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Review

The effects of environmental factors on the patient outcomes in hospital environments: A review of literature

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Abstract This study investigates the evidence supporting the impact of the built environment on the health outcomes for patients within the hospital setting. Improving the hospital environment may potentially impact the lives of millions of patients, patients' family, and staff. Prior research has suggested that the built environment can contribute to positive health outcomes. Reporting the most recent evidence may assist designers in making informed decisions. In this study, a literature review was conducted using the PICO framework within scientific databases and additional hand-searched documents. A total number of 15 articles were included. Effects of each environmental factor on patients' health outcomes were discussed in detail. Environmental factors that affect patient outcomes are (1) form, (2) unit layout, (3) floor material, (4) room features, (5) medical equipment visibility, (6) nature, (7) lighting, and (8) music. Although several studies have provided a high level of evidence, other studies have lacked a robust research design. Thus, evidence regarding several environmental factors is not conclusive. Additional studies using experimental/quasi-experimental research design have been suggested. In some studies, several environmental factors were introduced simultaneously which obscured the separate effects of each environmental factor.

Contents

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1. Introduction

Hospital environments affect large numbers of people in the United States, including patients, their family members, and the hospital staff who care for them (McDermott et al., 2017). Evidence has suggested that patients' psychological state can affect their healing process. For example, a study found that the wounds of patients under stress took 24% longer to heal than the wounds of patients not under stress; this condition increased the hospital stays of these patients (Kiecolt-Glaser et al., 1995). This result is important because short hospital stays have various benefits, including increased patient satisfaction and decreased healthcare costs. Several scholars have emphasized the importance of patients' environments to their health outcomes, and empirical evidence supports these benefits.

Several theoretical frameworks, including restoration theory (Kaplan and Kaplan, 1989), positive distraction, supportive design (Ulrich, 2001), and biophilic theory (Ulrich and Gilpin, 2003), can be used to explain how patients' environments can improve their outcomes. According to Ulrich's (2001) theory of supportive design, a supportive environment can improve patients' healing process and provide other positive outcomes in reducing patients' stress. This article reviews empirical evidence for the effects of environmental factors on patient outcomes.

Table 1 PICO search model.

P	Patient or Problem	Inpatient
I	Intervention	Environment
C	Comparison Intervention (if necessary)	NA
O	Outcomes	Patient Outcome, Patient Experience

The review seeks to answer the question, "Which environmental factors contribute to positive patient outcomes and improve patients' experiences in hospital environments?".

2. Methods

The search was limited to scholarly publications written in English and published between 2008 and 2017; 2008 was chosen as the starting point to ensure that the search would include only articles published after the literature review conducted by Ulrich et al. (2008). Two databases (MEDLINE and CINAHL) and one journal (Health Environments Research and Design Journal) were searched. The PICO search model (Table 1) was used to form the search formula, and the keywords searched were chosen from among the keywords prepopulated by each database (e.g., "MeSH" for MEDLINE) (Table 2). Additional articles were identified by reviewing the reference lists of articles identified in the initial search and via a hand search. The search strategy followed the preferred reporting items for systematic reviews and meta-analysis (PRISMA) model (Fig. 1).

All articles included in this study met the following criteria: (1) they were empirical, quantitative studies written in English and published between 2008 and 2017, (2) they investigated the impact of patients' physical environments on their health outcomes, (3) they described studies conducted in healthcare environments, and (4) they were of sufficient quality to fall into level 2 or 3a of Stichler's (2010) model. In this review, "patient outcomes" refer to patients' physiological states, pain, lengths of stay, sleep, stress, anxiety, fear, satisfaction, and interaction.

The relevance of each article was evaluated in three steps: 1) a review of its title, 2) a review of its abstract, and 3) a review of its full text. Each article judged to be relevant and included in the final list was evaluated for its level of evidence using the criteria adapted from Stichler (2010) (Table 3). The search, analysis, and synthesis were conducted from October 2017 to January 2018 by a team of environmental design researchers.

3. Results

A total of 15 articles satisfied the inclusion criteria. Fig. 1 is a graphical representation of the search process. As a result of the search, eight classes of patient outcomes were identified: physiological state, pain, length of stay, sleep, stress, anxiety, fear, and patient experience. Table 4 lists the included articles by the class of patient outcome. The following narrative synthesizes the key components and findings of each study and includes a table for each class of patient outcome. It is divided among subheadings for the classes of patient outcomes and the aspects of patients' physical environments that affect those outcomes.

3.1. Physiological states

Three level 2 studies (Park and Mattson, 2009; Pati et al., 2016a; Cutshall et al., 2011) investigated the effects of nature and music on the physiological states of patients (Table 5).

