Ann Ig 2019; 31: 165-180 doi:10.7416/ai.2019.2269

Evidence Based Hospital Design. A literature review of the recent publications about the EBD impact of built environment on hospital occupants' and organizational outcomes

A. Brambilla[1], A. Rebecchi[1], S. Capolongo[1]

Key words: Hospital, Built environment, Quality, Evidence Based Design, Patient satisfaction, Fall reduction, Job satisfaction

Parole chiave: Ospedale, Ambiente costruito, Qualità, Evidence Based Design, Soddisfazione del paziente, Riduzione delle cadute in ospedale, Soddisfazione lavorativa

Abstract

Introduction. *Healthcare facilities are complex infrastructures where different features from technological, social, clinical and architectural field interact. In modern healthcare systems there is a growing attention to the need of quality in terms of process and outcome, while the structural (physical) aspects are not often considered. Since the Nineties the theory of the Evidence Based Design (EBD) states that there is significant relationship between built environment and health related outcomes.*

Objective. *Aim of this paper is to investigate, in the recent scientific literature, which are the most important occupants' and organizational outcomes influenced by EBD hospital built environment qualities.*

Methodology. *A Literature Review based on Scopus and PubMed databases has been run in order to understand the existing situation in terms of hospital quality evaluation from the physical and architectural point of view and to highlight the current trends. The results of the different reviews, empirical studies and post Occupancy Evaluations have been analyzed according to Ulrich's EBD conceptual framework.*

Results. *35 peer reviewed papers from the last 2 years were included. The methodologies adopted are very different and data are mainly collected through structured interviews or observations and elaborated with qualitative (33%), quantitative (26%) or mixed (41%) methodologies. The topic is mostly investigated in USA, Australia, Canada, UK and in the Scandinavian region; few contributions come also from Italy.*

Built environment variables that affect user's or organizational outcomes are mainly the Visual Environment (29%), the Audio Environment (20%) and the Patient Room Design (20%).

Discussion and Conclusion. *The most recurrent outcomes found to be affected by the built environmental qualities are staff job satisfaction (n=11), patients' stress reduction (n=9), patients' satisfaction (n=6) and patients' fall reduction (n=6). Organizational outcomes are mentioned only two times.*

Although EBD is an old theory, the topic is both contemporary and relevant. Due to the diversity of the contributions and the limitations of the research, a deep comparison is challenging. Further investigation is necessary to deepen each of the variables identified.

[1]*Department of Architecture, Built Environment, Construction Engineering, Politecnico di Milano, Milan Italy*

Introduction

The context and the problem

Nowadays, Healthcare Systems try to converge several economic and social factors to deliver the best services at the lowest cost, aiming in this way to obtain simultaneously the maximum of effectiveness combined with the maximum of efficiency. Hospital facilities are one of the most complex building type, due to the diverse and multitude daily users, the massive integrated technologies and systems, and the building's role as an open venue for promoting Public Health. Hospitals are large, complex institutions that continuously evolve (1) and in many cases, these care settings are built and expanded in phases across a period of decades (2). In the next 20 years 80% of the current knowledge about medicine and technology will change and healthcare facilities must be resilient to this evolution (3, 4). Considering that today about 40% of hospitals is not in line with the contemporary functional and technological model (i.e. pavilion typology, low ceiling, etc.) the future of healthcare environment is challenging (5). For example, within the current Italian context, the existing healthcare heritage is not able to fulfill the requirements of such transformations, due to the hospital age and increasing rate of obsolescence (estimated in 40-50 years). In fact, only 30% of the national healthcare real estate has been built after 1971 and shows consistent criticalities in terms of adaptation to new models of care, such as the "cure intensity model" (6). The most recent survey about Italian hospital shows that more than 50% of the total Gross Floor Area needs intervention (7).

The relevance of the topic

Researches show that the physical environment is a fundamental factor in the quality of healthcare (8-11). Indeed, architecture is considered an important component that contributes to the creation of a high-quality health service to promote health and well-being (12-14) and there are demands that decisions about the design of the healthcare facilities have to be based on the best available information from solid research and evaluations (15). Healthcare facilities are very important because they are part of a much larger network of social infrastructures that occupy a central role in defining every city and region's health and welfare system (16) and represents the platform where social, environmental, economic and medical inputs interact. Medicine is seeking for extremely high standards and hospitals have to stay in line with this trend. The high quality of the medical outcomes is due to the well-established systems within medical management field that since decades concentrate the attention into the measurability, replicability and improvements of the outcomes. In the field of medicine and healthcare management measure-oriented approaches are used as the foundation of every clinical activity. This approach is significantly embedded into the medical field and has been theorized in several structured approaches, such as the Evidence-Based Medicine (EBM) (17) in medical field, as well as the Quality Assurance models (QA) in the health managerial sector (18). Quality is here defined as "*the relationship between the improvement obtained and the best possible improvements expected based on the current state of knowledge*" (18). Quality in sanitary field is related to an articulated system of interdependent variables, where more or less complex factors interact in a multidimensional vision. This includes the managerial competencies, the innovation governance, the human resources policy addressing, the rationalization of the sources and the risk management along with sanitary policies that are related to organizational, structural and technological aspects. The concept of quality depends on the different socio-economic and cultural issues that evolved during time until the contemporary categories of safety, comfort,

efficiency, effectiveness, utility, esthetics, ethics, functionality (19).

