: 2++ Staff: 2-	Rating client based on Glind et al., 2007; Staff See Dijkstra et al., 2011 . Paper not excluded like Dijkstra, 2011, but 2- rating due to risk of confounded results.		6,7
Page, 2004	Chaudhury,2009	Effect single room vs multibed on staff and patients.	Expert opinion			Single-occupancy rooms have been associated with better communication among staff, reduced need for patient transfers, fewer medication errors, and decreased infection rates.			4	Reported in review, not checked rated as expert opinion.		8
Anonymous, 2000	Chaudhury, 2009	Benefits single rooms	Expert opinion			Benefits of single-occupancy rooms include shortening a patient's length of stay, a reduced risk of acquiring a hospital born infection, and the reduced risk of medication errors.			4	Reported in review, not checked, rated as expert opinion.		9
Ulrich & Wilson, 2006	Ulrich et al., 2008	Effect on easiness to clean single vs multibed rooms.				Single rooms more easy to clean (HPV procedures) after discharge patient (not always possible or extra challenges with others in the room (need to be transferred).			4	Included in review, not checked, rated as expert opinion.		10
Romano, 2004	Glind, 2007	single vs multibed room	moderate expert opinion			Decrease infection, less noise better sleep, satisfaction increase.		Glind +	4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		11

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
Sandrick, 2003	Glind, 2007	single vs multibed room	moderate expert opinion			Decrease infection, less noise better sleep, satisfaction increase.		Glind +	4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		12
Marshall, 2002	Glind, 2007	single vs multibed room	moderate expert opinion			Decrease infection		Glind +	4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		13
Mader, 2002	Glind, 2007	single vs multibed room	moderate expert opinion			Decrease infection, less noise better sleep, satisfaction increase.		Glind +	4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		14
Hamilton, 2000	Glind,2007	single vs multibed room	moderate expert opinion			Decrease infection, satisfaction .increase		Glind +	4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		15
Coile, 2002	Glind,2007	single vs multibed room	moderate expert opinion			Decrease infection, less noise better sleep, satisfaction increase.		Glind +	4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN		16

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
										ratings available, SIGN rating copied.		
Berry, Parker, Coile, O'Neill, Sadler, 2004	Glind, 2007	single vs multibed room	moderate expert opinion			Decrease infection, less noise better sleep.		Glind +	4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		17
Berry et al., 2004			Opinion article		Hospital	Estimated larger space for single rooms = 100 s.mt per bed (e.g. 255 bed) construction cost increase of 4,7 million dollar.			4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.	also included by Glind	17
Landro, 2006	Glind, 2007	single vs multibed room	moderate expert opinion			Decrease infection, less noise better sleep.		Glind +	4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		18
Barlas, Sama, Ward, Lesser, 2001	Glind, 2007, Detsky, 2008, Boardman, 2011; Dowdeswell, 2004	Curtains vs solid walls			ED	Auditory and visual privacy (5% less communication and examination) was significantly less in curtains setting vs solid walls setting. Negative opinion: Direct observation of patients and efficient movement of people and equipment .		Glind++	2	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		19

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
Jolley, 2005	Glind, 2007					Increased privacy and dignity in single room, satisfaction increase.		Glind++	3	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		20
Lawson, Phiri, 2000	Glind, 2007, Chaudhury, 2005	comparison patient in single room vs multibedroom.				Increased privacy and dignity (more satisfied) in single room vs multibedroom.		Glind ++	3	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		21
Kaldenberg, 1999	Glind, 2007; Calkins and Cassella (2007)	comparison between single bed ratio's and satisfaction scores and between individual patients in single vs multibedrooms.	Comparison study between 111 with different single bed ratio's.		111 hospital settings	Higher satisfaction in hospitals with higher single room ratio and same pattern found for patients in single rooms.		Glind++	2+	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		22
Pease, Finlay, 2002	Glind, 2007, Chaudhury, 2005	single vs multibed room	Survey	36 relatives, 41 patients	17 bed oncology ward, palliative	20% patients preferred single room, 68% patients preferred open area: not lonely, time quicker, someone to talk to. Relatives higher preference single room. Preference relative & patient differed in 50% of cases.		4+, Glind ++	4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		23
Dolson, Helsa, Krewson, Parimu, 1976	Glind, 2007	single vs multibed room				satisfaction increases		Glind+	4	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN		24

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
										ratings available, SIGN rating copied.		
Miller, Friedman, Coupey, 1998	Glind, 2007	Preference for roommates in adolescents inpatients and outpatients.	Preference survey	95	Adolescents	40% alone or with one person 39%, more than 1 20%. Female prefer single room more than man.		Glind++	3	Rating translation. Glind +++ = 2++, Glind ++ is 2+ if reported by other review too, otherwise 3; Glind + = 4. In case other SIGN ratings available, SIGN rating copied.		25
Chaudhury, Mahmood, Valente, 2006	West et al., 2010, Dijkstra, 2011; Queensland, 2007	Single vs double room	survey: rating existing double en private rooms in hospital	77	medical-surgical unit 4 hospitals	Single rooms in favour . Less probable errors, appropriate patient care +, interaction family+, mix-up dietary-, patient comfort+, medication error-, recovery rate+. Surveillance somewhat problematic in both rooms.		3++	3	Based on rating West et al., 2010		26
Hilton, 1985	Calkins and Casella (2007): Ulrich & Zimring, 2004; Chaudhury, 2005, Boardman, 2011	Noise in multibed and single-bed intensive care units (ICUs) and general care units	Descriptive; continuous noise level recordings made at several locations in each unit; observation of sound sources; structured patient interview.	Four intensive care and two general care units in three hospitals (one large with multibed rooms, two smaller hospitals with single-bed ICUs); 25 patients; sound measured for 24 hours at head of each patient's bed.	Hospital	Continuous noise levels were high in the larger hospital's multibed recovery room and ICU (48.5–68.5 dBA); lower levels were measured in the smaller hospitals' single-bed ICUs (32.5–57 dBA), and varies in general ward areas (34.25–62.5 dBA). Noise peaks from equipment reached 90 dBA. The difference in noise levels between the large hospital ICU and the two smaller ICUs was related to the number of beds per room. Patients' perceptions of noise were strongly negative in the large hospital's eight-bed recovery room. Closing doors reduced sounds from outside rooms by 10–15 dBA.			4	Mentioned in multiple reviews, included as expert opinion as quality could not be checked.		27
Press-Gany, 2003	Calkins and Cassella (2007) Ulrich et al., 2008	Preference for single room	Satisfaction survey	2.000.000	Hospitals	Satisfaction with privacy was on average, 4,5 percent higher for people in private rooms than shared rooms. In single rooms more satisfied with noise.	Limited		4	Not clear whether single and multibedroom differed on other aspects too, but due to high number of patient risk of confounding limited.	Reported in 2 reviews, not checked, rated as expert opinion.	28