3.1.1. Nature—physiological states

One level 2 study (Park and Mattson, 2009) measured the physiological states of 90 surgical patients to determine the effects of indoor plants on patient outcomes. Although the patients in the experimental group had lower systolic blood pressures, no significant differences were observed for heart rate, temperature, respiratory rate, and diastolic blood pressure (Park and Mattson, 2009). In another level 2 experimental study (Pati et al., 2016a), the impact of a ceiling fixture featuring a photograph of the sky on patients was investigated. Given that patients spend most of their time in bed, the authors suggested that placing a natural image on the ceiling would be a logical intervention. Surprisingly, the authors found that the patients in the experimental group had higher systolic blood pressure than the other group. However, this difference was statistically insignificant. This inconsistency may have been caused by differences in the acuity levels of the subjects in experimental and control groups (Pati et al., 2016a).

3.1.2. Music—physiological states

The results of another level 2 study (Cutshall et al., 2011) suggested that music can reduce diastolic blood pressure.

3.2. Pain

Patients' pain is influenced by the following environmental factors: nature, music, natural light, and artificial ambient

Table 2 Example of the Formula used to Search MEDLINE based on MeSH.

Population	(MM "Patients") OR (MM "Inpatients")
Intervention	(MM "Environment") OR (MM "Environment Design") OR (MM "Interior Design and Furnishings") OR (MM "Patients' Rooms") OR (MM "Health Facility Environment") OR (MM "Hospitals") OR (MM "Architecture as Topic")
Outcome	(MM "Pain") OR (MM "Anxiety") OR (MM "Fear") OR (MM "Blood Pressure") OR (MM "Heart Rate") OR (MM "Sleep") OR (MM "Stress, Psychological") OR (MM "Depression") OR (MM "Length of Stay") OR (MM "Privacy") OR (MM "Social Support") OR (MM "Patient Satisfaction")

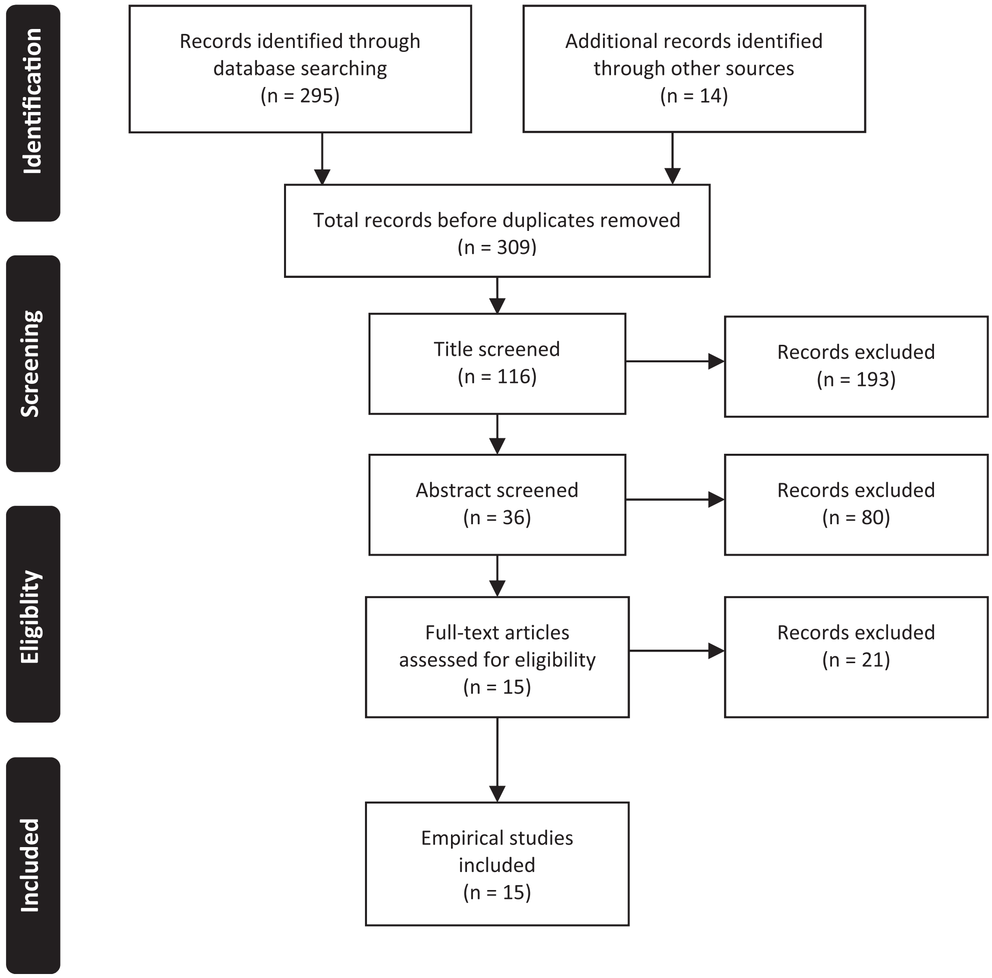

Figure 1 Graphical Representation of the Literature Review Search Process based on Moher et al. (2009).

