

# Exploring the Impact of Environmental Design on Patient Healing: A Systematic Literature Review

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## Abstract

*In this study, a systematic literature review (SLR) was conducted primarily aimed to study the relationship between environmental design and patient healing. For this purpose, the search strategy was initiated by using various databases including Google Scholar, ProQuest, EBSCOhost, SCOPUS and Springer, etc. The inclusion criteria for the studies were based upon the investigation of the role of environment design in enhancing patient safety, comfort, social and needs. Using these inclusion criteria, the search was conducted and a sample of 121 papers was selected from different databases. The data were extracted from these papers and were subjected to analysis. The findings of the SLR explicitly showed that many factors affect patient needs in general. The dimension of design are divided into spatial, ambient and functional Dimension. The findings of the study support earlier research findings establishing a strong link between the built environment and patient needs and outcomes. Three key design dimensions were explored: spatial, ambient, and functional, all of which were found to influence patient needs in certain key design categories, including lighting, flooring, acoustic quality, visual quality, indoor quality, and accessibility.*

**Keywords:** Environmental Design, Built Environment, Healthcare, Patient Outcomes, Patient Needs, Design, Policy Evidence-Based Design, Framework.

## INTRODUCTION

A uniform definition of what constitutes a human need hasn't yet emerged in the literature, much less been created for use in all contexts (Asadi-Lari et al., 2003). The conceptualization of human needs has been a hotly debated area of study. Despite the significance of creating a uniform meaning of the phrase "patient needs" in this sector, healthcare research has had a particularly difficult time conceptualizing patient needs (Dover, 2013).

Many academics from various disciplines of study have been interested in the need to identify and define human needs ever since the early conceptualizations of needs in the context of social research (Bradshaw, 1978) and psychology (e.g. Maslow, 1943, 1971). Integrating the concept of human needs into architectural design is one of the most recent topics.

In order to create a healing environment, it is necessary to incorporate human requirements into the design of healthcare facilities, according to studies on the association between design and human needs in healthcare applications (Huisman et al., 2012; Ulrich et al., 2008; 2013).

The current shift in emphasis on rethinking healthcare systems that has taken hold over the past 20 years is manifested in many ways, including the creation of healing settings (Carpman et al., 1986; Malkin, 1992; Becker & Douglass, 2008). The patient is at the center of this shift, and healthcare providers and regulators have realized the need to understand how important environmental variables can be best manipulated to develop a facility with patients at its core in response to changes in medical practice and consumer demand (McCollough, 2009).

This subsequent shift was brought about by an increase in consumer demand as well as an increase in global awareness among healthcare administrators, medical professionals, and healthcare staff. While all of these groups are motivated by the desire to improve patient care, they are also motivated by the fact that they stand to benefit from this trend change (Ulrich, 1991). To put it another way, while the redesign of healthcare facilities is primarily concerned with patient recovery, healthcare staff also stand to gain from it by providing a better

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environment in which to carry out their duties, and management can use redesign to reduce costs and address sustainability issues (McCollough, 2009).

In order to understand how to improve the built environment, it is necessary to first assess the problem from the viewpoint of the environment's most frequent user groups, getting their feedback on the improvements they believe are important and how the environment could be constructed to meet their needs. First, getting direct feedback from a facility's main user groups is crucial for quality improvement in the healthcare industry because these users are most familiar with the problems they run into on a regular basis when using the environment.

With a few notable exceptions, Rashid (2013) claims that proponents of using design centered on human needs haven't done a very good job of systematically reviewing the sources of evidence that are currently available in the field of healthcare redesign. Rashid calls for more systematic reviews to summarize empirical findings.

Additionally, the majority of current systematic studies of healthcare environment design are either univariate in nature (looking at the effect of a single design variable on one or more patient outcomes) or multivariate in form. While using such an approach to assure the consistency of the evaluated studies may be the best option (Higgins et al., 2019), it has the disadvantage of not allowing for a simultaneous side-by-side comparison of the effects of various design elements.

For instance, Hadi et al. (2019) studied the impact of light on sleep (and physiological parameters associated with sleep) in a systematic study. The effect of flooring material and finishes on patient outcomes was studied by Dixit et al. in 2019. Similar to this, Fay et al. (2018) investigated whether one design change could be adapted to simultaneously meet the needs of two user groups by examining the effects of nursing station decentralization on patient safety and the quality of care received.

But the majority of these systematic reviews are quite modestly sized, and this study's largest major review was that carried out by Ulrich et al. (2008). Even though there have been evaluations after Ulrich and his colleagues', including those by Calkins et al. (2012), Huisman et al. (2012), Malkin et al. (2012), and Hadi et al. (2019), none could be claimed to live up to the standard they set. As a result, this study aims to follow in the footsteps of the review's authors in producing a more recent systematic analysis of the environmental design elements influencing patient demands and outcomes.

The primary question identified for this review is: What can past research tell us about the relationship between environmental design and patient healing?

## **METHODS**

### **Search Procedures**

A consistent search strategy was developed, consisting of database searches to find (presumably) high-quality papers from peer-reviewed journals and grey-literature web searches to account for publication bias, to ensure that a sizable portion of the vast body of literature was covered by the researcher.

The final list of searched databases/repositories is shown in Table 1.

**Table 1 List of Searched Databases**

Publisher	Name
APA	PsycArticles
	PsycINFO
BMJ	BMJ Journals
Cochrane	Cochrane Database
EBSCO	Academic Search Elite
	Art & Architecture Complete
	CINAHL
	Psychology & Behavioural Sciences Complete
Elsevier	ScienceDirect
Emerald	Emerald Insight

HERD	HERD Knowledge Repository
NCBI	MEDLINE

Any study that included healthcare setting design or layout in relation to patient requirements or outcomes was included in the initial search. 576,091 studies were found in total thanks to these searches. However, when SmartText searching—a sophisticated algorithm that produces more results—was applied, a sizable number of those results were irrelevant. Additionally, numerous journal articles were cross-posted across other databases.

To eliminate pointless search results, a second round of searches was carried out. Depending on whether the search space needed to be widened or narrowed, combinations of phrases relating to environmental design, healthcare stakeholders, and important functions/variables were applied using Boolean operators (e.g. OR; AND; NOR; etc.). For instance, since "Hospital-Acquired Infections" and "Nosocomial Infections" are synonyms, the disjunctive operator "OR" was employed to couple them when exploring the literature for the effects of design on infections. 8,206 results in total were obtained from this round of searches.

Yields from various databases were cross-examined to remove duplicate findings and were then evaluated online to see if they satisfied the exclusion/inclusion criteria in order to lower the number of articles to a more manageable quantity.

### Eligibility Criteria

The search results obtained via database and grey literature searches were evaluated to ensure that the predetermined inclusion and exclusion criteria were met for each source.

The inclusion and exclusion criteria are listed in Table 2.

**Table 2 Inclusion & Exclusion Criteria**

	Criteria
Relevance of Topic & Question (Criterion 1)	Careful examination of each title and abstract is required to ensure the validity and relevance of the results analysed, for which the first criterion is drawn. Irrelevant articles include papers examining aspects such as medical treatment/wound healing, or papers centred on the needs/outcomes of other facility users like staff or family members, with little or no mention of patient needs.
Relevance (Homogeneity) of Populations (Criterion 2-3)	Factoring in these considerations, the second criterion is drawn, since the aim of this paper is to examine the needs of hospital inpatients in general, and not the needs of a particular group or demographic of patients.
	The third criterion excludes studies by their scope, in which any studies taking place in a different healthcare facility type (such as nursing homes or special clinics) will be excluded from the analysis, for the same reasons mentioned above.
Methodological Soundness (Criterion 4-5)	Criterion 4 is drawn to ensure that only empirical or scientifically backed studies are included in the review. An emphasis is placed on empirical findings, however, for two reasons: <ol style="list-style-type: none"> <li>1. The majority of credible sources on the topic obtain their results through empirical findings (Huisman, 2012).</li> <li>2. Empirical findings are best suited for the analysis of cause and effect relationships and differentiating between correlation and causation in variable analyses (Heitink, 1999).</li> </ol>
	Criterion 5 is drawn to ensure that the study is conducted based on credible existing literature, as to reduce the likelihood of personal biases, judgement errors, and subjective analysis. Ensuring that the study is grounded in solid literary basis is essential to reducing the likelihood of error in the analysis.
Integrity & Impartiality (Criterion 6-7)	The sixth and seventh criteria are drawn to ensure the integrity and quality of the studies analysed, and to reduce bias, be that publication bias, or bias due to conflicts of interest, or funding concerns.
Availability for Review (Criterion 8-9)	Finally, the eighth and ninth criteria are drawn to ensure that the researcher is able to conduct a thorough analysis of any study included in the systematic review, in order to assess its design, analytical methods, and to address all of the aforementioned criteria.

A list of articles that were disqualified based on their titles is included in Table 3, along with the reasons for exclusion stated before.

**Table 3 Sample of Included & Excluded Titles**

Citation	Basis for Exclusion
Federman et al. (2000)	Special Group: Psychiatric Patients.
Kennedy et al. (2001)	Medical Condition, Demographic: Low-Birth Infant
Leather et al. (1998)	Setting Scope: General Work setting
Leppamaki et al. (2003)	Demographic: Female Patients
Lovell et al. (1995)	Demographic: Elderly Patients

### Extraction Method and Synthesis

Quantitative data are extracted and then synthesized once all search results have been checked against the inclusion/exclusion criteria. A total of 121 relevant papers that supported the selection criteria were found by the researcher. These papers provided the pertinent data that was needed.