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
Dowdeswell, 2004	Queensland,2007	Determinants for single rooms provision	Review and expert meetings, case studies		Europe	HAI seems lower in single rooms, improved patient satisfaction, increased flexibility (and utilization), cost depend on proportion bel curve: low 50% and 100%; high 70-80%. 50% equilibrium than rise costs (factors of design, spatial allocation, workforce impact and environmental service costs) cost reduce when near 100% due elimination for separate ancillary spaces (day care etc.). Cost in general higher for 100% single rooms than 50% (between £1,879 and £2,089 higher per bed)			3	Rating was done for case study (bell curve), Review was not evaluated as articles found were individually evaluated (see 'Included in Review' column).		29
Duffin, 2002	Calkins and Casella (2007); Chaudhury, 2005	Single rooms	Reports over MAAP study: working practices and surveys	7 hospitals	UK & Norway	in private rooms exposed to less noise, sleep better and have greater privacy			4	MAAP not available, but selected in 2 reviews. Included as expert opinion.		30
Mears et al., 2009		Capacity of isolation rooms	This study investigated the potential factors linked to healthcare associated infection (HCAI) rates in acute National Health Service hospitals, analysing mandatory surveillance data with existing data available to the Healthcare Commission, and supplemented by a bespoke questionnaire.	Questionnaire 155	acute National Health Service hospital	The more frequently Trusts were unable to follow their own guidance for the management of infection due to unavailability of a single room, the higher the rate of >48 h MRSA (r ¼ 0.324, N ¼ 43, P ¼ 0.034).			4	Not direct effect of single vs multibed room. But reasoned, if only single rooms exist there can't be a failure of isolation practice. Therefore rated as expert opinion in favour of 100% single rooms.		31
Bobrow & Thomas, 2000	Chaudhury 2005, Boardman, 2011	Single vs multibed room	Before/after study			Even with higher first or unit costs of construction furniture, maintenance, housekeeping, energy costs, nursing costs, and costs, single occupancy can match the cost of multibedrooms because of higher occupancy rates (100% single, 80-85% multibed due to less transfers, -500,000, annually).			3	Not tracked so quality of before/after study could not be evaluated, therefore rated as 3.		32

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
Delon & Smalley, 1970	Chaudhury 2005	Single vs multibed room	Expert opinion			higher first costs, higher occupancy rates single rooms. Travel costs nurses and traffic cost higher in private rooms.			4	Not tracked. Based on Boardman's remark, articles rated as opinion 4, unless reported by other reviewer.		33
Hill-Rom 2002	Chaudhury 2005, Chaudhury, 2009	Single vs multibed room	Expert opinion			Shorter stay and less medication errors, which reduces costs in single rooms.			4	Not tracked. Based on Boardman's remark, articles rated as opinion 4, unless reported by other reviewer.		34
Drake, 2001	Chaudhury 2005	Single vs multibed room	Expert opinion			Reduced operating costs for single rooms. Patient centred care 10% reduction staff cost with same satisfaction and quality.			4	Not tracked. Based on Boardman's remark, articles rated as opinion 4, unless reported by other reviewer.		35
Ulrich, 2003	Chaudhury 2005	Single vs multibed room	Expert opinion			Reduced operating costs for single rooms, patient consultation inconclusive, less sleep disturbances.			4	Not tracked. Based on Boardman's remark, articles rated as opinion 4, unless reported by other reviewer.		36
Bilchnik, 2002	Chaudhury 2005	Single vs multibed room	Expert opinion			Single rooms reduce medication errors and costs; patient consultation inconclusive.			4	Not tracked. Based on Boardman's remark, articles rated as opinion 4, unless reported by other reviewer.		37
Morrissey, 1994	Chaudhury 2005	Single vs multibed room	Expert opinion			Less medication errors en cost.			4	Not tracked. Based on Boardman's remark, articles rated as opinion 4, unless reported by other reviewer.		38
O'Connell & Humphreys, 2000	Chaudhury 2005	Single vs multibed room	Expert opinion			Single rooms decrease nosocomial infection rate.			4	Not tracked. Based on Boardman's remark, articles rated as expert opinion 4.		39
Silini et al., 2002	Chaudhury 2005	Single vs multibed room	Expert opinion			Single room less transmissions, less risk infection.			4	Not tracked, included as expert opinion		40
Bobrow & Thomas, 1994	Chaudhury 2005	Single vs multibed room	Expert opinion			Single room more privacy, more control.			4	Not tracked, included as expert opinion		41
Burden, 1998	Chaudhury 2005	Single vs multibed room	Expert opinion			Single room more privacy.			4	Not tracked, included as expert opinion		42

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
Clipson & Wehrer, 1973	Chaudhury 2005	Single vs multibed room	Expert opinion			Single room more privacy.			4	Not tracked, included as expert opinion		43
Solovky, 2002	Chaudhury 2005	Single vs multibed room	Expert opinion			Single room more privacy.			4	Not tracked, included as expert opinion		44
Dolce, Doleys, Raczynski & Crocker, 1985	Chaudhury 2005	Single vs multibed room	Expert opinion			Inconclusive			4	Not tracked, included as expert opinion		45
Rich, 2002	Chaudhury 2005	Single vs multibed room	Expert opinion			Inconclusive			4	Not tracked, included as expert opinion		46
Douglas, Steel, Todd & Douglas 2002	Chaudhury 2005	Single vs multibed room	Expert opinion			Inconclusive			4	Not tracked, included as expert opinion		47
Kirk, 2000	Chaudhury 2005	Single vs multibed room	Expert opinion			Inconclusive			4	Not tracked, included as expert opinion		48
Reid & Feeley, 1973	Chaudhury 2005	Single vs multibed room	Expert opinion			Inconclusive			4	Not tracked, included as expert opinion		49
Baker, Garvin, Kennedy & Polivka, 1993	Chaudhury 2005	Single vs multibed room	Expert opinion			Single room reduces noise level.			4	Not tracked, included as expert opinion		50
Hosking & Haggard, 1999	Chaudhury 2005	Single vs multibed room	Expert opinion			Single room reduces noise level.			4	Not tracked, included as expert opinion		51
Shumaker & Reizenstein, 1982	Chaudhury 2005	Single vs multibed room	Expert opinion			Single room more control.			4	Not tracked, included as expert opinion		52
Williams, 2001	Chaudhury 2005	Single vs multibed room	Expert opinion			Single room more control.			4	Not tracked, included as expert opinion		53
Persson, Mata, 2012		Advantages and disadvantages Multi-bedrooms (MBR)	Qualitative, interviews patients, focus-groups staff.	12 staff, 16 patients	multi-hospital bedroom	Disadvantage multibed: privacy & dignity, integrity (nurses). Advantage: feeling safe, social support (provided roommate not very ill or confused).			3	Non-analytic research		54
Tegnstedt, Gunther, Reichard, Bjurstrom, Alvarsson, Martling, Sackey, 2013		Effect of 1 vs 3 bedrooms and nursing station configuration on sound level.	Experiment: between subject variance analysis (room type), within subject (shift).	15 (5 per room), 14 men	ICU, hospital Sweden	There were no statistically significant differences between the room types in mean sound levels or in CRT (cumulative restorative time). Disruptive sounds were 40% less frequent in the single room with nurse station alcove (i.o separate room) than single room with bedside ns and 3 bedroom with NSA (NS dependent not room). Disruptive sounds related to monitor alarms and conversations, not care related. Trend longer cumulative restorative time in single bedroom with NSA than 3 bed with NSA.	Moderate		2+	+ Inclusion criteria that reduced confounding effects, - however small sample size.		55