light. The results of four level 2 studies (Park and Mattson, 2009; Pati et al., 2016a; Shepley et al., 2012; Cutshall et al., 2011) and two level 3a studies (Robinson and Green, 2015; Vincent et al., 2010) into the effects of environmental factors on pain are reported below (Table 6).

3.2.1. Nature—pain

In a level 2 study, Park and Mattson (2009) investigated the effects of indoor plants on patient outcomes. They found that the patients exposed to plants took fewer analgesics than the control group. However, this difference was statistically insignificant. The patients exposed to plants reported significantly lower pain intensities and pain distress than the control group (Park and Mattson, 2009).

Several other studies have found evidence that even images of nature can affect patient outcomes (Diette et al., 2003; Vincent et al., 2010). For example, a level 2 experimental study (Pati et al., 2016a) investigated the impact on patient outcomes of a ceiling fixture featuring a photograph of the sky. Surprisingly, the authors found that the patients in the experimental group took more analgesics than the other group. However, the experimental group reported less pain (measured by Face Scale) than the other group. Nevertheless, this difference was statistically insignificant. This inconsistency may have been caused by differences in the acuity levels of the subjects (Pati et al., 2016a).

One study used behavioral and physiological indicators to identify the image types that mostly affect pain. In this level 3a study, Vincent et al. (2010) exposed subjects to one of the image types determined on the basis of Appleton's prospect—refuge theory (1996). They found that the participants who were exposed to images in the mixed-prospect and refuge-image categories reported experiencing less pain. According to Appleton (1996), a prospect image presents a landscape that allows a person to survey their environment (from a higher level), and a refuge image presents a place suitable for hiding (Vincent et al., 2010).

3.2.2. Natural light—pain

In a level 2 study, patient pain levels in two ICUs with different natural light levels were compared; the results showed that increased natural light levels reduced pain perception, but this difference was statistically insignificant (Shepley et al., 2012).

3.2.3. Artificial light—pain

Artificial light can be used as a decorative environmental feature that acts as a positive distraction. In a level 3a study, Robinson and Green (2015) compared a new

Table 3 Levels of Evidence for Healthcare Design adapted from Stichler (2010).

Level	Description	Included
1	Systematic reviews of multiple randomized controlled trials (RCTs) or nonrandomized studies; meta-analysis of multiple experimental or quasi-experimental studies; meta-synthesis of multiple qualitative studies leading to an integrative interpretation	No
2	Well-designed experimental (randomized) and quasi-experimental (nonrandomized) studies with consistent results compared to other, similar studies	Yes
3a	Observational studies, descriptive correlational studies, or RCT or quasi-experimental studies that do not fulfill the criteria of Level 2	Yes
3b	Qualitative studies, integrative, or systematic reviews of correlational or qualitative studies	No
4	Peer-reviewed professional standards or guidelines with studies to support recommendations	No
5	Opinion of recognized experts, multiple case studies	No
6	Recommendations from manufacturers or consultants who may have a financial interest or bias	No

pediatric emergency department (ED) that featured ambient light, overhead lighting that cycled through a spectrum of colors, and wall-mounted LED screens to an older ED that did not share these features. They found that the patients in the new ED reported experiencing less pain than the patients in the older ED. However, the two EDs differed from each other in various ways. Thus, the individual effect of a given difference was difficult to determine.

3.2.4. Music—pain

In a level 2 experimental study, Cutshall et al. (2011) found that a group of subjects exposed to music reported experiencing less pain than the control group. The experimental group also took fewer analgesics than the control group. However, this difference was statistically insignificant.

3.3. Length of stay

Four level 2 studies (Park and Mattson, 2009; Pati et al., 2016a; Shepley et al., 2012; Leaf et al., 2010) investigated the effects on length of stay of three environmental factors: nature, natural light, and level of visibility (Table 7).

Table 4 Categorized List of Articles based on Patient Outcome/Experience and Environmental Factors.

