The physical environment and its effect on health outcomes: a systematic review.

THE PHYSICAL ENVIRONMENT AND ITS EFFECT ON HEALTH OUTCOMES – A SYSTEMATIC REVIEW

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Abstract

Objective: The study aims to identify and review the latest existing knowledge about evidence- based design (EBD) for healthcare architecture and determine the extent to which such findings pertain to the overarching goals proposed by the Institute of Medicine (IOM).

Background: There is increasing knowledge regarding influences of healthcare physical environments on health and well-being outcomes. The demand for more evidence has steadily grown, and systematic literature reviews have gained increased importance in the healthcare design field.

Research question: A systematic literature review was performed according to the guidelines proposed by The Swedish Agency for Health Technology Assessment and Social Services Assessment. Specific aims included evaluating the current status of research relating to evidence-based healthcare architecture and determining the extent to which such evidence corresponds to the key goals established by the IOM.

Methods: A systematic literature review with a Boolean search strategy was performed using the following databases: CINAHL, Medline, SCOPUS, Cochrane library, and Web of Science. The time period covered was 2010-2018. The reference lists of articles obtained from keyword searches were then examined to identify additional relevant studies. The articles retrieved have been screened for eligibility for inclusion, and the final retained articles have been evaluated with descriptive statistics to identify which IOM quality categories are addressed, what type of healthcare settings, physical environment intervention and target groups are investigated, and what types of research design and methodology have been implemented. Furthermore, two researchers are independently assessing the quality of the material retained. This data is part of an ongoing project therefore, preliminary results are reported.

Results: A total of 4546 articles were retrieved and screened for eligibility for inclusion, resulting in 688 retained articles published since 2010. Of these 92 has been analyzed until now with descriptive statistics and results suggest that the most frequently cited IOM goals are related to health (84%) and safety (46%), person-centred approach (29%) and effectiveness of care (28%). Moreover, research has been performed across acute care and overall hospital settings (22 and 21%).

Conclusion: The systematic literature review indicates that the body of knowledge relating to EBD is clearly growing, and the main focus is on design interventions to improve the health and safety of patients across acute care units. Lack of evidence are instead found in regard to other IOM aspects such as, equality of care and patients' participation.

Keywords: *Evidence based design, healthcare architecture, healthcare users, health outcomes, physical environment*

Introduction

Evidence-based design (EBD) has been defined as a process for using of the best available evidence from research and practice to inform the design of healthcare environments with the deliberate goal of improving outcomes (1). The purpose of applying EBD for the planning of healthcare environments is that of providing possibilities to develop supportive environments for patients' health, improve clinical results, facilitate effective work and reduce nurses' stress, account for waste of resources and sustainability issues (2, 3). Similar to evidence based medicine (EBM) that is used to support decision and intervention in the medical field, EBD for healthcare architecture becomes more and more important to enhance design decisions for a planned environment. EBD should support decision making across all phases of the process to develop new health care environments from planning, to designing and construction (4). Systematic reviews are required to contribute to evidence in all areas, including healthcare architecture (5).

Healthcare settings are complex and dynamic buildings in which technologies, organizational systems and various users such as patients, significant others and staff are constantly interacting with one another. Such interaction is dynamic in the sense that care and technologies, as well as patients' needs, are not stable over time but subject to changes, which set a great pressure on the way the physical environment is designed. Brambilla and colleagues (6) suggests that healthcare facilities should be resilient to the continued evolution of the healthcare system and in this sense, EBD is considered to be essential i.e., the possibility of constantly adding new knowledge about the impact of certain design solutions on health and organizational outcomes.

The role that the physical environment has in affecting health related outcomes has been recognized since the second half of the nineteen century, when the environmental theory proposed by Nightingale was developed (7). Nightingale observed that specific design elements such as good ventilation, cleanliness, light and noise were crucial for health outcomes. Nightingale also emphasized the importance to always consider the individual in the interaction with the environment in order to design environments that support the best possible conditions for healing to occur (7). This view corresponds with today's person-centred approaches for healthcare service (8).

It is an increased awareness that the physical environment is of crucial importance to the quality of care and can affect several important health results. This has created an exponential growth of research studies from several research areas (6).

The latest review conducted on EBD is from 2008 and the results predominantly stress evidence related to hospital design that reduced the frequency of acquired infections (9). For example, implementation of single-bed rooms, effective air quality control, placement of alcohol-based hand-run dispensers, cleanness of surfaces and floors and proper water system design to minimize water stagnation.

The present work seeks to undertake a new review and build upon Ulrich's work from 2008. The framework for the present review is Institute of Medicine's (IOM's) dimensions of quality (10, 11). The challenge of ensuring quality of healthcare remains high on the public and political agenda internationally (10, 12). We also based the review on important concepts such as person-centred and shared-decision making, as the quality perceived by the patient is significant today. Patient expectations and experiences of care has been an important outcome of care (15 13, 14). Recipients of health care services are more likely to expect quality from many perspectives, driven by their changing needs. For example, an acutely unwell patient may rate the dimension of effectiveness highly, but during rehabilitation they may rate person- centredness as the most important dimension of health care quality (15). The IOMs overall quality goals are summarized in the concept of good care in which the environment is seen as an important part to achieve it (11). However, little is still known about what aspects of the environment can contribute to good care outcomes.

This work aims to reduce such knowledge gap, and it is part of a larger research project, in which an update of the latest EBD reports and a detailed description of the current finding of EBD and its contribution to the field of healthcare architecture is developed. The focus of this paper is however, exclusively on the overview of the material found and a descriptive evaluation of it expressed in terms of; healthcare areas investigated, target groups involved, types of research design and methodology, physical environment interventions and IOM goals addressed.

