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Impact of room design on length of stay

Systematic literature review

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Description:	This literature review examines the available professional literature on the impact of room design on length of stay in the healthcare setting.
Purpose:	To inform NHSScotland guidance on the design of inpatient bedrooms.
Target Audience:	All NHSScotland staff involved in the procurement, design, maintenance, and operation of healthcare facilities in Scotland.
Update schedule:	Updated, as required for new projects as defined by Subject Matter Expert (SME).
Cross reference:	SOP Literature Review
Update level:	Practice – evidence-base recommendations provided on design elements that could reduce LoS Research – an area identified for future research was the impact of patient mobility on LoS.

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Approvals

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v1.0	05.04.23	Susan Grant	Principal Architect	NHSS Assure

Abbreviation list

Acronym	Definition
AAU	acuity-adaptable unit or room
BD	bipolar disorder
BES	bedside entertainment system
BMI	body mass index
CABG	coronary artery bypass graft
FC	family care
ICU	intensive care unit
IPU	inpatient unit or ward
LoS	length of stay
MBW	multi-bedded ward
MD	major depression
MICU	Medical ICU
MS	Medical–surgical
NICU	neonatal intensive care unit
NW	northwest
PEMR	Physician’s Estimate of Mortality Risk
RCT	randomised control trial
SAH	subarachnoid haemorrhage
SC	standard care
SE	southeast
SFR	single-family room
SICU	Surgical ICU
vs	versus
HBE	healthcare-built environment
wk/s	week/s
hr/s	hour/s

Contents

1. Background

1.1. This systematic literature review has been conducted to explore the existing evidence on healthcare-built environment (HBE) design factors that impact patient length of stay (LoS). It focuses on evidence related to the patient bedrooms. The outcome of this review will inform the development of NHSScotland (NHSS) guidance, ensuring decisions are evidence-based and providing avenues for future research.

Review Question

1.2. This review aimed to explore and understand what design features affect LoS and their impact. Therefore, for this purpose and to not restrict the search to existing preconceptions, the following open research question was developed to guide the review:

- What impact do healthcare-built environment (HBE) design factors have on patient length of stay (LoS)?

Report Structure

1.3. This review is structured as follows. Section 2 presents the methodology for conducting this review, providing details of the search strategy, inclusion and exclusion criteria and procedures. This is followed by an overview of the final included studies (Section 3), their findings which are structured into themes of individual design factors (Section 4) and a discussion on conclusions, quality and limitations of the studies (Section 5). The review concluded by discussing the implications for research (Section 6) and recommendations for practice (Sections 7).

2. Methods

2.1. A systematic literature review was chosen for this topic as it entails a thorough, transparent, and replicable literature search and analysis process. This review was produced using an established two-person systematic methodology, which will be briefly discussed in this section. The research question informed the search terms presented in Table 2-1. A search strategy was subsequently developed and adapted for five electronic databases (Embase, Medline, Web of Science, CINAHL, and Scopus); details of these are in Appendix 1. For accuracy, these search strategies were guided and reviewed by the Principal Architect at NHSS Assure and a Librarian. Additional relevant articles were also identified by screening references of included articles.

Table 2-1: Search terms

Word Group 1 (Setting/population)	Word Group 2 (Intervention)	Word Group 3 (Outcome)
• hospital* • health care facilit* • healthcare facilit* • hospital patient • inpatient*	• evidence-based design • evidence-based hospital design • hospital design • built environment • interior • furniture • décor • daylight • room design • acuity-adaptable	• length of stay • length of hospitalisation

Note: Terms within word groups combined using “or”; word groups combined using “and”

Study selection, eligibility criteria, data extraction and quality assessment

2.2. This review adopted a two-stage screening process which assessed the relevance of the studies to the topic. This was facilitated by adherence to the inclusion and exclusion criteria presented in Table 2-2. The authors conducted a first screening (reading the title and abstract) of all the studies and a second screening (assessing the full text of eligible studies). The outcomes from the screening process were recorded in the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) chart in Appendix 2.

Table 2-2: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• Empirical research, peer-reviewed, in English, any country, and any study design • Directly report the effect of the physical environment design on length of stay • Setting: All inpatient healthcare facilities, both the room and unit • Target groups: service users (inpatients) • with any underlying disease, type of surgery, age and gender	• Conducted prior to 2002 • Not in English • Only report on length of stay as an outcome of another intervention • Conducted in the emergency department or outpatient departments • Non-peer-reviewed, systematic literature reviews, commentaries, audits, dissertations, presented as a poster or abstract at a conference, reviews and expert opinion

2.3. Eligible studies were then critically appraised using the Scottish Intercollegiate Guidelines Network (SIGN) SIGN50 methodology checklists (Appendix 3), compliant with the criteria used by Appraisal of Guidelines for Research and Evaluation in Europe (AGREE) (Appendix 4).

2.4. This review synthesises the evidence narratively by the design interventions under seven identified themes. However, three studies[1-3] investigated multiple interventions with sufficient evidence to be categorised under more than one theme. The final recommendations were informed by a SIGN50 considered judgment form completed for each theme. A National Infection Prevention and Control Manual (NIPCM) grade of recommendation (Appendix 3) was assigned to denote the strength of underpinning evidence.

3. Results

3.1. The selection procedure can be seen in Appendix 2. The final selection consisted of 20 studies, including observational (n=9), before and after (n=8), randomised control trials (n=2) and a case-control (n=1) study. The characteristics of each study are provided in Appendix 5: consisting of the author(s), country, study design, study focus, patient and setting characteristics, intervention/comparison, results and evidence level. Table 3 1 contains a summarised version of each study reporting on the intervention's impact on LoS of the study population.

3.2. The largest study sample included 67,842 participants[4], and the smallest included 29 participants[2]. Frequently studied cohorts were surgery patients (n=9), five of which focused on cardiac surgery. The other studies investigated the impact of LoS on a general population of inpatients (n= 3), pre-and post-term infants (n=3), patients experiencing a depressive episode (n=3), critically ill patients (ICU stays) (n=1) and dementia patients with an acute illness (n=1).

3.3. The majority of included studies had a single-centred (n=18) design, focusing on one hospital. Two included studies had a multi-centred (n=2) design. Caution should be taken when interpreting findings from single-centred studies, as they can lack the scientific rigour and external validity to support the generalisability and strength of findings.

3.4. The studies were conducted in nine countries: United States (n =10), United Kingdom (n=2), Korea (n=2), Bangladesh (n=1), Denmark (n=1), Spain (n=1), China (n=1), Sweden (n=1), and Italy (n=1).

3.5. Each study reports LoS outcomes in one or two of three categories: total, post-op and ICU LoS. These were predominantly reported in -hrs or -days, although one study reports in percentage (%) difference[5] and another LoS decreased per increase in lux[3]. Averages were determined in mean (M) or median (Mdn), with only two studies[3, 5] not reporting which average was used. Significance was reported in p-values for, at least, the overall study results, except in one [6] . Due to variations in reporting, Table 3-1 provides clarity and coherence across findings by presenting LoS in -hrs or -days and percentages (%), and if they were statistically significant.; achieved by presenting study findings as reported or by calculating these from study data. Any missing figures were indicated by “x”. It is acknowledged that this could introduce bias to the result; therefore, for transparency, full details of existing study characteristics are provided in Appendix 5.

