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Healing environment: A review of the impact of physical environmental factors on users

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ABSTRACT

In recent years, the effects of the physical environment on the healing process and well-being have proved to be increasingly relevant for patients and their families (PF) as well as for healthcare staff. The discussions focus on traditional and institutionally designed healthcare facilities (HCF) relative to the actual well-being of patients as an indicator of their health and recovery. This review investigates and structures the scientific research on an evidence-based healthcare design for PF and staff outcomes. Evidence-based design has become the theoretical concept for what are called healing environments. The results show the effects on PF and staff from the perspective of various aspects and dimensions of the physical environmental factors of HFC. A total of 798 papers were identified that fitted the inclusion criteria for this study. Of these, 65 articles were selected for review: fewer than 50% of these papers were classified with a high level of evidence, and 86% were included in the group of PF outcomes. This study demonstrates that evidence of staff outcomes is scarce and insufficiently substantiated. With the development of a more customer-oriented management approach to HCF, the implications of this review are relevant to the design and construction of HCF. Some design features to consider in future design and construction of HCF are single-patient rooms, identical rooms, and lighting. For future research, the main challenge will be to explore and specify staff needs and to integrate those needs into the built environment of HCF.

1. Introduction

Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity [1]. Healthcare facilities (HCF) are places where patients with health conditions go for treatment, which is provided by specialists and other care professionals. In recent years, we see a growing interest in the role of technology and the built environment as part of the holistic treatment of patients. Discussions about the importance of the built environment for the patient's health and well-being and the provision and support of healthcare extend at least as far back as 400 BC [2] with Hippocrates and the 19th century with Florence Nightingale [3]. Burge described the relationship between symptoms of the "Sick Building Syndrome" (SBS) and the indoor environment of buildings [4]. The term SBS comprises a group of symptoms of unclear aetiology consisting of dry skin and symptoms related to mucous membranes, as in the eyes, nose, and throat, together with what are often called general symptoms of headache and lethargy [4]. In an office setting, the symptoms of SBS can reduce productivity and increase absenteeism from work. Similar problems occur in other buildings, for instance, in HCF. These effects of the physical environment on the patient's healing process, recovery, and well-being have consequences for the design and construction of HCF. In the 1990s, design solutions in healthcare, based on published research, were defined as "evidence-based design" (EBD). Evidence-based design has become the theoretical concept for what are called healing environments. Healing environments can be considered as "smart investments" because they save money, increase staff efficiency, and reduce the hospital stay of the patient by making the stay less stressful [5]. Based on the definitions of several academic researchers [6–9], a healing environment can be defined as a place where the interaction between patient and staff produces positive health outcomes within the physical environment.

The movement towards EBD in healthcare started with Ulrich [10], who compared the positive effect of views of natural scenery

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on the recovery of patients from surgery to patients in similar conditions who were exposed to a view of a brick wall. Ulrich showed that in comparison with the wall-view group, the patients with the tree view had shorter postoperative hospital stays, had fewer negative evaluative comments from nurses, took fewer moderately strong and strong medication, and had slightly lower scores for minor postsurgical complications. Since then, the impact of the physical environment of the hospital on the well-being and health of the patient has received extensive academic attention. Consequently, this resulted in a creation of spaces considered to be healing environments. An increasing body of knowledge on evidence-based healthcare design has become available, and the amount of information has grown rapidly in recent years.

This study surveys and structures the scientific research on evidence-based healthcare design from the perspective of the needs of end-users. The group of end-users is defined as patient, family (PF) and staff in this review. The perspectives of the designer or project developer are omitted from consideration in this review. Furthermore, this review distinguishes between empirical data and evidence-based data concerning the patient and staff health outcomes in hospital settings.

2. The review procedure

2.1. Aim

The aim of the review is to provide an overview of the evidence in the literature on healing environments. The hypothesis is that healing environments, through EBD, make hospitals less stressful and promote faster healing for patients and improve well-being for their families, as well as creating a pleasant, comfortable and safe work environment for staff [7,8]. Therefore, the following questions are explored in this review:

(1) Which findings of research related to PF outcomes and staff outcomes of healthcare design are evidence based or scientifically proven or are not (sufficiently) proven?
(2) Which findings of research related to PF outcomes and staff outcomes of healthcare design are under discussion?

2.2. Search methods for identification studies

The Cochrane Methodology [11] was used to search the data. Potentially relevant literature was identified through computerised searches. Pubmed [Medline], Jstor, and Scopus were the databases used to find relevant articles (Fig. 1). The search was performed using the keywords *evidence-based design, hospital design, healthcare design, healthcare quality, outcomes, patient safety, staff safety, infection, hand washing, medical errors, falls, pain, sleep, stress, depression, confidentiality, social support, satisfaction, single rooms, noise, nature* and *daylight*. The search criteria were based on characteristics of the several groups in this study. A total of 54 keywords were used and categorised into four groups: PF, staff, (physical) environmental factors, and relevant authors (such as *Ulrich, Zimrich & Bosch, Devlin & Arneill*).

For a further and more specific search, a combination of keywords was used in the Pubmed and Scopus research databases. The following combinations of keywords were selected: *healing environments AND patient outcomes; healing environments AND sleep; "hospital design and construction" [Mesh] AND safety; "hospital design and construction" [Mesh] AND stress; "healing environments" AND stress; "healing environments" AND patient safety; "evidence-based design" AND stress; "evidence-based design" AND outcomes; and "evidence-based design" AND physical environment and hospital design.*