Aim

This systematic literature review seeks to identify the existing knowledge about EBD for healthcare architecture and to develop a descriptive framework of them, which pursue to be informative for the goals of good care proposed by the Institute of Medicine (IOM).

Specific research questions can be summarized as follows:

1. Identify the state of art of EBD for healthcare architecture.
2. Description of the evidence found expressed in terms of; healthcare areas, target groups assessed, design and methodology implemented, physical environment interventions, and IOM goals.

Methods

Review design and search method

A systematic literature review about evidence based design for healthcare architecture was performed according to the method proposed by, The Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU) (16), and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (17).

The search was performed in the following data bases; Medline, Cochrane Library, Cinahl, Web of science and Scopus for the material published between the years 2010-2018. A Boolean search strategy, developed with the support of the university library at Chalmers University, was adopted (table 1).

The electronic search was performed by two authors (EM and AS) between May 2018 and June 2018. Furthermore, a free search was performed based upon the references found and the expertise of the researchers involved during the same timeframe.

Table 1. Boolean search terms by main topics

AND		
Architecture	Patient(s)	Healthcare setting(s)
OR	OR	OR
Architectural design	Client(s)	Healthcare facility(ies)
Building design	Consumer(s)	Healthcare space(s)
Environment Design	Family	Healthcare building(s)
Physical environment	Relatives	Health facility(ies)
Built environment	Visitor(s)	Hospital(s)
Health Facility Environment	Caregiver(s)	Healthcare service(s)
Evidence-Based Facility Design	Health Personnel	E-health
Evidence-based Design	Staff	Telemedicine
Environmental design	Nurse(s)	Telehealth
Hospital construction	Physician(s)	Medical home(s)
Hospital Design and Construction		Patient-centered medical home
Facility design		Ambulatory Care Facility(ies)
Universal design		Ward(s)
Interior design		Emergency department(s)
Garden(s)		Emergency Service, Hospital
		Intensive care
		Critical Care
		Acute care environment(s)
		Care unit(s)
		Outpatient
		Inpatient
		Waiting room
		Accident and emergency
		NICU
		Rehabilitation room
		PICU
		Operating room

Search outcomes and data screening

All articles that studied the influence of the physical environment of healthcare settings on their users (i.e., patients, staff and visitors) written in English and published in peer-reviewed scientific journals between 2010 and 2018, were eligible for inclusion.

The screening process complied the following steps;

a) Selection for inclusion was performed based upon title and abstract and performed by two authors (EM and AS), all duplicated were eliminated at this stage.

b) Abstracts were screened to determine relevance of the topic by all four authors (EM, AS, ME and RU) and a three-grade system was adopted in which each author independently evaluate the eligibility of the material by either retained, excluded, or uncertain. Uncertain material was solved by means of discussion among the authors (i.e. cross-checking technique per each uncertain abstract).

c) Full texts of relevant papers were retrieved

d) Each full-text was independently evaluated by three authors (EM, AS and ME).

The literature search ended in June 2018 and generated 7062 hits of which 2516 were duplicated and therefore eliminated.

After the first screening of relevance of the topic for the object of this investigation (N = 3483) papers were further eliminated since not addressing hospital setting but other types of residential care settings such as, nursing home and supported housing facilities. The remaining 1062 were independently evaluate by each author and screened in terms of abstract relevance, uncertain material (N = 279) (6%) was also discussed among the authors, following an agreement of 88%.

After this screening (N= 490) paper were eliminated resulting into (N =572) papers. Also, an additional of (N = 96) papers, identified via free search were included, resulting into a total of (N = 688) papers, which full-text is at present scrutinized to determine eligibility of inclusion. The final amount of papers deemed for inclusion will be defined after the full-text evaluation is completed. Also, since this work is part of a larger and ongoing research project, the quality appraisal of the included papers is yet uncompleted and will be reported in the next step of the research. However, the guidelines followed in order to estimate the quality of the material included are those of the "GRADE" system, provided by SBU, which focuses on person-centred perspectives (i.e. patients' benefits and risks) (16).

A flow chart, summarizing the above mention search outcomes, and the ongoing process of this systematic review work is provided in Figure 1.

Qualitative appraisal ongoing process

Two researchers (EM and ME) are independently assessing the quality of the material retained by means of the guidelines suggested by the SBU (2). Different protocols to assess the quality of the paper retained developed from the "GRADE" system used in medical science were therefore used, which implies different grid of evaluations depending on the study design (e.g. randomized control trial, qualitative studies and systematic review). The degree of evidence was based on the reliability, consistency, transferability of the data collected. In the case of disagreement, the researchers discuss their assessments and pursue further evaluation until an agreement is achieved. The quality appraisal phase is still ongoing and for this reason such results are not reported.