Table 3-1: Overview of results

Author	Intervention / Comparison	Population	LoS impact (% reduction)
Daylight availability or orientation			
Gbyl, Ostergaard Madsen [2a,b]	SE (higher) / NW (lower)	inpatients diagnosed with depression	M: -29.6-days[*L1] (50%)
Choi, Beltran [5]	SE (higher) / NW (lower)	general inpatients	x: x[L1] (16% - 31%) **across the six significant sets[c]** x: - x (29%[*,L1])
Benedetti, Colombo [7]	East (higher) / West (lower)	inpatients diagnosed with depression	**bipolar inpatients[c]** M: -3.67-days[*,L1] (16%) **unipolar inpatients[c]** M: -2.16-days[L1] (9%)
Park, Chai [4]	window (higher) / door (lower)	general inpatients	Mdn: -1 day[*,L1] (20%)
Canellas, Mestre [8]	high daylight / low daylight	depressive inpatients	Mdn: -3-days[*,L1] (21%)
Joarder and Price [3a]	high daylight / low daylight	coronary artery bypass graft (CABG) inpatients	x: -7.3-hrs per 100 lux increase[L2]
Li, Lou [9]	window (higher) / door (lower)	general surgery inpatients	Mdn: -x[L1] (x) **lowest education levels[c]** Mdn: -3-days[*,L1] (30%)
Acuity-adaptable unit (AAU) or acuity-adaptable single room			
Costello, Preze [10]	AAU / traditional care model	paediatric cardiac surgery inpatients	Mdn: -1-day[L1] (13%) Mdn: -1-day[*,L2] (14%)
Venditti [11]	AAU / traditional care model	cardiac surgery inpatients	Mdn: -1-day[*,L2] (14%)
Chindhy, Edwards [12]	AAU / traditional care model	cardiac surgery inpatients	Mdn: -1-day[*,L2] (17%) Mdn: -23-hrs[*,L3] (47%)
Hennon, Kothari [13]	AAU / traditional care model	pulmonary resection surgery inpatients	M: -2-days[*,L1] (40%) Mdn: -3.6-days[*,L1] (46%)
Bonuel, Degracia [14]	acuity adaptable room / traditional care room	renal transplant inpatients	M: -5.5-days[*,L1] (57%)
Jimenez, Rich [15]	decentralised unit / centralised unit	general inpatients	**Hospital 2 (48% to 100% single rooms)[c]** M-0.33-days[*,L1] (8%) Mdn: - 0.17-days [L1] (x%) **Hospital 2 (100% to 100% single rooms)[c]** M: & Mdn: x [L1] (x)
NICU single-family room (SFR)			

Author	Intervention / Comparison	Population	LoS impact (% reduction)
Domanico, Davis [16]	SFR / Open ward	pre-term infants (gestational age (g) <37wks)	**PEMR 2 & 3 (M: g.34wks)[c]** M: -2-days[L1] (11%) Mdn: -2-days[L1] (17%) **PEMR 4 (M: g.31-32wks)[c]** M: -2-days[L1] (3%) Mdn: -2days [L1] (15%)
Puumala, Rich [17]	SFR / Open ward	pre- and term infants (gestational age (g) <37wks and 37wks+)	Mdn: + 3.39-days[*,L1] (-50%) **<28wks[c]** Mdn: -11.18-days[L1] (13%) **28<32wks[c]** Mdn: -10.59-days[*,L1] (19%) **32<37wks[c]** Mdn: +0.19-days[L1] (-2%) **37+wks[c] (term)** Mdn: +1.14-days[*L1] (-39%)
Örtenstrand, Westrup [18]	family care (FC)/ standard care (SC)	pre-terms infants (gestational age (g) <37wks)	M: -5.3-days[*L1] (16%) Mdn: -2-days[L1] (12%) M: -4.7-days[*L3] (26%) Mdn: -3-days[*L3] (50%) **<30wks[c]** M: -10.1-days[L1] (15%) Mdn: -16-days[*L1] (23%) **30<34wks[c]** M: -4.4-days[L1] (19%) Mdn: -3-days[L1] (16%) **35<36wks[c]** M: -1.4-days[L1] (18%) Mdn: -1-days[L1] (13%)
Room bed numbers			
Gbyl, Ostergaard Madsen [2a,b]	Single room / Twin room	inpatients diagnosed with depression	M: -5.9-days[L1] (11%)
Young, Edwards [19]	Single room / MBW	dementia inpatient with acute illness	M: +19.76days[L1] (-47%)
Windowed vs windowless room			
Kohn, Harhay [1a]	Windowed room / windowless room	MICU inpatients	Mdn: +45.71-hrs[L1] (x) Mdn: +30.85-hrs[L3] (x)

Author	Intervention / Comparison	Population	LoS impact (% reduction)
Wunsch, Gershengorn [20]	Windowed room / windowless room	critically ill inpatients with acute brain injury	Mdn: -x^{L1} (x) Mdn: -x^{L3} (x) **Worst Hunt-Hess grade (I to III*) patients - likely to be awake[c]** Mdn: +1-day^{L1} (-13%)
Access to a view from window			
Joarder and Price [3a]	outdoor view / restricted access to outdoor view	CABG surgery inpatients	x: -17.4-hrs^{L2} (x%)
Kohn, Harhay [1a]	natural view / industrial view	SICU inpatients	Mdn: -30.66-hrs^{L1} (x%) Mdn: -4.33-hrs^{L3} (x%)
Personal TV			
Papaspyros, Uppal [6]	Access to personal TV / No access to personal TV	cardiac surgery inpatients	Mdn: +1day^{L2} (-14%)

Note. LoS = length of stay; NICU = neonatal intensive care unit; SICU = surgical ICU; MICU = medical ICU; SFR = single-family room; AAU = acuity adaptable unit; CABG = coronary artery bypass graft; g = gestational age; M = mean; Mdn = median; + beneficial effect on LoS; - negative effect on LoS; 0 inconclusive; ()* significant result; [a] study cited in more than one theme; [b] small sample (<100); [c] subgroup analysis; ^{L1} total LoS; ^{L2} post-op LoS; ^{L3} ICU LoS; 'x' figures nominal or not reported

Themes

3.6. Studies were tabulated, categorised and synthesised narratively; with seven overarching themes of design factors influencing LoS identified. The themes cover the spatial configuration, amenities, or ambient features of the inpatient bedroom and unit, including:

- daylight availability (n=7)
- acuity-adaptable unit (AAU) or acuity-adaptable single rooms (n=6)
- NICU single-family rooms (SFRs) (n=3)
- room bed numbers (n=2)
- windowed vs windowless rooms (n=2)
- access to a view from window (n=2)
- personal bedside entertainment system (n=1)

3.7. Within this section, each theme is individually presented with a brief description and summary of contributing studies in an introductory paragraph or sentence, depending on the number of studies. Paragraphs with study descriptions, key findings and effect on LoS follow this. Finally, each theme concludes with an overview of the quality and limitations of studies. This will be further detailed in Section 5.

Daylight availability or orientation

3.8. The studies reviewed showed that daylight is frequently shown to have a beneficial impact on patient recovery. This review identified seven studies focusing on the effect of daylight on LoS. The studies were categorised by patient population patients experiencing a depressive episode, general inpatients, and surgery patients.

3.9. Three studies involved a patient cohort experiencing a depressive episode. Two were conducted with controls[2, 7], and one was a before and after study[8]. One study found bipolar and unipolar patients assigned to southeast (SE)-facing rooms experienced a significantly reduced LoS of 29.6-days (50%) compared to those in northwest (NW)-facing rooms, 29.2-days vs 58.8days.[2] Further analysis found, although not significant, LoS was reduced by 15.8-days (29%) for those staying in summer and spring compared to autumn and winter, 37.8- vs 53.6-days. Bedroom light measurements were taken from near the window, allowing for the recording of maximum light received. Measurements show daylight levels were higher in summer than winter and remarkably higher in SE-facing rooms than NW-facing rooms: figures, taken at noon for SE- and NW-facing rooms show levels of 60,000 and 3,000 lux respectively, on the summer solstice; 40,000 and 20,000 lux on the autumn equinox; and 2,000 and 1,200 lux on the winter solstice. This one-year study gathered data from a small sample of 29 patients and included single and twin rooms.

3.10. The findings from the previous three studies were supported by a 3-year retrospective study that unipolar and bipolar patients in rooms receiving more daylight had reduced LoS.[7] In this study, light measurements calculated "ambient" conditions (i.e. avoiding direct sunlight) at 9am and 5pm on a clear, lightly cloudy and cloudy-day: east-facing rooms receiving nearly 900% more lux in the morning compared to west-facing rooms (15,000 vs 1,400 lux, on a bright-day) but 10% less in the evening (2,700 vs 3,000 lux, on a bright-day). Compared to west-facing rooms, LoS in east-facing rooms showed a significant 3.67-day (16%) reduction for bipolar patients (23.5- vs 19.8-days) and a non-significant 2.16-day (9%) reduction for unipolar patients (23.1- vs 20.9-days). Comparing seasonal effects, findings show that those staying in summer and autumn experience LoS differences, with no effect during winter.

3.11. A study by Canellas, Mestre [8] found patients with Dysthymia, major depression (MD), and bipolar experienced a significant 3-day (21%) reduction in LoS post-move (11-vs 14-days) to a department with potential exposure to 300% more daylight than pre-move (258,909 vs 86,145 lux/day). This effect was greater in MD and bipolar patients. Contrasting the methodology of the previous two studies, which recorded light measurements from a single point, this 4-year study calculated average potential daylight exposure from a patient daily timetable of scheduled time spent in five different spaces.