Patient Outcomes	Environmental Factors	Citations
Physiological State	Nature, Music	(Pati et al., 2016a; Cutshall et al., 2011; Park and Mattson, 2009)
Pain	Nature, Music, Natural Light, Artificial Ambient Light	(Pati et al., 2016a; Robinson and Green, 2015; Shepley et al., 2012; Cutshall et al., 2011; Vincent et al., 2010; Park and Mattson, 2009)
Length of Stay	Nature, Natural Light, Level of Visibility	(Pati et al., 2016a; Shepley et al., 2012; Leaf et al., 2010; Park and Mattson, 2009)
Sleep	Nature	Pati et al. (2016a)
Stress	Nature, Room Features, Equipment Visibility	(Andrade et al., 2017; Pati et al., 2016a; Tanja-Dijkstra, 2011)
Anxiety	Nature, Music, Artificial Ambient Light	(Pati et al., 2016a; Robinson and Green, 2015; Cutshall et al., 2011; Park and Mattson, 2009)
Fear	Form, Artificial Ambient Light	(Pati et al., 2016b; Robinson and Green, 2015)
Patient Satisfaction	Nature, Music, Equipment Visibility, Floor Material, Artificial Ambient Light	(Pati et al., 2016a; Robinson and Green, 2015; Harris, 2015; Cutshall et al., 2011; Tanja-Dijkstra, 2011; Park and Mattson, 2009)
Interaction	Room Brightness, Unit Layout, Room Feature	(Andrade et al., 2017; Rippin et al., 2015; Choi and Bosch, 2013; Okken et al., 2013)

Table 5 Physiological states and environmental factors.

Category	Citation	Setting	Participants	Study Design	Intervention	Outcome	Level
Nature	Park and Mattson (2009)	Surgical unit	Surgical patients, n = 90 (males, n = 43; females, n = 47; mean age = 47 ± 9.38)	Experimental	Indoor plant	↔ Heart rate ↔ Temperature ↔ Respiratory rate ↔ Diastolic blood pressure ↓ Systolic blood pressure ($p = 0.03$)	2
	Pati et al. (2016a)	Surgical unit	Surgical patients, n = 100 (mean age: Exp. G. = 56.86; C.G. = 57.83)	Experimental	Image of nature	↑ Diastolic blood pressure ($p = 0.01$) ↑ Systolic blood pressure [NS]	2
Music	Cutshall et al. (2011)	Cardiovascular surgical unit	Patients, n = 100 (mean age: Exp. G. = 65.6; C.G. = 60.2)	Experimental	Music	↓ Diastolic blood pressure ($p = 0.047$)	2

Note: ↑ = increase, ↓ = decrease, ↔ = no change, NS = not statistically significant, Exp. G. = Experimental group, C.G. = Control group.

3.3.1. Nature—length of stay

In a level 2 study, Park and Mattson (2009) found that the patients who stayed in rooms with indoor plants discharged sooner than the patients who stayed in rooms without ornamental indoor plants. However, this difference was statistically insignificant. Another level 2 study examined the effects of nature images on length of stay. In this experimental study, Pati et al. (2016a) exposed patients to a photograph of the sky mounted on the ceiling. The results from the posthoc analysis revealed that the patients in the experimental group had lesser lengths of stay. However, this difference was statistically insignificant.

3.3.2. Natural light—length of stay

In a level 2 study, the lengths of stay of patients in two ICUs with different light levels were compared; the results showed that natural light did not affect the length of stay (Shepley et al., 2012).

3.3.3. Level of visibility—length of stay

In a retrospective study, Leaf et al. (2010) found no correlation between the visibility of patients from the central nurses' station and patients' length of stay.

3.4. Sleep

3.4.1. Nature images—sleep

One level 2 study (Pati et al., 2016a) examined the effects of nature images on sleep. In this experimental study, Pati et al. (2016a) exposed patients to a photograph of the sky mounted on the ceiling. The patients in the experimental group had lower sleep quality and took more sleep medication than the other group. This result was inconsistent with the hypothesis. Given that the level of acuity was not measured, additional studies are needed to control for the effect of the level of acuity (Table 8).

3.5. Stress

Two level 2 studies (Pati et al., 2016a; Tanja-Dijkstra, 2011) and one level 3a study (Andrade et al., 2017) suggested that patients' stress levels were affected by the following environmental factors: nature, features of their rooms, and the visibility of medical equipment (Table 9).

3.5.1. Nature—stress

Pati et al. (2016a) found that the average acute stress reported by patients exposed to a photograph of the sky was 53.4% lower than that reported by patients in the control group. According to the authors, this result suggests that exposing patients to natural images that are mounted on the ceiling can reduce their acute stress.

3.5.2. Features of rooms—stress

On the basis of the theory of supportive design (Ulrich, 2001), Andrade et al. (2017) examined the influence of the number of room features, such as TV, painting and art, view, and window, on the stress levels that patients reported. They found that the stress level of a patient decreased as the number of favorable elements in the patient's room increased.

