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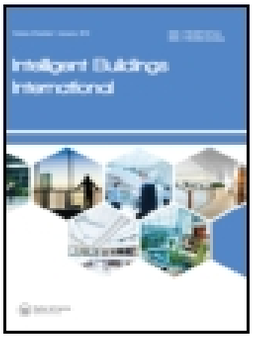
DOI
10.1080/17508975.2019.1613218

Publication date
2019

Document Version
Final published version

Published in
Intelligent Buildings International



Intelligent Buildings International

ISSN: 1750-8975 (Print) 1756-6932 (Online) Journal homepage: https://www.tandfonline.com/loi/tibi20

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To cite this article: AnneMarie Eijkelenboom & Philomena M. Bluyssen (2019): Comfort and health of patients and staff, related to the physical environment of different departments in hospitals: a literature review, Intelligent Buildings International, DOI: 10.1080/17508975.2019.1613218

To link to this article: https://doi.org/10.1080/17508975.2019.1613218

Intelligent Buildings International
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Comfort and health of patients and staff, related to the physical environment of different departments in hospitals: a literature review

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ABSTRACT
Due to the increasing demand for healthcare and the large impact on the finance of hospital buildings in the near future, study is needed on aspects that affect health and comfort of patients and staff in hospitals. Therefore, a literature review was performed on studies related to specific hospital departments and occupant groups, in order to contribute to a better understanding of relations of comfort and health indicators and the physical environment. Differences in comfort and health of occupants were compared between departments, and between occupant groups. It was concluded that staff was generally less satisfied than patients were. Some of the indicators studied (occupant, dose and building-related indicators) varied between departments. Most studies focused on a single dose or building-related indicator, although the occupant-related indicators, such as privacy, infection rate or mortality, were related to more than one dose or building-related indicator. It was concluded that staff in particular have been understudied in relation to the variation of health and comfort aspects in different departments.

ARTICLE HISTORY
Received 13 January 2019
Accepted 26 April 2019

KEYWORDS
Hospital design; indoor environment; layout; comfort; health; staff; patient

Introduction

Many studies have shown that the physical environment of hospitals may affect health and comfort of the occupants (staff, patients and visitors). With an increasing demand for healthcare, driven by the ageing population and a growing percentage of people suffering chronic diseases (Barker 2011), it is necessary to understand comfort and health related to the physical environment in hospitals better.

Environmental stimuli, such as noise or crowding stressors, may cause negative or positive stress reactions (Evans 2003). The extent, to which environmental stimuli cause stress, depends on the importance of the stressor, duration of exposure and degree of control (Folkman 2013). These stress reactions may vary between occupants, due to demographics, physiological characteristics, social aspects and previous experiences and exposures (Bluyssen 2014). The preferences and needs of individuals may vary during time as well, due to different activities, specific clothing, health state or other personal factors (Heerwagen 1998).

As hospitals are complex buildings, accommodating multiple functions, the relation between the physical environment and health and comfort of occupants may vary between hospital

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departments. The complexity of hospital buildings is shown in the former mandatory Dutch guidelines, (there are nowadays no mandatory building standards for hospitals in the Netherlands). General hospitals are required to house 39 different function groups for inpatient care, treatment, diagnostics and supporting facilities (CBZ 2002). Between departments, there are large differences in performed activities and the health state of patients and staff (Rashid and Zimring 2008). Due to differences in role and the duration of stay, the needs of patients can be contradicting to the needs of staff in a hospital (Fornara, Bonaiuto, and Bonnes 2006). Therefore, health and comfort of staff may differ from that of patients. Understanding the relation between the physical environment and health and comfort of the occupants, taking into account the specific preferences and needs of occupants, may contribute to appropriate guidelines for hospital design. Thus, a comparison is needed, regarding health and comfort of different groups of occupants at specific departments.

Within the perspective of this literature review, occupants in previous field studies, assessed comfort on three levels: sensation, perception and cognition. Privacy is for instance an aspect related to cognition, emphasising environmental or behavioural adaptation or modification of expectations (Shin 2016). Three types of indicators distinguish aspects for health and comfort: occupant, dose and building-related indicators (Bluyssen 2010). Occupant-related aspects are for example work strain, infection incidence (related to the physical environment) or rehospitalisation. Aspects such as temperature, illuminance, and air humidity are defined as dose-related indicators. Building-related indicators comprise for example the orientation of windows, the spatial layout or the possibility for the growth of fungi.

Previous literature reviews on health and comfort related to the physical environment in healthcare facilities provided their own contribution, varying in scope of studied occupants, study design, effects and building type (Dijkstra, Pieterse, and Pruyn 2006; Drahota et al. 2012; Huisman et al. 2012; Salonen et al. 2013; Ulrich et al. 2008). However, as far as we know, no previous research has been done on health and comfort of occupants related to different hospital departments, occupant groups and the relations of indicators. Therefore, a literature review was performed to study possible differences in indicators found in previous studies between different departments, occupant groups and relations between those indicators.