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
Boardman, Forbes, 2011		single vs double	Benefit-Cost analysis single rooms vs double rooms.		Hospital	Single room: Costs: CC: Land +, Construction + Maintenance +, housekeeping & operational costs+, care provision (travel distance)+; Benefit: PO: Health & Satisfaction (Noise , Privacy +, less adverse events (staff errors, hai); No evidence less infection) PI: option value (+) HI: patient transfers (-), longer distance, turnover + (due to higher patient turnover). +70K single room.			3	Well conducted research, but findings are based on many assumptions therefore rated as 3.	Benefits questionable. Researchers reasonably confident about costs, however depend on construction market (EU different from US/CA). Only financial evidence used . Individual articles were included for patient and staff outcomes.	56
Gregory, Astley, 2009		proportion single rooms	Literature review, survey			Single room: reduced complications treatment, improved health outcomes. Evidence suggests between 50-100%, possibly around 85% single rooms would be acceptable, but here is no a one size fits all solution. Staff behaviour, supported by operational protocols and new ways of working is equally a strong determinant of positive outcomes for patients. Increased bed occupancy.			4	Expert opinion		57
Bloemendaal, Fluit, Jansen, Vriens, Ferry, Argaud, 2009	Bartley, Olmsted, Haas, 2010	Acquisition of infections in different ICU settings: private and multibed rooms, and other factors.	multicentre cohort study		Six ICUs in 6 countries	Colonization pressure, the number of beds per nurse, and the treatment of all patients in private rooms correlated with the number of S. aureus acquisitions on an ICU. The type of ICU setting was related to MRSA acquisition only (not MSSA or S. aureus): lowest in ICU with private rooms (p =0.03, bivariate).	High		2-	Low number of infection acquisitions due to short data collecting period Confounders "average health status", The number of surgical patients, receiving mechanical ventilation.		58
Lorenz, 2009	Boardman, 2011	Private vs semi private rooms	Retrospective case comparative design	166	65+ teaching hospital	Relative risk of falling in a private room was 4,01 compared to semi-private room, no difference in likelihood of falling (4 out 5 in private room, 1 alone in bathroom. No effect in occurrence HAI.			3	Analytical study but not peer reviewed. Therefore rated as 3.		59
Vietri, Dooly, Davis, Longfield, Meier, Whelen, 2004	West, 2010; Detsky, 2008, Dowdswell, 2004; Queensland, 2007	Move from open bays with poor sinks, to mainly single and double beds on occurrence MRSA.	Before, after comparison	before 123, after 138	8 wards, 1 ICU	No significant effect on occurrence/ spread MRSA.		2++	2++	Rating based on West, 2010		60

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
Stelfox,2003	Detsky,2008; Boardman,2011; Queensland, 2007	Isolation room	2 Matched cohorts general patients, heart disease patients: comparison isolated non isolated patients.	2*78 (general); 2*72 (specific)	Teaching hospital US	Patients in isolation have fewer visits and more adverse events (falls), less satisfied. No effect mortality, or adverse drug events.			4	It is about isolated people not specifically people in a single room design. If all patients are in single rooms, nobody is isolated as everybody is. It is a an assumed risk, therefore rated as Expert opinion.		61
Maquire, Burger, O'Donell, Parnell, 2012		Refurbishment paediatric hospital with single rooms.	Repeated survey before move, and 1-8-15 months after, between subjects tests.	144, 187,109,90	Paediatric hospital	Increased stress levels for clinicians, disagreement that single room is good for patient care, more dangerous for ventilated patients. Patient and family care increased.	high		2-	confounded with patient-centred care, no control.		62
Teltsch, Hanley, Loo et al, 2011		Move from multibed to single room unit. Effect on infection rate.	Before, after and control	Data from 3 hospital information systems	ICU	The adjusted rate of acquisition of Clostridium difficile, vancomycin-resistant Enterococcus species, and methicillin-resistant Staphylococcus aureus combined decreased by 54% (95% confidence interval [CI], 29%-70%) following the intervention. The methicillin resistant S aureus acquisition rate fell by 47% (95% CI, 1%-71%), the C difficile acquisition rate fell by 43% (95% CI, 7%-65%), and the yeast acquisition rate fell by 51% (95% CI, 34%-64%). Twelve common and likely exogenous organisms and exogenous/endogenous organisms had a reduction in acquisition rates after the intervention; for 6 of them, this reduction was statistically significant. No effect was observed on the acquisition rate of coagulase negative Staphylococcus species, the most common endogenous organism, for which no change would be expected. The adjusted rate ratio of the average	low		2++	control group included and large sample size.		63

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
						length of stay in the ICU was 10% (95% CI, 0%-19%) lower after the intervention.						
Hamel, Zoutman, et al., 2010		Impact of exposure to hospital roommates on the acquisition of infections.	A retrospective cohort of adult patients 2001-2005	1 hospital, 37,697 patients (249,667 observations)	teaching hospital Canada	The number of roommate exposures per day was significantly associated with MRSA and VRE infection or colonization(MRSA: hazard ratio [HR] 5 1.10, 95% confidence interval [CI] 5 1.05 to 1.15; VRE: HR 5 1.11, 95% CI 5 1.02 to 1.21), and with Cdifficile infection (HR 5 1.11, 95% CI 5 1.03 to 1.19). A significant association also was found for number of unique roommateexposures per day and VRE (HR 5 1.15, 95% CI 5 1.02 to 1.28). Not for MRSA or Colonization, indicating that could also be result of other persons (visitors etc.) Increasedrisk of 1.10 to 1.11 for 1 roommate exposure.	Low		3	+ Controlled for Age, sex, and number of transfers within the hospital per day were included, as well as antimicrobial exposures before infection. '- Total roommate measure confounded for other people like visitors.The VRE results were not split between increase 0 to 1 roommate, so could not directly be related to single room design. Rating 3 as it indicates single rooms are not effective in reducing risks as visitors are also related to increased infection risk, not only unique roommates.		64
Baillie, 2012		Move to single bed facility	Expert opinion	1	NHS in Wales 100% single rooms	Care policy also has to change with implementation single rooms, some staff left. Result: + privacy, feeling of isolation +, communication staff + . Relations assumed with: +occupancy rates, less falls, more compliance hand washing and better patient flows.			4	Expert opinion		65
Florey, Finn, Isles, 2009		None	Survey	40 single, 40 in shared	Surgical & medical patients in Scotland	Preference for shared room older population and longer stay.			3	Non analytical research		66
Ehlander, 2009		single vs shared room (2-3 bed)	Survey upon discharge, comparison between patients who stated in	162 (83 shared,53 private, 26 excluded)	Veteran medical centre	Single room reported more adequate privacy and nurse availability than shared rooms (.01; 0.025). No difference loneliness. Strong	Moderate		2+	No randomization of single room patient, but controlled for demographical		67