Table 6 Pain and environmental factors.

Category	Citation	Setting	Participants	Study Design	Intervention	Outcome	Level
Nature	Park and Mattson (2009)	Surgical unit	Surgical patients, n = 90 (males, n = 43; females, n = 47; mean age = 47 ± 9.38)	Experimental	Indoor plant	↓ Pain intensity (p = 0.045) ↓ Analgesic intake [NS]	2
	Vincent et al. (2010)	Simulated patient room	Healthy people, n = 109 (males, n = 53; females, n = 56; mean age = 21.50)	Experimental	Image of nature	↓ Pain (p = 0.03)	3a
	Pati et al. (2016a)	Surgical unit	Surgical patients, n = 100 (mean age: Exp. G. = 56.86; C.G. = 57.83)	Experimental	Image of nature	↑ Pain medication ↓ Pain (face scale) [NS]	2
Music	Cutshall et al. (2011)	Cardiovascular surgical unit	Surgical patients, n = 100 (mean age: Exp. G. = 65.6; C.G. = 60.2)	Experimental	Music	↓ Pain (p = 0.001) ↓ Pain medication [NS]	2
Natural Light	Shepley et al. (2012)	ICU	ICU patients, n = 110 (mean age: Group 1 = 66.6; Group 2 = 63)	Quasi-experimental	Natural light intensity	↓ Pain [NS]	2
Artificial Ambient Light	Robinson and Green (2015)	Pediatric ED	Patient + accompany adults, n = 70 (patients mean age: Exp. G. = 4.45; C.G. = 7.82)	Quasi-experimental	Lighting as a positive distraction	↓ Pain (p = 0.049) ↓ Pain medication [NS]	3a

Note: ↑ = increase, ↓ = decrease, ↔ = no change, NS = not statistically significant, Exp. G. = Experimental group, C.G. = Control group.

Table 7 Length of stay and environmental factors.

Category	Citation	Setting	Participants	Study Design	Intervention	Outcome	Level
Nature	Park and Mattson (2009)	Surgical unit	Surgical patients, n = 90 (males, n = 43; females, n = 47; mean age = 47 ± 9.38)	Experimental	Indoor plant	↓ Length of stay [NS]	2
	Pati et al. (2016a)	Surgical unit	Surgical patients, n = 100 (mean age: experimental group = 56.86; control group = 57.83)	Experimental	Image of nature	↓ Length of stay [NS]	2
Natural Light	Shepley et al. (2012)	ICU	ICU patients, n = 110 (mean age: Group 1 = 66.6; Group 2 = 63)	Quasi-experimental	Natural light intensity	↔ Length of stay	2
Level of Visibility	Leaf et al. (2010)	ICU	Patients, n = 664 (mean age = 60.2 ± 17.4)	Quasi-experimental	High visibility (vs. low visibility)	↔ Length of stay	2

Note: ↑ = increase, ↓ = decrease, ↔ = no change, NS = not statistically significant, Exp. G. = Experimental group, C.G. = Control group.

Table 8 Sleep and environmental factors.

Category	Citation	Setting	Participants	Study Design	Intervention	Outcome	Level
Nature	Pati et al. (2016a)	Surgical unit	Surgical patients, n = 100(mean age: experimental group = 56.86; control group = 57.83)	Experimental	Image of nature	↓ Sleep quality (Face Scale) ↑ Sleep medication	2

Note: ↑ = increase, ↓ = decrease, ↔ = no change, NS = not statistically significant, Exp. G. = Experimental group, C.G. = Control group.

Table 9 Stress and environmental factors.

Category	Citation	Setting	Participants	Study Design	Intervention	Outcome	Level
Nature	Pati et al. (2016a)	Surgical unit	Surgical patients, n = 100 (mean age: experimental group = 56.86; control group = 57.83)	Experimental	Image of nature	↓ Acute stress ($p = 0.00$)	2
Room Features	Andrade et al. (2017)	Hospital	Surgical patients, n = 187	Observational — Cross-sectional	Increase in the number of room features	↓ Stress ($p < 0.001$)	3a
Equipment Visibility	Tanja-Dijkstra (2011)	Simulated patient room	Healthy people, n = 42 (mean age = 21.3)	Experimental	Medical equipment visibility	↑ Stress ($p < 0.05$)	2

Note: ↑ = increase, ↓ = decrease, ↔ = no change, NS = not statistically significant, Exp. G. = Experimental group, C.G. = Control group.