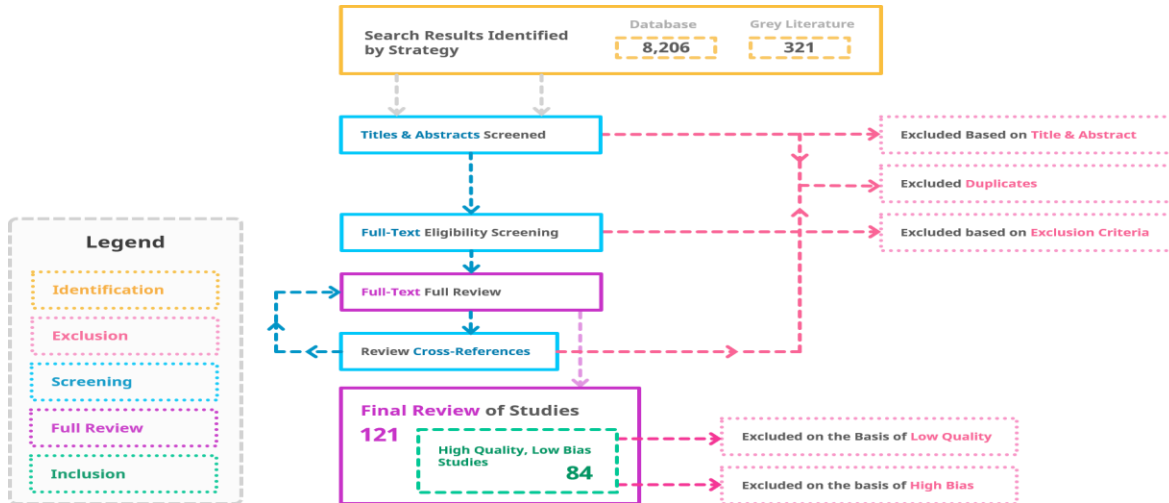


Figure 1 PRISMA phrase of SLR (prepared by author)

### FINDINGS AND DISCUSSION

#### Study Flow

After entering the keywords into the appropriate academic databases, more than 576,091 studies were retrieved. Journal articles that have been copied from several databases were eliminated from the final review. The evaluation enabled the researcher to filter 8,206 database research and 321 grey literature articles based on several characteristics such as the research title. Furthermore, the publications were screened using the abstract and full text, which resulted in the inclusion of 205 investigations. Based on this screening method, 121 research publications were chosen that met the established bias and quality criteria.

#### Features of Included Studies

Table 4 presents an overview of the design components identified in the literature

Table 4 Summary of Environmental Design Components & Authors

Dimension	Component	Supporting Studies
Spatial Design	Room Spaciousness	Ulrich et al. (2008); Huisman et al. (2012); Iyendo et al. (2016)
	Bed Spaciousness	Wiggerman et al. (2017); Zafiroopoulos et al. (2004); Smith et al. (2017); VanGilder et al. (2017)
	Seating Area Spaciousness	Ohde et al. (2012); Tzeng & Yin (2008); Mosley et al. (1998); Krauss et al. (2008); Guiterrez & Smith (2008)

	Orientation of Door	Huisman et al. (2012); Chaudhury et al. (2005); Taylor & Card (2018)
	Orientation of Nursing Station	Morgan et al. (1985); Wolf et al. (2013); Gutierrez & Smith (2008)
	Proximity of Bed to Bathroom	Morgan et al. (1985); Wong et al. (1981); Ulrich et al. (2008)
	Proximity of Bed to Nursing Station	Morgan et al. (1985); Wolf et al. (2013); Gutierrez & Smith (2008)
	Wayfinding (Signage Use)	Schaffer et al. (2012); Taylor & Hignett (2016)
	Wayfinding (Stairs & Elevators)	Calkins et al. (2012); Ulrich et al. (2008); Morse (1993); Paiva et al. (2010)
	Standardized Layout	Vassallo et al. (2000); Huisman et al. (2012); Ulrich (1991); Barnhart (1998); Buchanan et al. (1991)
	Tabular Arrangement of Seating	Holahan (1972); Huisman et al. (2012)
	Pathway Cluttering	Calkins et al. (2012); Ulrich (1991); Ulrich et al. (2008)
Ambient Design	Carpeted Flooring	Calkins et al. (2012); Cheek et al. (1971); Donald et al. (2000); Healey (1994); Warren & Hanger (2013); Skoutelis et al. (2004); Noskin et al. (2000)
	Wall Colour	Dalke et al. (2004); Zraati (2013); Ulrich et al. (2008); Schweitzer et al. (2004); Iyendo et al. (2016)

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Fabric Quality	Fijan & Turk (2012); Hota (2004); Fijan (2005); Wensley et al. (2017)
Daylight Intensity	Bell et al. (2008); Booker & Roseman (1995); Pati et al. (2012); Buchanan et al. (1991); Beachemin & Hays (1996; 1998); Frankenhaeuser (1980); Walch et al. (2005); Ulrich et al. (2008); Huisman et al. (2012); Malkin et al. (2012); Pati et al. (2012); Hadi et al. (2019)
Indoor Lighting	Calkins et al. (2012); Healey (1994); Wolf et al. (2013); Vieira et al. (2011); Bell et al. (2008); Choi et al. (2012); Ulrich et al. (2008); Huisman et al. (2012); Malkin et al. (2012); Pati et al. (2012); Hadi et al. (2019)
Garden Access / Nature View	Park & Mattson (2007); Satterfield (2010); Ulrich et al. (2008); Huisman et al. (2012); Malkin et al. (2012)
Window View	Verderber (1986); Huisman et al. (2012); Ulrich (1974); Schweitzer et al. (2004); Ulrich et al. (2008); Ulrich et al. (2004); Ulrich (1991); Ulrich (1992)
Artwork (Natural Scenery)	Kline (2009); Nanda et al. (2011); Nanda et al. (2012); Ulrich et al. (1993); Ulrich & Gilpin (2003); Ulrich et al. (2003)
Ventilation & Heating	Smedbold et al. (2002); Arlet et al. (1989); Panagopoulou et al. (2002); Malkin et al. (2012); Schweitzer et al. (2004)
Cleanliness & hygiene	Aygun et al. (2002); Boyce et al. (2007); Jonas et al. (2004); Malkin et al. (2012); Ulrich et al. (2008); Schweitzer et al. (2004)

	Indoor Noise	Barlas et al. (2001); Karro et al. (2005); Mlinker & Pierce (1997); Blomkvist et al. (2005); Bavo et al. (1995); Toph (2000); Ulrich (1991); Laursen et al. (2014); Malkin et al. (2012); Schweitzer et al. (2004); Iyendo et al. (2016)
	Outdoor Noise	Barlas et al. (2001); Karro et al. (2005); Mlinker & Pierce (1997); Blomkvist et al. (2005); Bavo et al. (1995); Toph (2000); Ulrich (1991); Laursen et al. (2014); Malkin et al. (2012); Schweitzer et al. (2004); Iyendo et al. (2016)
Functional Design	Disability Accessible	Quan et al. (2011); Ulrich et al. (2008); Kachne et al. (2019); O'Halloran et al. (2012); Steinfeld & Danford (1999)
	Acuity Adaptable	Brown & Gallant (2006); Huisman et al. (2012); Kwan (2011); Hendrich et al. (2004); Schweitzer et al. (2004)
	Storage Spaces	Quan et al. (2012); Ulrich et al. (2008); Douglas & Douglas (2004)
	Communication Tools	Chandra et al. (2018); Clever et al. (2008); Wensley et al. (2017); O'Halloran et al. (2012)
	Entertainment Tools	Ulrich (1991); Iyendo et al. (2016); Kiecolt-Glaser et al. (1998)
	Visibility/Location of Sink	Ulrich et al. (2008); Marjadi & McLaws (2010)
	Ease of Use	Lopez et al. (2010); Ulrich et al. (2008); Schweitzer et al. (2004)
	Control over Open Door	Huisman et al. (2012); Chaudhury et al. (2005); Taylor & Card (2018); Barnhart (1998); Prochansky et al. (1970); Ulrich (1992)
	Control over Window Shades	Huisman et al. (2012); Barnhart (1998); Prochansky et al. (1970); Ulrich (1992)
	Control over Light Dimmers	Huisman et al. (2012); Barnhart (1998); Prochansky et al. (1970); Ulrich (1992)
Control over Temperature	Huisman et al. (2012); Barnhart (1998) Prochansky et al. (1970); Ulrich (1992); Schweitzer et al. (2004)	

### Impact of Design on Patient Safety Needs

Patient falls are the main adverse event causing risks that endanger patient safety, as was previously noted in the theoretical review portion of this paper. As a result, this subject will be discussed first under the section on the causes of patient falls.

According to Calkins et al. (2012), there are numerous environmental elements that can cause a patient to fall, such as the amount of lighting, the type of flooring, and clutter both inside and outside the building. According to Morganet al. (1985) and Wong et al. (1981), the majority of falls happen in patients' rooms as opposed to hallways and other public areas. In terms of environmental risk factors, two studies (Calkins et al., 2012; Wolf et al., 2013) discovered that rooms with direct visibility or close proximity to nurse stations were associated with higher rates of falls. However, the authors of both studies suggested that the higher rates may have been brought on by the placement of the highest risk patients in those rooms.

Cheek et al. (1971) noted a disagreement between employees and management about the placement of carpets in healthcare facilities. The nuclear layouts in two units, where 85% of patient beds were visible from either one or two nursing stations, were found to contribute to a significantly lower number of falls than on a unit with visibility of only 20% of the patient beds (Vassallo et al., 2000).