Method

Literature was identified with searches in Scopus, Web of Science and JSTOR, in the field of architecture, indoor environment and environmental psychology. For all searches the keywords 'hospital' and 'healthcare facility' were combined with the search terms: 'wellbeing', 'stress', 'indoor environmental quality', 'comfort', 'health', 'architecture', 'daylight', 'thermal comfort', 'noise', 'air quality', 'patient room', 'waiting room', 'pain', 'layout'. The selection of papers addressing the physical environment and occupants' comfort and health in hospitals took place after screening titles and reading abstracts. Furthermore, references in the selected papers were examined, based on titles and abstracts. The search took place from June 2017 until May 2018. After reading the selected papers, 79 studies were included and 24 studies were excluded, according to the following inclusion criteria:

- Original peer reviewed articles, written in English.
- Field studies on comfort or health related to dose and building-related indicators in hospitals.
- Field studies on occupant preferences, related to dose and building-related indicators in hospitals.
- Study design: controlled clinical trials, case–control studies, cohort studies, cross-sectional studies and descriptive studies.

The exclusion criteria applied comprised:

Table 1. Studied departments (CBZ 2002).

Care type	Department
Nursing	Inpatient care
	Special care (intensive care, intermediate care, palliative care, isolation room)
	Day care[a]
Treatment and diagnostics	Delivery care
	Operating area (operating room, post anaesthesia area, post- operative room)
	Outpatient care
	Emergency department
Complete building	

[a]Day care is related to nursing as well as treatment.

- Studies on single indicators, which are beyond the scope of building engineering, such as music or art.
- Studies using dose-related indicators as a therapy (light, music).
- Simulation studies, for instance on thermal comfort.
- Studies performed in nursing homes or other healthcare facilities, not being a hospital.
- Studies with children as patients involved.

Health and comfort aspects, study design, number and type of occupants, instruments and hospital departments were extracted and categorised, according to the reported dose and building-related indicators. The field studies determined relations of dose and building- related indicators with indicators for performance, bodily processes, psychosocial aspects, comfort and symptoms. The main health and comfort indicators were compared for patients and staff in the different departments, structured according to Table 1.

Results

The results are presented in two parts, as showed in Figure 1. The first part reports findings related to the spatial layout, visual, acoustical, thermal, indoor air and overall quality, in order to provide an overview of the studied dose and building-related indicators. The second part provides a comparison between occupant groups, departments and relations between dose and building-related indicators for health and comfort aspects.

Part 1

Visual quality

Indicators that can be categorised under visual quality, such as the intensity of daylight, illuminance level or window view, were studied at inpatient wards, special care and outpatient areas. Numerous

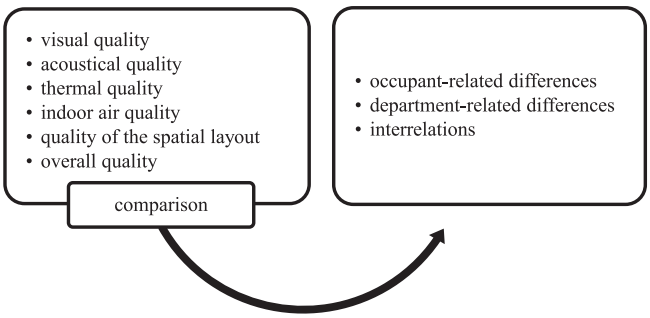

Figure 1. Structure of the reported results.

aspects of health and comfort, such as improved sleep quality, decreased incidence of delusion, hope, positive interaction, decreased errors and increased work satisfaction were found to be related to exposure of daylight (Alimoglu and Donmez 2005; Bano et al. 2014; Booker and Roseman 1995; Keep, James, and Inman 1980; Timmermann, Uhrenfeldt, and Birkelund 2015; Zadeh et al. 2014). A high intensity of artificial light appeared to decrease errors in medication preparation and work strain (Buchanan et al. 1991), bright artificial light during the day improved the length and quality of sleep of patients at night (Wakamura and Tokura 2001).

The orientation of windows in patient rooms to the morning sun was associated with decreased duration of stay, reduction of mortality rate and reduction of the intake of pain analgesics (Beauchemin and Hays 1998; Choi, Beltran, and Kim 2012; Walch et al. 2005). In addition to the window orientation, the specific view of a window and the intensity of daylight affected the duration of stay and intake of pain analgesics as well as the satisfaction with the social environment (Joarder and Price 2013; Ulrich 1984; Verderber 1986). Patients and staff were more satisfied in rooms with large windows and a low sill height; they perceived rooms with windows smaller than 15% of the facade, as windowless (Verderber 1986).