3.12. There were two studies conducted with large samples of general inpatients. A study by Choi, Beltran [5] conducted with 1,167 inpatients in single rooms from four departments had similar results to Gbyl, Ostergaard Madsen [2]. The study comprised 24 comparison sets, with data categorised by room orientation and orientation of the patient's eye-level view out of the window. Bedroom light measurements were comprehensively calculated through different points in the room, and simulation modelling and measurements show SE-facing rooms received, on average, 200 lux/day more than NW-facing rooms. The findings across all 24 sets show that SE-facing rooms consistently decreased LoS, with authors speculating that morning light could contribute to this. There were six significant sets, finding those assigned SE-facing rooms had a 16% - 31% LoS reduction compared to NW-facing rooms. Park, Chai [4] supported these findings with a sample of 67,842 general inpatients that those assigned to the window bed (high level of light) compared to the door bed (low level of light) of a six-bedded room had a 1-day (20%) reduced LoS, 4- vs 5-days.

3.13. Two studies conducted with surgery patients recorded the daylight level received above the patient bed. The first found that post-op coronary surgery patients experienced a 7.3-hr LoS reduction per 100 lux increase above the patient bed[3] A study by Li, Lou [9] adopted a similar methodology to Park, Chai [4], reviewing the differences in LoS between patients assigned to the window or door side of a 7-, 4-, or 2-bedded room. Findings show that, although not statistically significant, higher daylight levels reduced LoS for general surgery patients. In addition, further subgroup analysis identified that patients with the lowest education level beside the window experienced a significantly reduced 3-day (30%) LoS than those beside the door, 7- vs 10-days.

Quality and limitations of studies

3.14. Together, these studies outline that exposure to increased daylight levels can reduce LoS for inpatients, particularly evident for patients experiencing depressive episodes and surgery patients. Furthermore, it appeared that SE- and east-facing room orientations seem significant and highlight morning light may be most beneficial for reducing LoS. In addition, two studies [2, 7] identified reductions were most substantial in summer, spring and autumn compared to winter, possibly due to light intensity. Although the studies adopted various methodologies, which made it difficult to compare directly, the similarity of the findings allows for generalisations to be concluded. All the studies failed to account for human factors, such as daylight preferences, blind use, activities inside the room, time spent in the room, time spent with eyes open, and sedation medication. Canellas, Mestre [8] attempted to mitigate these by averaging potential light received through daily patient schedules, which heightened the reliability of results. In addition, five of the studies either included shared rooms[2, 3, 9] or did not report room bed numbers [7, 8], which introduces a confounding factor.

Acuity-adaptable unit (AAU) or acuity-adaptable single rooms

3.15. An acuity-adaptable unit (AAU) is an innovative model of care delivery. An essential element of the model is acuity-adaptable single rooms, designed to support all patient care requirements from admission to discharge, regardless of acuity level. These differ from rooms in traditional units, where patients were moved rooms based on their acuity level. This review retrieved six studies that explored the impact of acuity-adaptable rooms on patient LoS. When referencing to ICU LoS, this would be facilities directly within acuity-adaptable rooms in AAUs but in separate dedicated ICU unit room for the traditional unit.

3.16. Five studies reported the impact of AAU on the LoS of surgery patients, three of which were cardiac surgery patients [10-12]. Findings from Chindhy, Edwards [12] report a significant 1-day (17%) reduction in post-op LoS for those treated in the acuity-adaptable room, 5- vs 6-days; this included a significant 23-hrs (47%) reduction in ICU LoS, 26- vs 49-hrs. Similarly, Venditti [11] found a significant 1-day (14%) reduction in post-op LoS, 6- vs 7-days. A study by Costello, Preze [10] focused on a paediatric population (0-18 years old) of cardiac surgery patients, found similar results to the previous two: a significant 1-day (14%) reduction in total post-op LoS for those treated in the acuity-adaptable single room, 6- vs 7-days. They additionally report a non-significant total LoS reduction of 1-day (13%), 7- vs 8-days:. This trend of acuity-adaptable single room reducing LoS was replicated for two studies involving other surgery patients.[13, 14] Acuity-adaptable single rooms equate to a 3.6-day (Mdn) (46%) reduction in total LoS for pulmonary resection surgery patients, 4.2- vs 7.8-days [13] and a 5.5-day (57%) reduction for renal transplant patients, 4.1- vs 9.6—days. [14]

3.17. Differentiating from the previous studies is a study by Jimenez, Rich [15]; instead of the move from a traditional unit to AAU, it is the move from a centralised to a decentralised unit. The similarity being the decentralised unit contains acuity-adaptable single rooms. The study included a general sample of inpatients admitted to ICU, women and children's (WC) or medical–surgical (MS) units and involved two hospital sites. Pre-move, one hospital contained all single rooms and one contained a mix of twin and single rooms; post-move, both contained all acuity-adaptable single rooms. The hospital that moved from a mix of twin and single rooms to all acuity-adaptable single rooms experienced a significant 0.33-day (8%) LoS reduction, 3.37- vs 3.70-days; with no significant effect found for the other hospital.

Quality and limitations of studies

3.18. Findings from the five studies conducted with cardiac, pulmonary resection and renal transplant surgery patients suggest that, in comparison to traditional care units, assignment to AAU could result in a reduced LoS.[10-14] However, findings should be treated with caution due to the heterogeneity of the studies being unable to control for the simultaneous implementation of multiple variables that come with a move to a new facility, including organisational changes to accommodate the demands of the AAU. Three of the studies also had disproportionately more patients in the AAU group than in the pre-AAU group.[11-13] Interestingly, the final included study suggests that the single room played a considerable role in LoS reductions in the acuity-adaptable room. In particular, one study findings showing they play a significant role in reducing post-op LoS, compared to total LoS. [10]

NICU single-family rooms (SFRs)

3.19. The unrestricted presence of parents/ caregivers in the NICU environment has become increasingly recognised as important in the care of critically ill infants. To support this, the single-family room (SFR) was introduced, with a similar concept to the AAU; it allows parents to stay in the same room as their infant: the room containing a bed for parents and all required clinical equipment. This review includes three studies exploring the effect of SFRs on pre-term infants (<37wks gestational age) LoS.[16-18] The study by Puumala, Rich [17] additionally included term infants (37+wks gestational age).

3.20. Two of these studies involved pre-move from an open bay ward (infants moved based on acuity) to a post-move unit comprising SFRs (infants remained in the same room).[16, 17] Domanico, Davis [16] conducted subgroup analysis based on Physician's Estimate of Mortality Risk (PEMRs) indices, which were assigned based on illness severity; PEMR 2 & 3 being less ill and PEMR 4 being the most ill infants. Their findings show that PEMR 2 & 3 infants (M: 34wks) in SFRs experienced a 2.2-day (11%) reduction in LoS (15.7- vs 7.9-days) and PEMR 4 infants (M: 31-32wks) had a 2-day (3%) reduction in LoS (68- vs 70- days). A study by Puumala, Rich [17] concluded similar results in their subgroup analysis with pre-term infants (<32wks), SFRs reducing LoS in infants <28wks by 11.18-days (13%) (77.98- vs 89.16-days) and infants 28<32wks by 10.59-days (19%) (45.86- vs 56.45-days). However, in their overall sample SFRs increased LoS by 3.39-days (-50%) (6.84- vs 3.45-days), which has been influenced by their overall sample containing 66% term infants (37+wks) who had increased stays of 1.14-days (-39%) (4.10- vs 2.96-days) and 25% moderately pre-term infants (32<37wks) who had increased stays of 0.19-days (-2%) (12.33- vs 12.14-days).

3.21. A randomised control trial (RCT) by Örtenstrand, Westrup [18] examined the impact of standard care (SC) and family care (FC) wards on pre-term infant LoS at two hospitals. Unlike SFRs, infants in FC wards stay in a 4-bed intensive care room before moving to a private family room once stabilised, containing a bed, en-suite, infant bed and clinical equipment: with parent overnight stays encouraged. Findings show LoS was significantly reduced by 5.3-days (16%) in the FC ward, 27.4- vs 32.8-

days: the subgroup analysis revealed most benefits for ICU LoS by a 4.7-day (26%) reduction.