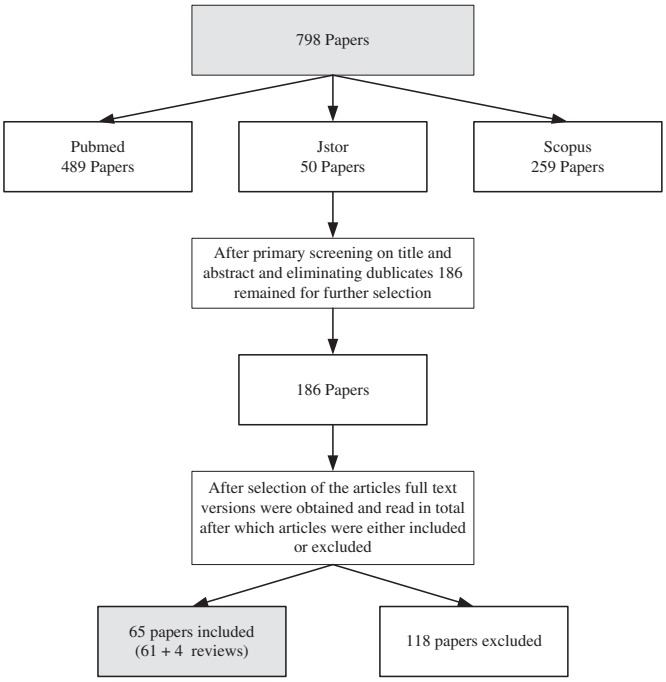

Fig. 1. Flowchart of the screening process of the literature.

The screening process, shown in Fig. 1, indicates the different selection stages. After eliminating duplicate articles, the remaining articles were examined for further selection. At the final stage, articles were selected that referred to the physical environment of HCF in their titles and abstracts. The references from the identified articles were verified to determine whether they would result in additional literature. Studies were rejected or accepted for further analysis based on the titles and abstracts and the incorporation of the characteristics in one of the four groups of PF, staff, environmental factors or relevant authors.

2.3. Theoretical approaches for healing environments

To order and structure the evidence regarding healing environments, the frameworks of integrated building design by Rutten [12] and Ulrich et al. [7,8] were used and adapted (Fig. 2). This new

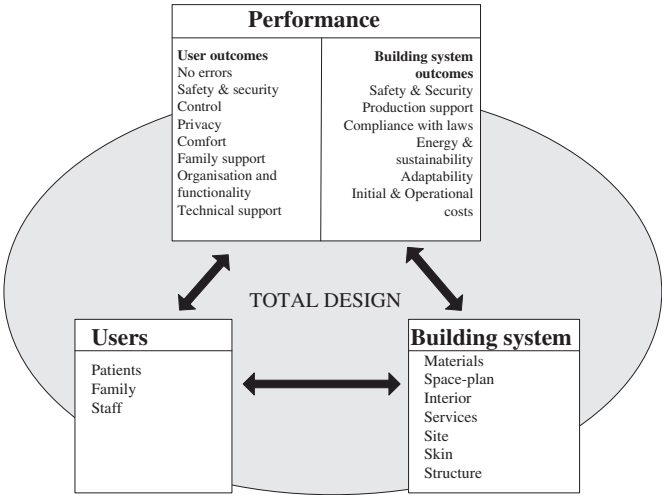

Fig. 2. The framework of integrated building design, based on the work of Rutten [1996] and Ulrich et al. [2004, 2008].

framework can contribute to the understanding of all of the various aspects and dimensions that need to be taken into consideration throughout the process of designing and constructing new HCF. The framework describes a triangular relationship among the building system, the performance, and the users; each single element affects the other two. Within the framework, users are defined as PF, or staff. Within the framework, a building delivers performances that are among the user needs and are installed and fitted to meet those user needs; in turn, the building systems are translated to user outcomes (Fig. 2). Each building system has a specific set of functions (which can be seen as solutions) that contribute to the optimisation of a particular user need. The success of the final design is the result of how well the needs of the stakeholders are met by the building systems.

2.4. Inclusion and exclusion criteria

The screening process (Fig. 1) is based on the following inclusion and exclusion criteria.

- Articles were limited to those published in English between 1984 and 2011. The start date was chosen based on Ulrich's 1984 publication addressing the effect of views of nature on patients.
- A cross-reference method was used for relevant literature outside the computerised searches. This also yielded papers older than the 1984 search limit. Consequently, relevant literature from 1960, 1970, 1976 and 1980 was included in this review.
- Articles were selected based on their references to the physical environment of HCF in the title and abstract.
- Articles were excluded that concerned aspects of medical treatment or wound healing.
- The title and abstract of the articles were rejected or accepted for further analysis based on the characteristics of the four groups.
- After selection of the articles, full-text versions were obtained and read in their entirety. The articles were either included or excluded based on the criteria that should be examined regarding the influence of environmental factors on PF and staff.

2.5. Analysis

The studies included in this review were further divided into two groups, PF outcomes and staff outcomes, by applying the so-called pyramid of evidence [13]. Systematic reviews are at the top of the hierarchy, providing the richest source of the best evidence. Evidence obtained from randomised controlled trials (RCTs) (level four) is next, followed by evidence obtained from controlled trials without randomisation and from cohort studies and case-controlled studies (level three). Descriptive studies, evaluation studies, best practices, and qualitative studies are positioned at the base of the pyramid (level two). Agreement between the first and second authors and a third independent researcher was assessed using Cohen's Kappa [14].

The topics and subtopics chosen for this systematic review are based on topics as arranged in the literature reviews of Ulrich et al. [7,8] (Fig. 3).

Some relevant design features are addressed only at level two of the levels of evidence. In this review, only studies with level two or higher evidence are included for the analyses of the design features. Studies with a low evidence level are qualified with level one and are not included for further analyses of the design features.

3. Results

The initial search strategy generated 798 papers. The first and second authors of this study evaluated the titles and abstracts, and a total of 798 papers were found to fit the inclusion criteria. Of these, 186 articles were included for further selection. After the final selection, 65 articles are included in the review and rated for four levels of evidence. The degree of reliability between the first and second authors and a third independent researcher had a value of 0.72. The value of 0.72 was considered a good level of agreement (beyond chance) for the level of evidence [14]. Addressing the research questions of this review there were only 28 articles (fewer than 50%) classified as having a high level of evidence (Table 1). Most of these 28 fitted into the category of comfort, in particular, view and acoustic comfort. A distinction was made between PF outcomes and staff outcomes. Because these two user groups have different experiences with their built environments, they can have different beliefs regarding their surrounding environments and associate different meanings with them [15]. For instance, the patient visiting the hospital and the staff working at the hospital may not share the same experiences of their environment.