Acoustical quality

Noise levels, noise sources and noise reducing ceiling panels, which can be considered as aspects of acoustical quality, were studied at inpatient wards, operating rooms, emergency departments and wards for special care. Measured noise levels in hospitals have been found to be significantly higher than recommended in the WHO guidelines and have also increased since 1960 (Busch-Vishniac et al. 2005). Although a $L_{\underline{A}}eq$ of 35dBA is recommended for treatment and observation areas during the day, Darbyshire and Young (2013) reported that $L_{\underline{A}}eq$ levels were all above 45 dBA in 5 intensive care units. The $L_{\underline{A}}eq$ was between 52 and 57 dBA more than 50% of the time; the highest $L_{\underline{A}}^{peak}$ recorded was 127.9 dBA. The main sources for high noise levels were medical devices as well as talking of staff and patients (Allaouchiche et al. 2002; Ryherd, Waye, and Ljungkvist 2008). Staff perceived that high noise levels were related to feeling sick at the end of the day (Andrade et al. 2016), tension headaches, fatigue and irritation. Although high noise levels were related to an increased heart rate and arousal during sleep (Aaron et al. 1996), high noise levels did not affect the duration of sleep (Bano et al. 2014). A reduction of the reverberation time with acoustical ceilings reduced work strain for staff as well as the incidence of rehospitalisation of patients (Blomkvist et al. 2004; Hagerman et al. 2005).

Thermal comfort

Thermal comfort was studied at inpatient wards, operating rooms and an outpatient ward. In several studies, patients were more satisfied with the thermal conditions than expected according to the ASHRAE guidelines and measurements of air temperature, relative air humidity, air velocity and clothing (Hwang et al. 2007; Verheyen et al. 2011). Both patients and staff were more satisfied with the indoor temperature in summer than in winter, during the heating season, although the actual temperature did not vary (Hashiguchi et al. 2005; Skoog, Fransson, and Jagemar 2005). In winter, the satisfaction with air humidity was low, which was in line with the measured humidity. Staff encouraged patients to drink more water in winter, in order to compensate for the low humidity (Hashiguchi et al. 2005).

Air quality

Indicators that can be categorised under air quality, such as filtration, direction of the airflow and ventilation rate, were studied at inpatient wards, operating rooms, day care and overall buildings. In some studies, decreased incidence of infection and mortality of vulnerable patients were related to filtration of indoor air and laminar airflow (Oren et al. 2001; Yavuz et al. 2006). Air filtration with HEPA filters was effective, but the infection rate of patients in rooms with portable filtration did not differ from those without a portable filtration unit (Engelhart et al. 2003). In addition to the infection

and mortality rate, aspects of the air quality have been associated with several self-reported symptoms of staff, such as a dry skin, fatigue, nasal inflammation and ocular symptoms (Hellgren et al. 2011; Smedbold et al. 2002; Wieslander et al. 1999). Symptoms were related to a low air humidity, a low ventilation rate, presence of mould in the ventilation units, emission of VOCs and high noise levels of the ventilation system.

Quality of the spatial layout

The configuration of rooms, the number of beds in rooms and regulation of privacy with curtains can be categorised under the quality of the spatial layout. Studies were performed at inpatient, special, delivery and day care. Single bedrooms were more supportive to privacy of patients than multiple bedrooms, which were enclosed from the circulation area, or bay wards, which were open to the circulation area (Chaudhury, Mahmood, and Valente 2006; Maben 2015). For instance, the interaction with family improved and the communication of physicians with patients improved (Van De Glind, Van Dulmen, and Goossensen 2008). Unexpectedly, the exchange of medical information was also better at open wards, which comprised 36 beds without separation walls, than at bay wards, with separation walls between 4 and 6 beds. The background noise at the open wards were supportive to privacy (Pattison and Robertson 1996). Although the privacy of patients in single bedrooms improved, staff reported lower work satisfaction, associated with a limited ability to oversee and overhear the patient needs and concerns about patient isolation (Donetto et al. 2017). Single bedrooms (only) did not have a positive effect on infection control or the intake of pain analgesics (Dolce et al. 1985; Maben 2015).

Overall quality

Studies on the overall quality identified relations between multiple dose- and building related indicators and health and comfort. The scope of field studies on the overall quality was not limited to building or dose-related indicators; additional features, such as furniture, amenities or artworks were part of the studies as well. An example is the combination of a high number of sinks, filtered air supply and single bedrooms, which was related to an increased infection incidence and mortality rate (Deniz et al. 2017). Newly well decorated areas, with for instance balanced colour schemes, individual control of temperature and high illuminance levels, were related to improved comfort, alertness, satisfaction with work and with care (Janssen et al. 2000; Leather et al. 2003; Mroczek et al. 2005). The findings on satisfaction with care, related to the interior of patient rooms were inconsistent. Patients were more satisfied with care in well-decorated hotel-like rooms, compared to those in basic rooms (Swan, Richardson, and Hutton 2003). On the contrary, Siddiqui et al. (2015), who did not find a relation between room quality and satisfaction with care, suggested that this difference might be caused by the fact that patients had to pay $40 extra per day for the well decorated rooms in the study mentioned before.