Quality and limitations of studies

3.22. Collectively, these studies outline a critical role SFR/FC wards play in reducing LoS for pre-term infants (<37wks gestational age), but perhaps not for term/ post-term infants. The overall LoS increase in SFRs in the study by Puumala, Rich [17] could be explained by the larger combined sample size of moderately pre-term and term infants, equating to 91% of the total sample; which could indicate those with less exposure to the SFRs (i.e. ~2-13-days instead of ~46-89-days) could suggest intervention effects and benefits might not be fully achieved. Therefore, we can broadly conclude that pre-term infants with longer LoS, derive most benefits from SFRs. In addition, LoS could be influenced by confounding variables from parental factors, their characteristics and time spent with infants (although encouraged to stay in SFRs and FC, this might not always be the case). Two studies were single-site and had no control, due to their before and after nature[16, 17]. The RCT was a multi-site study with controls, increasing the results' reliability.[18]

Room bed numbers

3.23. In recent years, single (adaptable acuity, family supportive) rooms are increasingly preferred in new schemes worldwide, compared to traditional MBWs or shared rooms. This review identified two studies investigating the impact of room bed numbers on LoS. One observational study with 37 patients diagnosed with depression involved a unit containing a mixture of twin and single rooms.[2] Findings show those assigned to single rooms experienced a 5.9-day (11%) reduction in LoS compared to those in twin rooms, 49.2- vs 55.1-days.

3.24. In contrast, a study involving dementia patients with acute illness assigned to single rooms experienced an increase of 19.8-days (-47%) in LoS compared to those in traditional MBWs, 62.2- vs 42.45-days.[19] Caution should be taken when interpreting these results as it compared samples across two hospitals, one had 100% single rooms, and the other had MBWs; they were in the same health board and had similar patient characteristics, but there is potential bias due to different operational procedures. Other limitations of that study were the unspecified design and number of beds in the MBWs, the significantly higher number of patients admitted from their own homes into single rooms, and a slightly higher proportion of patients discharged to a new care home from single rooms. In addition, poor recording of cognitive status in MBWs meant this was based solely on clinical notes.[19]

Quality and limitations of studies

3.25. These studies suggest depressed patients admitted to single rooms experience a reduced LoS than those in twin rooms, but dementia patients admitted to single rooms compared to MBWs might have increased LoS. The differences in results might be due to the sample population. The studies looked at bed numbers rather than bedroom layouts or amenities.

Windowed vs windowless rooms

3.26. Access to a window has shown to be beneficial for patient recovery due in part to the access to daylight. However, this review identified two observational studies which did not measure the potential exposure to daylight in lux, but instead compared the differences in LoS for critically ill patient cohorts in ICU windowed and windowless rooms.[1, 20] A study with 6,138 patients admitted to windowless rooms in medical ICU (MICU) found a total LoS reduction of 45.71-hrs (x%) and an ICU LoS reduction of 30.8-hrs (x%), compared to those admitted to windowed rooms.[1] In contrast, another study with acute brain injury patients found that those admitted to windowed rooms in the neurological ICU had a marginally reduced total and ICU LoS, only apparent in the interquartile ranges as reported in Appendix 5 [20]. Unexpectedly, the subgroup analysis of patients more likely to be awake (Worst Hunt-Hess grade I to III), and therefore benefit from a window showed an increased 1-day (13%) total LoS in windowed rooms.

Quality and limitations of studies

3.27. This review did not present sufficient evidence to provide a definitive conclusion on the impact of windowed and windowless ICU rooms on LoS. These inconclusive results could be due to the limited time spent in the rooms (i.e. hours instead of-days), or the cohort may not benefit from access to daylight (i.e. patients with an acute brain injury might be less influenced by external stimuli). Caution should be taken when interrupting results from these studies, as no measures of daily sedation medication, delirium, agitation or sleep were recorded. In addition, there was no consistency or details on potential light exposure nor follow-up when patients were moved from the ICU to other departments.

Access to a view from a window

3.28. Access to windows with views of nature is frequently seen as a positive intervention for patient healing and recovery. In this review, two observational studies investigated the impact of room views on LoS. One study examined the LoS difference between those in twin rooms with beds next to the window and those in the bed beside the door with restricted window access due to a 1.8m portable privacy screen.[3] Their findings show that post-op LoS for coronary surgery patients was reduced by 17.4-hrs for those with unrestricted window access. Another study by

Kohn, Harhay [1] found that in comparison to industrial views, rooms with views of nature (trees) slightly reduced total LoS by 30.66-hrs and ICU LoS by 4.33-hrs in the surgical ICU (SICU).

Quality and limitations of studies

3.29. These studies show that unrestricted access to windows and views of nature can reduce LoS in surgery patients. However, the evidence is insufficient to draw definitive conclusions, with the two studies looking at different aspects of access to a window view. In addition, neither study included LoS figures for the intervention or comparison groups, making it difficult to see this reduction's overall impact. One strength of the study by Kohn, Harhay [1] was the large sample of 6,631 patients over 4-years.

Personal bedside entertainment services (BES)

3.30. Bedside entertainment services (BES) offers patients individual access to a telephone and television, among other technology options. The review identified one RCT involving the impact of personal BES on LoS.[6] The study found that cardiac surgery patients admitted to rooms with access to a personal TV (as part of the BES package) experienced an increased LoS by 1-day (14%), from 6- vs 7-days. However, the study did not provide information on how long patients spent watching TV or how far away the communal TV area or other facilities were, e.g. toilets.

Quality and limitations of studies

3.31. This study suggests that having no personal TV access could reduce LoS. However, the other notable study finding was that no access to a personal TV increased patient mobility, walking ~85% more. Therefore, reduction in LoS could have been significantly influenced by this increase in mobility, although this increase could be due to walking further to the communal TV room or other entertainment areas.

4. Discussion

4.1. This systematic literature review aimed to gather evidence of the effect of the physical environment on patient length of stay (LoS). It included all types of study design and excluded non-empirical studies (e.g. literature reviews, critical studies, conference papers, and expert opinion). Following the SIGN50 methodology (Appendix 3), 17 of the 20 studies identified for review were graded as level three, apart from one cohort study and two randomised controlled trials graded as level two. When cross-referenced with the AGREE tool (Appendix 4), all the studies were graded as low to moderate quality evidence. Although level two studies are generally considered higher quality evidence, they had a high risk of bias and confounding factors, meaning causality could not be clearly determined. The study identified seven themes related to room aspects. The power and significance of the results are presented in Table 4-1, where each symbol ('+' or '-') represents one study.

Table 4-1: Power and significance of results

Intervention	No Studies	Impact
Increased daylight	7[a]	(+[b]++++)*++
Acuity adaptable room	6	(++++++)*
NICU single-family room	3	(+)*+0
Single room	2	+[b] -
Windowed room	2[a]	+ -
Unrestricted window access	1[a]	+
Nature view	1[a]	+
Personal TV	1	-

Note. LoS = length of stay; NICU = neonatal intensive care unit; + beneficial effect on LoS; - negative effect on LoS; 0 inconclusive; ()* significant result; [a] Some studies were cited in more than one column; [b] small sample (<100)

4.2. Three of the seven themes provided significant evidence that the provision of acuity-adaptable single rooms, increased daylight levels and NICU family single rooms can reduce patient LoS. Seven studies supported the premise that increased daylight availability can reduce LoS for patients who experience a depressive episode, surgery, and general inpatients. However, the studies had various methodologies, making it challenging to accurately compare findings. The general conclusions show LoS reductions of: (1) 7.3-hrs per each 100 lux increase above the bed for surgery patients, (2) 16%-31% for general surgery patients and 50% for patients with depressive episodes in SE-facing rooms compared to NW-facing rooms, (3) 9-16% for depressed inpatients in east-facing rooms compared to west-facing rooms, (4) 21% for depressed inpatients receiving potentially ~300% more daylight per day and

20% for general inpatients receiving higher levels of daylight, and (5) 30% for the least educated surgery patients in shared rooms assigned beds beside windows in comparison to doors. Six studies found acuity-adaptable single rooms could reduce total LoS for surgery patients by 13% - 57% for total LoS, 14% - 17% for post-op LoS and 47% for ICU LoS; and reduced total LoS by 8% for general inpatients. Finally, three studies supported that the provision of single-family rooms (SFRs), or family care (FC) rooms, can reduce pre-term infants total LoS between 3% - 16% and by 26% for ICU LoS. Contrastingly, subgroup analysis by Puumala, Rich [17] showed a minimal impact for pre-term infants at 32-37wks and an 39% increased LoS for term infants (37+wks).