As a result of this review, 86% of the articles were included in the group of PF outcomes, and the other 14% of the identified articles fitted into the group of staff outcomes. Articles with a level two formed the majority of the studies in the staff category. Table 1 shows an overview of the included studies and their levels of evidence [13].

This section provides an overview of the current theoretical information related to healing environments concerning PF and staff outcomes.

3.1. Outcomes for patients and their families

In this section, the outcomes of healthcare design on PF were divided into the following main topics: no errors, safety and security, control, privacy, comfort and family support (Fig. 3). All of these topics and their subtopics are addressed in this section.

3.1.1. Reduction of errors

One of the main concerns of patients is avoiding being subjected to human errors by staff and medical professionals working in a hospital. Two subtopics related to the physical environment in the category "no errors" can be distinguished, namely, identical rooms and lighting.

3.1.1.1. Identical rooms. The standardisation of patient rooms and equipment makes routine tasks simpler and decreases errors by staff. When the facility has identical rooms, the nursing staff encounter exactly the same distribution, layout and lighting in every room [16,17]. In addition, natural and electrical light is also an important aspect to consider for avoiding errors [18].

3.1.1.2. Lighting. Several studies described the influence of lighting on errors. Booker & Roseman [19] investigated the seasonal pattern of hospital medication errors in Alaska because 58% of all medication errors occurred during the first quarter of the year. Medication errors were 1.95 times more likely to occur in December than in September. In a similar article, although with the focus on electrical lighting, three different illumination levels were evaluated (480 lx, 1100 lx, 1570 lx). Buchanan et al. [18] associated poor illumination with errors in dispensing medications. An illuminance of 1570 lx (the highest level) was associated with a significantly lower error rate (2.6%) than the 480 lx baseline level of 3.8%. There was a linear relationship between each pharmacist's error rate and that pharmacist's corresponding daily prescription workload for all three

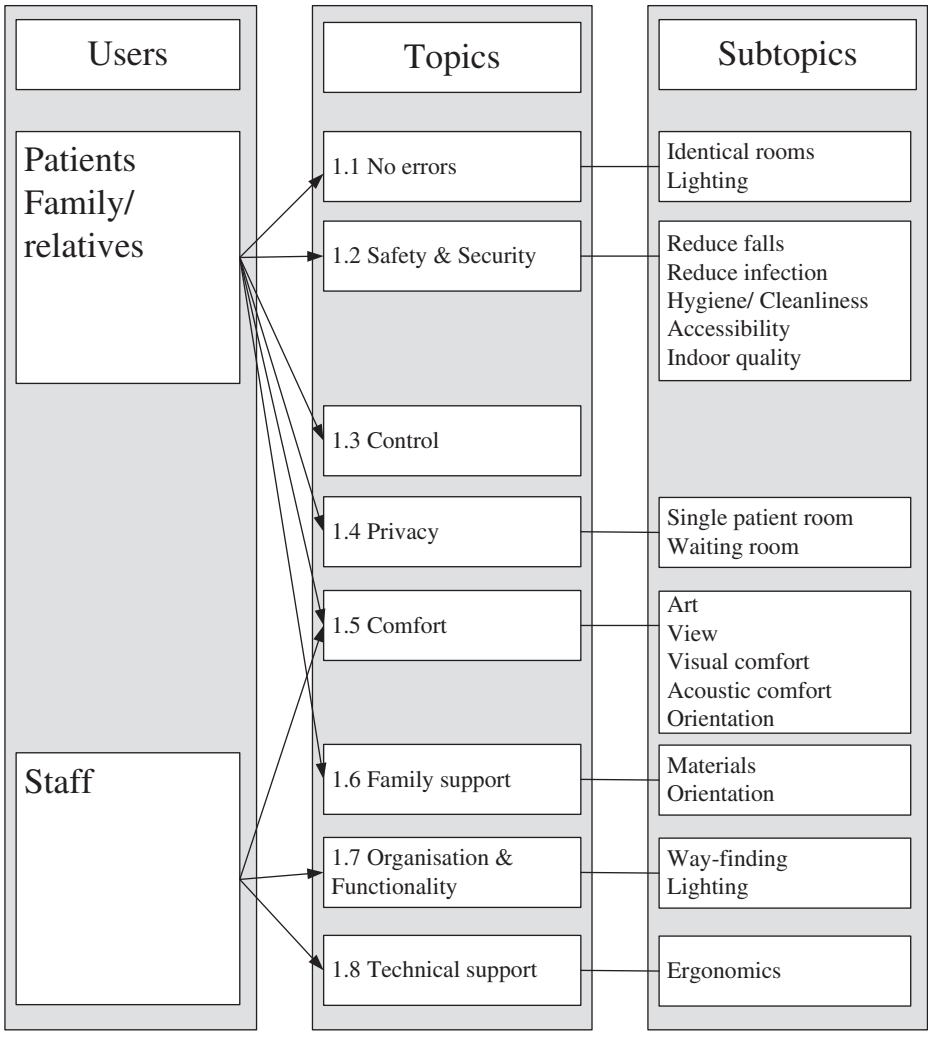

Fig. 3. User perspectives classified in topics and subtopics based on literature reviews by Ulrich et al. [2004, 2008].

Table 1
Characteristics of the studies included and their level of evidence in the review for patients, family, and staff categorised by topics and subtopics.