For instance, Lopez et al. (2010) referred to functional adjacencies, noting that solutions were found when ongoing patient supervision was impossible due to the location of tasks like drug preparation and documentation.

As a result of patients being more likely to request assistance from nearby professionals, a research that constructed satellite nursing stations outside of patient rooms showed a significant decrease in patient falls (Gutierrez & Smith, 2008).

The value of family involvement in a falls-prevention program has been discussed in a number of studies using a variety of methodologies and design quality appraisals (Gutierrez & Smith, 2008; Krauss et al., 2008; Mosley et al., 1998), as well as providing assistance when appropriate (Ohde et al., 2012; Tzeng & Yin, 2008). Another study revealed that although family members ought to be included, they had nothing to contribute to a discussion on falls, raising the possibility that they do not see fall prevention as their responsibility (Vieira et al., 2011). As part of the overall analysis, statistically significant positive findings were obtained in half of the studies that referenced family presence.

Ten of the studies that were included used visual cues, which are frequently used to resolve communication breakdowns. The majority of these studies were classified as being of medium quality, and half of them generated statistically significant outcome outcomes.

While the majority of the other studies said that signage was located in the immediate area outside the patient's room, one study (Schaffer et al., 2012) did not give this information. In order to visually alert staff (and family) to a patient's fall risk, hallway signage was frequently included in a combination of visual cues that also included signage inside the room and/or colored patient wrist identification bracelets. The findings of another systematic study focused on patient falls (Taylor & Hignett, 2016) also support this conclusion.

The comparison of carpeting and vinyl flooring materials has received the greatest attention in terms of flooring types (Donald et al., 2000; Healey, 1994; Warren & Hanger, 2013). However, the results of this comparison have been inconsistent throughout and have not produced statistically significant findings in the comparative analyses.

Analysis of four years' worth of accident forms revealed in Healey's (1994) retrospective study that although the frequency of injuries from falls appeared to be lower on carpeted floors than it was on vinyl, there were no more falls on vinyl than there were on carpeting.

Lighting was a component of the bundled solution in numerous studies of various quality, although the intervention descriptions weren't always precise. The requirement for nighttime lighting, whether continuous or motion actuated, was mentioned in a number of studies (Fonda et al., 2006; Gowdy & Godfrey, 2003; Mosley et al., 1998; Tzeng & Yin, 2008).

According to one study, low-level lighting is safer than abrupt changes in lighting (from light to dark) and that patient areas should never be fully dark (Healey, 1994). Some people mentioned the position of the illumination. In one study, night lights were in the bathroom (Vieira et al., 2011), and in another study, night lights were both under the bed frame and 2 feet above the floor near to the bathroom (Wolf et al., 2013).



One staff-focused study (Bell et al., 2008) emphasized the importance of having sufficient lighting in all workspaces, whether they are indoor or outdoor. Although the results of several studies that used lighting strategies were statistically significant, Calkins et al. (2012) found no statistically significant correlation between falls and lighting, night lights, or the degree of control patients had over the light in their environments.

With the justification that summer seasons received noticeably more daylight than winter seasons, Booker & Roseman (1995) looked into seasonal patterns in medical errors in Alaska. According to the survey, 58% of prescription errors happened in the first quarter of the year, and December has about a twofold higher risk of medical errors than September.

Being the victim of medical and prescription blunders by healthcare professionals is one of the top concerns for patients that is frequently mentioned. Errors in the prescription and administration of medication are a result of numerous environmental factors. Lighting from both indoor and outdoor sources has been the most frequently found to be a cause in prescription inaccuracy. Lighting was cited in several research in this analysis as a key factor in medical errors in general (Pati et al., 2012).

The rate of prescription errors in healthcare settings is also known to be greatly impacted by indoor lighting. Three light levels were evaluated in a study by Buchanan et al. (1991) to assess this association. The rate of prescription errors was found to be dramatically reduced from 3.8% to 2.6% at the maximum lighting level.

Another crucial element in reducing the frequency of prescription errors is standardization. According to two studies by Ulrich et al. (1991) and Barnhart et al. (1998), staff errors were dramatically reduced in wards with consistent layout distributions.

Since contaminants can be transferred from one patient to another via the contaminated gloves of healthcare workers, avoiding contamination of touch surfaces is frequently necessary to reduce infection (Aygün et al., 2002; Boyce et al., 1987).

Since MORs (Multi-Occupancy Rooms) often have more touch surfaces for transmission (such as bedside rails, handles, curtains, etc.) and more patients close to one another, infection also seems to be connected to the room's occupancy (Jonas et al., 2004).

No research found statistically significant differences in infection levels between these categories, despite the fact that carpeted flooring typically has higher microbe counts than vinyl or rubber surfaces (Skoutelis et al., 2004; Noskin et al., 2000).

Figure 2 summarizes the list of design components identified in Table 4, denoting which of those components influences patient safety via the four mediating factors: (1) Way finding/ Accessibility, (2) Fall/ Fall-Related Injury, (3) Medical/ Prescription Error, (4) Contamination/ Infection.

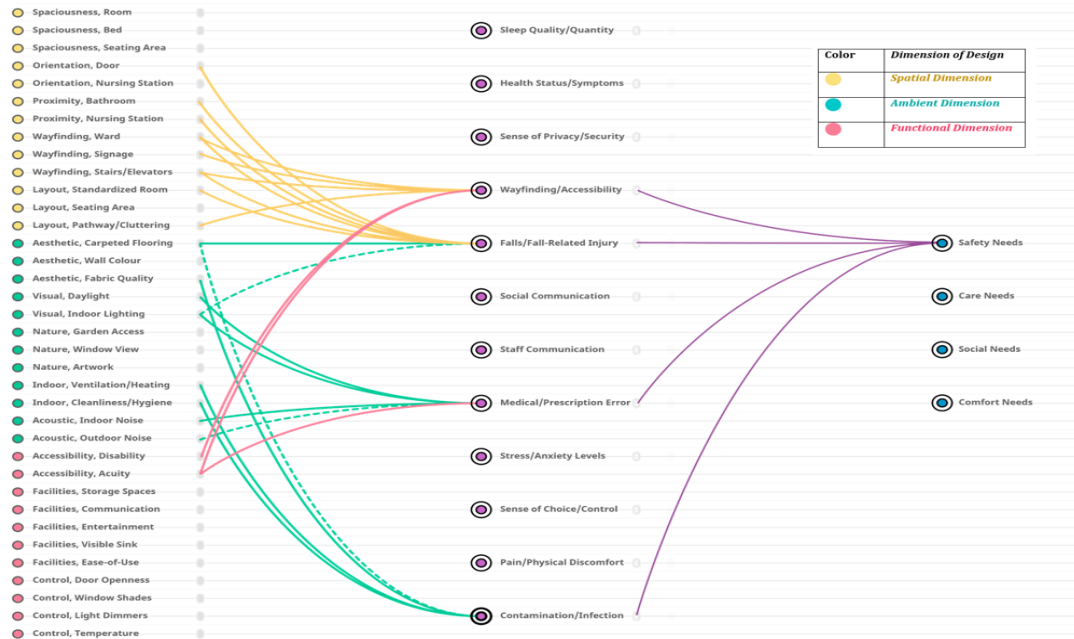


Figure 2 Visual Representation of Factors Influencing Patient Safety Needs, Network Diagram

### Impact of Design on Patient Comfort Needs

According to Smedbold et al. (2002), Arlet et al. (1989), and Panagopoulou et al. (2002), thermal and interior quality—which includes heating/ventilation, air quality, and cleanliness—are crucial elements to improving patients' overall comfort and promoting the development of a healing environment.

Another crucial element to meeting patients' comfort needs seems to be giving them control over the room's ambient elements. Ulrich (1991) identified one of the main causes of patient stress and anxiety as the fulfillment of a patient's sense of lack of control, which appears to be tied to the problem.

Patient control is broken down by Huisman et al. (2012) into the following categories: bed, room temperature, interior lighting, outdoor lighting, sound/music, and entertainment equipment. According to Firestone et al.'s (1980) research, there is a significant relationship between the kind of room occupancy and patients' perceptions of privacy and their capacity for social interaction.

Many factors are frequently taken into account when deciding whether to put artwork in the space (either print or electronic), to make sure that it is suitable for usage in healthcare settings. Ulrich et al., 1993, Ulrich & Gilpin, 2003, and Ulrich et al., 2003 are among the sources that link artwork to decreased stress and anxiety.

According to Ulrich and Giplin's (2004) research, displaying artwork directly in front of patients has the ability to significantly lower tension and discomfort levels. On the other hand, patients tended to view abstract art and other confusing imagery negatively, which led to cognitive anguish in patients.

Verderber (1986) found that for context clues about what is happening outside the facility, patients and staff members preferred window views of plants and other natural scenery, the general neighborhood, and other people outside engaged in daily activities.

The term "view" was not always employed in the context of views from the windowpane, Huisman et al. (2012) note out in their review of the literature. One such instance is distraction therapy, which frequently used visual stimulation to distract patients from their present health conditions and uncomfortable procedures and frequently presented patients with a window view.

Beachemin & Hays (1996; 1998) compared two groups of patients, one in a sunny room and the other in a room with low lighting, to investigate how much daylight hospital inpatients were exposed to. Higher mortality rates were observed in groups facing away from the sunny side, with results consistent across both genders.

According to Choi et al. (2012), there is a substantial negative correlation between the patient's length of stay and the intensity and exposure of the indoor lighting. When compared to exposure in the afternoon or evening, this relationship was particularly found for prolonged morning exposure to external lights.