4.3. Generalisations that the premise that single rooms with the adaptability to support all clinical requirements throughout a stay could reduce LoS were supported by the evidence from the acuity-adaptable single rooms and NICU family single rooms. Following a similar premise, a theme of room bed numbers looked at the comparative LoS between single rooms vs twin rooms and MBWs. These studies were not included in the previous themes due to limited details of single rooms and the inability to determine if these were acuity-adaptable. The two identified studies had conflicting evidence, one supporting that single rooms can reduce LoS, finding a 11% reduction in LoS for patients diagnosed with depression in single rooms and a contradictory study finding a 47% increased LoS for dementia patients in single rooms compared to MBWs. Definitive conclusions could not be made due to study limitations and differences in variables; notably, the design/layout or amenity provision of these rooms were not stated, and they used different comparators of twin rooms and MBW. Further confounding factors and limitations include small population sample, different demographics and operational management. However, findings from the study by Jimenez, Rich [15], included in the acuity-adaptable single room theme, could be additionally applicable to this theme as they highlight single rooms could play a prominent role in reducing LoS: their findings showing LoS reductions only in the hospital that moved from half single to all single rooms compared to no effect in the hospital that had single rooms both pre-and post-move.

4.4. An overview of the evidence on daylight availability supports the premise that increased lux levels can reduce LoS. In particular, morning light (i.e. SE- and east-facing rooms) significantly reduced LoS. However, recordings of lux levels in the studies were not consistently measured and could be influenced by many factors such as artificial lamps, placement of recording devices, room layout, and patient bed location. In addition, confounding variables could be type of view, use of shading devices, patient condition, and actual light exposure. In addition to the significant findings of daylight, another theme suggests that unrestricted access to a window and views of nature can reduce LoS; equating to 17.4- and 30.66-hr reduction in LoS for surgery patients. In contrast, conflicting results in the theme of windowed vs windowless rooms found assignment to windowed rooms marginally reduced LoS (figures not reported) for neurological ICU patients but increased by 13% for those patients more likely to be awake and by 45.71-hrs in another study for medical ICU (MICU) patients. It can be concluded that these types of studies would benefit from more control elements to determine the cause and effect more accurately.

General Limitations

4.5. This review has some limitations. For example, most studies had a single-centre design, which limits the generalisability of findings to the context of that study. However, this is mitigated by studies having similar populations, such as the three studies on the effectiveness of daylight on inpatients diagnosed with depression .[2, 7, 8] Another consideration is that the small sample size in some studies reduce the power of effect and increases the likelihood of significant effects being a coincidence. Although most of the studies with smaller samples focus on a specific patient cohort or department: which can be beneficial for determining differences between patient cohorts, such as the findings that single rooms potentially reduce LoS for some depressed patients but not for some dementia patients.[2, 19]

4.6. The nature of before and after studies meant that simultaneously comparing groups was not achievable due to patients no longer being cared for in the previous environment. In addition to the complexity of the hospital system, it is difficult to isolate the impact of a single entity, and it is beneficial to consider the environment holistically without separating the effects of individual design elements. Furthermore, it was unfeasible to control for the simultaneous implementation of other variables, such as changes in surgical techniques, staffing, and patient recording.[11-14, 21] Another potential bias related to sampling was identified in three studies, with staff knowing of interventions and some unable to be blinded.[2, 6, 20] However, departments were typically fully occupied, and patients were assigned on a one-in-one-out basis with minimal opportunity to selectively place patients.

5. Implications for research

5.1. There is a small body of scientific evidence on the impact of design on LoS in healthcare settings. However, it must be acknowledged that many confounding variables were not controlled due to the heterogeneity of the studies. This meant that the quality of research was often classified as low-to-moderate evidence. Future investigations could focus on reducing or controlling for confounding factors in research design, improving methodologies, and consistency of measurements across studies. This could include more detailed descriptions or photographs of rooms and further description of the multiple factors at play e.g. MBW bed numbers, floor plans, layout and window description. In addition, replicating studies in larger controlled trials with different cohorts or slight intervention alterations could provide more robust findings.

5.2. More research in diverse settings with various patient populations is needed to examine the contribution of specific interventions such as nature views on the overall healing process and their effect on LoS.

5.3. One study that indicated an interesting area for future research was found by Papaspyros, Uppal [6]: where access to a personal TV increased post-op LoS by 14%, with the confounding variable of increased mobility (~85%) for those without personal TV access potentially influencing findings. Therefore, design which encourages and supports movement could potentially reduce LoS.

6. Summary of Evidence

6.1. The following summary of evidence for reductions to patient length of stay (LoS) were provided based on evidence gathered by this systematic literature review. Included recommendations were based on specific interventions this review had shown to have a significant impact, as seen in Table 5-1. Due to the limitations of the studies and the high risk of bias, all the summaries have been graded as a Category B recommendation, in line with the AGREE tool (See Appendix 4). This grading means each summary is based on low to moderate quality of evidence suggesting net clinical benefits over harm.

6.2. The applicability of the summary of evidence should be considered on a case-by-case basis. However, to facilitate this, evidence has been provided with the number (n=) of supporting studies. It should be noted that these points offer compounding effects, for example; the provision of a window, with a view of nature, and orientated to achieve maximum daylight would provide greater benefits over just one.

6.3. Outside the scope of this review, the design interventions were found to contribute to overall holistic improvement; other than LoS, other benefits identified were a reduction in hospital or ICU readmission,[12, 13] patient mortality,[10, 12, 13, 16] and clinical errors,[16] and improvements in patient satisfaction and safety,[11, 15] clinical outcomes,[2, 16] and staff skills [14].

Provision of single rooms

Single rooms vs shared rooms. Provision of single rooms compared to twin rooms or MBWs can reduce LoS for inpatients diagnosed with depression, general inpatients, and surgery patients. Therefore single rooms are generally recommended (n=7); though this may not apply to all patient cohorts, such as dementia patients with an acute brain injury (n=1).

Acuity-adaptable single rooms. Provision of single rooms within decentralised units (e.g. acuity-adaptable units (AAUs)) can reduce LoS for general inpatients. This effect is replicated in surgery patients, with more pronounced reductions in post-operative LoS. Therefore, acuity-adaptable single rooms that can allow patients to remain in the same room for the entirety of their stay are recommended (n=6). If not achievable for total LoS, then at least provide for post-operative LoS (n=3).

Single-family Rooms (SFRs). SFRs and family care (FC) rooms can reduce LoS in the Neonatal ICU (NICU). This effect was particularly significant for pre-term infants (<37wks gestational age) but effects were absent in term-infants (37wks+ gestational age). Therefore, SFR rooms which provide sufficient clinical equipment for pre-term infants and dedicated overnight amenities to support caregivers to stay with infants 24/7 are recommended (n=2); though this may not apply to term-infants or those with shorter stays (n=1).

Access to daylight and window

Maximise daylight. Increasing daylight can reduce LoS for inpatients experiencing depressive episodes, general patients and surgery patients. Therefore, maximising patient exposure to daylight for the duration of their stay is recommended (n=7), being achieved in bedrooms through increased window sizes, room layouts, patient eye orientation, inbound rather than outbound en-suites. Additional consideration should be given to maximising patient exposure to daylight in other areas they have access to during their stay (n=1).

Light intensity. Room window orientations exposing patients to daylight can reduce LoS for various patient populations. Several studies found morning light (SE or east) exposure, in particular, reduces LoS. Inpatient stays in winter can increase LoS. Therefore, orientations that achieve the highest available daylight level for each unit should be used for patient bedrooms (n=2) and if shared rooms then each bedspace should have equal access to light from windows (n=2). Patient eye orientation should be towards the window but shielded from glare to avoid blinds being drawn (n=2).

Access to window. Inpatient window access, for natural light and views, can reduce LoS for surgery patients. One study finding in a shared room the design enable equal window and view access from each bed/ patient location or communal space. Therefore, unrestricted access to a window for each patient is recommended (n=3); though this may not apply to all patient cohorts, as shown in some critically ill patients during ICU stays (n=2).

Outdoor views

Bedroom windows with a view of nature, e.g. trees/ greenery, can reduce LoS for surgery patients. Therefore, view of nature from bedroom window are recommended (n=1); while industrial views should be avoided (n=1).