	Topics	Subtopics	References and level of evidence	Total number of references	Lowest level of evidence	Highest level of evidence
Patient, Family (PF)	No Errors		[16]-2, [17]-2, [18]-3, [19]-3	4	2	3
	Safety and Security	Falls	[20]-2, [21]-2, [22]-2, [23]-2	4	2	2
		Infection	[24]-2, [25]-2, [26]-4, [27]-2, [28]-2, [29]-1, [30]-3, [31]-2	8	1	4
		Indoor Quality	[32]-2, [33]-3, [34]-3	3	2	3
	Enhancing control		[17]-2, [36]-1	2	1	2
	Privacy		[37]-3, [38]-2, [39]-2	3	2	3
	Comfort	Comfort	[7]-4 (review), [86]-1	2	1	4
		Materials	[27]-2, [40]-2	2	2	2
		Art	[8]-4 (review), [90]-4 (review)	2	4	4
		View	[10]-4, [42]-2, [44]-4, [45]-3; [46]-4, [47]-4, [48]-3, [49]-2	8	2	4
		Visual comfort	[50]-3, [51]-3	2	3	3
		Acoustic	[55]-1, [56]-1, [57]-3, [58]-4 (review), [59]-2,			
		Comfort	[60]-1, [61]-2, [62]-2, [63]-3, [64]-2, [65]-3	11	1	4
		Orientation	[52]-3, [53]-3, [63]-3, [67]-4, [68]-1, [74]-2	6	2	4
	Family support		[75]-2, [76]-2, [77]-2, [88]-2	4	2	2
Staff	Organisation and functionality		[74]-2, [79]-2, [7]-4	3	2	4
	Technical support		[80]-4, [81]-2, [82]-2, [83]-3, [84]-3	5	2	4
	Comfort		[85]-2	1	2	2

Level of evidence [9] 1 = poor (expert opinion); 2 = fair (case series, case reports); 3 = good (cohort studies, case control studies); 4 = excellent (randomised controlled trials, systematic reviews).

illuminance levels. Consequently, the rate of prescription-dispensing errors was associated with the level of illumination.

Summary of design features to address with a level of evidence of two or higher: identical rooms; lighting.

3.1.2. Increasing safety and security

This topic refers to all of the measures, interventions and elements that the hospital applies or has access to in order to increase the safety and security of their patients. The subtopics address reduced falls, reduced infections, improved hygiene and cleanliness, accessibility, and indoor quality.

3.1.2.1. Reduced falls. The subtopic of reduced falls describes the environmental influences in the hospital room that are related to patient falls. However, falls are often a result of an interaction between individual factors and environmental factors. For instance, Morgan et al. [20] confirmed that there is a higher risk for patients admitted with a diagnosis of a mental disorder but there is no higher risk for those admitted with musculoskeletal problems or diseases of the central nervous system and sense organs. Falls were associated with activities requiring a change of posture (for instance, getting out of bed after having been in a recumbent position). Wong et al. [21] and Morgan et al. [20] explained that most falls occurred in the patients' room, mostly near the bed. Of the falls investigated, 29% occurred in the private bathroom attached to each patient room, and two-thirds of those occurred near the toilet. Of the 167 falls in the patient rooms, 57 occurred on the way to or from the bathroom. At least half of the total falls were bathroom-related, whereas in a similar study by Alcee [22], only 30% were related to the bathroom.

Falls may be prevented with design features that consider the frailty of patients inside and outside their bathrooms. Once these basic features are corrected, patient falls can be decreased by up to 17.3% [23].

3.1.2.2. Reduced infection rates. The subtopic of reduced infection rates explains how the design of the patient room can contribute to reduced contact spread. Infections and cleanliness are related to hygiene, which are, in turn, associated with the materials used in a hospital. It should be mentioned that many environmental surfaces and features become contaminated near infected patients, and personnel may subsequently contaminate their gloves by touching these contaminated surfaces [24,25]. This manner of transmission is thought to be more common in multi-bed units. Examples of surfaces found to be contaminated frequently via contact with patients and staff include overbed tables, bed privacy curtains, computer keyboards, infusion pump buttons, door handles, bedside rails, blood pressure cuffs, chairs and other furniture, and countertops [6]. Anderson et al. [26] found higher microorganism counts on carpeted floors than on bare floors. Furthermore, air above carpeting contained more consistent concentrations of organisms than air above the bare flooring. However, no difference was found in patients in a hospital room with carpet versus a room without carpet. Another study confirmed that contamination of carpeting was not associated with a significantly increased frequency of pseudomembranous enterocolitis infections [27]. In addition to the fabric on floors, the fabric or upholstery of furniture can also be a reservoir for bacteria. Noskin et al. [28] examined the contamination with vancomycin-resistant enterocci (VRE) of fabric-covered furniture versus vinyl-covered furniture and vinyl surfaces. They showed that vinyl also became contaminated. However, routine disinfection was successful in removing VRE from vinyl surfaces, although not from fabric surfaces. In a similar study, Palmer [29] investigated the bacterial contamination of curtains in clinical areas. In that case, the bed curtains had much higher counts of bacteria than the window curtains. In addition, ward bed curtains were a persistent source of contaminants and bacteria, including methicillin-resistant *Staphylococcus aureus* (MRSA).

It is common knowledge that the chances of infection by bacteria on hands are lower if hands are washed more often. Larson et al. [30] discussed the effect of the use of an automated sink on the practice of hand washing and attitudes towards hygiene in high-risk units in two hospitals. Hands were washed better or more thoroughly but significantly less often using the automated sink.

In addition, the design of patient rooms can have an effect on the incidence of infections because tight corners are more difficult to clean than smooth edges. This may, in turn, have a negative effect on the performance of the building. In terms of logistics, McManus et al. [31] compared common infections (*Pseudomonas aeruginosa*) and pneumonia (*Pseudomonus bacteremia*) in burn patients in single-bed rooms and in open wards. The study showed that single-bed rooms and good air quality substantially reduce infection incidence and reduce mortality.

3.1.2.3. Indoor quality. This subtopic encompasses elements such as ventilation, dust, smell, relative humidity, and air quality. A number of studies have focused on healing environments and ventilation. Smedbold et al. [32], Arlet et al. [33], and Panagopoulou et al. [34] described the indoor quality related to the content of indoor air that could affect the health and comfort of building occupants and to the building materials, ventilation, and activities conducted in HCF.