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
			single vs shared rooms			preference for private rooms (79%). Those who favoured shared rooms, conversation important. No effect race, older more likely to prefer shared.				factors and length of stay. Not generic only men.		
Larsen, Larsen, Birenlund, 2013		None	qualitative: observation & interview	Observation n = 85, interview n= 20	Oncology ward	18 out of 20 preferred shared room (except too ill). Preference for 2-bed. Challenges: loss of personal privacy and control, but it also offered the possibility of good company and support from fellow patients. Refuge from fellow patients was hard to achieve and the fact that personal conversations might be overheard by fellow patients caused patients to withhold important information from healthcare professionals.			3	Non analytical research		68
Glind, Dulmen, Goossensen, 2008		Single vs multibedrooms (4p)	Comparison between single and multibedrooms (4p) based on observational audiotaped data.	52 patient-clinician encounters: 21 single, 31 multibed	Urology ward	Encounters during ward rounds in single rooms significantly took up more time than encounters in four-bedded rooms. The patients asked more questions and made more remarks in single rooms compared to four-bedded rooms. Empathic reactions of the physician were scored significantly more often in single rooms than in four-bedded rooms. No differences were observed concerning the extent to which intimate subjects were brought up.	low		2+	+randomisation single room patients, - sample size (small due to between design)		69
Cone, Short, Gutcher, 2010		Move open bay, single rooms NICU	Post occupancy 1 year after move: survey	107 interdisciplinary team members	NICU	The results suggest that when compared to the open unit "Baby Barn" design, the SFR model was deemed to be better for patient care, less stressful for staff, and provided an improved physical environment for patients, families, and staff.			4	Expert opinion staff		70
Huang, 2006	West et al.,2010	Impact of exposure to hospital roommates on the acquisition of infections.						2+	3	No evidence single vs multibed, however assumes that there is no difference as single beds also have previous patients. Therefore rated as 3 (compare 64)		71

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
Paikada, 2010		private vs general ward	Questionnaire comparison between patients in private vs general ward. Descriptive cross-sectional research design.	65 staff, 40 patients (20 private, 20 general ward)	hospital, India	Private room more satisfied with: Nurses easy to call homely atmosphere, wellbeing, interior design, quiet area for reading, cleanliness, facilities to keep in touch outside world and connection, (no difference privacy talk, confidentiality, caring family).			3	Analytical Master thesis, non-peer reviewed.		72
Adamson, 2003	West et al.,2010				UK	Construction cost: higher (+60K dollar per patient) single vs mixed floor plan .		2+	2+	Rating based on West, 2010		73
Bettin, 1990	West et al.,2010				Surgical ward patients	Longer stay 12,2 vs 9,6 and 7,6 (2, 4 bed).		2-	2-	Rating based on West, 2010		74
BTY, group, 2003	West et al.,2010					Construction cost: higher (+19K dollar per bed) single vs double beds.		2+	2+	Rating based on West, 2010		75
Chaudhury, 2003	West et al.,2010					Decrease medication errors, Increase satisfaction bed area, feel better.		3++	3++	Rating based on West, 2010		76
Douglas & Douglas 2005	West et al.,2010		Postal survey			Ex-patients more satisfied in single rooms(49,5% vs 29,26,32,5%).		3++	3++	Rating based on West, 2010		77
Harris, 2006	West et al.,2010					cost per sq. foot single rooms + 9 dollar. Compared to double room -37 dollar.		2+	2+	Rating based on West, 2010		78
Harrison, 2005	West et al.,2010					11% reduction hospital acquired infection when moved to single room. 6% construction cost increase single rooms, 1 year PBT.		4+	4+	Rating based on West, 2010		79
Lawson, 2004	West et al.,2010					Mental health prefer single room, overall 54% shared, 43% single.		2+	3	Rating based on West, 2010		80
Maki, 1982	West et al.,2010					No difference nosocomial infection incidence .	Moderate	2+	2+	Rating based on West, 2010. Possible confounding with heating, ventilation and isolation rooms .		81
McManus, 1994	West et al.,2010		two 10 year cohorts		Burn patients	Less infection single bed isolation cohort.		2+	2+	Rating based on West, 2010		82
NHS Estates, 2005	West et al.,2010; Queensland, 2007				UK	Cost per bed 100% single vs 50% single + 8k pound.		2+	2+	Rating based on West, 2010		83
Parker, 2005	West et al.,2010				Public (no patients)	52% prefer single, 37% shared.		4+	4+	Rating based on West, 2010		84
Rosenblum, 2005	West et al.,2010				NICU	shorter stay in single room: 36,2 days as opposed to 38,3 days.		NA	NA	Rating based on West, 2010		85
Thompson, 2002	West et al.,2010, Dowdeswell, 2004				Burn patients	No effect LOS before during and after move to single rooms.		2+	2+	Rating based on West, 2010		86
Williams 1995	West et al.,2010				LOS: heart transplants patients	No difference infection incidence single vs semi-private rooms. Nursing care costs higher private vs semi private (+ 4075 dollar). Longer stay (9,5 days vs		2+	2+	Rating based on West, 2010		87

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Risk confounding or bias	Other rating	SIGN rating	Explanation	Remarks	Article reference
						6,1 in semi-private).						
West et al.,2010			Before/After	Patients:204 single, 176 multibed. Staff:23	Hospital UK	<ul style="list-style-type: none"> - No effect infection. - Trend increase falls. - Sig. higher satisfaction (not wrt social contact). - No effect length of stay. - Staff supportive, but not wrt monitoring, safety staff, falls (indication). - No effect staff levels (indication). - Increase cleaning cost, due to greater floor area. - No effect medication cost. 	High		PS: 2- Other: 3	Patient satisfaction 2- as no control for other differences between the two comparison groups. Other: no control group, no randomization of single room patients, small sample size. Not able to control for case mix etc. Therefore rated as 3.		88
Chaudhury, 2009			Focus group 90-120 min (different types of hospital nurses)	19	Acute Care US	Staff overwhelmingly preferred single over double rooms due to privacy, safety and reduced errors.			3	Non-analytic research		89
Wigglesworth & Wilcox, 2006,	CHD, 2008	Single room capacity and prevalence of MRSA	12-month prospective observational study of every infection control request for isolation.		1150-bed teaching hospital	There was a statistically significant correlation between isolation failures and MRSA incidence. Capacity +30% only 1 failure incidence.			4	Indirectly related to single rooms, if 100% single rooms, no failures possible. Therefore rated as expert opinion.		90

B (Systematic) review papers

The below table shows the assessed (systematic) review papers. From left to right the matrix indicates: the author (s) and issue date of the “Review study”; the “Topic” of the review; “Type of study” indicating the type of review and timeframe, “N” indicating the number of selected individual papers; “Type of studies” indicating the type of studies that were selected; the “Setting” that was relevant for the review; the reported “Results”; the outcome of the “SIGN” assessment which is explained below, and the resulting “SIGN rating”; “Remarks” showing remarks of any kind with regard to the review.