Part 2

Studied population

Previous studies focused mainly on patients only, or patients with staff and or visitors, as presented in Table 2.

Table 2. Proportion of participant types studied.

Type participant	% of studies
Patients	59%
Staff	29%
Patients and staff	10%
Patients and visitors	1%
Patients, visitors and staff	1%

Some health and comfort indicators were exclusively related to patients or staff, as shown in Table 4. In the studies concerned with both patients and staff, staff was less satisfied with spatial layout, thermal, air, acoustical and visual quality (De Giuli et al. 2013; Del Ferraro et al. 2015; Eijkelenboom, Blok, and Bluyssen 2018; Skoog, Fransson, and Jagemar 2005). In a study performed by Sattayakorn, Ichinose, and Sasaki (2017), although thermal comfort of patients and staff was generally related to gender and age, patients accepted larger temperature differences compared to visitors and staff. In another study, staff rated 50% of the view types more negative than patients (Verderber 1986). In a study performed by Hashiguchi et al. (2005), staff reported more building-related symptoms than patients did.

Additionally, some studies also showed differences in the preferences between patients and staff. Harris (2017) showed that more patients than staff preferred single patient rooms and control of the window view with curtains. Although patients preferred carpet in their bedroom, due to the appearance, lower noise and reduced anxiety of falling, staff preferred on the other hand vinyl, due to cleanliness and air freshness. This is in line with some of the studies that identified cleanliness and air freshness among the most important aspects of the physical environment for staff (Mourshed and Zhao 2012; Sadatsafavi, Walewski, and Shepley 2015).

Differences between patients were found to be related to specific diseases, their vulnerability and personal factors. Patients suffering psychiatric or neurological diseases did not appear as sensitive as other patients to thermal comfort, to the effect of window orientation or the decoration of the ward (Benedetti et al. 2000; Vaaler, Morken, and Linaker 2005; Verheyen et al. 2011). In a study of Leaf, Homel, and Factor 2010, it was seen that only the most vulnerable patients had a higher mortality rate, which was related to the visibility of the patient rooms from the nursing station. In another study, physical strength overshadowed the aspects age and gender for thermal comfort as well (Sattayakorn, Ichinose, and Sasaki 2017). Hweidi (2007) found that aged patients and patients with a lower income reported higher stress levels.

Comfort and health of staff members were associated with health state, demographic and social factors, as well as with different activities. Building-related symptoms were associated with asthma, hay fever, smoking, a low degree of control and dissatisfaction with comfort (Nordstrom, Norback, and Akselsson 1995; Smedbold et al. 2001). In addition, compared to nurses exposed to more than three hours of daylight per day, those exposed to less than three hours of daylight reported lower job satisfaction and increased work-related strain, which are indirectly related to burnout (Alimoglu and Donmez 2005). Higher levels of burnout were directly related to nurses with sleeping disorders. Perception of noise was related to the position of different staff members in the room as well as to their responsibility. The feeling that noise has a negative impact on the job was for anaesthetists stronger than for surgeons and nursing personnel. The head surgeons reported that talking was the main source of noise, in contrast to the other staff members, who reported the air-conditioning systems as the main source of noise (Tsiou, Efthymiatos, and Katostaras 2008). Last, differences on thermal comfort between staff members in operating rooms were related to differences in clothing, metabolic rate, stress and their location in the room (Mazzacane et al. 2007; Van Gaever et al. 2014). The clothes varied from lead overalls while using X-ray, plastic overalls and paper overalls. The anaesthetist was cold, wearing short sleeves, sitting next to the patient. The surgeons were hot, wearing lead aprons, performing on a high activity level. With an increasing complexity of the task, the skin temperature of the surgeon increased and the air humidity between skin and overall reached a saturation of 100% (sweat).

It was also found that age, gender and working hours affected the perception of importance of dose and building-related indicators. Staff working more than 40 h a week perceived thermal comfort, the proximity of wards, illumination, availability of daylight and spaciousness more important than those working less than 40 h a week (Mourshed and Zhao 2012). Staff aged over 49 years perceived air quality in work spaces and patient areas more important than younger staff. Visual privacy was perceived more important in work spaces by staff working longer than 10

Table 3. Proportion of departments studied.

Department	% of studies
Inpatient care	51%
Special care	18%
Day care	3%
Delivery care	4%
Operating area	6%
Outpatient care	5%
Emergency department	1%
Complete building	12%

years in the building, compared to those working less than 10 years in the building, as well as by nurses, compared to other staff (physicians, therapists, technologists, etc.) (Sadatsafavi, Walewski, and Shepley 2015).