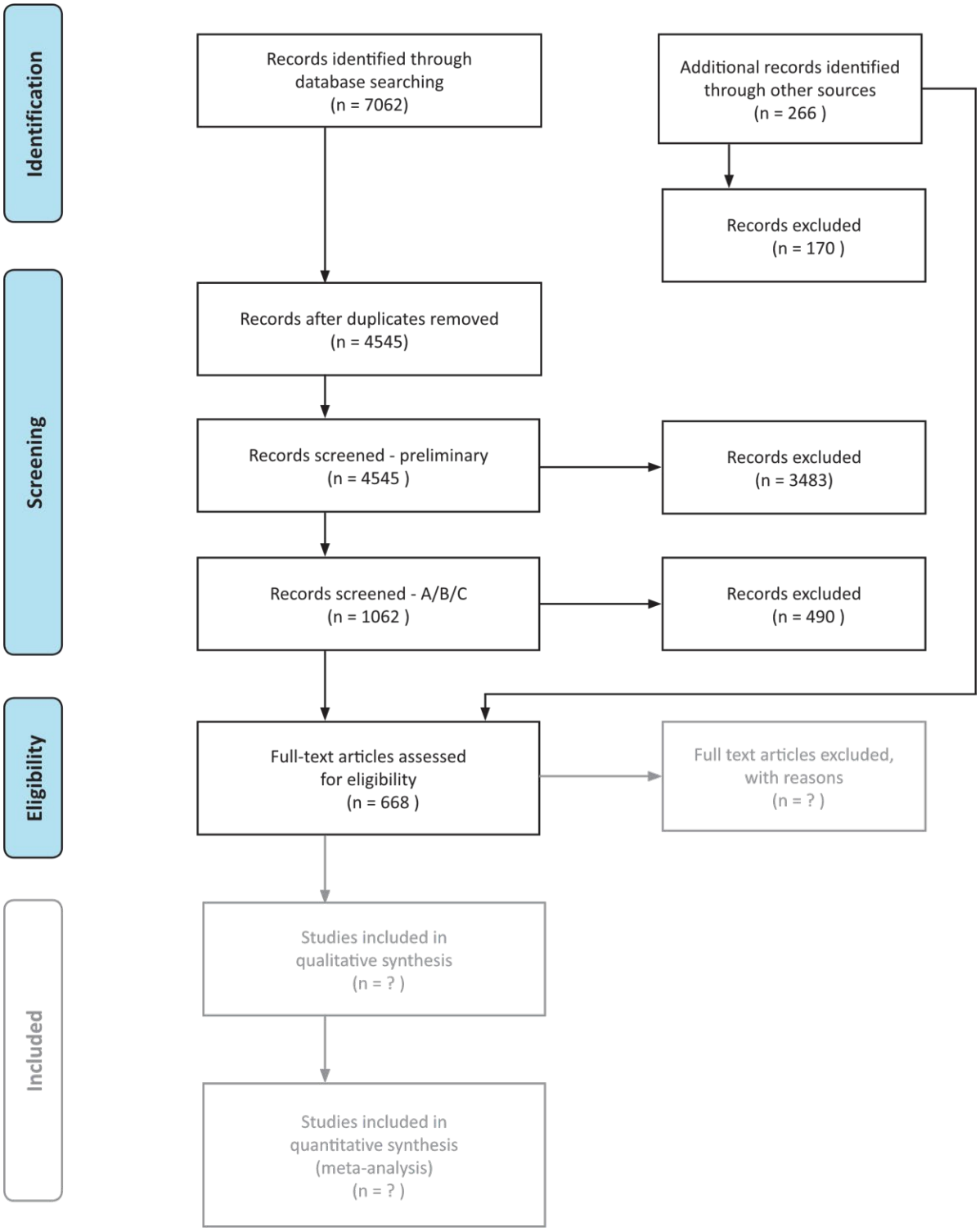
Data extraction and synthesis

Descriptive statistics was used to identify the frequency of appearance of the different healthcare goals, in order to establish which domains were explored and which were overlooked upon. Furthermore, the data synthesis lifts what target groups were investigated what aspects of the physical environment and in which hospital area, as well as, what type of research design and methodology was used.

For this data extraction and synthesis analysis an overarching matrix was used, where three of the co-authors reported the information per each of the full paper included in this study.

A summary of the material included in the present review is reported in Appendix 1. Information includes, authors' name, year, title, journal type, target group, healthcare area of investigation, research design and methodology, physical environment interventions and IOM goals.

Figure 1. PRISMA chart – ongoing process



Results

Preliminary results of the ongoing evaluation of EBD for healthcare architecture

On the whole, the present work confirms the extensive growth of publications addressing evidence based design research studies with a total of 688 eligible for inclusion. The present project is ongoing, and the results refer to the material assessed so far (N = 92). These latter articles suggest that the main areas object of investigation were that of, acute care units (22%) and overall hospital setting (21%), followed by, neonatal units (12%) and psychiatry departments (9%).

Majority of the evidences were derived from the Journal of Health Environments Research and Design (HERD) (20%) tailed by, nursing and medical journals respectively, 17% and 16% of the material evaluated. Such evidences are largely derived by studies conducted in Northern America (N = 45) (49%) and Europe (N = 30) (33%).

Mainly the studies presented a non-experimental research design (72%) (i.e., cross-sectional, cross-over and longitudinal studies) and adopted a mix-method approach of investigation (36%), implying the use of different methodology for the collection of data such as, questionnaires, interviews and observations. Only 6% of the study adopted an experimental research design (i.e., randomized control trial) and 14% were review of the literature on EBD (i.e. systematic reviews and scoping reviews).

The theoretical background was mentioned exclusively in 24% of the study evaluated, and of these, 21% referred to the stress reduction theory proposed by Ulrich and colleagues (1991) (14). Furthermore, the primary target of the investigations on EBD for healthcare architecture seems to be that of patients (60%) followed by that of staff (40%) and visitors (8%).

The physical environment of healthcare settings was found to be investigated primary with regard to its overall layout and configuration (67%), what Harris and colleagues (2002) would define in terms of, *architecture features* (e.g. single vs multiple rooms, centralized vs decentralized nursing stations) whereas, little information about *ambient features* (i.e. light and noise conditions) (22%) and *interior design elements* (i.e. furniture, greenery and other types of positive distractors) (17%) was found.

Across the study evaluated, users' experience of place and care (i.e., perceived quality of place, satisfaction, atmosphere perception) is the principle outcome investigated (60%) followed by safety, stress reduction and infection reduction (between 9-13 % of studies).