SIGN assessment

The numbering in the “SIGN” columns refer to questions in the SIGN checklist for reviews:

- 1.1 The study addresses an appropriate and clearly focused question.
- 1.2 A description of the methodology used is included.
- 1.3 The literature search is sufficiently rigorous to identify all the relevant studies.
- 1.4 Study quality is assessed and taken into account.
- 1.5 There are enough similarities between the studies selected to make combining them reasonable.
- 2.1 How well was the study done to minimize bias? Code ++, +, or -. “Explanation” shows the reason for coding.

The assessment outcome for question 1.1-1.5 means:

- 1= Well covered
- 2= Adequately addressed
- 3= Poorly addressed
- 4= Not addressed
- 5= Not reported
- NA= Not applicable

Table 8 Assessed (systematic) review papers

Review study	Topic	Type study	N	Type of studies	Setting	Results	SIGN 1.1	SIGN 1.2	SIGN 1.3	SIGN 1.4	SIGN 1.5	SIGN 2.1	Explanation	SIGN rating	Remarks
Chaudhury, 2005	Single vs multibed rooms	Review	38 articles no quality criteria	Unclear	Cure	Costs: operational costs -, occupancy rates +, construction costs +, medication error & costs -; Infection: infection rate -, patient transfers -, stay -, infection burn patients -, HVC transmission -, diarea transmission -; Patient outcomes: privacy +, pain medication (?), consultation (?), preference (?), noise -, sleep disturbances -, satisfaction +, control +	1	3	1	3	2	-	Quality of studies included unclear	2-	Broadman, 2011 about quality: most of research is based on focus groups or is anecdotal (self-evident). Individual articles included. Rating of West, 2010 (2++) not related to review but individual article.
Queensland department of Health, 2007	Single bedrooms	Review (time scope unclear, reports included of 2007)	153 studies	Unclear	Australia Acute Care	The changing nature of healthcare and patient demographics suggests that an increased number of single-bed rooms would be desirable. The exact proportion cannot be determined as a general statement of principle to be followed on all projects and for all patients populations.	1	2	1	2	2	+	Quality of journal was determining quality score, however scoring of journals was not reported. The evidence could be either qualitative or quantitative.	2+	Individual articles are checked for evidence

Review study	Topic	Type study	N	Type of studies	Setting	Results	SIGN 1.1	SIGN 1.2	SIGN 1.3	SIGN 1.4	SIGN 1.5	SIGN 2.1	Explanation	SIGN rating	Remarks
West et al.,2010	Effect single rooms	Systematic Review 1996-2006	28 studies	Cohort, Case-control, other	Hospitals	Outcomes mixed: not possible to say with certainty that single-rooms reduce outcomes such as infection rates and length of stay and increase patient satisfaction, due to confounded effects or not attributable to design. Medical error decrease.	1	1	1	1	2	++		2++	Results individual articles included.
Dijkstra, Pieterse, 2011	The psychological effects of the healthcare physical environment on health care personnel (including architectural features)	Cochrane Review up to date Nov 2010	1	RCT, CCT, CBA, ITS	Cure & Care	Only one article found on the effect of refurbished ward. No evidence to support or refute the impact of the physical healthcare environment on work related outcomes of health care staff. More research needed.	1	1	1	1	1	++		1++	Effect single rooms was included in search, however no papers were selected.
Chaudhury, 2009	Effect physical environment on patient and staff outcomes	Review		Unclear, empirical/non-empirical	Acute Care	Single room patient outcomes +: quality of care, shorter stay, less risk infection. Staff outcomes + better communication, reduced need for transfers, fewer medication errors, decreased infection rate	1	1	1	3	Na	3	No quantitative data provided .	3	Individual articles are checked for evidence.
Huisman et al., 2012	Effect design on patient and staff outcomes	Review 1984-2011	65 papers	Unclear	Care & Cure	Single vs multibed better patient comfort	1	1	1	2	2	+	Systematic reviews were not quality assessed.	2+	No individual articles included as evidence was based on Ulrich et al., 2004 or nursing home evidence.
Glind, 2007	Effect Single vs multibedrooms on patient outcomes	Systematic Review 1970-2006	25 studies	RCT's, controlled trials without randomization; Quasi experimental, comparative, correlation, case-control; expert opinion	Hospital design	Single room moderate effect on PSF: satisfaction care, noise and quality of sleep and experienced privacy & dignity; Conflicting results infection rates (no nosocomial, positive association number beds and MSRA infection rates); no evidence recovery and safety issues.	1	1	1	1	1	++	Most evidence based on + category (strong opinion), strong evidence lacking.	2++	Broadman, 2011 about quality review: most of research is based on focus groups or is anecdotal (self-evident). Individual articles not evaluated, rating based on Glind, 2007.

C Excluded papers

The below table shows the excluded papers . From left to right the matrix indicates: the “Individual study” showing the author (s) and issue date; “Included in review” showing the review paper (s) if the paper was selected in that review; the “Intervention” of the study if relevant; the “Type of study” if reported, “N” indicating the number and type of participants if reported ; the “Setting” in which the research was conducted if reported; the reported “Results” if assessed before exclusion, and the reason for exclusion in “Explanation”.

Table 9 Excluded papers

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Explanation
Cooper, stone, Kibbler, 2004	Detsky, 2008	Effective isolation measures MRSA	Review			4 studies evidence that intensive control measures including patient isolation were effective in controlling MRSA, in two others isolation wards failed. Major methodological weaknesses.	Excluded results not related to room design, but MRSA policies
Rashid, 2009		None	Review			Patients interact more frequently when they are given private rooms (Holahan & Seagert, 1973; Ittleson, Proshansky, & Rivlin, 1970).	Excluded not related to single room design. Interesting references identified, however not referred to in other reviews, not further investigated and excluded.
Ulrich & Zimring, 2004	Dowdswell, 2004		Review		Hospital		Excluded since results are not clearly related to single room design, however some references were further investigated
Calkins and Cassella, 2007			Review		Nursing homes		Excluded nursing homes, but hospital references were investigated. Individual articles <2006 were only included when mentioned by other reviews too.
Ulrich et al., 2008			Review (extension research 2004)		Hospital		Excluded since results are not clearly related to single room design, however some references useful.
Bracco, Dubois, Bouali, Eggimann, 2007	Bartley, Olmsted, Haas, 2010	Effect single vs multibed on infection rate	Prospective observational data acquisition over 2.5 years		14-bed medico-surgical ICU, composed of six single-bed rooms (consisting of 2 single rooms and 4 cubicles (1 room but wall separating) plus a six-bed and a two-bed bay room served by the same staff	Risk of acquiring infection is lower for those cared for in private compared to open ward or multibedrooms	Excluded results not focused on single rooms only but also cubicles with open wall (4 beds).
CHD, 2011		Single vs double or multibed	Review		Cure, NICU	Single-bed patient rooms scored higher than double-bed and multibed rooms in terms of patient satisfaction.	Excluded since results are not clearly related to single room design, however some references useful.