Studied departments

Comparison of health and comfort at specific departments was difficult, as half of the studies were conducted only at inpatient wards, as presented in Table 3.

Some health and comfort indicators were exclusively related to one or a small selection of departments, as shown in Table 4.

Aspects such as the duration of stay or sleep quality, were inherently related to patients at nursing departments (inpatient, special care). Aspects such as mortality or infection occurred to the most vulnerable patients treated in the operating area and special care. Some conditions were related to a specific (room in a) department as well. The sound pressure levels at the ICU were found to be higher than in the inpatient bedrooms (Allaouchiche et al. 2002; Moore et al. 1998). In the study performed by Van Gaever et al. (2014), indicating differences in thermal comfort between staff members, it was seen that the temperature and laminar airflow in the operating room was controlled by a low temperature setting in order to reduce the possibility of infection. Air filtration with HEPA filters was applied in operating and seclusion rooms, in order to reduce the infection incidence (Deniz et al. 2017; Oren et al. 2001).

In several studies it was seen that needs for privacy varied between day-care, special care, emergency departments and inpatient care (Barlas et al. 2001; Maben 2015; Pease and Finlay 2002; Wang and Pukszta 2017). Although most patients at an inpatient ward preferred single bedrooms, patients at day-care preferred a combination of private, semi-open and open areas. At an emergency department, patients were even satisfied with the privacy in examination rooms, divided by curtains. Stress of patients varied between departments as well (Andrade et al. 2017; Becker and Douglass 2008; Hweidi 2007; Leather et al. 2003). As patients in an ICU perceived only noise as a stressor, patients in inpatient wards perceived stress related to the number of features, such as adjustable temperature, a chair for visitors, a large window and a clock. In outpatient areas, patients perceived stress related to the layout, light, colours and decoration of the waiting room. Staff perceived pieces of artwork, daylight and a view to the outside more important in staff areas than in patients' areas or workspaces (Sadatsafavi, Walewski, and Shepley 2015).

Relations between dose, building and occupant-related indicators

It can be seen from the above discussion of literature results that most occupant-related indicators, such as duration of stay or mortality, were related to more than one dose or building related aspect, as summarised in Table 5.

Duration of stay was related to the window orientation, view on nature and illuminance level in studies performed by Benedetti et al. (2000), Choi, Beltran, and Kim (2012) and Ulrich (1984). Mortality was affected by window orientation, the direction of air flow, filtration of air, line of

Table 4. Health and comfort aspects of the included studies at different departments.

	Occupant	Inpatient care	Special care	Day care	Delivery care	Operating area	Outpatient area	Emergency	Overall	References
Performance										
Duration of stay	p	x	x							Beauchemin and Hays (1996, 1998), Benedetti et al. (2000), Choi, Beltran, and Kim (2012), Joarder and Price (2013) and Ulrich (1984)
Consumption pain analgesics	p	x	x							Dolce et al. (1985), Ulrich (1984) and Walch et al. (2005)
Rehospitalisation	p		x							Hagerman et al. (2005)
Medication errors	s	x					x			Booker and Roseman (1995) and Buchanan et al. (1991)
Bodily process										
Mortality	p	x	x			x			x	Beauchemin and Hays (1998), Leaf, Homel, and Factor (2010), Passweg (1998), Shirani et al. (1986) and Yavuz et al. (2006)
Delusion	p		x							Keep, James, and Inman (1980)
Infection	p	x	x			x				Deniz et al. (2017), Engelhart et al. (2003), Oren et al. (2001), Sherertz et al. (1987), Shirani et al. (1986) and Yavuz et al. (2006)
Stress (heart rate and/or perceived)	ps	x	x		x		x		x	Andrade et al. (2016), Applebaum et al. (2010), Hweidi (2007), Leather et al. (2003), Sundberg et al. (2017), Vaaler, Morken, and Linaker (2005) and Wang and Pukszta (2017)
Sleep quality		x	x							Aaron et al. (1996), Bano et al. (2014), Freedman et al. (2001) and Wakamura and Tokura (2001)
Symptoms										
Building related symptoms	ps	x							x	Andrade et al. (2016), De Giuli et al. (2013), Hashiguchi et al. (2005), Hellgren et al. (2011), Nordstrom, Norback, and Akselsson (1994, 1995), Ryherd, Waye, and Ljungkvist (2008), Smedbold et al. (2001, 2002) and Wieslander et al. (1999)
Evaluation										
Comfort	psv	x	x			x	x		x	Allaouchiche et al. (2002), Bukh, Tommerup, and Madsen (2015), Chaudhury, Mahmood, and Valente (2006), De Giuli et al. (2013), Del Ferraro et al. (2015), Eijkelenboom, Blok, and Bluyssen (2018), Frank et al. (1992), Harris (2017), Hashiguchi et al. (2005), Hwang et al. (2007), Mazzacane et al. (2007), Moore et al. (1998), Pattison and Robertson (1996), Sadatsafavi, Walewski, and Shepley (2015), Sattayakorn, Ichinose, and Sasaki (2017), Skoog, Fransson, and Jagemar (2005), Sundberg et al. (2017), Tsiou, Efthymiatos, and Katostaras (2008), Van Gaever et al. (2014) and Verheyen et al. (2011)