The study's findings of perceived noise levels by patients are extremely consistent with those found in the literature, showing that perceived noise levels have a significant impact on patients' sensory comfort, patient satisfaction, stress levels, and anxiety levels.

The primary source of noise in healthcare facilities appears to primarily come from inside the ward; more specifically, from the ward and adjacent rooms, as well as the equipment inside the patient's room, as many researchers have noted (Barlas et al., 2001; Karro et al., 2005; Mlinker & Pierce, 1997).

According to Blomkvist et al. (2005), the acoustic environment can have a significant impact on patients' comfort levels, and Bayo et al. (1995) and Toph (2000) found a strong association between noise levels and patients' healing processes as well as levels of general stress and anxiety.

According to certain studies, indoor plants might reduce tension and anxiety in patients and enhance their psychological comfort in healthcare settings (Park & Mattson, 2007; Satterfield, 2010).

According to numerous studies, acoustic quality contributes to the greatest number of healing variables, making it one of the most crucial elements in healthcare environmental design. The idea that hospital environments can directly increase patient wellness—if created to remove what the author characterized as environmental stressors—was initially put out by Ulrich (1991).

Finally, since it affects all stakeholders collectively, the impact of the healthcare environment overrides the conceptual framework and acts as its outermost layer (Wensley et al., 2017).

Figure 3 summarizes the list of design components identified in Table 4, denoting which of those components influences patient comfort via the three identified mediating factors: (1) providing patients with a sense of privacy, (2) providing patients with a sense of control, (3) reducing pain and discomfort.

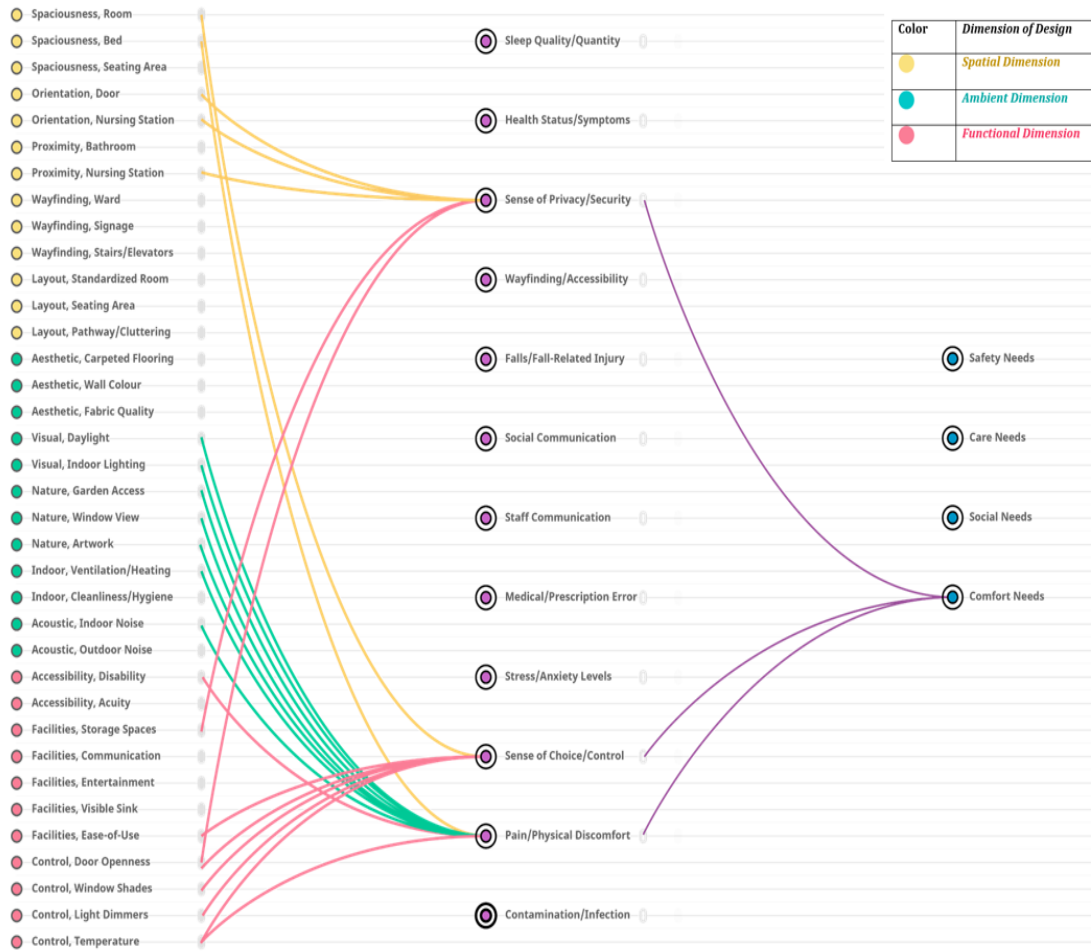


Figure 3 Visual Representation of Factors Influencing Patient Comfort Needs, Network Diagram

### Impact of Design on Patient Social Needs

The communication styles of staff members may have an impact on patient satisfaction, as well as beneficial outcomes including medication adherence, less symptoms, and overall greater HRQOL measures (Chandra et al., 2018; Clever et al., 2008).

There is also a ton of evidence showing how friendly and outgoing hospital staff members affect patients' reported levels of physical and psychological comfort, which in turn affects patient satisfaction (Angstrom-Brannstrom & Norberg, 2014; Arruda et al., 1992).

The quantity of social engagement and conversation that the patients had engaged in was strongly correlated with the seating arrangements and layout of private patient rooms, according to a study by Holahan (1972).

In contrast to placing them at a table near to the patients, seating along a wall appeared to discourage social interaction.

Even when research papers and systematic reviews both point to significant beneficial outcomes, there is virtually always a cost associated with deciding to put a design intervention into practice. In particular, this is true for SORs (Single-Occupancy Rooms) (Chaudhury et al., 2005; Taylor & Card, 2018), where some subjective considerations must be made to gauge the extent of one impacted factor to a counteracting factor (e.g., privacy vs. companionship, social interaction vs. infection control).

The presence of family members in hospital rooms causes many of these trade-offs because they can significantly improve the safety and care needs of patients in addition to meeting their social and informational demands.

Staff members were also identified as a key stakeholder in meeting the social needs of patients, which mainly depended on whether the patients had direct channels of communication with the staff and whether conditions like ambient noise and other factors made that possible.

Figure 4 summarizes the list of design components identified in Table 4, denoting which of those components influences patients' social interactions and needs, as mediated through the following two mediating factors: (1) social communication (communicating with family and friends), (2) staff communication (communicating with caregivers and obtaining self-care information).

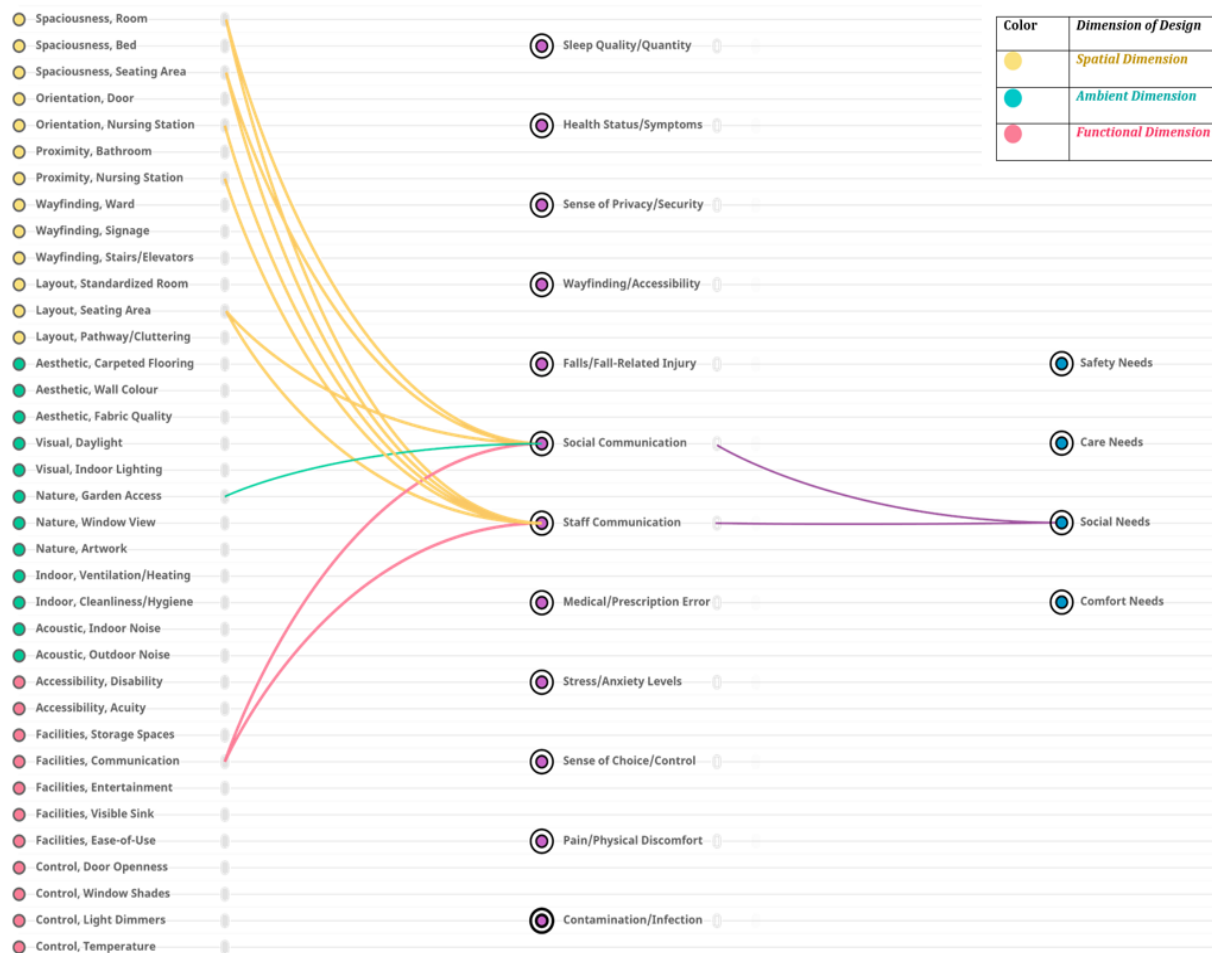


Figure 4 Visual Representation of Factors Influencing Patient Social Needs, Network Diagram

### Impact of Design on Patient Care Needs

Reducing stress and anxiety is arguably the most frequently mentioned goal in evidence-based design, and research suggests that the majority of patients experience significant stress during their hospital stay, which is frequently accompanied by increased anxiety, delirium, higher blood pressure, and higher medication intake/doses, particularly for painkillers (Wilson, 1972; Ulrich, 1991).