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Explanation
Harris, Shepley & White, 2006	CHD, 2011	Comparison staff satisfaction and stress on NICU single bed or open bay arrangements.	Within comparison staff that worked in single bed and open bay facilities.	75	NICU	SFR NICU (single vs open-bay design) may increase staff satisfaction and reduce staff stress.	Only abstract available, therefore article could not be evaluated. Excluded.
Soufi et al., 2010	CHD, 2011	Comparison overall patient satisfaction in double room or multibed (6) room.	Factor analysis, items related to satisfaction, survey/face to face interview	214	Hospital, marrow	Room occupancy sign. related to satisfaction: Patients in double room more satisfied than in multibedroom.	Excluded, not related to single room design.
Gardner, Court, Brocklebank, Downham & Weightman, 1973	CHD, 2011, Ulrich & Zimring, 2004	Ward design: single cubicles vs. open ward with some cubicles.	Quasi experimental; concurrent comparison;	16, 19	Paediatric wards	Trend cross infection rate in wards with single-bed cubicles lower than multibed-wards. However group too small to make statistical comparisons.	Excluded cubicles are not single rooms as they are connected in a ward.
Menzies, Fanning, Yuan & Fitzgerald, 2000	CHD, 2011	Factors associated with Tuberculin conversion.	Cross sectional observational survey.	17 hospitals	Community or university hospitals	Tuberculin conversion associated with inadequate ventilation in general wards, not in respiratory isolating rooms .	Unclear whether due to design or ventilation. Excluded.
Pati, Cason, Harvey, & Evans, 2010	CHD,2011	Effect same-handed vs mirror-image room configuration on staff efficiency.	Content and statistical analysis based on process videos in different configurations	20 (10 left handed, 10 right handed nurses)	Lab	No effect	Excluded, no effect of single room vs multibedroom.
Shepley, 2002	CHD, 2011	Open (bay 3X6 baby stations) vs closed (rooms with 1-5 beds) configuration of NICU.	Multi-approach, behavioural mapping, interviews, surveys, noise and temperature data.		NICU	Less travel time in open floor plan compared to floor plan with rooms containing 1 to 5 beds (not significant), more family transactions in open bay.	Excluded. No clear comparison between open bay and single bedroom.
Berry and Parisch, 2008	CHD, 2011	Comparison old vs new unit multiple factors of which 100% single rooms in new unit.	Before/after study	Survey, focus group	447	New unit more satisfied and less stress.	Excluded results could not be related to single room design.
Kirk, 2002	Calkins and Cassella (2007)	Preference for single room			Hospice/ long term care	Majority preferred single room to shared room.	Excluded long-term care
McKendrick & Emond, 1976	Ulrich & Zimring 2004; Dowdeswell, 2004	Different multibed ward designs: large with ventilation to corridors, small with no ventilation to corridors, doors open and closed.				Higher incidence of cross-infection of both chicken pox and measles was recorded in large wards with ventilation to corridors. Small wards with no ventilation to corridors had lower incidence of cross-infection. Door opening and staff shortage were also related to higher incidence.	Excluded on ventilation, not single room design.
102 publications evaluated	Ulrich et al., 2008: Vonberg and Gastmeier (2005)	Isolation of cystic fibrosis patients (air infection): Burkholderia cepacia species, Pandoraea species, Pseudomonas aeruginosa, Stenotrophomonas maltophilia, or Alcaligenes species.	Review 39 studies	CF patients	Hospital	They found in 31 out of 39 studies that cross-infection of Pseudomonas aeruginosa had been halted by isolating patients. Recommendation to isolate.	Effect of isolating patients not about single vs multi-bedrooms, therefore excluded.
McManus, Mason, McManus, & Pruitt, 1992; 1994; 1985; Shirani et al., 1986).	Ulrich et al., 2008; Huisman,2012,; Calkins and Cassella (2007); Chaudhury, 2005: Ulrich & Zimring 2004, Dowdeswell, 2004	Effect Single room + air quality on health burn patient (air infection).	5 studies Quasi-experimental		Burn patients	For burn patients patient provides fair evidence that single rooms in combination with air filtration substantially reduce the incidence of infection and mortality.	Excluded not differentiated between air & single rooms .
Farquharson & Baguley, 2003.	Ulrich, 2008, Dowdeswell, 2004	SARS study on infection rates in hospitals in Asia and Canada.	Case study			SARS 75% hospital acquired compared to community acquired. Multibed spaces in emergency departments (EDs) and ICUs worsened SARS cross-infection	Excluded, not related to single room design.

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Explanation
Goldmann, Durbin, & Freeman, 1981; McManus, McManus, Mason, Aitcheson, & Pruitt, 1985;	Ulrich et al., 2008, West,2010	Effect on hand-washing single room with convenient sink or multibed with fewer sinks.			ICUs and burn units, NICU	Single units with conveniently placed sinks improved hand washing compliance compared to multibed open units.	Excluded, more about sinks than single room design. Conclusions that have been drawn are often assumed and interpreted based on related evidence in cited references. This in order to support their vision. References have not been checked.
MacKenzie et al. 2007	Ulrich et al., 2008	hospital MRSA prevalence in relation to patterns of antimicrobial use and infection control policies.	observational, cross-sectional study that used retrospective data from 2001 and linear regression to model relationships.	173 hospitals	Hospitals across Europe	infection control policy recommendations associated with lower MRSA prevalence rates were (i) use of alcohol-based solutions for hand hygiene (mean difference 10.3%, 99% CI 1.2–10.3), and (ii) placement of MRSA patients in single rooms (mean difference 11.2%, 99% CI 1.4–20.9).	Excluded. The research is about isolation policies, not about single room design vs multibed. Question remains if these patients were all in single rooms at the beginning, whether prevalence MRSA was lower.
Chang & Nelson, 2000;	Ulrich et al., 2008, Calkins and Cassella (2007); Ulrich & Zimring 2004	Association between having a roommate and infection.	Association study, regression analysis.	2,859 patients	community hospital	For patients with nosocomial antibiotic-associated diarrhea (AAD), exposure to a roommate with AAD (RR, 3.94; 95% CI, 1.27–12.24) was significant risk factor. Physical proximity was identified too as risk factor for nosocomial acquisition of Clostridium difficile-associated diarrhea (CDAD), however this was confounded with neighbouring patients that also belonged to the subcategory 'close'.	This analysis is about roommates, which was interpreted by Ulrich as when you have no roommates there is less risk for infection, so in favour of single room. However, in this study when you have no infected roommates in a multibed ward, you also belong to the group no roommates, so it was not a comparison between single and multibedroom and therefore excluded.
Pegues & Woernle, 1993	Ulrich, et al., 2008	Association between having a roommate and infection.			Nursing home	Excluded	Excluded, nursing home.
Healthcare Commission, 2006, 2007; Malamou-Ladas, O'Farrell, Nash, & Tabaqchali, 1983	Ulrich, 2008	Causing factors spread of C. difficile.	Association study			Predominance of multibed rooms with shared toilets, and a scarcity of single rooms with private toilets were identified as key factors that prevented the timely isolation of patients and contributed to the spread of C.difficile and the duration and high mortality of these outbreaks.	Excluded results could not be related to single room design.
Cepeda et al 2005	CHD, 2008; Glind, 2007; Detsky, 2008	Spread of infection when infected people were moved to single bedrooms after ca. 3 days in multibedrooms (when tested positive).	prospective 1-year study		ICUs	That moving patients to single-bed rooms after testing positive for MRSA (having stayed on multibedroom) did not reduce cross-infection to other patients, indication quick contamination via f.i. surfaces.	Excluded results could not be related to single room design.
Ucgun, Dagli, Kiremitci, Yildirim, Ak, Aslan, 2013		Effect moving from 4 bed ICU ward to isolated rooms with 2 beds on prevalence HAP (hospital acquired pneumonia).	Before/after study	532	ICU	Single rooms decrease prevalence HAP from 22.9% to 17.4% (relative decrease 24%; p 0.18)	Excluded, isolation room consists of 2 beds, not single bedroom.
Rashid & Zimring, 2008	CZB,2008						Excluded. Effects reported of noise, lighting, air quality, temperature and overall quality, but no link to single rooms.
Review 33 articles, strict inclusion criteria: conclusion based on: 1: Cooper et al., 2003; 7: Forceville X, Faibis F, Lahilaire P, et al.,2002; 9: Halcomb E, Fernandez R, Griffiths, 2002; 11: Fernandez R, Griffiths R, Halcomb,	Glind, 2007; Loveday, Pellowe, Jones, Pratt, 2006	Interventions for prevention and control MRSA.	Review			Some evidence isolating patients infected patients contribute to reductions in outbreak MSRA. Methodology weaknesses.	Excluded effect of isolating patients when infected, not single vs multibed room.