Psychosocial									
Satisfaction with job or care	ps	x	x		x		x		x	Alimoglu and Donmez (2005), Becker and Douglass (2008), Donetto et al. (2017), Janssen et al. (2001), Janssen et al. (2000), Maben et al. (2015), Shepley et al. (2012), Mroczek et al. (2005), Siddiqui et al. (2015), Sundberg et al. (2017), Swan, Richardson, and Hutton (2003), Verderber (1986) and Wessels et al. (2010)
Work strain	s	x	x							Alimoglu and Donmez (2005), Blomkvist et al. (2004) and Buchanan et al. (1991)
Privacy	psv	x		x	x			x		Barlas et al. (2001), Burden (1998), Maben (2015), Shepley et al. (2012), Pattison and Robertson (1996), Pease and Finlay (2002), Verderber (1986) and Wang and Puksza (2017)
Positive interaction, mood	s	x								Chaudhury, Mahmood, and Valente (2006), Janssen et al. (2000), Pattison and Robertson (1996), Timmermann, Uhrenfeldt, and Birkelund (2015), Van De Glind, Van Dulmen, and Goossensen (2008) and Zadeh et al. (2014)
Subsidiary behaviour	s	x								Zadeh et al. (2014)

x = studied relation indicated, *p* = patient, s = staff, v = visitor.

Table 5. Relations of occupant, dose and building-related indicators of the included studies.

	Dose related indicator														
Occupant related indicator	Illuminance	Luminance	Daylight exposure	Sound pressure level	Reverberation time	Noise source	Air temperature	Radiant temperature	Relative humidity	Air velocity	Indoor CO2	Indoor microorganisms	Indoor VOC's	Traffic pollution	Dust concentration
Performance															
Duration of stay	x														
Consumption pain analgesics	x														
Rehospitalisation				x	x										
Medication errors	x		x												
Bodily process															
Mortality															
Delusion															
Infection												x			
Stress (heart rate/ pulse amplitude, and/or perceived)	x			x	x	x									
Sleep quality	x			x											
Symptoms															
Building related symptoms				x			x		x	x	x	x	x	x	x
Evaluation															
Comfort	x	x		x		x	x	x	x	x	x	x	x		x
Psychosocial															
Satisfaction (with job or care)			x												
Work strain	x		x	x	x										
Privacy															
Positive interaction, mood	x														
Subsidiary behaviour	x														

	Building related indicator																
Occupant related indicator	Window orientation	Window view	Window size	Presence window	Lighting fixture	Sound absorbing ceiling	Closed doors	Curtains	Air filtration	Laminar airflow unit	Ventilation system	Dampness	Distance bed-window	Single or multiple bedrooms or ward type	Proximity of rooms or departments	Line of sight between nursing station and bedroom	Multiple dose and building related indicators
Performance																	
Duration of stay	x	x															
Consumption pain analgesics	x	x															
Rehospitalisation						x											
Medication errors					x												
Bodily process																	
Mortality	x								x	x						x	x
Delusion				x													
Infection							x		x	x							x
Stress (heart rate/pulse amplitude, and/or perceived)				x		x											x
Sleep quality					x								x				
Symptoms																	
Building related symptoms											x	x					x
Evaluation																	
Comfort							x							x			x
Psychosocial																	
Satisfaction (with job or care)		x	x		x									x	x		x
Work strain					x	x								x			
Privacy								x						x			x
Positive interaction, mood		x	x	x										x			x
Subsidiary behaviour				x													

sight between nursing station and bedroom, and a combination of indicators in studies performed by Beauchemin and Hays (1998), Leaf, Homel, and Factor (2010), Shirani et al. (1986) and Passweg et al. (1998).

Discussion

Strengths and limitations

One of the limitations of this study is the search strategy. Some keywords, such as 'architecture' or 'stress', have different definitions depending on the research field. These words revealed a large number of titles with a low relevance to this review. However, the combination with keywords that are more specific and the cross-reference procedure may cover the most relevant studies. Another limitation is the difficulty to compare studies on psychological constructs, such as privacy, comfort or stress, due to a variety of instruments and methods administered in the different studies. Finally, the findings of the field studies are presented equally, although differences in methods and study design imply weaker and stronger relations between dose, building and occupant-related indicators. Detailed information on dose or building related indicators was scarce, mainly in the studies on psychosocial indicators and bodily processes. However, this literature review intended to reveal information on dose, building and occupant related indicators at different hospital departments for patients and for staff.