3.5.3. Visibility of medical equipment—stress

Various tubes, wires, and equipment are present at patients' bedsides. Tanja-Dijkstra (2011) examined the influence of the visibility of medical equipment on patients' stress levels. First, the participants were asked to imagine that they were hospitalized after surgery. Then, the stress levels of the participants were measured after they were exposed to photos of two different patient rooms: one with visible medical equipment, and the other without it. The results revealed that the participants experienced less stress when the medical equipment was not visible. However, this study was limited by that the participants were not actual patients.

3.6. Anxiety

Three level 2 studies (Park and Mattson, 2009; Pati et al., 2016a; Cutshall et al., 2011) and one level 3a study (Robinson and Green, 2015) partially examined the effects of three environmental factors, namely, nature, music, and artificial ambient light, on patients' anxiety levels (Table 10).

3.6.1. Nature—anxiety

Park and Mattson (2009) investigated the effects of indoor plants on patient outcomes. They found that patients who were exposed to the plants during their recovery periods reported levels of anxiety that were lower to a statistically significant level than those reported by the patients in the control group (Park and Mattson, 2009).

In a level 2 study, Pati et al. (2016a) exposed patients to a photograph of the sky mounted on the ceiling. They measured the patients' anxiety levels using the state trait anxiety inventory for adults. The results revealed that the average anxiety level of the patients in the experimental group was 34.79% lower than that of the patients in the control group.

3.6.2. Music—anxiety

In an experimental study, Cutshall et al. (2011) exposed cardiovascular patients to music twice each day and measured their levels of anxiety. They found that the anxiety levels of the patients in the intervention group were lower than those of the patients in the control group. However, this difference was statistically insignificant.

3.6.3. Artificial ambient light—anxiety

Robinson and Green (2015) investigated the effect of artificial ambient light on anxiety, but their study incorporated too many variables for this effect to be clearly determined. They found that the parents of patients in a new pediatric ED reported less anxiety than the parents of patients in an older ED. However, the new ED differed from the older ED in various ways, including the addition of ambient light, LED screens, and overhead colorful lighting.

3.7. Fear

Two studies investigated the effects of two different environmental factors on patient fear. A level 2 study (Pati et al., 2016b) examined the effect of interior form on patient fear, and a level 3a study (Robinson and Green, 2015)

Table 10 Anxiety and environmental factors.

Category	Citation	Setting	Participants	Study Design	Intervention	Outcome	Level
Nature	Park and Mattson (2009)	Surgical unit	Surgical patients, n = 90 (males, n = 43; females, n = 47; mean age = 47 ± 9.38)	Experimental	Indoor plant	↓ Anxiety (p = 0.02)	2
	Pati et al. (2016a)	Surgical unit	Surgical patients, n = 100 (mean age: experimental group = 56.86; control group = 57.83)	Experimental	Image of nature	↓ Anxiety (p = 0.04)	2
Music	Cutshall et al. (2011)	Cardiovascular surgical unit	Surgical patients, n = 100 (mean age: Exp. G. = 65.6; C.G. = 60.2)	Experimental	Music	↓ Anxiety [NS]	2
Artificial Ambient Light	Robinson and Green (2015)	Pediatric ED	Patient + accompany adults, n = 70(patients mean age: Exp. G. = 4.45; C.G. = 7.82)	Quasi-experimental	Lighting as positive distraction	↓ Anxiety (p = 0.031)	3a

Note: ↑ = increase, ↓ = decrease, ↔ = no change, NS = not statistically significant, Exp. G. = Experimental group, C.G. = Control group.

Table 11 Fear and environmental factors.

Category	Citation	Setting	Participants	Study Design	Intervention	Outcome	Level
Form	Pati et al. (2016b).	Lab (Hospital)	Healthy people, n = 36	Experimental	Interior curved forms	↑ Fear	2
Artificial Ambient Light	Robinson and Green (2015)	Pediatric ED	Patient + accompany adults, n = 70(patients mean age: Exp. G. = 4.45; C.G. = 7.82)	Quasi-experimental	Lighting as positive distraction	↓ Feeling scared ($p = 0.031$)	3a

Note: ↑ = increase, ↓ = decrease, ↔ = no change, NS = not statistically significant, Exp. G. = Experimental group, C.G. = Control group.

explored the effect of ambient artificial light on patient fear (Table 11).

3.7.1. Interior form—patient fear

Empirical evidence has suggested that interiors with different forms can trigger different emotions. In a level 2 study, Pati, et al. (2016b) used fMRI to determine the effects of two kinds of interior forms on the brain activity of 36 participants. The participants were exposed to several images featuring either sharp or curved contours and asked to indicate whether they liked or disliked each image. As they did, their brain activity was captured via fMRI. The results revealed that, although the subjects preferred images featuring curved contours, the amygdala, which is associated with fear, was highly active while they viewed these images. This result suggests that hospitals with curved interior forms can generate fear responses in patients (Pati et al., 2016b).