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Explanation
2002; 13: Talon D, Vichard P, Muller A, Bertin M, Jeunet L, Bertrand, 2003; 14: Masaki H, Watanabe H, Degawa S, et al., 2001; 15:Eveillard M, Eb F, Tramier B, et al.2001; 16:Gastmeier P, Schwab F, Geffers C, Ruden H, 2004.							
Borg, 2003	Glind, 2007	Bed occupancy in multibed bays.	(MRSA) incidence and bed occupancy rates were assessed over a 24-month period, correlation		Hospital general wards incorporating mainly four and eight-bedded bays with larger areas partitioned into two-bedded bays. Single rooms rare.	Positive association between bed occupancy (73%=86%) and MRSA infection cases.	Excluded, not related to single room design.
Firestone, Lichtman, Evans, 1980	Huisman, 2012; Ulrich & Zimring, 2004		structured interview	66	nursing home	Multibed less secure and less able to control social encounters than single bed.	Excluded, nursing homes.
Altimier, 2004	Glind, 2007	Design change to decentralized nursing pods and open floor plan with separation illusion.	After study	?	NICU	Privacy for family increased in new ward setting,	Excluded design change not just single room.
Davidson, Smylie, Macdonald, Smith, 1971	Ulrich & Zimring 2004	Effect open ward vs racetrack unit with 40% single rooms on cross postoperative wound infection.	Quasi experimental; before-after comparison of two units; hypotheses; microorganism surveillance; observation; chart records	1,000 general surgical operations in two surgical wards in a UK hospital (493 surgery patients in Nightingale unit, 507 in newer racetrack unit)		The cross-infection was significantly lower after the Nightingale open ward was changed to a racetrack unit with 40% single rooms and controlled ventilation.	Excluded. Confounded with ventilation.
Jernigan, J. A., Titus, M. G., Groschel, D. H., Getchell-White, S., & Farr, B. M.,1996.	CHD, 2008; Calkins and Casella (2007): Ulrich & Zimring, 2004	Effect double isolation room vs open bay on transmission MRSA.	Quasi experimental; comparison between patients; hypotheses; microbial surveillance; chart records.	331 neonates in a 33-bed neonatal intensive care unit (NICU) in Virginia (one two-bed isolation room, one open bay).	NICU	The rate of transmission of MRSA among patients in the contact isolation room was substantially lower than the rate for patients not in isolation.	Excluded not related to single room design.

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Explanation
Bentley, S., Murphy, F., & Dudley, H., 1977	Calkins and Casella (2007): Ulrich & Zimring, 2004	Perceived noise in surgical wards and an intensive care area.	Descriptive survey of noise distribution; sound meters mounted on walls above heads of patients.		Five 24-hour periods in an open Nightingale ward, a cubicle of the ward, and an ITU in the UK.	Noise levels in all three areas were higher than internationally recommended levels at all times of day.	Excluded, not clear whether cubicle is single room. Not checked as not mentioned by other reviews.
a) Langly, Hanakowski, (Geeen suggesties), 1994; b) Kim, Mindorf, Patrick, Gold, Ford-Jones, 1987	Calkins and Casella (2007): Ulrich & Zimring, 2004	Availability of single rooms for isolation purposes.	Survey, chart records	a)1,634; b) 585 beds	paediatric hospital	Hospitals with less than 33% single bed paediatric rooms reported this percentage to be inadequate.	Excluded as < 2006 and not mentioned by other reviews (also see remarks Calkins and Casella, 2007).
Obbard, J. P., & Fang, L. S., 2003.	Calkins and Casella (2007): Ulrich & Zimring, 2004	Airborne concentrations of bacteria in a hospital environment in Singapore in relation to occupant density.	Prospective study	air sampling different locations for 5 minutes	General hospital in Singapore	Occupant density and humidity were identified as important factors affecting concentrations of airborne bacteria.	Excluded not related to single room design but occupant density.
Mlinek, E. J., & Pierce, J.,1997.	Calkins and Casella (2007): Ulrich & Zimring, 2004	Emergency room patient rooms with curtain walls vs. glass walls vs. solid walls; reception desk.	Quasi experimental; prospective; observation; interview.	18 hours period	emergency department patient rooms	Overhearing and visual breaches occurred in rooms separated by curtain walls and glass walls, but not in rooms with solid walls.	Excluded as < 2006 and not mentioned by other reviews (also see remarks Calkins and Casella, 2007).
Falk, S. A., & Woods, N. F.,1973.	Calkins and Casella (2007): Ulrich & Zimring, 2004	Noise in three different types of patient physical environments.	Descriptive; recordings of noise levels and observation of noise sources at different locations; sound-level meter	Six infant incubators, a 17-bed surgical recovery room, and two rooms in a seven-bed acute care.	800 bed hospital	Noise levels in the recovery room and acute care unit rooms were significantly correlated with the numbers of staff members and patients.	Excluded as < 2006 and not mentioned by other reviews (also see remarks Calkins and Casella, 2007).
Gabor, J. Y., Cooper, A. B., Crombach, S. A., Lee, B., Kadikar, N., Bettger, H. E., et al., 2003.	Calkins and Casella (2007): Ulrich & Zimring, 2004	Noise levels in an 18-bed open plan intensive care unit (ICU),with curtain partitions between beds.	Quasi experimental; correlational; comparison of normal room and noise-reduced room; hypotheses; polysomnography and sound-meter recordings.	Seven mechanically ventilated patients in an ICU and six healthy volunteers.	ICU, healthy participants	Healthy volunteers slept better in the typically loud ICU environment than patients. Participants in the open ICU identified alarms and staff conversation as the most disruptive environmental noises. Healthy participants experienced significant improvements in total sleep time and night sleep compared with the open ICU. However, sleep architecture and arousal and awakening indices were not significantly different between the open ICU and the single room. No differences existed in any variable between those healthy subjects randomized to the single room first and those placed in the open ICU first.	Excluded as < 2006 and not mentioned by other reviews (also see remarks Calkins and Casella, 2007).
Hilton, B. A., 1976.	Calkins and Casella (2007): Ulrich & Zimring, 2004	Sources of noise that disturb sleep in a multibed respiratory intensive care unit.	Descriptive; continuous polygraphic sleep recordings (EEG, EMG, EOG); observation and recording of sleep disturbing factors; patient interview.	10 patients in a respiratory intensive care unit, each monitored continuously for 48 hours.	ICU	Sleep-disturbing factors occurred an average of 20 minutes per hour. Sources of disturbance were mainly therapeutic procedures, staff talking, and environmental noises. Most disturbances were linked to the presence of other patients in the multibed unit.	Excluded, not clearly related to single room design and not mentioned in other reviews.