Summary of design features related to safety and security to address with a level of evidence of two or higher: no slippery floors, appropriate door openings, correct placement of rails and accessories, correct toilet and furniture height, single-bed rooms, easy-to-clean surfaces, automated sinks, and smooth edges in rooms.

3.1.3. Enhancing control

Providing a patient with a choice appears to be a key element in environmental psychology [35]. According to Ulrich [15], the patient's lack of control is a major problem in hospital settings, which promotes stress and anxiety in patients. There seems to be a growing trend among some HCF to give patients more "control" over their environments [5,36].

Summary of design features related to enhancing control to address with a level of evidence of two or higher: self-supporting systems, such as control over the position of the bed, control over the temperature (air conditioning and heating), control over the lights (including dimmers), control over the sound (music and television), and control over the natural light.

3.1.4. Privacy

There are two subtopics in the field of privacy, namely, waiting rooms and single-bed rooms.

This section describes the relationship of single-bed rooms to the privacy of the patient and the relationship between the waiting room and a lack of privacy. According to Mlinek & Pierce [37], overhearing conversations at the reception desk was the main problem in the waiting room. Mlinek & Pierce suggested achieving a more audibly secure area by changing the structural design. Thus, the addition of background music or the use of physical barriers could be used to limit noise transmission and overhearing of conversations.

Firestone et al. [38] examined the lack of privacy among residents of four-bed rooms in comparison with single-bed room residents. The study indicated that ward residents view their dwelling as less secure and feel less able to control social encounters occurring therein than do residents of single-bed rooms.

Hutton [39] examined the strong need for privacy with respect to the bathroom (using the toilet, showering, and grooming) for adolescents in hospitals. The study showed that a quiet space or room was important to the adolescents for activities such as reading and homework. However, a separate area was not seen as necessary for quiet activities that can be performed in the bedroom.

Summary of design features related to privacy to address with a level of evidence of two or higher: single-patient rooms, design of waiting rooms. For instance, solid walls instead of curtain walls.

3.1.5. Comfort

Comfort is divided into several subtopics, consisting of materials, art, view, visual comfort, acoustic comfort, and orientation. These topics describe the influence of the physical environment on the well-being of the patient. For example, comfort in the patient room is related to having a single-bed room instead of staying in a multi-bed room [7]. Comfort is not related to the definition of the state of mind expressing satisfaction with certain physical environmental parameters, such as thermal comfort, per se.

3.1.5.1. Materials. The use of carpet is frequently associated with the home environment but rarely with the hospital environment. There are studies that support the idea of using carpet, whereas others categorically reject it. Cheek et al. [40] identified a negative reaction from staff members towards the installation of carpet. However, the administration of the hospital considered it a success. For instance, the safety had been improved as well as the appearance of the unit. Secondly, carpeting was a success because it was incorporated into the design before people moved in, and an effort was made to have cleaning systems in place from the beginning. This type of success depends on situational and social organisational variables. However, the evidence is more empirically based than scientifically proven. In addition, the satisfaction levels of the respondents are difficult to measure. Another published study investigated a possible relationship between the contamination of patient room carpeting and the prevalence of *pseudomembranous enterocolitis* (PME). The usual cause of PME is toxicogenic strains of *Clostridium difficile*. Skoutelis et al. [27] found no evidence that environmental contamination resulted in an increased frequency of PME in patients housed in carpeting rooms. However, carpeting should be considered as a potential reservoir of this organism.

3.1.5.2. Art. Ulrich & Giplin [41] discussed how certain types of "psychologically appropriate" artwork, including representational images with themes relating to waterscapes, natural landscapes, flowers and gardens, as well as figurative art showing emotionally positive gestures and facial expressions, can reduce stress and improve outcomes such as pain relief. However, abstract or ambiguous images or emotionally challenging subject matter can evoke dislike or other distinctly negative reactions among patients. According to Ulrich & Giplin [41], the limited research on art supported the conclusion that art selection for HCF should be evidence-based.

3.1.5.3. View. Regarding the effects of the view from the window of the patient room, Ulrich [10] demonstrated that patients with a view of nature (trees) had shorter postoperative stays, took fewer potent pain drugs, and received more favourable comments about their condition in nurses' notes than did matched patients in similar rooms with a window facing a brick building wall. Following this strain of thought, Verderber [42] noted that the most preferred window views among patients and staff were those of plants, the surrounding neighbourhood, and people and those that provided information about outside activities. In contrast, window views of architectural features (i.e., concrete buildings) or monotonous views were not preferred. If artificial substitutes for window views were necessary because of the lack of windows, patients and staff preferred representations of nature. Respondents were not satisfied with the following features: views into the hospital; the degree of personnel control of windows, screens, and curtains; and poor views from treatment rooms or the lack of windows. Moreover, in a study conducted on an intensive therapy unit (ITU), Keep et al. [43] confirmed previous studies showing that most ITU patients are conscious of their surroundings and retain some long-term memory of their stay. Patients who received care in a windowless ITU, in contrast to those in an ITU with windows, had a less accurate memory of the length of their stay and were less well orientated regarding time during their stay. The incidence of hallucinations and delusions reported by patients was more than twice as high in the windowless unit.

Another trend found in research addressing views is distraction therapy. In this case, the term "view" does not necessarily mean a view from a window but a visual stimulation that will serve as a diversion in an effort to make painful procedures more bearable [44]. Following this line of thought, Diette et al. [45] explored how the odds of better pain control were greater in the nature-distracted intervention patients than in the control patients, after adjustment for age, gender, race, education, health status, and dosage of narcotic medication. There was no difference in patient-reported anxiety and satisfaction. Other distraction techniques include virtual reality intervention for women receiving chemotherapy [46] and sensory stimulation (*snoezelen*) for the management of chronic pain [47]. In all of these studies, the group exposed to one of these distraction techniques reported significantly reduced pain and, in some cases, improvements in terms of disability (physical, psychological, and recreational), sleep, coping, and sickness impact profile. Other studies, such as that by Ulrich et al. [48], measured the blood pressure and pulse rates of blood donors to determine that donor stress was lower during periods of watching no television (blank monitor) than of watching daytime television. Additionally, during conditions of low stimulation (nature tape + without TV) and high stimulation (urban tape + TV), pulse rates were much lower with the nature tapes. A similar study by Ulrich et al. [49] demonstrated faster recovery from stress when participants were exposed to a tape of a natural setting than those exposed to tape of an urban setting.