7. References

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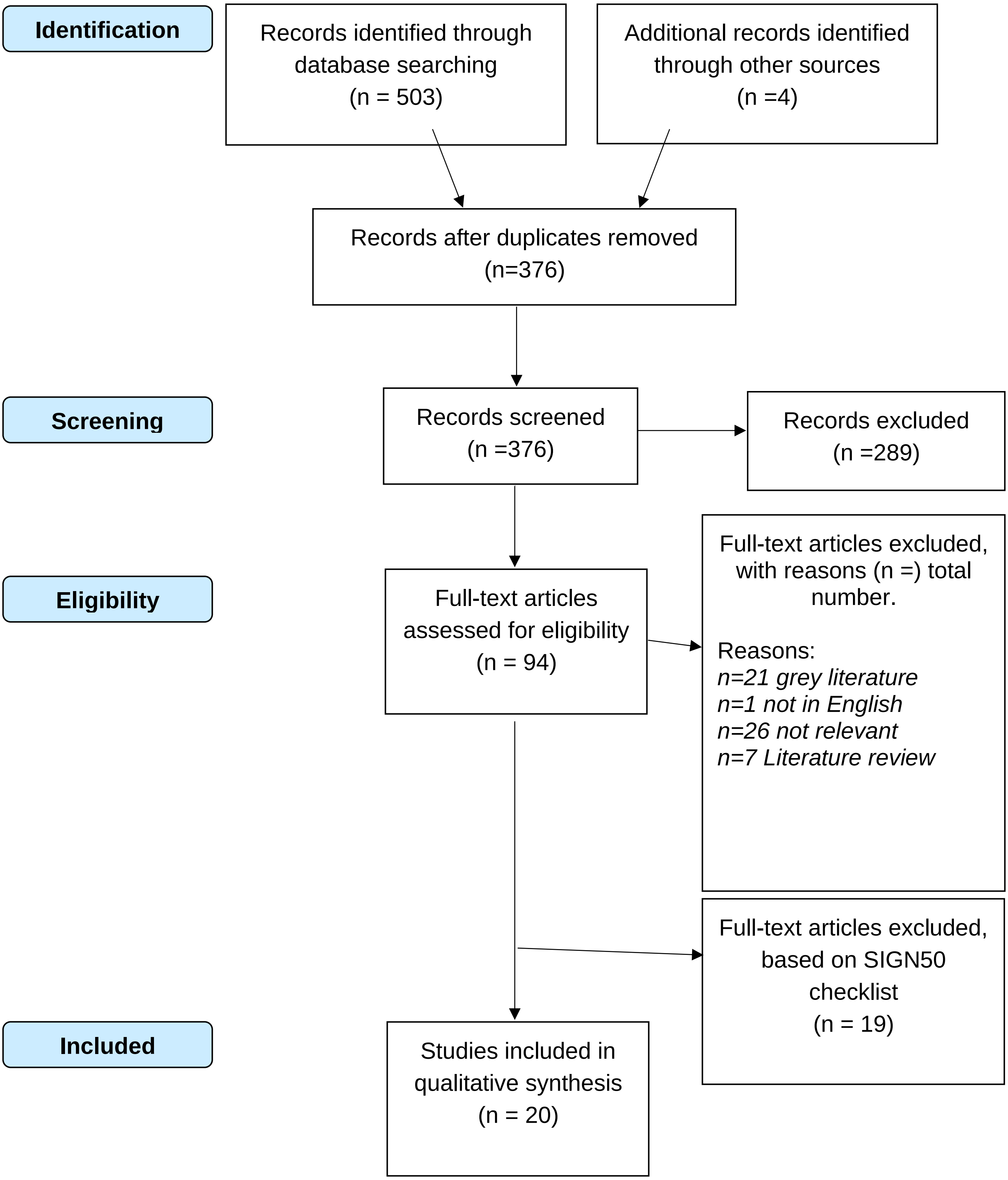
Appendix 1: Search Strategy

Database	Number of results	Search string
Embase (OVID)	Initial search: 126	1. hospital*.mp. 2. healthcare facilit*.mp. 3. health care facilit*.mp. 4. hospital patient/ or Inpatient*.mp. 5. 1 or 2 or 3 or 4 6. "length of hospitalisation".mp. 7. "length of stay"/ 8. 6 or 7 9. evidence based design.mp. 10. evidence-based hospital design.mp. 11. hospital design/ 12. built environment.mp. 13. Interior.mp. 14. furniture/ 15. Decor.mp. 16. daylight.mp. 17. room design.mp. 18. Acuity-adaptable.mp. 19. 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 20. 5 and 8 and 19 21. limit 20 to (english language and yr="2002 -Current")
MEDLINE (OVID)	Initial search: 64	1. hospital*.mp. 2. healthcare facilit*.mp. 3. health care facilit*.mp. 4. hospital patient/ or Inpatient*.mp. 5. 1 or 2 or 3 or 4 6. "length of hospitalisation".mp. 7. "length of stay"/ 8. 6 or 7 9. evidence based design.mp. 10. evidence-based hospital design.mp. 11. hospital design/ 12. built environment.mp. 13. Interior.mp. 14. furniture/ 15. Decor.mp. 16. daylight.mp. 17. room design.mp. 18. Acuity-adaptable.mp. 19. 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 20. 5 and 8 and 19 21. limit 20 to (english language and yr="2002 -Current")
Web of Science	Initial search: 50	1. ALL=(hospital* OR "healthcare facilit*" OR "health care facilit*") 2. ALL=("length of hospitalisation" OR "length of stay") 3. #1 AND #2

Database	Number of results	Search string
		4. ALL=("evidence based design" OR "evidence-based hospital design" OR “hospital design” OR "built environment" OR Interior OR furniture OR Décor OR-daylight OR “room design" OR Acuity-adaptable) 5. #3 AND #4 6. #5 AND (PY==("2022" OR "2021" OR "2020" OR "2019" OR "2018" OR "2017" OR "2016" OR "2015" OR "2014" OR "2013" OR "2012" OR "2011" OR "2010" OR "2009" OR "2005" OR "2004" OR "2002"))
CINAHL	Initial search: 62	("hospital*" OR (""healthcare facilit*"") OR (""healthcare facilit*"") OR ((MH "hospital patient") OR Inpatient*)) AND ((""length of hospitalisation"") OR ((MH "length of stay"))) AND ((""evidence based design"") OR (""evidence-based hospital design"") OR ((MH "hospital design")) OR ((MH "hospital design")) OR ((MH "Hospital Design and Construction")) OR ((MH "Built Environment")) OR (""built environment"") OR ((MH "Interior Design and Furnishings")) OR ((MH furniture)) OR "Decor" OR "daylight" OR (""room design"") OR "Acuity-adaptable")
SCOPUS	Initial search: 201	(TITLE-ABS-KEY (hospital* OR "healthcare facilit*" OR "hospital patient" OR "health care facilit*" OR inpatient*)) AND (TITLE-ABS ("length of hospitalisation" OR "length of stay")) AND (TITLE-ABS-KEY ("evidence based design" OR "evidence-based hospital design" OR "hospital design" OR "built environment" OR interior OR furniture OR décor OR-daylight OR "room design" OR acuity-adaptable)) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2006) OR LIMIT-TO (PUBYEAR , 2005) OR LIMIT-TO (PUBYEAR , 2004) OR LIMIT-TO (PUBYEAR , 2003) OR LIMIT-TO (PUBYEAR , 2002)) AND (LIMIT-TO (LANGUAGE , "english"))

Appendix 2: PRISMA Flow Diagram



Adapted from: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLOS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Appendix 3: SIGN 50 levels of evidence

1++	High quality meta analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1+	Well conducted meta analyses, systematic reviews of RCTs, or RCTs with a low risk of bias
1-	Meta analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
2++	High quality systematic reviews of case-control or cohort studies High quality case-control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal
2+	Well conducted case control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal
2-	Case control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g. case reports, case series
4	Expert opinion

Appendix 4: Grades of recommendation

Grade	Descriptor	Levels of evidence
Mandatory	'Recommendations' that are directives from **government policy, regulations or legislation**	N/A
Category A	Based on **high to moderate quality** evidence	SIGN level 1++, 1+, 2++, 2+, AGREE strongly recommend
Category B	Based on **low to moderate quality** of evidence which suggest net clinical benefits over harm	SIGN level 2+, 3, 4, AGREE recommend
Category C	Expert opinion, these may be formed by the NIPC groups when there is **no robust professional or scientific literature** available to inform guidance.	SIGN level 4, or opinion of NIPC group
No recommendation	Insufficient evidence to recommend one way or another	N/A