The greater majority of the evidence found accounted for the IOM goals of; health (84%) and safety (46%) whereas, a paucity of investigations was found with regard to the IOM goals that are related to a more active engagement of patients into the process of care such as, patients participation, equality and self-care support (4-3% of the investigations).

An overview of the above mentioned results is reported in table 2.

Table 2. Descriptive statistic of the ongoing systematic review (results are not mutually exclusive)

EBD Healthcare area	Theoretical framework	Research design and methodology	Target group	Physical environment intervention	Study outcomes	IOM outcomes
Acute care units (N = 20) (22%) Hospital in general (N = 19) (21%) Neonatal units (N = 11) (12%) Psychiatry dep. (N = 8) (9%) Others (i.e., stroke and geriatric units, waiting areas, cancer units) (N = 34) (37%)	Stress Reduction theory (N = 19) (21%) Other theories (N = 5) (5%) Missing (N = 70) (76%)	Non-experimental (N = 66) (72%) Systematic review (N = 13) (14%) Experimental (N = 5) (6%) Mix-method (N = 33) (36%)	Patients (N= 55) (60%) Staff (N= 37) (40%) Visitors (N= 7) (8%)	Architectural features (N = 62) (67%) Interior design (N = 20) (22%) Ambient features (N= 16) (17%)	Users perception (i.e., experience and satisfaction with place and care) (N = 55) (60%) Safety (N = 12) (13%) Stress reduction (N =10) (11%) Infections (N = 8) (9%) Infant related (N = 6) (6%) Activities (N = 5) (5%)	Health (N = 77) (84%) Safety (N =42) (46%) Person-centred (N = 27) (29%) Effectiveness (N =26) (28%) Shared decision (N = 8) (9%) Patients participation (N = 8) (9%) Timely (N =6) (6%) Self-care support (N = 4) (4%) Equality (N =3) (4%)

Discussion

On the whole the present work confirms the growing body of investigation of EBD for healthcare architecture. Based upon the material investigated up until now, it seems relative clear that certain IOM goals are more studied than others. For example, greater evidence appears to be available for what concern the topic of health and safety as resulting respectively from, users' perception of environmental quality and specific layout and interior design solutions (i.e., single rooms and placement of sanitizers). On the other hand, the IOM goals that account for a more active view of the person receiving care such as that of, participation and self-support seem to have been overlooked.

Also, a lack of theoretical anchor was found, and the little theoretical framework that is reported seems to relay exclusively on the Stress reduction theory proposed by Ulrich (18). Nevertheless, the great focus of the work evaluated addressed other outcomes than just stress, highlighting the need for future integration of other useful theoretical framework such as affordance (19), supportive design and perceived control (20). The integration of further theoretical knowledge can influence what environmental attributes are studied, and what relationships between these attributes and human responses are explored (21-23). Furthermore, theories can help to frame research questions, choose research methods, and help interpretation of results (24). It can also facilitate a better understanding and a more fruitful discussion on how to translate research findings into EBD for hospital's planners and to support their decision making (25).

This is of particular relevance with consideration of the fact that the large majority of the investigation found, lack an experimental design solution, which is known to be the best available research design in order to draw reliable conclusions about the physical environmental influence on health outcomes. However, the results from this work stress the need to be more open towards other types of research design investigations, which appear to be more common when accounting for the complex scenario of human-environment interaction and health outcomes occurring in healthcare settings.

The issue of quality and reliability of the results is then related to how well the methodology of investigation was developed and the data collected, analysed and interpreted. This is also suggested by the guidelines proposed by the SBU (2), which aims at evaluating the quality of each individual research design without implying that one is better than another. This approach and related guidelines were applied for this study and the evaluation of quality per each included paper is ongoing and performed by three of the researchers involved in this work.

The majority of the EBD outcomes seem to stress the importance of integrating users' experience of the environment into the evaluation of healthcare environment quality. Thus, rather than report medical and physiological responses such as, heart rate, blood pressure and infections, the focus appear to be more commonly to report the psychosocial experience of place (i.e., overall impression, beliefs, attitudes, perceived quality of care and social support). This emphasizes the importance of using methods to be able to better understand the influence of patients' subjective experience on health related outcomes. The patients are no longer passive receptors of medical treatment, for which also a sterile and institutionalized hospital environment might function well but should be rather recognizes as active participants in their own care systems, who are sensitive to both physical and social stimulus (26, 27).

From these preliminary descriptive results, we can see how the evidence are indeed dealing mainly with how improvements in the physical environment can promote users' perception of physical environment quality and overall safety. On the other hand, knowledge about how the design might promote the implementation of person-centred care is still missing. As a matter of fact, the preliminary findings of this work have highlighted how those IOM goals that foster a more active view and role of hospital's patients (i.e., shared decision and participations goals) are still overlooked upon by the literature on EBD.