3.1.5.4. Visual comfort. Visual comfort encompasses daylight factors, luminance, and luminance intensity and their effects on people. Access to daylight in HCF seems to have a significant impact on patients as well as on staff. Eastman et al. [50] used bright light treatment for winter depression. The study showed that bright light therapy had a specific antidepressant effect beyond its placebo effect, but it took at least three weeks for a significant effect to develop. Similarly, Lewy et al. [51] compared both morning and evening light treatments of patients who were experiencing winter depression and established that morning light was at least twice as effective as evening light in the treatment of seasonal affective disorder. Regarding this field of study, Beauchemin & Hays [52,53] found that patients had shorter hospital stays when staying in sunny rooms compared with dimly lit rooms. Patients treated in sunny rooms had an average stay of 16.6 days compared with 19.5 days for those in dim rooms. Moreover, there was significant difference between women and men. Mortality in both sexes was consistently higher in dim rooms. Choi et al. [54] showed that there appears to be a significant relationship between indoor daylight environments and a patient's average length of stay. They also noted that the high illuminance in the morning seemed to be more beneficial than the light in the afternoon.

Moreover, materials with qualities such as glare were related to the healing environment. For example, polished floors are a common source of glare and pose problems for people with visual impairments. Therefore, the use of matte surfaces is not only convenient but also solves the problem of glare [55,56].

3.1.5.5. Acoustic comfort. Blomkvist et al. [57] indicated that the improved acoustics had affected the psychosocial environment. The study showed that improved acoustic conditions in the healthcare environment reduce risks of conflicts and errors. When considering noise and room acoustics, the most important parameters are sound pressure level and reverberation time. These parameters are crucial in creating supportive environments, both in terms of supporting hearing and of reducing negative effects associated with sounds and noise [58]. The negative effects of noise are associated with a patient's recovery [59] and increased levels of stress [60]. Regarding the background noise level, Allaouchiche et al. [61] studied the noise in a post-anaesthesia care unit (PACU). They found that high noise levels were present in the PACU and that most of these noises could be prevented. However, noise was not perceived as the main cause of discomfort by patients. In a similar study, Bayo et al. [59] indicated that the most important noise sources were located primarily inside the hospital. They found that noise levels present in the hospital mainly affected the patients' comfort and, to a lesser extent, the patients' recovery. One of the main repercussions of a high noise level is the effect on patients' quality and quantity of sleep [62]. Quality of sleep in a respiratory intensive care unit (ICU) was poor for all patients; no complete sleep cycles were experienced. Sources of disturbance were mainly therapeutic procedures, staff talking, and environmental noises. Most disturbances were linked to the presence of other patients in the multi-bed unit. Moreover, sound peaks greater than 80 dB(A) and erratic patient interruptions by staff left little time for condensed sleep [63]. In an attempt to implement solutions, Moore et al. [64] reduced sound levels on patient care units by 6 dB(A) on average by closing patient doors, a change that patients readily perceived. Conversely, in the ICU, closing doors increased noise levels, presumably because most noise emanates from equipment within the room [65]. Harris & Reitz [66] studied the effects of room reverberation and noise on speech discrimination by older adults. They demonstrated that older normal-hearing subjects performed much poorer than younger normal-hearing subjects under the reverberant noisier condition, and that there was a drastic 48% decline in speech discrimination among older adults with a hearing impairment from the best acoustic condition (quiet + shorter reverberation time (RT)) to poorest (noise + longer RT). For healthcare facility design, the findings imply that consideration should be given to providing sound-absorbent ceilings and other measures that shorten RT and reduce noise propagation, thereby increasing speech discrimination among older patients and possibly older staff.

3.1.5.6. Orientation. Holahan [67] showed that seating patterns exerted a powerful control over the amount of social interaction among patients in a dayroom setting. Arrangements with chairs positioned shoulder-to-shoulder along the dayroom walls strongly suppressed social interaction. By contrast, arranging chairs around small tables in the middle of the room increased interaction, especially among socially inclined patients.

Location and site are aspects of the orientation subtopic. Evidence from various studies suggests that animals and pets, plants, views of natural landscapes, and active wilderness experiences have positive effects on human health and well-being [68]. Additionally, there is a clear preference among staff and patients to be surrounded by natural open settings [17]. A significant portion of the literature on healing gardens, such as Leibowits [69], Kromm & Kromm [70], Tyson [71], Cohen-Mansfield & Werner [72] and Zeisel & Tyson [73], focused on the effects of gardens on persons with dementia. However, the scope of this study is limited to hospitals and clinical settings that do not include special population clinics or nursing homes.

Secondly, there is increasing evidence that simply viewing gardens can mitigate pain. In addition to reducing stress and pain, gardens can heighten satisfaction and facilitate wayfinding or navigation in healthcare buildings for patients and visitors [16]. Wayfinding is important because if PF or staff have difficulties orienting themselves within the HCF, they may become frustrated and disoriented, which in turn may lead to experience stress [74].

Summary of design features related to orientation to address with a level of evidence of two or higher: single-bed rooms, materials without glare, windows with a view, daylight and wayfinding.