Agreements and disagreements with other reviews

Several reviews on the relations between the physical environment and health and comfort in healthcare facilities have been performed before, as mentioned in the introduction. In the reviews of Dijkstra, Pieterse, and Pruyn (2006) and Drahota et al. (2012), the studies considered were limited to controlled clinical trials and case–control studies. Dijkstra, Pieterse, and Pruyn (2006) found evidence for window-orientation, illuminance and view, as well as for privacy related to layout, in line with this review. They concluded findings of acoustical quality as inconsistent, which might be related to their limited focus of including studies on 'psychological processes as a result of sensory perceptions'. Drahota et al. (2012) reported evidence for window-orientation as well, but considered the evidence of air quality on infection weak, due to differences in building services and infection sources.

On the contrary, the review of Ulrich et al. (2008) determined a large number of health and comfort indicators, based on 'reliable patterns of findings' between empirical studies, theory and knowledge. Inconsistent to findings of this review, is for example the relation between the incidence of infection and single bedrooms compared to multiple bedrooms. Huisman et al. (2012) reviewed literature on wellbeing, faster healing processes and a comfortable environment of patients and staff in healthcare facilities, in order to provide an overview of literature for designers and engineers of hospitals. Studies on thermal comfort were not included. The main conclusion, that staff are understudied, is consistent with the findings of this review as well as with the review of Salonen et al. (2013). They indicated only different needs for aspects of the spatial layout between patients and staff, and no differences in comfort related to thermal, visual, acoustical and air quality. None of the studies compared differences between departments. Table 6 presents an overview of the characteristics of previous literature reviews.

Population

The comparison of studies on different occupant groups emphasised the gap in studies on staff. Due to staff shortage, increased complexity and the increased workload of hospital staff (Sherman, Chiang-Hanisko, and Koszalinski 2013), the need to study health and comfort of staff in

Table 6. Characteristics of previous literature reviews.

Author	Year	Occupants	Study design	Building type[a]
Dijkstra, Pieterse and Pruyn	2006	patients	controlled clinical trials, case control studies	healthcare facilities
Ulrich et al.	2008	patients, visitors, staff	controlled clinical trials, case control studies, cohort studies, cross sectional, descriptive studies, reviews, expert opinion	healthcare facilities
Huisman et al.	2012	patients, staff	systematic reviews, controlled clinical trials, case control studies, cohort studies, cross sectional, descriptive studies	healthcare facilities
Drahota et al.	2012	patients	controlled clinical trials, case control studies	hospitals
Salonen et al.	2013	patients, staff	controlled clinical trials, case control studies, cohort studies, cross sectional, descriptive studies, reviews	healthcare facilities

[a]Healthcare facilities comprise different building types, such as nursing homes, hospitals, dentists.

hospitals has increased as well. It has been shown in several studies that staff are concerned about the effect of the physical environment on comfort and health of patients (Maben et al. 2015). However, it is important to emphasise that concern about comfort and health of staff can be beneficial to patient outcomes as well (Duffield et al. 2011; Firth-Cozens and Greenhalch 1997; Wallace, Lemaire, and Ghali 2009). The variation in the occupants' responses to environmental stimuli, related to health state, demographic and social aspects, has been shown in several studies (Alimoglu and Donmez 2005; Nordstrom, Norback, and Akselsson 1995; Smedbold et al. 2001), demonstrates that these aspects need to be included in future studies on health and comfort. Determination of user profiles addressing differences in preferences and needs may contribute to a better fit between the occupant and the environment (Ortiz and Bluyssen 2018).

Departments

The identified differences between departments with respect to privacy, thermal comfort, sound levels and stress of staff and patients, suggest that it is necessary to address specific departments. Differences in privacy might be explained by the definition of Altman (1976), that control of privacy is 'an active and dynamic regulation process', dependent on changes in situation or motivation. Other aspects related to the spatial layout, such as different needs for communication and concentration in offices, due to the heterogeneity of performed activities (Hoendervanger et al. 2018), might occur in hospitals as well. In line with differences in thermal comfort between hospital departments, comfort varied between different building types, such as homes, schools and offices (Frontczak and Wargocki 2011).

Analysis of the studied departments indicated a scarcity of previous field studies for treatment and diagnostic areas. Because of differences in health and comfort of staff and patients between departments and the decreasing need for inpatient beds (Halpern and Pastores 2010; WHO 2017), it is relevant to contribute to filling this gap.

Relations

Although most of the studies focused on single indicators, confounding variables may have affected the findings as well. For instance, the window view may affect findings in a study comparing the orientation of windows. The suggestion of Bluyssen (2014) to study relations, was endorsed by the large number of studied aspects presented according to the six-S shearing layer-model (Brand 1994) in Figure 2.