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Appendix 1

Descriptive material of the papers included in this systematic literature review

Author	Year	Title	Journal	Setting	Physical environment	IOM	Outcome
Aburas	2017	The Influence of Nature Stimulus in Enhancing the Birth Experience	Health Environments Research and Design Journal	Birthing clinic	Expose to nature	Person centered, Safety, Timely, Effectiveness, Health	Patient's perspective on quality of care. Labor duration, vital signs, pain relief
Adams	2010	Kids in the atrium: Comparing architectural intentions and children's experiences in a pediatric hospital lobby	Social Science and Medicine	Pediatric hospital	A large atrium	Person centered	Children's views
Agrest	2018	Day hospital treatment for people with severe mental illness according to users' perspectives: what helps and what hinders recovery?	J Ment Health	Psychiatry day hospital		Health	Patient perspectives
Ajiboye	2015	Effects of revised consultation room design on patient-physician communication	HERD	Outpatient setting	Concultation room design	Person centered, Patient participation	Patient satisfaction
Alexiou	2016	The impact of facility relocation on patients' perceptions of ward atmosphere and quality of received forensic psychiatric care	J Forensic Leg Med	Forensic ward	New design of the built environment	Person centered, Shared decision making, Patient p., Safety	Patients' perceptions of ward atmosphere and quality of care
Alfonsi	2014	Evidence Based Design and healthcare: an unconventional approach to hospital design	Annali di igiene: medicina preventiva e di comunità	Hospital	Homelikeness and comfortable atmoshpere, as well as colours of the wall facility	Health	Case studies concerning: - reduction of infections - reduction of stress on medical staff - improved patient healing.
Alvaro	2016	Evaluating Intention and Effect: The Impact of Healthcare Facility Design on Patient and Staff Well-Being	HERD	Rehabilitation clinic	New design of the built environment	Shared decision making, Self-care support, Patient p., Health	Patients and staff perceptions of improvement in mental health, selfefficacy in mobility, satisfaction, and inter-professional interactions
Anaker	2018	The physical environment and patients' activities and care: A comparative case study at three newly built stroke units	Adv Nurs.	Stroke units	Physical environment	Health	Activity level and interactions
Anaker	2017	A comparative study of patients' activities and interactions in a stroke unit before and after reconstruction. The significance of the built environment	PLoS ONE	Stroke unit	Stroke unit from multiple to single room	Safety, Health	Recovery, activities and social interaction
Andersen	2010	Critical incidents related to cardiac arrests reported to the Danish Patient Safety Database	Resuscitation	Hospital	Room design and locks on doors	Shared decision making, Safety, Effectiveness, Health	Number of critical incidents reported relating to the physical environment
Andrade	2017	Do the hospital rooms make a difference for patients' stress? A multilevel analysis of the role of perceived control, positive distraction, and social support	Journal of Environmental Psychology	Orthopedic	"Favorable design features"	Person centered, Health	Patients stress and perceptions
Annemans	2016	Being Wheeled or Walking: A Qualitative Study of Patients' Spatial Experience in Two Distinct Day Surgery Centers	HERD	Day surgery centers	Physical environment	Person centered	Patients' spatial experience
Apple	2014	A comparative evaluation of Swedish intensive care patient rooms	Health Environments Research and Design Journal	ICU	Daylight and single room, all positive aspects for patients and family. However, not the same experience for the staff	Safety, Timely, Effectiveness, Health	Multifaceted. Impact on patients, families, and staff, (observed and experienced).

Author	Year	Title	Journal	Setting	Physical environment	IOM	Outcome
Applebaum	2010	The Impact of Environmental Factors on Nursing Stress, Job Satisfaction, and Turnover Intention	Journal of Nursing Administration	Medical surgical units	Odor, noise, light and color	Health	Personells perceived stress
Baillie	2012	Caring for older people with dementia in hospital Part one: Challenges	Nursing Older People	Hospital NHS (eldelry care)	Floor safety, homelikeness and more environmental friendly settings for dementia users	Safety, Health	Adult nursing students' experiences of caring for older people with dementia in hospital
Bakker	2011	Effects of hospital-wide interventions to improve care for frail older inpatients: a systematic review	BMJ Qual Saf	Hospital	Hospital-wide interventions	Safety, effective-ness, health	For elderly: patientrelated outcomes, quality of care, patient safety, resource use or costs
Banerji	2016	An attempt to explore components of empathic architecture in hospitals – a study of Indian hospitals	Journal of Architecture and Urbanism	Hospital	Overall physical environment configuration	Person centered, Patient participation, Safety, Health	Psychological comfort, stress
Bayramzadeh	2018	Understanding Design Vulnerabilities in the Physical Environment Relating to Patient Fall Patterns in a Psychiatric Hospital: Seven Years of Sentinel Events	J Am Psychiatr Nurses Assoc	Psychiatric hospital	Physical environment	Safety	Falls
Bayramzadeh	2014	Centralized vs. Decentralized nursing stations: An evaluation of the implications of Communication techno-logies in healthcare	Health Environment s Research and Design Journal	Nursing station	Centralized and one decentralize nursing stations (picture on page 67) 4 units in total	Timely, Effectiveness	Differences in the use of communication technologies
Bazley	2016	Interior effects on comfort in healthcare waiting areas	Work	Waiting areas (office of hospital settings)	Feng shui elements	Health	Patients' selfreported comfort levels.
Bazuin	2015	If I were a band-aid, where would I be? Researching the use and location of supplies on two patient units	Health Environment s Research and Design Journal	NICU	Supplies location	Timely, effectiveness	Mapping of supply system location requirements
Beckstrand	2012	Emergency Nurses' Perception of Department Design as an Obstacle to Providing Endof-Life Care	Journal of Emergency Nursing	Emergency	None		Emergency nurses perception on the impact of ED design on EOL care.
Bevan	2016	Dignified care for older people: Mixed methods evaluation of the impact of the hospital environment - single rooms or multi-bedded wards	Healthy Aging Research	Hospital wards NHS (for elderly people)	Single room vs multiple rooms types of wards	Safety, Health	Patients' perspectives on dignified care and level of satisfaction
Blazejewski	2015	Efficiency of hydrogen peroxide in improving disinfection of ICU rooms	Crit Care	ICU	Disinfection techniques	Safety, Health	Environmental bacterial load
Blennerhassett	2018	Behavioral Mapping of Patient Activity to Explore the Built Environment During Rehabilitation	HERD	Rehabilitation center - rehabilitation unit	Physical environment	Person centered, health	Physical activity, location, and social interaction
Bonuel	2013	Review of the literature: Acuityadaptable patient room	Critical care nursing quarterly	Patient room	acuity adaptable room	Safety, Effectiveness, Health	Literature review (discusses length of stay, infection control, patientsafety, nurse activities, noise levels, and patient and staff satisfaction)
Boog	2013	Assessing the optimal location for alcoholbased hand rub dispensers in a patient room in an intensive care unit	BMC Infect Dis	ICU Single patients room	Different arrangements of alcholbased hand rub dispensers in single room (N =4)	Safety, Health	Usage of alcoholbased hand rub dispensers