3.1.6. Family support

Visitors to the hospital may play an important role in patients' recovery, but there are also other serious implications, such as transmitting of infections and breeching respect for hospital norms. Hamrick & Reilly [75] indicated that open visiting hours were not associated with increased infection rates. Pettinger & Nettleman [76] argued that visitors spending more time in patient rooms were associated with improved compliance with norms. Compliance was higher for persons entering as a group compared with those entering alone. Astedt-Kurku et al. [77] explored the role of visitors in the hospital. The authors argued that family members spent considerable time at their relative's bedside, most of them up to several hours a day. Approximately half of all visits (49%) took place in the patient room. Family members, who saw themselves as "close" to the patient, had the most positive effects on patients' mental status. Concerning the effect of family visits, there seems to be no consistent effect on patients' mental status because some patients improved after the visit whereas others experienced a decline in their mental status.

The significance of the waiting room is indicated, to some extent, in the study by Foss & Tenholde [78] on the expectations and needs of persons with family members in an ICU as opposed to a general ward. The categories of family needs that were considered important or very important by respondents both in general wards and ICUs included the following: patient information, proximity and access to the patient (waiting room, overnight accommodations), emotional support, and a physical environment to support personal needs (nearby bathroom, convenient telephone, comfortable furniture in waiting room, food available 24 h a day).

Summary of design features related to family support to address with a level of evidence of two or higher: there are no design features to address in the topic family support.

3.2. Staff outcomes

Staff outcomes were divided into the primary topics of organisation and functionality, technical support and comfort (Fig. 3). These topics are addressed in this section.

3.2.1. Organisation and functionality

Relatively few studies have examined the workplaces of staff compared to those that address PF outcomes. One theme that has been receiving increasing attention over the last few years in the literature about healing environments is wayfinding. Moeser [74] proved that mental representations of maps do not develop automatically in a complex spatial environment. The study showed that first-time visitors performed significantly better on objective measures of cognitive mapping than nurses with two years of

experience working at the hospital. In addition to a complex floor plan, there are other elements that contribute to poor wayfinding and inadequate or conflicting cues such as colours and lighting [79]. In addition to these elements, clear and understandable wayfinding and maps are fundamental to becoming oriented in HCF. However, maps should be oriented so that the top signifies the direction of movement for ease of use [7]. Moreover, the number of signs available has a significant effect on wayfinding along many different measures including travel time, the frequencies of hesitations, the number of times directions were asked, and the reported level of stress. The results suggest that directional signs should be placed at or before every major intersection, at major destinations, and where a single environmental cue or a series of such cues (for instance, a change in flooring material) conveys the message that the individual is moving from one area into another. If there are no key decision points along a route, signs should be placed approximately every 4.6–7.6 m [7].

Summary of design features related to organisation and functionality to address with a level of evidence of two or higher: directional signs should be placed at or before every major intersection.

3.2.2. Technical support

Most of the literature available on technical support is related to identifying problems that have a direct effect on staff and that could be addressed through design solutions or protocol interventions. For instance, Alexandre et al. [80] evaluated a program to reduce back pain in nursing personnel, Caboor et al. [81] introduced an adjustable bed height during standard nursing tasks to enhance the quality of spinal motion, and Dariaseh et al. [82] examined musculoskeletal outcomes in multiple body regions and effects on nurses' work. The consequences of working conditions are thus known to some extent. However, the type of interventions to prevent these consequences appears to need exploration. In this sense, Garg & Owen [83] investigated the efficacy of an ergonomic intervention in a nursing home. The study showed that with systematic and appropriate ergonomic intervention physical stresses can be significantly reduced, hence reducing the future risk of musculoskeletal injuries and, in particular, low-back injuries.

Regarding the furniture in the patient rooms of the hospital, there have been several investigations in the fields of ergonomics and nursing studies addressing transportation in hospital beds. Petzall & Petzall [84] experimented with two types of wheels for transportation of patients in hospital beds. In their findings, standard small-diameter caster wheels made the bed easier to manoeuvre in limited spaces, whereas larger wheels on fixed axles made the bed more comfortable for long-distance transportation.

Summary of design features related to technical support to address with a level of evidence of two or higher: supporting systems, training in patient transferring, modifying toilets and shower rooms, and beds with different types of wheels for transportation.

3.2.3. Comfort

From the perspective of staff, noise levels were sufficiently high to interfere with their work and to affect patient comfort, and recovery. Other studies aimed to identify the most disruptive hours in a hospital and, in this respect, Gast & Baker [85] confronted the hypotheses and previous studies that the "quiet hour" had higher noise levels than the "noisy hour". They concluded that possible explanations for this included visitors and open doors of patient rooms.

Summary of design features related to comfort to address with a level of evidence of two or higher: there are no design features to address.

4. Discussion

This systematic review has identified a growing body of literature that examines the effect of the physical environment on the healing process and the well-being of PF and staff. The review encompassed mixed methods and qualitative studies. Although we identified several extensive studies, consisting of good examples of qualitative research, there was a general lack of consideration of the impact of outcomes in a holistic way. Most significantly, because the lack of strategies, methodologies and tools to measure include subjective concepts such as perception, privacy, comfort, and satisfaction of users in their interactions with the built environment, these features remain in the qualitative realm or have simple quantitative ratings. In addition, studies did not highlight the confounding parameters, for example in studying view and light.

This review has certain limitations. For example, the search strategy focused on specific keywords. Some relevant words outside of the field of the chosen keywords may have been excluded. For instance, keywords in the domain of building physics. Further, the search strategy was focused on numbered data sources. It has been noted that in the articles studied, no distinction has been made in HCF. Despite the endless epistemological and methodological debates, this type of research does not seem to meet the criteria of decision makers for the investment in new healthcare construction.

4.1. Reorganising topics and subtopics

The classification of users' perspectives in topics and subtopics is based on reviews by Ulrich et al. [7,8]. This raises the question of whether a reordering of the topics is actually needed. For example, one of the main concerns of patients is to avoid being subjected to human errors made by staff and medical professionals. However, nurses also consider the elimination of errors in their work as their main concern. Our suggestion is to add the topic "no errors" to the list of known staff needs. For example, the transmission of infection by bacteria on hands is reduced if hands are washed more often. An automated sink or faucet could also be among the solutions. However, as mentioned before, this is not considered a solution from the perspective of staff. Larson et al. [30] found in their study that staff expressed negative attitudes about certain features of automated sinks. For instance, they avoided washing their hands when they were busy because of a 15-s water flow interruption programmed in the automated sinks.