Conclusions

The literature review performed indicates that health and comfort of staff as well as of patients from different hospital departments vary. The field studies determined relations of dose and building

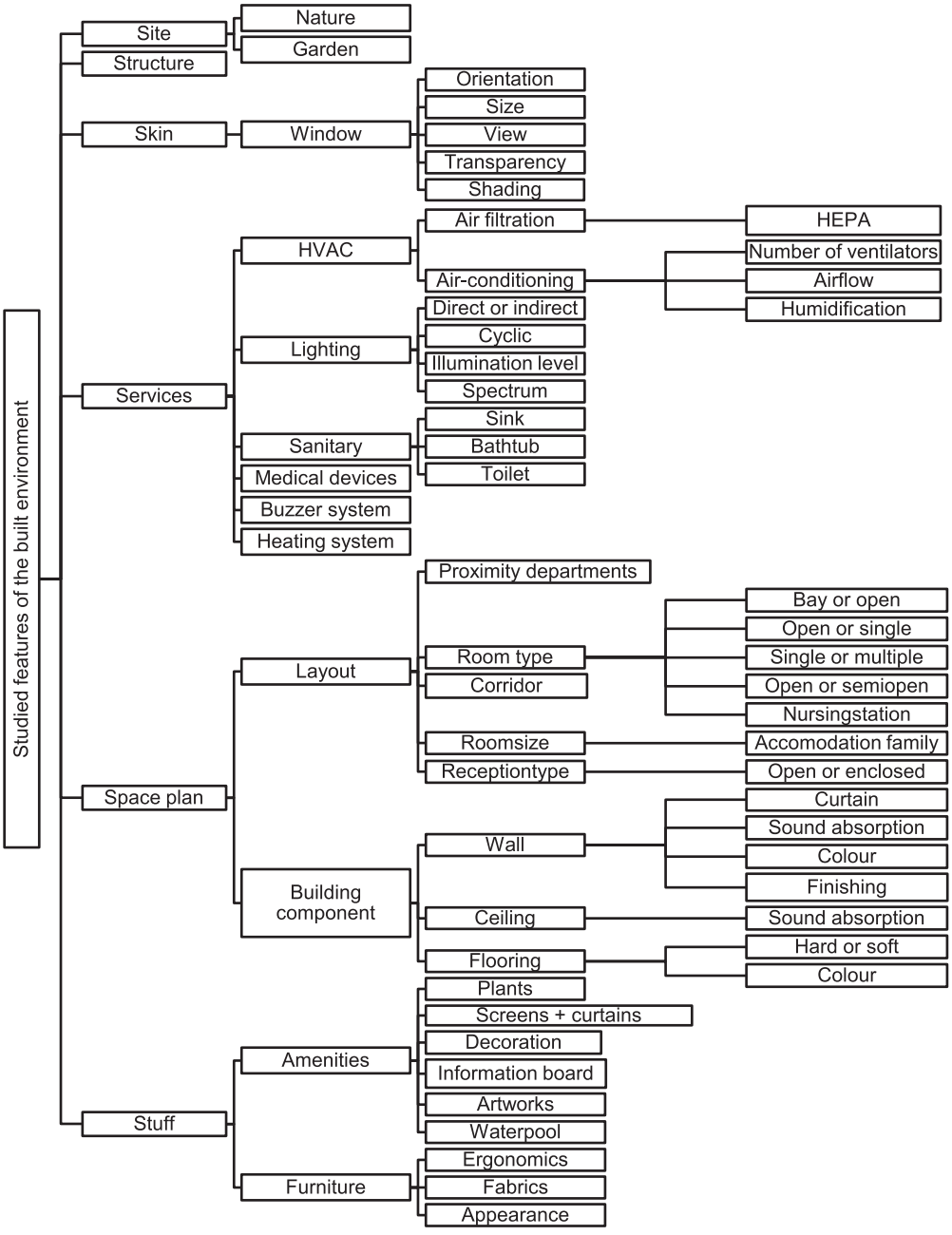

Figure 2. Overview studied building features of the included studies.

related indicators with occupant-related indicators such as performance, bodily processes, psychosocial aspects, comfort and symptoms. Specific indicators, such as duration of stay or high noise levels, were inherently related to one department or care type. Indicators for stress, privacy and preferences varied between departments. Differences in health state, activities, demographic and social aspects were associated with the perception of health and comfort as well. In line with previous studies on schools, offices and homes, most occupant-related indicators were related to a combination of dose and/or building-related indicators.

Staff wereless satisfied than patients with spatial layout, thermal, air, acoustical and visual quality. Due to the increasing demand put on staff and the reduction of inpatient beds, future study is needed on health and comfort of staff working on outpatient wards. An integrative approach, including personal and social factors, as well as the performed activities, may contribute to a better understanding of relations between dose, building and occupant related indicators for comfort and health of staff in hospitals.

Acknowledgment

The authors would like to thank Daikin Nederland and EGM Architects for their support.

Disclosure statement

No potential conflict of interest was reported by the authors.

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