Author	Year	Title	Journal	Setting	Physical environment	IOM	Outcome
Borckardt	2011	Systematic investigation of initiatives to reduce seclusion and restraint in a state psychiatric hospital	Psychiatr Serv	Psychiatric inpatient	Multiple	Self-care support, Patient p., Equality, Effectiveness, Health	Rate of seclusion and restraint
Borhani	2016	Facilitators and threats to the patient dignity in hospitalized patients with heart diseases: A qualitative study	International J of Community Based Nursing and Midwifery	ICU for coronary diseases	Clean environment, Comfort equipment, Green hospital and Silence in the intensive care unit	Person centered, Health	Patient dignity
Bosch	2012	Staff perceptions before and after adding singlefamily rooms in the NICU	Health Environment s Research and Design Journal	NICU	Added singlefamily NICU rooms / unit renovation.	Person centered, Safety, Health	Staff perceptions: Lower levels of stress.
Brereton	2012	The hospital environment for end of life care of older adults and their families: An integrative review	Journal of Advanced Nursing	Hospital in general	Layout configuration and noise	Safety, Health	Literature review. Various outcomes studied. Patients and families: Satisfaction and experiences.
Broadbent	2014	Implications of the emergency department triage environment on triage practice for clients with a mental illness at triage in an Australian context	Australasian Emergency Nursing Journal	ED	Triage environment (physical and othervise)	Effectiveness	Quality of triage assessment
Browall	2013	Patients' experience of important factors in the healthcare environment in oncology care	International J of Qualitative Studies on Health and Well-being	Oncology	Design for privacy	Health	Patients' perceptions of the environment
Brown	2013	Access to mainstream health services: A case study of the difficulties faced by a child with learning disabilities	British Journal of Learning Disabilities	Healthcare general	Physical environment	Person centered, Equality, Effectiveness, Health	Case study. No outcome is measured.
Bukh	2015	Impact of healthcare design on patients' perception of a rheumatology outpatient infusion room: an interven-tional pilot study	Clin Rheumatol	Outpatient rooms	Room modification in terms of; colours, artificial plants and a water bubble wall were added to the room	Health	Patients' perceptions
Burton	2010	Gaining efficiency and satisfaction in the handoff process	Journal of Hospital Medicine	Hospital	Smaller room, noise reduction, closed door, as well as non PE interventions.	Timely, effectiveness	Staff perceptions on handoff efficiency
Chahal	2012	Service Quality and Performance in the Public Health-Care Sector	Health Marketing Quarterly	Hospital (i.e., medicine, surgery, pediatrics, ortho-pedics, gynecology)		Timely, Effective-ness, Health	Waiting time, patient satisfaction, patient loyalty.
Chang	2017	The Influences of Landscape Features on Visitation of Hospital Green Spaces-A Choice Experiment Approach	International J of Environmental Research and Public Health	Hospital	Landscape features (on photographs)	Person centered, Health	Preferred landscape features

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Chekol	2016	Dimensions of patient satisfaction with comprehensive abortion care in Addis Ababa, Ethiopia	Reproductive Health	Abortion care	The physical environment consisted of five items describing physical environment as general pleasantness, comfort, attractiveness, and conform-ableness with the procedure and waiting room, including cleanness of facilities and equipment.	Person centered, Health	Patient satisfaction
Choi	2011	Developing a multi-systemic fall prevention model, incorporating the physical environment, the care process and technology: A systematic review	Journal of Advanced Nursing	Hospital	Design of room and floor	Safety, Health	Systematic review. Falls.
Chrysikou	2013	Accessibility for mental healthcare	Facilities	Mental healthcare facilities	Universal design aids	Person centered, Equality, health	Mapping of hindrances of movement
Cloutier	2016	Experimental identification of potential falls in older adult hospital patients	Journal of Biomechanics	Hospital (i.e., clinical room and bathroom)	Mock-up of hospital room	Safety, Health	Potential falls motion capture.
Combariza	2018	Costeffectiveness analysis of interventions for prevention of invasive aspergillosis among leukemia patients during hospital construction activities	Eur J Haematol	Hospital (i.e., trauma center)	Isolation room	Safety, Health	Number of incidences of Invasive Aspergillosis.
Cone	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	NICU	Single-family rooms	Person centered, Safety, Effective-ness, Health	Staff perception
Copeland	2017	Effects of Unit Design on Acute Care Nurses' Walking Distances, Energy Expenditure, and Job Satisfaction: A Pre-Post Relocation Study	HERD	Nursing stations (centralized vs decentralized)	Nursing stations	Safety, Health	Acute care nurses' walking distances, energy expenditure, and job satisfaction
Corsano	2015	The waiting room as a relational space: Young patients and their families' experience in a day hospital	Child: Care,Health and Development	Day hospital, paediatric wards, waiting room	Waiting room	Health	Patient and family experience
Cummings	2010	Caring with comfort rooms. Reducing seclusion and restraint use in psychiatric facilities	J Psychosoc Nurs Ment Health Serv	Acute adult inpatient unit	Comfort room	Safety, Effective-ness, Health	Patients' perceived reduction of stress
Cure	2015	Effect of hand sanitizer location on hand hygiene compliance	Am J Infect Control	Hospital	Localization of sanitizer (12 rooms were evaluated with similar design but different location of sanitizer)	Safety, Health	Hand hygiene compliance
Curtis	2017	The impact of single and shared rooms on family-centred care in children's hospitals	Journal of Clinical Nursing	Children's hospitals	Single or shared rooms	Person centered, Shared d. m., Self-cares., Effectiveness	Patients', family members' and staffs' experience.
Davis	2011	Rooftop hospital gardens for physical therapy: A postoccupancy evaluation	Health Environment s Research and Design Journal	Hospital (i.e., roof top)	Roof top with greenery	Health	Patient and personnel reported perspectives, accessibility and satisfaction
de Korne	2012	Safety by design: effects of operating room floor marking on the position of surgical devices to promote clean air flow compliance and minimise infection risks	BMJ Qual Saf	Operating room	Floor markings for surgical devices	Safety	Proper placement of equipment
Dendaas	2011	Environmental congruence and work-related stress in acute care hospital medical/surgical units: a descriptive, correlational study	HERD	Acute care hospital	Configuration and environmental crowding	Health	Reported levels of work related stress and nurses attitudes towards environ-mental congruence.