These stressors, as defined by Ulrich (1991) and numerous other writers (Iyendo et al., 2016; Williams & Irurita, 2005; 2008), are environmental stimuli that heighten stress. They are typically a result of sensory (visual, auditory, and olfactory) cues in the environment.

According to Kiecolt-Glaser et al. (1998), lowering stress in medical settings can hasten outpatient patient recoveries, lower the need for painkillers and other narcotics, lessen anxiety and depressive symptoms, and even lower patient mortality and morbidity rates.

In addition to psychological effects, stress and anxiety can also have physiological effects on the body, such as changes in blood pressure, muscle tension, and stress hormone levels. These physiological effects can create a positive feedback loop that amplifies the effects of stress (Frankenhaeuser, 1980). Such physiological and psychological manifestations are frequently utilized as indicators in EBD to link a change in the environment to a decrease in stress and anxiety. The stress and anxiety levels experienced by patients appear to be the most often identified function mediating the link between the built environment and patient needs/outcomes.

Figure 5 summarizes the list of design components identified in Table 4, denoting which of those components influences patient care needs, manifesting in their health status and as reflected by their functional status upon their leave. The mediating factors affecting this need include: (1) improving patients' sleep quality and quantity, (2) improving patients' health status and symptoms, (3) reducing stress and anxiety levels.

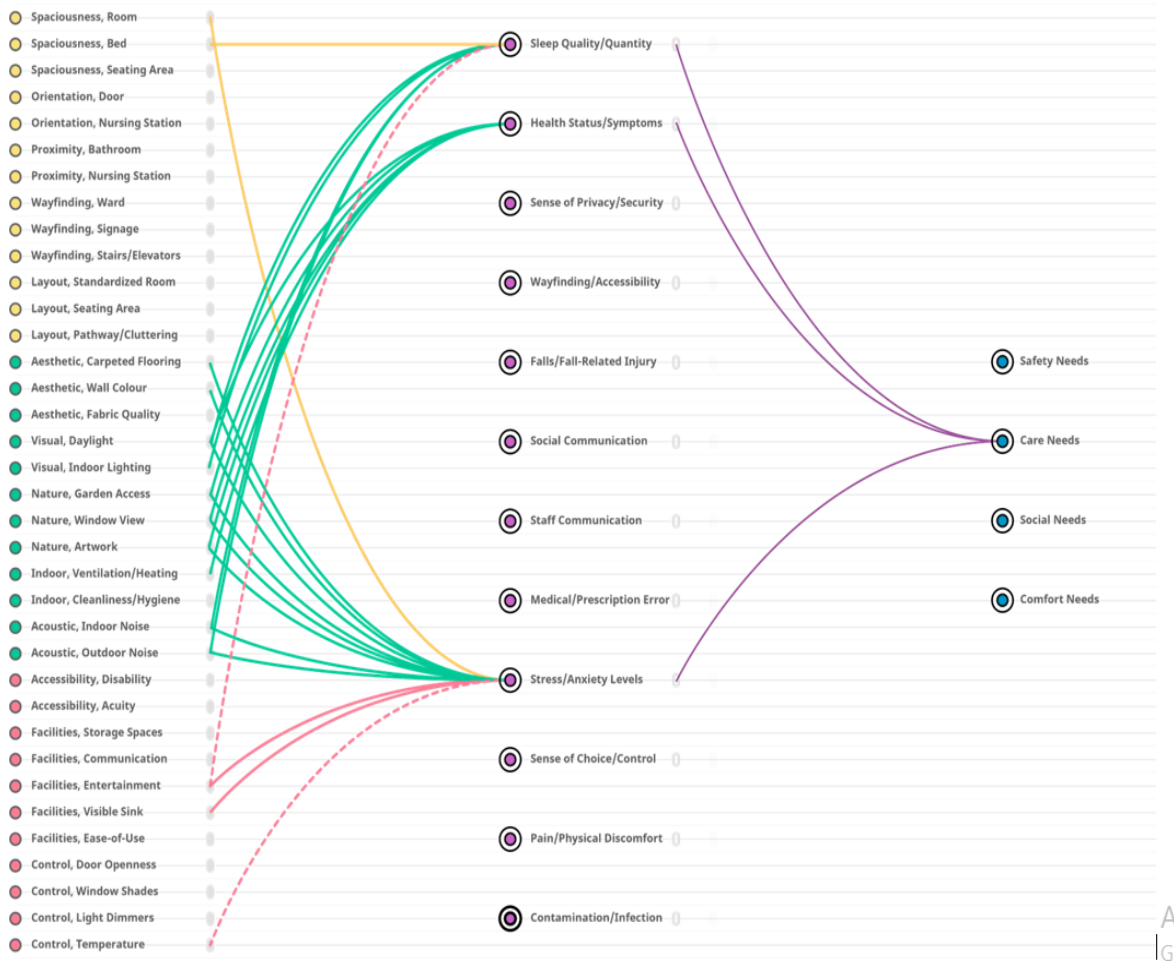


Figure 5 Visual Representation of Factors Influencing Patient Care Needs, Network Diagram

### Excluded Findings & Observation

#### General Observation

In order to investigate one aspect of the built environment in relation to one particular health result, the majority of extant research tend to be relatively narrow and linear. For example, Walch et al. (2005) employed an RCT design to investigate the effect of daylight exposure on the use of post-operative analgesic medications in two

patient groups who were hospitalized in identical rooms but in separate wings of the same hospital. Such a situation is the ideal natural experiment since it changes only one feature of the built environment—the quantity of daylight a patient receives—while controlling for the effects of the majority of intervening factors (since the rooms are identical).

Given the vulnerable position of the majority of patients, it is frequently very difficult to intervene in the setting of a single design element in healthcare settings. This is an important concern for the methodological design of EBD studies. Additionally, in these experimental designs, researchers must frequently take into account the placebo effect, typically by keeping the intervention a secret from all participants (Rehn & Schuster, 2017).

Another crucial point to remember is that many external factors interact with design features, making it extremely harder to pinpoint which of these elements is responsible for the observed change in outcome measures. These variables could be things like in-patient management, the training and experience of healthcare professionals, as well as several demographic and socioeconomic variables relevant to the patient.

### **Studies Conducted in Jordan**

Although the term "Jordan" was frequently used in conjunction with other keywords during database searches, only a small number of articles could be found to be pertinent to the study; none of these were included in the systematic review's final results because they did not meet one or more of the inclusion/exclusion criteria outlined in the methods section.

Despite not being included, it was nevertheless beneficial to review these publications because they might help the researcher identify some factors to take into account when performing the study given the paucity of Jordanian research studies.

Furthermore, Taylor et al.'s (2018) systematic review suggests that there may be some prejudice that is unique to the nation under examination, albeit it was unclear if the bias in question was a result of reporting bias, a cultural or contextual difference, or some other undiscovered factor.

One study (AlZoubi & Al-Rqaibat, 2014) investigated the effects of hospital daylight quality in the pediatric (children's) ward at KAUH (King Abdullah University Hospital), the main medical facility in Jordan's northern area and one of the country's few teaching hospitals. The study took into account a number of factors related to variations in the daylight environment (using multiple measurements for daylight & brightness).

According to the study, the average amount of daylight at KAUH was 20%, 39%, and 45% more on average than what was suggested for the months of March, June, and December, respectively. These differences were statistically significant ( $p < 0.01$ ).

Even while the writers did find a correlation between general daylight and worker productivity, general health, and performance, none of those claims were examined empirically in the authors' study, therefore they were also disregarded. The reflectivity and glare that reflected off the surfaces in the space were, however, at far greater levels than the averages that the Chartered Institution of Building Services Engineers (CIBSE) had advised as guidelines.

Although these recommendations are insufficient on their own to prove a connection between lighting and patient needs/outcomes in Jordanian hospitals specifically, they should still be mentioned because they may be a sign of a problem with the country's healthcare system as a whole.

Another study by Muhsein et al. (2017) looked at how patients' desires for safety were impacted by the deployment of an electronic safety program at the ICU in Al-Istishari Hospital [a hospital used as a sample in this study, see Section 4.4.2.2a]. The HSE (Health Service Executive) Change Module, a project management lifecycle model designed to implement change to the hospital's technological safety-related infrastructure, is the subject of the in question electronic safety program (Barry et al., 2018).