Appendix 5: Study characteristics

Author / Country	Study design	Study Focus	Patient	Setting	(1) Intervention / (2) comparison	Results (* indicates significance)	Evidence Level
Bonuel, Degracia [14]/ USA	Case control	AAU	143* renal transplant patients (approx. as not stated)	Multiorgan Transplant Unit AAU: patient remained in acuity-adaptable room throughout stay traditional care: patient moved from unit to ICU post-operatively	(1) acuity-adaptable room / (2) traditional care room	acuity-adaptable rooms reduced **mean** total LoS by 5.5days (4.1(±1.3)- vs 9.6(±11.0)- days) p=0.004*	3
Chindhy, Edwards [12]/ USA	Before and after study (pre-and post-move)	AAU	2,930 cardiac surgery patients	Cardiothoracic Division of the Department of Surgery AAU: patient remained in acuity-adaptable room throughout stay traditional care: patient moved from unit to ICU post-operatively	(1) acuity-adaptable room / (2) traditional care room	acuity-adaptable rooms reduced **median** post-op LoS by 1-day (5(4,7)- vs 6(4,10)- days) p<0.01* acuity-adaptable rooms reduced **median** ICU LoS by 23hrs (26(19,45)- vs 49(27,99) hrs) p<0.01*	3
Costello, Preze [10] / USA	Before and after study (pre-and post-move)	AAU	2,363 paediatric cardiac surgery patients (0-18yrs)	AAU: patient remained in acuity-adaptable room throughout stay and received care from the same clinical team	(1) acuity-adaptable room / (2) traditional care room	acuity-adaptable room reduced **median** total LoS by 1day (7(4,40)- vs 8(3,44)- days) p =0.64	3

Author / Country	Study design	Study Focus	Patient	Setting	(1) Intervention / (2) comparison	Results (* indicates significance)	Evidence Level
				traditional care: predominantly shared rooms with patients moved among three units (NICU, PICU or cardiology unit), received care from different clinical services based on age, severity of illness, and operative status		acuity-adaptable room reduced **median** post-op LoS by 1day (6(3,24)- vs 7(3,30)-days) p = 0.07*	
Hennon, Kothari [13] / USA	Before and after study (pre-and post-move)	AAU	488 pulmonary resection surgery patients	Cardiothoracic Unit AAU patient remained in acuity-adaptable room throughout stay traditional care: patient moved depending on acuity to GC, IMC, or ICU	(1) acuity-adaptable room / (2) traditional care room	acuity-adaptable room reduced **mean** total LoS by 3.6-days (4.2(±0.3)- vs 7.8(±1.2)-days) and **median** total LoS by 2-days (3- vs 5-days) p<0.001* (both)	3
Venditti [11] / USA	Before and after study (pre-and post-move)	AAU	1,120 post-operative cardiac surgery patients	Cardiothoracic Unit AAU patient remained in acuity-adaptable room throughout stay	(1) acuity-adaptable room / (2) traditional care room	acuity-adaptable room reduced **median** post-op LoS by 1-day (6(5,8) vs 7(5,10)-days) p < 0.0001*	3

Author / Country	Study design	Study Focus	Patient	Setting	(1) Intervention / (2) comparison	Results (* indicates significance)	Evidence Level
				traditional care: segregated cardiac intensive care unit (CICU)			
Jimenez, Rich [15] / USA	Before and after study (pre-and post-move)	AAU	General inpatients **Hospital 1:** 4,782 **Hospital 2:** 7,794	Three departments: ICU, WC, and MS decentralised unit: both hospitals had acuity-adaptable single rooms with same-handed configuration, outboard toilets and increased space for visitors and staff. centralised unit: both hospitals patient rooms with mirrored layouts and inboard toilets. **Hospital 1** had 100% single rooms and **Hospital 2** had 48% single rooms and the rest twin rooms	(1) decentralised unit / (2) centralised unit	decentralised units in **Hospital 2** reduced **mean** total LoS by 0.33-days (3.37(±2.74)- vs 3.70(±3.08)-days) and median total LoS by 0.17-days (2.72(1.82,3.96)- vs 2.89(1.88,4.42)-days) $p< 0.001$* (M) decentralised unit**s in Hospital 1** increased **mean** total LoS by 0.02-days (3.52(±2.61)- vs 3.50(±3.06)-days) but reduced **median** total LoS by 0.02-days (2.95(1.97,4.11)- vs 2.97(1.96,4.10)-days) p-value not reported but not-statistically significant	3
Papaspyros, Uppal [6] / UK	Random-control-trial (RCT)	Access to personal TV	100 cardiac surgery patients	Cardiothoracic Unit	(1) access to personal TV / (2) no access to personal TV	Access to personal TV increased **median** post-op LoS by 1day (7(6,7)-vs 6(5,7)-days) p-value not reported but not-statistically significant	2-

Author / Country	Study design	Study Focus	Patient	Setting	(1) Intervention / (2) comparison	Results (* indicates significance)	Evidence Level
Canellas, Mestre [8] / Spain	Before and after study (pre-and post-move)	Daylight	207 depressive* inpatients *due to dysthymia, MD, or BD	Psychiatric Unit pre-move: located in basement with mean 86,145lux* post-move: located on ground floor with mean 258,909lux* (~300% more). *Lux measured in areas according to patient daily schedule including: (1) sunny, open sky courtyard; (2) shadowed, open sky courtyard; (3) aisles; (4) dining and occupational therapy rooms; and (5) bedrooms.	(1) high daylight levels / (2) low daylight levels	the unit with higher daylight levels reduced **median** total LoS by 3-days (11(6,15) vs 14(8,19)-days) p=0.007*	3
Joarder and Price [3] / Bangladesh	Observational	Daylight	263 coronary artery bypass graft (CABG) surgery patients	After surgery patients transferred to the Cardio-Thoracic Intensive Care Unit (CT ICU), then to the Cardiac Surgery Inpatient Unit (CSIU). CSIU Located on 10th floor with 13 single	(1) high daylight levels / (2) low daylight levels	With each 100 lux increase post-op CSIU LoS was reduced by 7.3 hours p=0.016	3

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				bedrooms and 9 twin bedrooms.			
Choi, Beltran [5] / Korea	Observational	Daylight	1,167 inpatients	24 comparison sets (per floor, orientation, room type, and spring, fall and winter) all single bedrooms Either Room type A or B, facing SE or NW on the 8th (Gynaecology), 11th (Surgery), 12th (Otolaryngology) and 16th (Internal) floors. compared to NW, SE received higher illuminance, by 300-400lux, in the morning, and lower, by 30-150 lux, in the afternoon. Overall SE received ~200 higher daily lux than NW rooms patient view from bed: SE Room Type A towards south and B towards east. NW Room Type A towards west and B view towards north.	(1) SE-facing room / (2) NW-facing room	SE-facing rooms reduced total LoS by 16%-31%. Six of the test were statistically significant, or marginally significant and showed SE-facing rooms reduced total LoS by 29% The two statistically significant cases included reduction in total LoS for those assigned to SE rooms: (1) on the Gynaecology floor, in Room type B, during spring by 3.17-days (4.53- vs 7.7-days). p=0.015* (2) on the Surgery unit, in room type A, during fall by 1.87-days (5.22- vs 7.09-days). p=0.048* Not reported if average mean or median	3

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Li, Lou [9] / China	Observational	Daylight	2,998 general surgery patients	Unit located on 6th floor with shared rooms of 7, 4 or 2 beds all facing south (bed next to the window or door) mean daily daylight for sunny and overcast day were: Window bed: 756.9 and 296.6 lux Door bed: 39.7 and 10.7 lux	(1) window bed / (2) door bed	Assignment to the window beds reduced **median** total LoS by a nominal amount (6(3,12)- vs 6(3,13)-days) p = 0.579 Subgroup of patients with lowest education in window beds reduced total **median** total LoS by 3-days (7(4,14)- vs 10(5,19)-days) p=0.011* Subgroups of lowest education levels in window beds reduced **median** total LoS by: 7-days in those aged 68+ (15- vs 8-days) p = 0.003* 4.5-days in those in the normal range BMI (12 vs 7.5-days) p = 0.009* 4-days in those with diagnosis of benign tumours (9 vs 5-days) p = 0.005*	3
Park, Chai [4] / Korea	Observational	Daylight	67,842 inpatients	Hospital departments included ENT, GIMD,	(1) window bed / (2) door bed	Assignment to the window bed reduced **median** total LoS by 1-day (4(3,7)- vs 5(3-	3