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Deshpande	2017	Are hospital floors an underappreciated reservoir for transmission of health careassociated pathogens?	Am J Infect Control	Hospital		Safety, Health	Floor contamination
Devlin	2016	Qualities of Inpatient Hospital Rooms: Patients' Perspectives	HERD	Hospital rooms	Design features of hospital rooms	Person centered, Health	Patient experience
Digby	2014	People with dementia and the hospital environment: The view of patients and family carers	International Journal of Older People Nursing	Geriatric hospital		Health	Patients' and family carer's perspectives on environment/-design features.
Ding	2017	Factors influencing patients' sleep in the intensive care unit: Perceptions of patients and clinical staff	American Journal of Critical Care	ICU	Environmental and non-environmental factors in the medical intensive care unit that affect patients' sleep.	Health	Perceptions of patients and clinical staff
Dobrohotoff	2011	Psychogeriatric inpatient unit design: A literature review	International Psycho-geriatrics	Psychogeriatric inpatient unit	Unit design	Person centered, Patient p., Safety, Effectiveness, Health	Literature review
Doig	2010	The hazards of using floor mats as a fall protection device at the bedside		Hospital (i.e., bed)	Check the impact of floor mat besides bed	Safety, Health	Falls, near falls and balance (video recorded)
Domanico	2011	Documenting the NICU design dilemma: Comparative patient progress in open-ward and single family room units	J Patient Saf	NICU	Single rooms of NICU	Health	Infants rate of apneic events, nosocomial sepsis and mortality. Time untill transition to enteral nutrition. Number of mothers sustaining stage III lactation, and number of infants discharged breastfeeding.
Donald	2015	Consumer perspectives on the therapeutic value of a psychiatric environment	Journal of Mental Health	Psychiatric	Psychiatric environment	Person c., Shared d. m., Self-cares., Patient p. Safety, E., H.	Patients' experience
Drahota	2012	Sensory environment on health-related outcomes of hospital patients	Cochrane Database of Systematic Reviews	Hospital	Interventions explored were: 'positive distracters', to include aromas (two studies), audiovisual distractions (five studies), decoration (one study), and music (85 studies); interventions to reduce environmental stressors through physical changes, to include air quality (three studies), bedroom type (one study), flooring (two studies), furniture and furnishings (one study), lighting (one study), and temperature (one study); and multifaceted interventions (two studies).	Health	Systematic review. Mostly patient reported outcomes (example: anxiety)
DuBose	2018	Exploring the Concept of Healing Spaces	Health Environments Research and Design Journal	Healing spaces	Built environment	Health	Literature review
Eggert	2014	Personenvironment interaction in a new secure forensic state psychiatric hospital	Behavioral Sciences and the Law	Forensic psychiatric hospital	comparison of two building design	Safety, Health	Ward climate, safety, job satisfaction, and treatment outcomes