While Muhsein and his coworkers suggest that the results are typically positive, they did not do any adequate/sound analytical measures to support the assertion and did not provide any other such supporting

data. Instead, they used descriptive statistics to suggest that the sample's responses were somewhat more positive. As a result, the study was also left out of the evaluation.

## **Design Components & User Needs/Outcomes**

### **Intercorrelations in Design Impact**

While this study's specific goal is to look at how patient requirements and outcomes relate to the built environment, other forces at work in the environment—forces that may or may not be indirectly related to the environment—are crucial to this investigation. A healthcare facility's stakeholders and users, as well as elements like the patient's health and condition, income, and mode of treatment, are examples of such influences.

Due to the overlap between these influences and environmental design, it may be extremely difficult, if not impossible, to pinpoint the root causes of a change in the variables that reflect patient demands and outcomes.

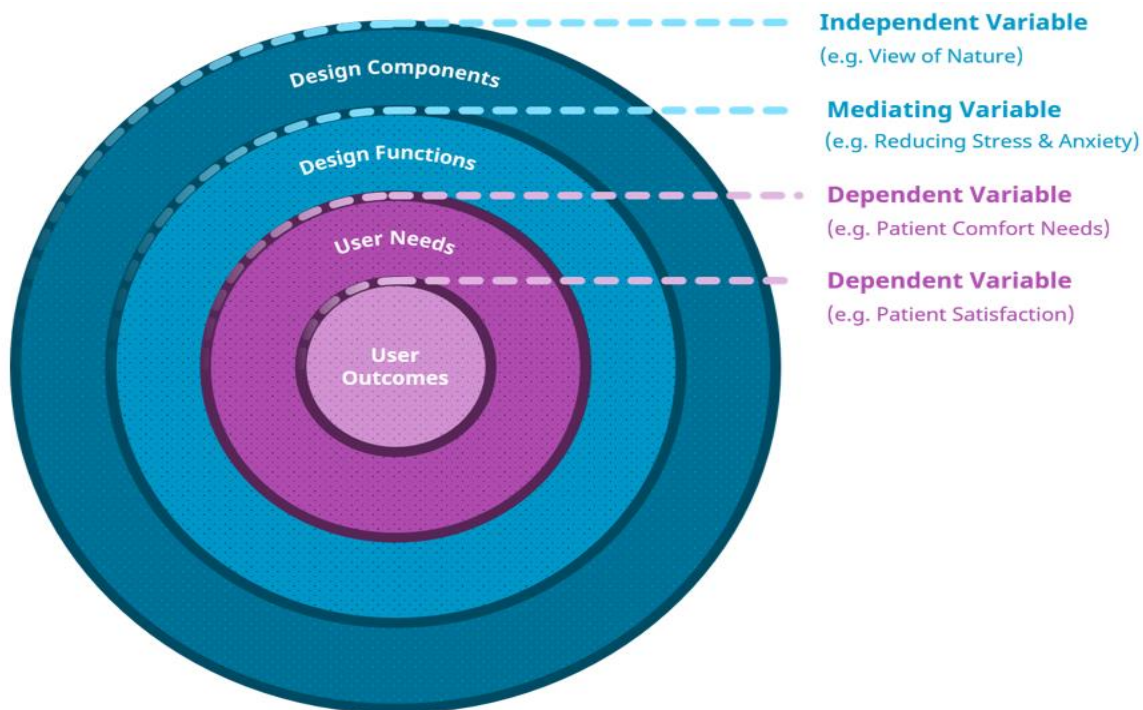
To elaborate, it should be noted that while there are numerous factors of the built environment that are associated to patient falls, it is also true that having family members present in the room has the ability to lessen or eliminate patient falls. Continuing along this line of reasoning, family presence in the room may or may not be related to the built environment, including elements like the room's size and the orientation and arrangement of the furnishings (Huisman et al., 2012).

Given how frequently researchers uncover contradictory relationships between design variables and how little is currently explored and understood in the field of healthcare environmental design, it may be impossible to account for all possible intercorrelations between environmental design variables.

Given the aforementioned interrelationships, it was crucial to develop a conceptual framework that would allow a single design element to have many, varied degrees of effects on various patient requirements and outcomes. As a result, as seen in Figure 23, the conceptual framework for this study is made up of four concentric circles. Design elements (such as Indoor Lighting) and design functions (such as Reducing Stress & Anxiety) were represented by the two outermost circles. The two outermost rings represented user outcomes (such as satisfaction with care) and user needs (such as care needs).

It is thus possible to apply the conceptual framework, which provides a logical visual depiction of the concepts explored inside these theoretical frameworks and illustrates the different relationships between the study's important factors, variables, and patterns. A conceptual framework, as opposed to a theoretical one, is frequently based on both theoretical and empirical writings by authors. It is helpful in assisting a researcher in explicitly formulating an expected link between two or more study variables (Rocco & Plakhotnik, 2009).





**Figure 6** Research Conceptual Framework

The ability of the two outermost circles to rotate around the circles inside of them is the framework's key feature. As a result, one design element, such as indoor lighting, may have multiple purposes, such as lowering stress and anxiety levels and decreasing the likelihood of medical or prescription errors. These functions in turn affect two different needs, such as safety needs and care needs, both of which are necessary for one patient outcome, such as functional status.

Based on the systematic review's findings, the example described above is merely a presumptive effect; nevertheless, the true effect cannot be fully established unless it is assessed using empirical methods.

Based on the main conclusions of the systematic review, Figure 7 depicts the top three conceptual levels of the study with variables filled in. Patient outcomes were not included in this model because there were insufficient data to include them in the framework of the study and because the results of the systematic review on patient outcomes were inconsistent across the board.

Each of the numbered components in the framework above corresponds to a specific design element of the hospital's built environment, which either has one or many effects on the requirements and outcomes of the facility's various users. Additionally, these components are color-coded to signify which design dimension they belong to.

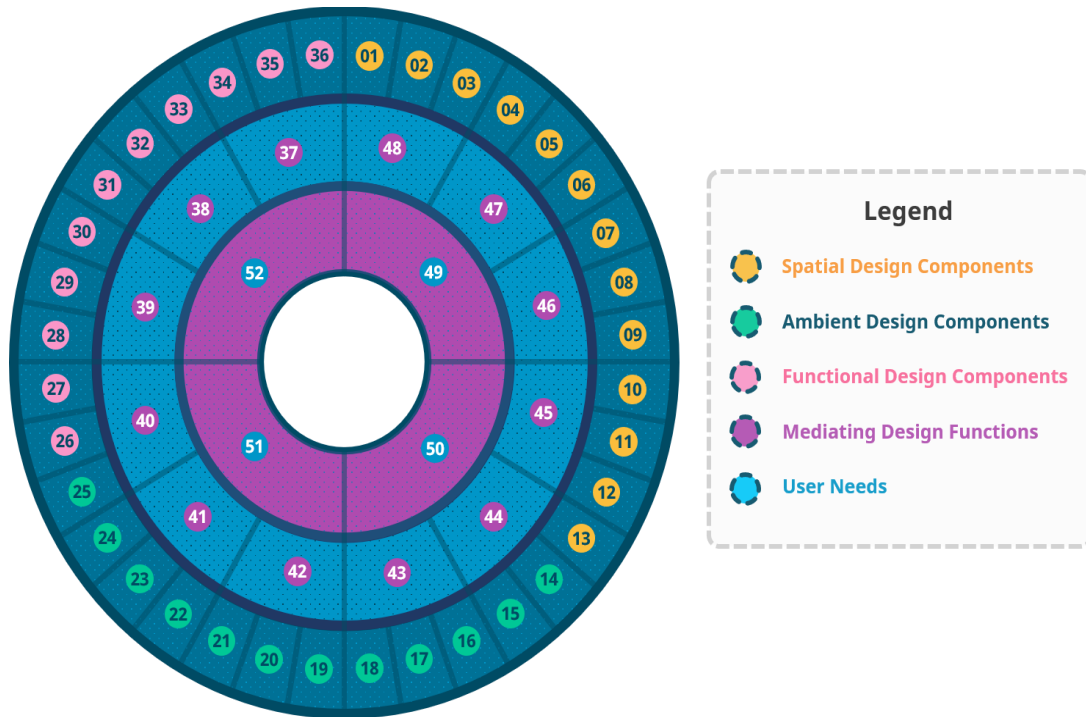


Figure 7 Research Conceptual Framework, Systematic Review Results, Colour-Coded (Dimension)

### Dimension of Space

The physical and quantifiable qualities/characteristics of the physical environment are used to categorize the spatial dimension and include the following:

**Spaciousness:** Describes an area's or an object's actual size and dimensions in terms of height, width, and length.

For instance, the (1) room's size, (2) the couch, and (3) the patient's bed.

**Orientation:** Indicates how two elements of the built environment are oriented with respect to one another.

For instance, (4) the nursing station facing the bed, and (5) the bed facing the door.

**Proximity:** Indicates how close or far apart two elements of the built environment are from one another.

For instance, (6) Bed to Bathroom Proximity, (7) Room to Nursing Station Proximity

**Wayfinding:** This term describes the patient's capacity to discover amenities and move about the area with ease.

For instance, (8) the ward's general accessibility, (9) the use of guiding signage, and (10) the location of stairs and elevators

**Layout:** This term describes the actual positioning and design of building materials.

Example: (11) Standardization of patient rooms; (12) arrangement of seating areas around tables; (13) cluttering of room/pathway

### Ambient Dimension

The non-physical and quantifiable qualities/characteristics, as felt by body senses, are used to categorize the ambient dimension. These consist of:

**Aesthetic Quality:** Describes the overall look, feel, and quality of the environment's elements.

For instance, (14) Carpeted Flooring, (15) Wall Color, and (16) Fabrics for Furniture

**Visual Quality:** Describes the sense of sight experienced by hospital patients, primarily including indoor and outdoor illumination.