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Explanation
Parthasarathy, S., & Tobin, M. J., 2004.	Calkins and Casella, 2007: Ulrich & Zimring, 2004	Review on sleep quality	Review 87 articles			Effective measures to improve sleep include single rooms, decreasing noise, earplugs, and sedative agents.	Excluded as < 2006 and not mentioned by other reviews (also see remarks Calkins and Casella, 2007).
Southwell, M. T., & Wistow, G., 1995.	Calkins and Casella, 2007: Ulrich & Zimring, 2004	Sources of sleep disturbance in different hospital environments.	Descriptive; survey; questionnaire.	454 patients and 129 nurses	Four hospitals in the UK	Major sources of noise disturbance were other patients, nurses attending other patients, phone rings, and patients' and nurses' conversations.	Excluded as < 2006 and not mentioned by other reviews (also see remarks Calkins and Casella, 2007).
Tutuarima, 1997	Calkins and Cassella, 2007	Risk factors for falls in hospitals	Suggestion	Stroke patients		Multi-bedrooms might reduce the occurrence of falls, as roommates could remind individual not to rise without assistance.	Excluded as < 2006 and not mentioned by other reviews (also see remarks Calkins and Casella, 2007).
Calkins and Cassella, 2007		Risk factors for falls in hospitals	Focus group		Nursing home	several staff mentioned that there are more falls in shared rooms "no doubt about it"	Excluded, nursing home.
Kappstein & Daschner, 1991	Chaudhury, 2005	Single vs multibed room				Private rooms are needed for patients suffering from pneumonia, skin lesion, or MRSA because these patients potential for widespread contamination.	Excluded isolation practices, not effect of single room design.
The Centre for Health Design, 2003	Chaudhury, 2005	Single vs multibed room				Single rooms with proper ventilation have lower nosocomial infection rates.	Excluded. Confounded with ventilation.
Pittet, Tarara & Wenzel, 1994; Zhan & Miller, 2003	Chaudhury, 2005	Single vs multibed room				Patients with infections stay longer, private room less risk for infection.	Excluded Zhan & Miller, 2003, about excess cost medical injuries. Pittet about length of stay, death and extra cost when infected. Not related to single room design, excluded.
Korpela, Karpanoja & Siitonen, 1995	Chaudhury, 2005	Single vs multibed room	?	2?	Ward internal medicine	Nosocomial transfer of shigella spp occurred between patients sharing rooms and toilets. Patients with diarrhea should be isolated.	Excluded, no evidence on single rooms.
Morgan, Stewart, 1999;	Chaudhury, 2005	Move to new facility with single rooms.			Dementia	Family satisfied with ability to personalize room and disruptive behaviour seemed to reduce.	Excluded, long-term care.
Christenfield, 1989	Dijkstra, Pieterse, 2011	Effect refurbishment on staff.	Before/ after	27 intervention, 44 control	Long-term care psychiatric centre	In new ward staff was significantly less depressed. No effect ward atmosphere, unscheduled absence.	Excluded, not about single room. No papers found on single rooms, which indicate scarcity of good research.
Kola, Schwab, Barwolff, Eckmanns, Weisst, Dinger, 2010	Bartley, Olmsted, Haas, 2010	none	Prospective cohort study during 24 months.	24,362	Eleven intensive care units from two university hospitals	No association between frequency of cross transmission and HAI, duration of hospitalization or use of devices. Other factors such as patient characteristics more dominant.	Excluded, not related to single room design.
Kibbler, Quick and O'Neill, 1998		Adding 5th bed in 4 bed bay on colonisation MRSA.	An 18 month prospective survey		3 acute medical wards	Increasing the number of beds (5 to 4) in a fixed area heightens the risk of cross-infection with MRSA.	Excluded not related to single room design.
Griffiths, Renz Hughes, Rafferty, 2009		Factors impacting infection control.	Review: 7 articles on bed occupancy & patient turnover			Suggested association between high bed occupancy and high patient turnover and HCAI, particularly MRSA: probable reason availability isolation room.	Excluded not related to single room design.
Emamina, Corcoran et al, 2012		Move from traditional wards to universal bed model (single rooms, other nursing policy).	Comparison Ub-unit, traditional nation and regional units.	intervention (610) control 1(225K), control 2 (373K)	Cardiac surgery ICU	Decreased stay in ICU & hospital, improved post-operative patient outcomes, improved as result cost savings.	Excluded not related to single room design only.
Barlow, 2002	West et al.,2010						Excluded, unclear how results link to open bay vs single rooms.
Geldner, 1999	West et al.,2010					Cost associated with MRSA.	Excluded, not related to single room design, but to MRSA infection. Relevant when single room is related to MRSA infection.

Individual study	Included in Review	Intervention	Type of study	N	Setting	Result	Explanation
Herr, 2003	West et al.,2010						Excluded not related to single room design, but to MRSA infection.
Plowman, 1999	West et al.,2010						Cost of infection not related to single vs multibedroom.
Wilcox, 1996	West et al.,2010					Result LOS unclear, more about clostridium difficile than single vs multibed.	Excluded, data reported unclear.
CZB, 2008		Effect of single bedrooms on health/wellbeing/satisfaction of patients and staff.	Review		Cure	Single room reduces infection rates (see also CHD, 2008); Patients more satisfied due to lower noise levels in single rooms; more satisfied due to higher appreciation of privacy in single rooms; mixed results on social support easier rooming in of family in single rooms vs loneliness; in multibed social support roommate vs noise roommate.	Excluded, due to bad quality of review. Quality of references used not clear, and quality of the literature review not clear, unsupportive evidence could have been missed.