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Ellison	2014	Hospital ward design and prevention of hospital-acquired infections: A prospective clinical trial	Canadian J of Infectious Diseases and Medical Microbiology	Hospital (i.e., Medical ward)	comparison between four-bedrooms with shared bathrooms and a newly renovated 'new design' ward (predominantly single rooms with private bathrooms).	Safety, Health	Event rates of hospital-acquired infection and colonization
Fay	2018	Emergency Nurses' Perceptions of Efficiency and Design: Examining ED Structure, Process, and Outcomes	J Emerg Nurs	Emergency department	Units configuration, lighting, layout of patients room, technology, visibility and storage	Effectiveness, Health	Emergency nurses' perceptions of efficiency and satisfaction
Fenko	2014	The influence of ambient scent and music on patients' anxiety in a waiting room of a plastic surgeon	Health Environment s Research and Design Journal	Plastic surgery (waiting room)	Music and scent	Health	Patients' measured anxiety
Ferri	2015	Evidence-based design in an intensive care unit: End-user perceptions	BMC Anesthesiology	ICU	New constructed ICU with EBD approach	Health	Healthcare providers, support staff, and patient family members impressions and experiences.
Flacking	2014	Creating a positive place and space in NICUs	The practising midwife	NICU		Health	Perceived quality of NICU and breastfeeding
Flaherty	2011	Matching the environment to patients with delirium: Lessons learned from the delirium room, a restraint-free environment for older hospitalized adults with delirium	Journal of the American Geriatrics Society	Acute care for elders unit	Delirium room	Safety, Effectiveness, Health	Lenght of stay, number of deaths and more.
Gaboury	2017	Effect of the Postpartum Hospital Environment on the Attainment of Mothers' and Fathers' Goals	Obstet Gynecol Neonatal Nurs	Neonatal/ Postpartum	Privacy and space for the father	Person centered, Health	Perception of quality especially in regard to privacy and space for the other partner
Gharaveis	2018	The Impact of Environmental Design on Teamwork and Communication in Healthcare Facilities: A Systematic Literature Review	Health Environments Research and Design Journal	Healthcare facilities	Environmental design	Effectiveness	Literature review
Shannon	2018	Can the physical environment itself influence neurological patient activity?	Disabil Rehabil	Neurologic al stroke rehabilitation	Comparison between an old environment and a new built	Patient cetered	Mapping of patient physical and social activity, and location of that activity.
Shen	2011	Hospital environment, nurse-physician relationships and quality of care: Questionnaire survey	Journal of Advanced Nursing	Inpatient care	non	Effectiveness	Self-reported relationship between nurse /phys
Siddiqui	2015	Changes in patient satisfaction related to hospital renovation: Experience with a new clinical building	Journal of Hospital Medicine	General both medical and surgery	Total new building - 100% single room and higher-amenity	Patient centered	Visitor-related satisfaction.
Singh	2015	Outcome of inpatient falls in hospitals with 100% single rooms and multibedded wards	Age and Ageing	General medicine ward	SB/MB	Safety, Health	Falls
Smith	2016	Occupancy and patient care quality benefits of private room relative to multibed patient room designs for five different children's hospital intensive and intermediate care units	Work	Childrens hospital	Design fr MBR to PR		-
Soremekun	2014	The effect of an emergency department dedicated midtrack area on patient flow	Acad Emerg Med	ED	Dedicated area in ED		Time from triage to treatment
Stevens	2010	Neonatal intensive care nursery staff perceive enhanced workplace quality with the single-family room design	Journal of Perinatology	NICU	Design of the ward SR or open bay	Safety	Self-reported from personel the quality of safety and security
Stiffler	2015	Hallway Patients Reduce Overall Emergency Department Satisfaction	J Emerg Med	ED	HW vs TR		Patient satisfaction

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Walsh	2010	Satisfaction with the emergency department environment decreases with length of stay	Emergency Medicine Journal	ED			Number of incidents of pneumonia and deaths caused by pneumonia.
Wang	2018	Private Rooms, Semi-Open Areas, or Open Areas for Chemotherapy Care: Perspectives of Cancer Patients, Families, and Nursing Staff	HERD	Cancer center			Patient satisfaction
Watkins	2011	Same-handed and mirrored unit configurations: Is there a difference in patient and nurse outcomes?	Journal of Nursing Administration	Surgery medical wards	Different layout design	Safety, Health	Needs and preferences of cancer outpatients, their families, and nursing staff
Watson	2015	Impact of noise on nurses in pediatric intensive care units	American Journal of Critical Care	ICU pediatric	A comparison between 3 different ICU	Health	Patients and nurses experiences
Weiland	2017	Managing Acute Behavioural Disturbances in the Emergency Department Using the Environment, Policies and Practices: A Systematic Review	The western journal of Emergency medicine	ED	Non	Safety, Effective-ness, Health	Nurses heart rate and stress ratings
Williams	2011	Optimizing seating in the intensive care unit for patients with impaired mobility	American Journal of Critical Care	ICU	Test seating surfaces- 3 conditions	Safety	Incidence, duration, or severity of ABDs, incidence of injuries, staff absenteeism, frequency or duration of restraint use, and staff or client perceptions
Wingler	2015	Demonstrating the effect of the built environment on staff healthrelated quality of life in ambulatory care environments	Health Environments Research and Design Journal	Health center	Describe staff HRQL and their view of the environment air quality, (2) thermal comfort, (3) spatial layout, (4) lighting, (5) acoustics, (6) office furnishings, and (7) cleanliness.	Health	Number of cells recording exessive preassure for different chair surfaces.
Vokurka	2014	The availability of HEPA-filtered rooms and the incidence of pneumonia in patients after haematopoietic stem cell transplantation (HSCT): results from a prospective, multicentre, eastern European study	Journal of clinical nursing	Hematology and transpl center	HEPA filter	Safety, Health	Staff satisfaction and perceived productivity
Währborg	2014	Nature-assisted rehabilitation for reactions to severe stress and/or depression in a rehabilitation garden: Longterm follow-up including comparisons with a matched populationbased reference cohort	Journal of Rehabilitation Medicine	Rehab garden for sick leave persons due to stress symptom	Nature ass. terapi	Health	Sick-leave status and healthcare consumption
Yelden	2015	A rehabilitation unit at night: Environmental characteristics of patient rooms	Disability and Rehabilitation	Neurological rehabilitation	Non	Health	Noise level, light, temperature and humidity.
Zaal	2013	Intensive care unit environment may affect the course of delirium	Intensive Care Med	ICU	Exposure to light levels and light quality but also multiple vs single room	Safety, health	Delirium incidences
Zhou	2016	Three modes of power operation: Understanding doctor-patient conflicts in China's hospital therapeutic landscapes	Health and Place	Primary care	Non	Person centered, Shared decision making, Patient participation	The physician patient relationship
Zisberg	2016	Factors related to the mobility of hospitalized older adults: A prospective cohort study	Geriatric Nursing	Acute care		Safety, Health	Mobility levels