3.7.2. Ambient artificial light—fear

In a level 3a study, Robinson and Green (2015) used a questionnaire to compare the emotional states of the parents (or accompanying adults) of children in two pediatric EDs. The newer ED featured ambient lighting, overhead colorful lighting, and LED screens, whereas the older ED did not. The results revealed that the parents of the children in the new ED reported fewer negative emotions (including feeling scared) than the parents of the children in the older ED.

3.8. Patient experience

Patient's experience can be divided into two categories: patient satisfaction and interaction. The results of four level 2 studies (Park and Mattson, 2009; Pati et al., 2016a; Cutshall et al., 2011; Tanja-Dijkstra, 2011) and two level 3a studies (Harris, 2015; Robinson and Green, 2015) suggested that patient satisfaction was affected by the following environmental factors: nature, music, the visibility of medical equipment, floor material, and ambient artificial light (Table 12).

3.8.1. Patient satisfaction

3.8.1.1. Nature—patient satisfaction. In a level 2 study, Park and Mattson (2009) found that the patients who stayed in rooms with plants were more satisfied with their rooms than the patients who stayed in rooms without plants. In another level 2 study, Pati et al. (2016a) found that the patients who stayed in rooms with a nature image on the ceiling reported being 12.4% more satisfied with their environments than the patients who stayed in rooms without a nature image on the ceiling.

3.8.1.2. Music—patient satisfaction. In a level 2 study, Cutshall et al. (2011) found that music could increase patient satisfaction. In this study, a group of surgical patients was exposed to music for 20 min twice each day. The results revealed that the patients who were exposed to music were more satisfied than the patients who were not exposed to music. However, this difference was statistically insignificant.

3.8.1.3. Visibility of medical equipment—patient satisfaction. Tanja-Dijkstra (2011) investigated the

Table 12 Patient satisfaction and environmental factors.

Category	Citation	Setting	Participants	Study Design	Intervention	Outcome	Level
Nature	Park and Mattson (2009)	Surgical unit	Surgical patients, n = 90 (males, n = 43; females, n = 47; mean age = 47 ± 9.38)	Experimental	Indoor plant	↑ Satisfaction ($p < 0.05$)	2
	Pati et al. (2016a)	Surgical unit	Surgical patients, n = 100 (mean age: experimental group = 56.86; control group = 57.83)	Experimental	Image of nature	↑ Satisfaction ($p = 0.03$)	2
Music	Cutshall et al. (2011)	Cardiovascular surgical unit	Surgical patients, n = 100 (mean age: Exp. G. = 65.6; C.G. = 60.2)	Experimental	Music	↑ Satisfaction [NS]	2
Equipment Visibility	Tanja-Dijkstra (2011)	Simulated patient room	Healthy people, n = 42 (mean age = 21.3)	Experimental	Medical equipment visibility	↓ Trust to healthcare providers ($p < 0.05$)	2
Floor material	Harris (2015)	Unit corridor	Staff, patients	Quasi-experimental	carpet tile (vs. terrazzo, rubber)	↑ Satisfaction [NS]	3a
Artificial Ambient Light	Robinson and Green (2015)	Pediatric ED	Patient + accompany adults, n = 70 (patients mean age: Exp. G. = 4.45; C.G. = 7.82)	Quasi-experimental	Lighting as positive distraction	↑ Satisfaction with care	3a

Note: ↑ = increase, ↓ = decrease, ↔ = no change, NS = not statistically significant, Exp. G. = Experimental group, C.G. = Control group.

Table 13 Interaction and environmental factors.

Category	Citation	Setting	Participants	Study Design	Intervention	Outcome	Level
Room Brightness	Okken et al. (2013)	Simulated exam room	Healthy participants, n = 90 (mean age = 20.94)	Quasi-experimental	Room brightness, Threatening scenario	↑ Self-disclosure intention ($p = 0.039$)	2
Room's Feature	Andrade et al. (2017)	Hospital	Surgical patients, n = 187 (mean age: US subjects = 65.85; Portuguese subjects = 56.61)	Observational – Cross-sectional	Increase in the number of room features	↑ Social support ($p < 0.001$)	3a
Unit Layout	Rippin et al. (2015)	Neuro ICU	Patients, family, staff	Observational-Comparative	Family-centered design	↑ Family-staff interaction	3a
	Choi and Bosch (2013)	ICU	Patients, n = 81	Quasi-experimental	Patient centric (vs. traditional)	↑ Patient-family interaction ($p < 0.01$)	2

Note: ↑ = increase, ↓ = decrease, ↔ = no change, NS = not statistically significant, Exp. G. = Experimental group, C.G. = Control group.

effects of visibility of medical equipment on patients' trust. In this study, two groups of participants were exposed to images of two types of patient rooms: one where medical equipment was visible, and the other where the medical equipment was hidden. The results revealed that the participants who were exposed to the images of rooms where the medical equipment was hidden reported more trust in the healthcare provider than the other group (Tanja-Dijkstra, 2011).