For instance, (17) Daylight, and (18) Indoor Lighting

**Acoustic Quality:** The word describes the auditory experience of hospital patients, mostly referring to noise from both internal and external sources.

For instance, items 19 and 20 (indoor noise from equipment or adjacent rooms) and

**Natural Elements:** Describes natural elements, such as water, or the surroundings of those elements.

For instance, (21) Access to an Outdoor Garden, (22) A View from a Window, or (23) Appropriate Artwork

**Indoor/Air/Thermal Quality:** This category describes how well the room is ventilated and heated in general.

For instance, (24), Heating and Ventilation (HVAC), and (25), Hygiene and Cleanliness

### **Functional Dimension**

According to the features, utility, and purposefulness of design elements, the functional dimension is divided into the following categories:

**Accessibility:** Concerns features of room design that improve the user experience for specific user groups. such as (26) Disability Accessible (27) Rooms with Acuity Adjustment

**Facilities/Amenities:** Include the presence and operation of specific environment tools that are connected to the room's actual facilities/amenities.

e.g., (31) Visible Sinks for Handwashing, (32) Communication Tools & Equipment, (33) Entertainment and Recreational Tools, (34) Storage Space Availability & Sufficient, (35) (32) Generally User-Friendly

Option/Control the extent to which users have power and choice over various aspects of an environment, as well as the degree to which these aspects are initially modifiable, are related to this characteristic.

For instance, (33) Control for Opening and Closing the Door; (34) Control for Window Shades; (35) Control for Light Dimmer; (36) Control for Temperature

### **Limitations**

Although the researcher made every effort to take the possibility of bias into account when doing this review, there are still some restrictions. These restrictions mostly resulted from the size of the EBD domain and the fact that most of its applications are still rather recent. Another element that affected the systematic review was subjectivity. Many significant studies were included even though they did not clearly fall under the earlier specified exclusion criteria since they included key works that served as the foundation for later efforts, which required some subjectivity on the part of the researcher to recognize.

### **CONCLUSION**

This systematic review was conducted to adopt a rigorous qualitative review process to identify the most relevant articles discussing the effects of design interventions in healthcare facilities, and their potential effects on patients' and staff members' satisfaction and well-being. The search method was started for this aim by utilizing a number of databases, including Google Scholar, ProQuest, EBSCOhost, SCOPUS, and Springer, among others. The research of how environment design can improve patient safety, comfort, and social needs served as the foundation for the inclusion criteria for the studies. These inclusion criteria were used in the search process, which resulted in the selection of 121 papers from various databases. These papers' data were

mined for information, which was then analyzed. The SLR's findings made it clear that a variety of factors influence patient demands in general. There are three types of design dimensions: spatial, ambient, and

The study's results confirm past studies' conclusions that there is a significant relationship between patient requirements and outcomes and the built environment. Three important design factors—spatial, ambient, and functional—were investigated. It was discovered that each of these factors affected patient demands in several significant design areas, including lighting, flooring, acoustic quality, visual quality, interior quality, and accessibility.

## REFERENCES

- Alzoubi, H. H., & Al-Rqaibat, S. M. (2015). The effect of hospital design on indoor daylight quality in children section in King Abdullah University Hospital, Jordan. *Sustainable Cities and Society*, 14, 449-455. DOI: 10.1016/j.scs.2014.08.008
- Asadi-Lari, M., Tamburini, M., & Gray, D. (2004). Patients' needs, satisfaction, and health related quality of life: Towards a comprehensive model. *Health and Quality of Life Outcomes*, 2(1), 32-47. DOI: 10.1186/1477-7525-2-32
- Barnhart, S. K., Perkins, N. H., & Fitzsimonds, J. (1998). Behaviour and outdoor setting preferences at a psychiatric hospital. *Landscape and Urban Planning*, 42(2-4), 147-156. DOI: 10.1016/S0169-2046(98)00083-8.
- Barry, S., Dalton, R. and Eustace-Cook, J. (2018). Understanding Change in Complex Health Systems – a review of the literature on change management in health and social care 2007-2017, commissioned by Organisation Development and Design Services, Kells, Co Meath, Ireland. Available at: [www.hse.ie/changeguide](http://www.hse.ie/changeguide) and [https://www.tcd.ie/medicine/health\\_policy\\_management/research/Accessing\\_documentation](https://www.tcd.ie/medicine/health_policy_management/research/Accessing_documentation)
- Bayo, M. V., García, A. M., & García, A. (1995). Noise levels in an urban hospital and workers' subjective responses. *Archives of Environmental Health: An International Journal*, 50(3), 247-251. DOI: 10.1080/00039896.1995.9940395
- Becker, F., & Douglass, S. (2008). The Ecology of the Patient Visit. *Journal of Ambulatory Care Management*, 31(2), 128-141. DOI: 10.1097/01.JAC.0000314703.34795.44
- Blomkvist, V., Eriksen, C. A., Theorell, T., Ulrich, R., & Rasmanis, G. (2005). Acoustics and psychosocial environment in intensive coronary care. *Occupational and Environmental Medicine*, 62(3), 1-8. DOI: 10.1136/oem.2004.017632
- Booker, J. M., & Roseman, C. (1995). A seasonal pattern of hospital medication errors in Alaska. *Psychiatry Research*, 57(3), 251-257. DOI: 10.1016/0165-1781(95)02677-O
- Brown, K. K., & Gallant, D. (2006). Impacting patient outcomes through design: Acuity adaptable care/universal room design. *Critical Care Nursing Quarterly*, 29(4), 326-341. DOI: 10.1097/00002727-200610000-00006
- Buchanan, T. L., Barker, K. N., Gibson, J. T., Jiang, B. C., & Pearson, R. E. (1991). Illumination and errors in dispensing. *American Journal of Hospital Pharmacy*, 48(10), 2137-2145. DOI: 10.1093/ajhp/48.10.2137
- Calkins, M. P., Biddle, S., & Biesan, O. (2012). Contribution of the designed environment to fall risk in hospitals. Concord, CA, U.S.: The Center for Health Design, & Ideas Institute. URL: [https://www.healthdesign.org/sites/default/files/fall\\_risks\\_report\\_final.pdf](https://www.healthdesign.org/sites/default/files/fall_risks_report_final.pdf)
- Chaudhury, H. (2005). *The Use of Single Patient Rooms vs. Multiple Occupancy Rooms in Acute Care Environments*. Buranby, Canada: Simon Fraser University. ISBN: 978-0974376325
- Cheek, F. E., Maxwell, R., & Weisman, R. (1971). Carpeting the ward: An exploratory study in environmental psychiatry. *Mental Hygiene*, 55(1), 109-118. ISSN: 0025-9683
- Choi, J. H., Beltran, L. O., & Kim, H. S. (2012). Impacts of indoor daylight environments of patient average length of stay (ALOS) in a healthcare facility. *Building and Environment*, 50(1), 65-75. DOI: 10.1016/j.buildenv.2011.10.010
- Dalke, H., Littlefair, P. J., Loe, D. L., Camgoz, N. (2004). Lighting and Colour for Hospital Design. R&D Report B (01)02. Status in Wales: Information. URL: [http://www.wales.nhs.uk/sites3/Documents/254/B\\_\(01\)02%20Lighting\\_%20and\\_%20colour.pdf](http://www.wales.nhs.uk/sites3/Documents/254/B_(01)02%20Lighting_%20and_%20colour.pdf)
- Douglas, C. H., & Douglas, M. R. (2004). Patient-friendly hospital environments: exploring the patients' perspective. *Health expectations*, 7(1), 61-73.
- Dover, M. A. (2013). Human needs: Overview. In T. Mizrahi & L. E. Davis (Eds.), *Encyclopedia of Social Work*, 20th ed. Oxford, U.K.: Oxford University Press. DOI: 10.1093/acrefore/9780199975839.013.554
- Federman, E. J., Drebing, C. E., Boisvert, C., Penk, W., Binus, G., & Rosenheck, R. (2000). Relationship Between Climate and Psychiatric Inpatient Length of Stay in Veterans Health Administration Hospitals. *American Journal of Psychiatry*, 157(10), 1669–1673. DOI: 10.1176/appi.ajp.157.10.1669
- Fijan, S., & Turk, S. Š. (2012). Hospital Textiles, Are They a Possible Vehicle for Healthcare-Associated Infections? *International Journal of Environmental Research and Public Health*, 9(9), 3330–3343. doi:10.3390/ijerph9093330
- Fijan, S.; Sostar-Turk, S. & Cencic, A. (2005). Potentially pathogenic microorganisms and procedures for hygiene assurance in textile laundries. *Tekstil*, 54, 53-60.
- Hadi, K., Du Bose, J. R., & Choi, Y. S. (2019). The Effect of Light on Sleep and Sleep-Related Physiological Factors Among Patients in Healthcare Facilities: A Systematic Review. *HERD: Health Environments Research & Design Journal*, 12(4), 116-141.