Furthermore, indoor quality is mentioned as a subtopic related to safety and security. However, emphasising the importance of indoor quality of HCF actually indicates that this subtopic has become a new topic in its own right.

Another aspect is the frequency of subjects that fall into different topics. As mentioned in the preceding section, a single-bed room improves the privacy and comfort of the patient and is thus placed in both topic groups. Although privacy is an important performance indicator of the patient in a hospital, the trend of creating "residentiality" in new HCF has been spreading throughout the United States with positive reactions from patients [86]. Moreover, the effects of single-bed rooms have yet to be proven. These effects have become apparent primarily through research conducted on healing environments (the effects of light, sound, music, and art), whereas the concept itself has seldom been studied as a separate research project [87]. Another example is that the literature related to the healing environment and the waiting room is based on the distribution of music and furniture. Routhieaux & Tansik [88] claimed that the presence of music significantly reduced stress levels compared with the absence of music in the waiting room.

This finding illustrates the complexity of the distinction between the different topics in relation to the healing environment. Thus, these topics require clear descriptions.

4.2. Key findings

A few of the reviews, randomised controlled trials and experiments found in this review concern the topics of comfort (Table 1). These studies link specific design features or interventions directly to impacts on healthcare outcomes. Most of the evidence is found in the topic comfort and, especially, in the subtopics of view and acoustic comfort. However, there is a scarcity of evidence found in the comfort topic with the staff.

Hence, there is a need for more evidence-based research focussing on the following topics: the elimination of errors, safety and security, control enhancement, organisation and functionality, and staff comfort. Furthermore, the research should pay attention to procedures and the description of data collection and analysis. Rather than describing data, research is needed that explores in-depth perceptions, meanings, and the impact of these topics (as mentioned above) on PF and especially on staff in HCF.

The diversity of methodologies and perspective views used in these studies makes it difficult to synthesise all of the data. This review, however, draws attention to some key findings that may be useful for future research.

Key findings from this study include evidence that the physical environment has an effect on the healing process and the well-being of PF and staff. Furthermore, there is evidence that the built environment can contribute to reducing errors, falls, and infections; improving privacy and comfort; and enhancing control. However, several aspects remain to be discussed. For example, more attention should be given to the incidence rate and delayed post-burn day of colonisation of the common infection versus the invasive burn-wound infection in the single-bed room. Regarding pneumonia and invasive burn-wound infections, the single-room unit had a lower frequency and later time of post-burn colonisation [31].

The research also identified some design features related to the physical environment and the well-being of PF and staff. These features include single-patient rooms, identical rooms, technical equipment and indoor (environmental) quality. In this case as well, the literature is written from the perspective of the patients and not from the perspective of the care professionals. Moreover, articles that described staff outcomes are often related to the characteristics of working conditions. Features such as wayfinding or technical support are practical elements that improve the labour conditions of staff. However, there is lack of evidence on factors such as accessibility and those relating to the physical environment and the well-being of professionals. Further research is needed to determine what staff require in and from their work environment.

4.3. Integrated building design

For the design and construction of new HCF, it is important to understand the needs of stakeholders. Each of the stakeholders involved in such an operation has a unique set of beliefs and associated meanings about the surrounding environment [15], thereby adding to the complexity of a design process of HCF that considers many stakeholders who are involved in building a new healthcare environment [89].

Another major difficulty is to ensure that practitioners clearly understand the research results reported in academic journals [9] and the subsequent implications of such results for the construction of new healthcare settings. The application of research findings, in practice, may be performed based on a clear theoretical framework that will help to position and relate the implications of certain studies. However, the problem is that there is a lack of consensus concerning the theoretical framework, given the current literature on healing environments [90]. Some of the frameworks that were proposed are the following:

- Setting-related studies (such as single-versus multi-occupancy rooms [91];
- Systems performance-related studies (such as ventilation systems [92] and air conditioning [93,94];
- Illness-related studies [95], including substance abuse and stress [96,97];
- Problem-solving studies (such as increasing the safety of patients [98] and improving wayfinding [99]); and
- Built environment features and characteristics (such as light [100–102], noise [59,103,104], colour [105], temperature [106].

The five frameworks mentioned above do not address the built environment in its entirety because they have been determined by researchers with backgrounds in the study of various aspects of HCF [2]. According to Durmisevic & Ciftcioglu [107], no current methodology was adequate to handle the different environmental features in a holistic way. Another factor is a lack of knowledge about the cumulative effects of various environmental aspects on health. In this regard, an adequate tool has yet to be developed for the efficient knowledge management and modelling of EBD data based on individual studies. As a result, Durmisevic & Ciftcioglu [107] presented a framework concerning the design for a performance-based tool. This tool provided support for decisions during the design and evaluation of a healthcare setting by the overall design performance of various aspects.

5. Conclusion

Addressing the effects of the physical environment on the healing process and well-being of PF and staff has become increasingly important in HCF design and construction. We have investigated the meaning of physical environmental factors on PF and staff outcomes. It was found that evidence for staff outcomes is scarce. Most staff outcomes are empirically based and not scientifically proven. It has been noted that the literature presents a variety of theoretical frameworks and technologies in the study of health outcomes on patients that are unsuitable for future research on healing environments. This shortcoming is because most of these studies have focused on the perspective of patient needs or on the perspective of the designer. Another reason why the conclusions of the current study are interesting for healthcare organisations is that HCF are developing a more customer-oriented management approach. This means that for designing and constructing new healthcare settings or renewing HCF, it is also crucial to understand the needs and relationships between the staff and other stakeholders related to the built environment. The main challenges for further research are the specifications of staff needs and the integration of all these needs into the built environment of HCF.

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