3.8.1.4. Floor material—patient satisfaction. In a level 3a study, Harris (2015) examined the effects on patient satisfaction of three types of flooring: terrazzo, rubber, and carpet tile. Each of these materials was installed for three months in a corridor of a hospital unit. Patient satisfaction was measured using the Hospital Consumer Assessment of Healthcare Providers and Systems. The results revealed that the patients were most satisfied when the carpet tiles were installed. However, this difference was statistically insignificant.

3.8.1.5. Ambient artificial light—patient satisfaction. Artificial light can increase patients' satisfaction. In a level 3a study, Robinson and Green (2015) compared the satisfaction of patients in a new pediatric ED featuring ambient light, overhead lighting that cycled through a spectrum of colors, and wall-mounted LED screens to the satisfaction of patients in an older ED without these features. The results revealed that the patients in the new ED reported higher levels of satisfaction with care on several measures than the other group (statistically insignificant).

3.8.2. Interaction

Two level 2 studies (Okken et al., 2013; Choi and Bosch, 2013) and two level 3a studies (Andrade et al., 2017; Rippin et al., 2015) investigated three forms of interaction: patient—doctor interaction, patient—family interaction, and family—staff interaction (Table 13).

3.8.2.1. Room brightness and patient—doctor interaction. In a level 2 study, Okken et al. (2013) found that room brightness could affect patient self-disclosure intention. They presented 90 participants with either a "low threatening" scenario or a "high threatening" scenario. Next, they presented the participants with one of two photographs of a consultation room, one of which was brighter than the other. Finally, they asked the participants to complete a questionnaire designed to measure intended self-disclosure. They found that, among the participants who were presented with the high threatening scenario, those who were shown brighter consultation rooms had higher scores for self-disclosure intention.

3.8.2.2. Features of patients' rooms and patient—family interaction. Empirical evidence has shown that the design of a hospital environment affects patient—family interaction and social support (Choi and Bosch, 2013; Rippin et al., 2015). In a level 2 study, Choi and Bosch (2013) compared two ICU facilities with different designs. They found that the patients in an ICU with a patient-centric design spent more time with their families than those in the other group. Therefore, ICUs with patient-centric designs provide large opportunities for patient—family interaction. In a level 3a study, Andrade et al. (2017) investigated the effects of various features of patients' rooms, such as TV, art, large window, and view, on patients' perceptions of the possibility of social support. They found a positive relationship between the number of favorable elements in patients' room and perceptions of the possibility of social support.

3.8.2.3. Unit layout and family—staff interaction. Although family involvement in the care process can be beneficial, family members can increase nurses' stress by interrupting them. In a level 3a study by Rippin et al. (2015), large family—staff interactions were observed in the unit designed to support family involvement. However, nurses complained that family needs can interrupt caregiving and can thus delay treatment and decrease its efficacy.

4. Conclusions and limitations

The effects of nature have been investigated most frequently, and several theories (e.g., positive distraction and biophilic theory) offer explanations of these effects. The results of several studies have collectively suggested that different manifestations of nature, such as a view of nature from a window, images of nature, and indoor plants, can positively affect patients' outcomes, including decreased pain, anxiety, and depression of patients and their lengths of stay.

Several environmental factors, including the form and layout of a unit and visibility of patients, are fundamental architectural features. Decisions concerning these components are made at the very beginning of the design process. Unfortunately, too few studies have examined these fundamental architectural features. Given that subjective measures may not yield robust evidence, objective measures and methods are suggested. In addition, considering that several studies have used participants who were not actual patients, which can affect results, studies using real patients are recommended.

One limitation of studying patients in hospital settings is that controlling all of the relevant variables can be difficult. When too many variables in a hospital setting are available and thus cannot be controlled effectively, changes in policies or operational procedures instituted during experiments can affect the results. This limitation can compromise the results of studies that compare two settings (e.g., an old ICU and a new ICU).

This study has several limitations. First, this study attempts to update the review conducted by Ulrich et al. (2008). However, the former review has included literature on patient safety and staff outcomes, but the current review does not. Second, this review excludes articles published before 2008. A review of Ulrich et al. (2008) is recommended to obtain a complete picture of the literature. Third, given that the purpose of this review is to report studies of the highest quality, it includes only studies with scores of 2 and 3a on the evidence scale and does not include literature reviews, qualitative studies, and expert opinions.

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