- Han, W. (2012). Health care system reform in developing countries. *Journal of Public Health Research*, e31-e31.
- Heitink, G. (1999). *Practical Theology: History, Theory, Action Domains: Manual for Practical Theology*. Grand Rapids, MI, U.S.: Wm. B. Eerdmans Publishing Co. ISBN 978-0802842947
- Higgins, J. P. T., Thomas J., Chandler J., Cumpston M., Li T., Page M. J., Welch V. A. (Eds.) (2019). *Cochrane Handbook for Systematic Reviews of Interventions* (2nd Ed.). Chichester, U.K.: John Wiley & Sons. URL: <https://training.cochrane.org/handbook>
- Holahan, C. (1972). Seating patterns and patient behavior in an experimental dayroom. *Journal of Abnormal Psychology*, 80(2), 115-124. DOI: 10.1037/h0033404
- Hota, B. (2004). Contamination, disinfection, and cross-colonization: Are hospital surfaces reservoirs for nosocomial infection? *Clin. Infect. Dis.*, 39, 1182–1189.
- Huisman, E. R., Morales, E., van Hoof, J., & Kort, H. S. (2012). Healing environment: A review of the impact of physical environmental factors on users. *Building and Environment*, 58(1), 70-80. DOI: 10.1016/j.buildenv.2012.06.016
- Jonas, W. B., & Chez, R. A. (2004). Toward optimal healing environments in health care. *The Journal of Alternative and Complementary Medicine*, 10(1), 1-6. DOI: 10.1089/acm.2004.10.s-1
- Kachne, A., Kiernan, J., Ridley, J. (2019). Systematic review of study designs and methods in health transition research for young people with intellectual disabilities, Edge Hill University. DOI: 10.1016/j.heliyon.2019.e02750
- King Abdullah University Hospital. (2016). *KAUH Newsletter*. Amman, Jordan: King Abdallah University Hospital. URL: [http://www.kauh.jo/kauh\\_magazine/8.pdf](http://www.kauh.jo/kauh_magazine/8.pdf)
- Krauss, M. J., Tutlam, N., Costantinou, E., Johnson, S., Jackson, D., & Fraser, V. J. (2008). Intervention to Prevent Falls on the Medical Service in a Teaching Hospital. *Infection Control & Hospital Epidemiology*, 29(6), 539–545. DOI: 10.1086/588222
- Kwan, M. A. (2011). Acuity-adaptable nursing care: Exploring its place in designing the future patient room. *HERD: Health Environments Research & Design Journal*, 5(1), 77-93.
- Malkin, J. (2012). The business case for creating a healing environment. In E. Cooper (Ed.), *Business Briefing: Hospital Engineering and Facilities Management*. London, U.K.: Business Briefings Ltd. ISBN: 978-1903150764
- Marjadi, B., & McLaws, M. L. (2010). Hand hygiene in rural Indonesian healthcare workers: barriers beyond sinks, hand rubs and in-service training. *Journal of Hospital Infection*, 76(3), 256-260.
- Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, 50(4), 370-396. DOI: 10.1037/h0054346
- Maslow, A. H. (1971). *The Farther Reaches of Human Nature*. New York, NY, U.S.: Penguin-Arkana. ISBN: 978-0140194708
- Morgan, V. R., Mathison, J. H., Rice, J. C., & Clemmer, D. I. (1985). Hospital falls: A persistent problem. *American Journal of Public Health*, 75(7), 775-777. DOI: 10.2105/AJPH.75.7.775
- Morse, J. M. (1993). Nursing Research on Patient Falls in Health Care Institutions. *Annu Rev Nurs Res*, 11, 299-316.
- O'Halloran, R., Grohn, B., & Worrall, L. (2012). Environmental Factors That Influence Communication for Patients With a Communication Disability in Acute Hospital Stroke Units: A Qualitative Metasynthesis. *Archives of Physical Medicine and Rehabilitation*, 93(1), S77–S85. doi:10.1016/j.apmr.2011.06.039
- Paiva, M. C. M. da S. de, Paiva, S. A. R. de, Berti, H. W., & Campana, Á. O. (2010). Caracterização das quedas de pacientes segundo notificação em boletins de eventos adversos. *Revista Da Escola de Enfermagem Da USP*, 44(1), 134–138. doi:10.1590/s0080-62342010000100019
- Panagopoulou, P., Filioti, J., Petrikkos, G., Giakouppi, P., Anatoliotaki, M., Farmaki, E., Kanta, A., Apostolakou, A. A., Samonis, G., & Roilides, E. (2002). Environmental surveillance of filamentous fungi in three tertiary care hospitals in Greece. *Journal of Hospital Infection*, 52(3), 185-191. DOI: 10.1053/jhin.2002.1298
- Park, S. H., & Mattson, R. H. (2007). Ornamental indoor plants in hospital rooms enhanced health outcomes of patients recovering from surgery. *The Journal of Alternative and Complementary Medicine*, 15(9), 975-980. DOI: 10.1089/acm.2009.0075
- Pati, D., Cason, C., Harvey, T. E., & Evans, J. (2012). An Empirical Examination of Patient Room Handedness in Acute Medical-Surgical Settings. *Health Environments Research & Design Journal*, 4(1), 11–33. DOI: 10.1177/193758671000400103
- Prochansky, H.M., Ittelson, W.H., & Rivlin, L.G. (1970). Freedom of choice and behavior in a physical setting. (Eds.) *Environmental Psychology: Man and His Physical Setting*, New York.
- Quan, X., Joseph, A., Malone, E., & Pati, D. (2011). *Healthcare Environmental Terms and Outcome Measures: An Evidence-Based Design Glossary*. Concord, CA, U.S.: The Center for Health Design. URL: [https://www.healthdesign.org/system/files/chd408\\_researchreportglossary\\_v6\\_final\\_0.pdf](https://www.healthdesign.org/system/files/chd408_researchreportglossary_v6_final_0.pdf)
- Rashid, M. (2013). The Question of Knowledge in Evidence-Based Design for Healthcare Facilities: Limitations and Suggestions. *Health Environments Research & Design Journal*, 6(4), 101–126. DOI: 10.1177/193758671300600407
- Rehn, J., & Schuster, K. (2017). Clinic Design as Placebo—Using Design to Promote Healing and Support Treatments. *Behavioral Sciences*, 7(4), 77.
- Rocco, T. S., & Plakhotnik, M. S. (2009). Literature reviews, conceptual frameworks, and theoretical frameworks: Terms, functions, and distinctions. *Human Resource Development Review*, 8(1), 120-130. DOI: 10.1177/1534484309332617
- Schweitzer, M., Gilpin, L., & Frampton, S. (2004). Healing Spaces: Elements of Environmental Design That Make an Impact on Health. *The Journal of Alternative and Complementary Medicine*, 10(supplement 1), S–71–S–83. doi:10.1089/acm.2004.10.s-71

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- Smedbold, H. T., Ahlen, C., Unimed, S., & Nilsen, A. M. (2002). Relationships between indoor environments and nasal inflammation in nursing personnel. *Archives of Environmental & Occupational Health*, 57(2), 155-161. DOI: 10.1080/00039890209602930
- Steinfeld, E., & Gary, D. (1999). *Enabling Environments: Measuring the Impact of Environment on Disability and Rehabilitation*. Springer.
- Taylor, E., & Card, A. (2018). Single-Occupancy Patient Rooms: A Systematic Review of the Literature Since 2006. *Center for Health Design*, 11(1), 85-100 DO: 10.1177/1937586718755110
- Ulrich, R. S. (1984). View through a window may influence recovery from surgery. *Science*, 224(4647), 420-421. DOI: 10.1126/science.6143402
- Ulrich, R. S. (1991). Effects of interior design on wellness: Theory and recent scientific research. In *Proceedings from the Annual National Symposium on Health Care Interior Design (U.S.)*. *Journal of Healthcare Interior Design*, 3(1), 97-109. ISSN: 1068-11323
- Ulrich, R. S. (1992). How design impacts wellness. *Healthcare Forum Journal*, 35(5), 20-25. ISSN: 0899-9287
- Ulrich, R. S., & Gilpin, L. (2003). Healing arts – Nutrition for the soul. In S. B. Frampton, L. Gilpin, & P. A. Charmel (Eds.), *Putting Patients First: Designing and Practicing Patient-Centered Care*. San Francisco, CA, U.S.: Jossey-Bass. ISBN: 978-0787964122
- Ulrich, R. S., Lundén, O., & Eltinge, J. L. (1993). Effects of exposure to nature and abstract pictures on patients recovering from heart surgery. In the *Thirty-Third Meeting of the Society for Psychophysiological Research*, Rottach-Egern, Germany. *Psychophysiology*, 30(1), 7. DOI: 10.1111/j.1469-8986.1993.tb02377.x
- Ulrich, R. S., Zimring, C., Zhu, X., DuBose, J., Seo, H.-B., Choi, Y.-S., Quan, X., & Joseph, A. (2008). A review of the research literature on evidence-based healthcare design. *Health Environment Research and Design*, 1(3), 61-125 DOI: 10.1177/193758670800100306
- Vassallo, M., Amersey, R. A., Sharma, J. C., & Allen, S. C. (2000). Falls on Integrated Medical Wards. *Gerontology*, 46(3), 158–162. DOI: 10.1159/000022152
- Verderber, S. (1986). Dimensions of person-window transactions in the hospital environment. *Environment and Behavior*, 18(4), 450-466. DOI: 10.1177/0013916586184002
- Walch, J. M., Rabin, B. S., Day, R., Williams, J. N., Choi, K., & Kang, J. D. (2005). The Effect of Sunlight on Postoperative Analgesic Medication Use: A Prospective Study of Patients Undergoing Spinal Surgery. *Psychosomatic Medicine*, 67(1), 156–163. DOI: 10.1097/01.psy.0000149258.42508.70.