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				GS, HOMD, OS, PED, and others. Six-bedded room in a bed next to the window or door		8)-days) p<0.001*	
Benedetti, Colombo [7] / Italy	Observational	Daylight (orientation)	415 unipolar and 187 bipolar inpatients diagnosed with depression	east- and west-facing rooms Lux 9am Bright: E=15,500, W=1,400 Light clouds: E=1,500, W=150 Cloudy: E=650,W=150 5pm Bright: E=2,700, W=3,000 Light clouds: E=200, W=1,500 Cloudy: E= 140, W=600	(1) high daylight levels / (2) low daylight levels	east-facing rooms reduced **mean** total LoS for: bipolar patients by 3.67-days (19.80(±9.48)- vs 23.47(±11.78)-days) p=0.020* unipolar patients by 2.16-days (20.92(±10.50)- vs 23.08(±10.94)- days) p=0.062	3
Gbyl, Ostergaard Madsen [2] / Denmark	Observational	Daylight (orientation)	29 depressed patients: 6 bipolar depression, 10 unipolar single-episode depression, and 13	The Affective Disorders Unit 14 bed ward: 4 twins and 6 single rooms facing SE or NW	(1) SE-facing room / (2) NW-facing room	SE-facing rooms reduced **mean** total LoS by 29.6-days (29.2(±26.8)- vs 58.8(±42.0)-days) p = 0.01* Summer and spring reduced	3

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			with a recurrent unipolar depressive disorder.	lux measured at 12:00 for SE and NW is: summer solstice: 60,000 and 3,000 autumn equinox: 40,000 and 2,000 winter solstice: 20,000 and 1,200		**mean** total LoS (37.8(±24.8)- vs 53.6(±45.6)-days) compared to autumn and winter p = 0.46	
Gbyl, Ostergaard Madsen [2] / Denmark	Observational	Room bed number	37 depressed patients: No further diagnosis provided	The Affective Disorders Unit. 14 bed unit: 4 twins and 6 single rooms	(1) single room / (2) twin room	single rooms reduced **mean** total LoS by 5.9-days (49.2(±43.9) vs 55.1(±49.9)-days) p = 0.63	3
Young, Edwards [19] / UK	Observational	Room bed numbers	100 dementia patient with acute illness	Two hospitals, one with single rooms and one with MBWs	(1) single room / (2) MBW	single rooms increased **mean** total LoS by 19.76days (62.23(± 41.79) vs 42.47(± 40.50)-days) p=0.027	2-
Puumala, Rich [17] / USA	Before and after study (pre-and post-move)	Single family room	9,995 Infants extremely pre-term: <28wks gestational age (g) very pre-term: 28<32wks g. moderately pre-term: 32<37wks g. term or post-term: 37wks+ g.	NICU Pre-move: open wards with units of 4-6 infant cots each totalling about 90 cots with central workstation – infants moved based on acuity post-move: unit with 12 SFRs and	(1) SFR / (2) open ward	SFR increased **median** total LoS by 3.39-days (6.84(3.42, 17.48)- vs 3.45(2.34, 8.78)-days) p=<0.0001* Subgroups: SFR increased **median** LoS for gestational age: “moderately pre-term” infants by 0.19-days (12.33(6.9, 20.7)- vs 12.14(6.3, 22.3)-	3

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				decentralized workstations with infants remaining in the same room during treatment		days) p=0.71 "term/post-term" by 1.14 (4.10(3.0, 7.0)- vs 2.96(2.2, 4.3)-days) p=<0.0001* SFR reduced **median** LoS for gestational age: "extremely pre-term" by 11.18-days (77.98(16.4,107.4) vs 89.16(31.4, 124.5)-days) p= 0.02 "very pre-term" by 10.59-days (45.86(31.9, 62.8) vs 56.45(38.3, 74.1)-days) p=<0.0001*	
Örtenstrand, Westrup [18] / Sweden	RCT	Single-family room	365 pre-terms infants (<37wks gestational age)	Two hospitals that contained both a standard care (SC) ward (of 15 and 13 beds) and a new family care (FC)/ ward (of 13 and 10 beds) level 2 NICU SC wards A 4-bed intensive care room in each ward and	(1) FC ward / (2) SC ward	FC wards reduced **mean** total LoS by 5.3-days (27.4(23.2-31.7)- vs 32.8(29.6-35.9)-days) and **median** total LoS by 2-days (15(9,31)- vs 17(9,35)-days) p= 0.05* and p=0.25 FC wards reduced **mean** ICU LoS by 4.7-days (13.3(10.2-16.4)- vs 18.0(15.7-20.3)-days) and **median** ICU LoS	2+

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				intermediate care rooms with 2 to 4 infant cots. Parents advised to be with their infant as much as possible during the day but overnight stays were limited to a few-days prior to discharge FC wards A 4-bed intensive care room. In addition they had separate family rooms with bed, private bathroom, infant cot and clinical equipment. Parents expected to stay 24hrs with infant, the infant being moved to their room when they reached a stable state		by 3-days (3(1,10)- vs 6(2,14)-days) p=0.02* (both) FC wards reduced **mean** and **median** total LoS in gestational age subgroups: <30 wks by 10.1-days (56.6(43.7-69.5)- vs 66.7(54.2-79.3)-days) and 16-days(53(44,67)- vs 69(49,90)-days) p= 0.26 and p=0.02* 30-34wks by 4.4-days (19.2(15.4-23.1)- vs 23.6(20.2-27.1)-days) and 3-days (16(11,23)- vs 19(12,29)-days) p= 0.10 and p=0.16 35-36wks by 1.4-days (6.4(2.3,10.6)- vs 7.9(5.8-10.0)-days) and 1-day (7(4,12)- vs 8(3,10)-days) p= 0.54 and p=0.39	
Domanico, Davis [16] / USA	Before and after study (pre-and post-move)	Single-family room	240 pre-term infants (<37wks gestational age (g))	NICU pre-move: open-bay 382m^2 ward, with 3.35m^2 per infant space	(1) SFR / (2) open ward	SFR reduced PEMR 2 & 3 infants **mean** total LoS by ~2-days (11%) (15.7- vs 17.9-days) and **median** total LoS by 2-days (10.0- vs 12.0-	3

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			PEMRs 2 and 3, (less ill) with mean gestational age (g) of 34wks PEMR 4 (most ill) with mean g. age of 31-32wks	post-move: 1302m^2 unit with ~16m^2 individual SFR rooms. SFR were found to be a quieter, more hygienic facility with controllable natural lighting same staff for pre-and post-move an no new staff hired		days) p=0.34 (**mean**) SFR reduced PEMR 4 infants **mean** LoS by 2-days (3%) (68 vs 70-days) and **median** total LoS by 2-days by 11-days (60- vs 71-days) p=0.89 (**mean**)	
Kohn, Harhay [1] / USA	Observational	Window view	6,282 critically ill patients	24 bedded SICU: 11 with natural view (trees), 13 with industrial views (buildings).	(1) natural view / (2) industrial views	Natural views reduced **median** total LoS by30.66 (–59.67, –1.66)-hrs and ICU LoS by and 4.33(–13.27, 4.62)-hrs p=0.04 and p = 0.34 (Adjusted Per-Protocol sample)	3
Joarder and Price [3] / Bangladesh	Observational	Window view	263 CABG surgery patients	After surgery patients transferred to the Cardio-Thoracic Intensive Care Unit (CT ICU), then to the Cardiac Surgery Inpatient Unit (CSIU). CSIU Located on 10th floor with 13 single	(1) unrestricted outdoor view / (2) restricted outdoor view	unrestricted outdoor view reduced post-op CSIU LoS by 17.4hrs p= 0.037	3

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				bedrooms and 9 twin bedrooms. *1.8m high movable privacy screens were used in twin bedrooms and restrict access to view.			
Kohn, Harhay [1] / USA	Observational	Windowed room	6,090 critically ill patients	24 bedded MICU: 14 rooms with window and 7 without	(1) windowed room / (2) windowless room	Windowed rooms increased **median** total LoS by 45.71(22.64,68.79)-hrs and ICU LoS by 30.85(20.29,41.41)-hrs p = <0.01 and p = <0.01 (Adjusted Per-Protocol sample with no LoS of windowed and windowless rooms provided, only the difference in LoS)	3
Wunsch, Gershengorn [20] USA	Observational	Windowed room	789 critically ill patients with acute brain injury	Neurological ICU with 12 patient rooms: seven with windows and five without	(1) windowed room / (2) windowless room	Windowed rooms reduced **median** total LoS x-days (4(2-11)- vs 4 (2-8)-days) and ICU LoS x-days (13(9-19)- vs 13(9-19)-days) p=0.52 and p=0.97 Windowed rooms increased **median** total LoS by 1-day for patients with Worst Hunt-Hess grade (I to III*) (7 (4,9)- vs 8 (5,10)-days p=0.05	3

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						*most likely to be awake	