According to the Donabedian model it is possible to identify three main dimensions of quality (20):

i) Structure: the physical and organizational characteristics where healthcare occurs

ii) Process: focus on the care delivered to patients (e.g. services or treatments)

iii) Outcome: effect of health care on the status of patients and populations.

The research gap

Within healthcare organizations several different methodologies have been adopted in order to measure and control the clinical, organizational and managerial quality. Among modern healthcare systems there are several tools developed to assess the quality of the hospitals but mainly focusing on dimensions, ii) process and iii) outcome. The excellence accreditation systems such as Joint Commission International, Australian Commission on Safety and Quality in Health Care, Accreditation Canada and UK Care Quality Commission (21, 22) are worldwide recognized as tools to foster the quality improvement in all the aspects of care delivery and management for hospital organizations (23, 24). Nevertheless, few pieces of evidence have been collected about dimension i) Structure and, in particular, its physical characteristics. While for other building typologies (i.e. offices, residential, commercial) it is possible to collect a variety of tools and evaluation frameworks (25, 26), in the hospital sector there is the need of collecting and systemizing reliable data to assess the relationship between built environment and occupants' health.

The existing approaches

In this context Evidence-Based Design (EBD) is the most diffuse theory available to describe an approach for quality improvements in the design process of healthcare architecture and recognized as the grounding concept for all future developments (27, 28). Since Ulrich's first empirical studies (29), EBD approach revealed significant relationships between specific design solutions in healthcare and health outcomes such as: anxiety reduction, blood pressure decrease, postoperative course improvement, pain medication needs reduction and shortening of the hospital stay (15). EBD is closely related to continuous quality improvements, where the expected outcomes of the care environment in terms of users' needs are in tight relation to the best available research, knowledge, and experience in the field (30). According to EBD there are several Environmental Variables that have impact on users or organizational-related outcomes, as shown in Fig. 1 (15). In particular:

Built Environmental Design Variables (A):

- Audio Environment
- Visual Environment
- Safety Enhancement
- Wayfinding System
- Sustainability
- Patient Room
- Family Support Spaces
- Staff Support Spaces
- Physician Support Spaces

can have different impacts (B) on:

- Patients outcomes
- Families outcomes
- Physicians outcomes
- Staff outcomes
- Organizational outcomes

The research objective

Aim of this work is to collect and review the most recent studies and compare the built environmental variables (A) with the related users' and organizational outcomes (B) in order to discuss the most important and recurrent topics. A secondary objective is to understand whether EBD, which has been theorized in the 90s, is still a relevant field of research.

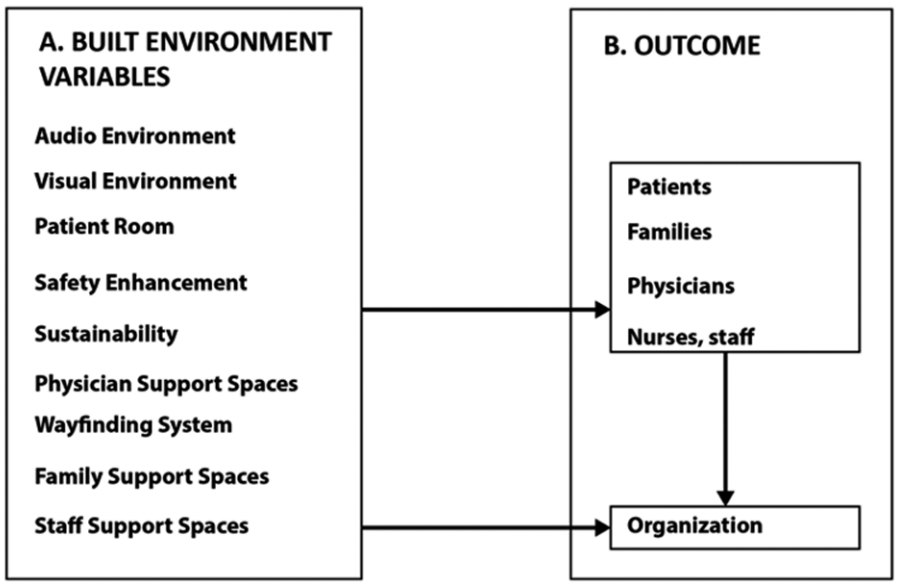

Fig. 1 - The Evidence Based Design theoretical framework. Taken from Ulrich (15) and elaborated by the authors

Methodology

In order to achieve most of the information about the topic, a systematic and explicit design for identifying, evaluating and interpreting the existing body of recorded documents has been considered (31, 32). With the objective of highlighting blank or weakly covered areas for grounding incremental studies in the field, a step-by-step methodological model has been followed for the literature search, summarized in the diagram in Fig. 2 (33).

Identification

First, the definition of appropriate search terms has been done. Here a three-level keywords assembly structure has been defined. The first level defined the context "HOSPITAL" or "HEALTHCARE ENVIRONMENT" or "HEALTHCARE BUILDING" or "HEALTHCARE FACILITIES" as the physical and organizational platform where the search is conducted. At the second level there is the main content searched which is "QUALITY", kept as broad as possible due to the very different possible interpretations according to the various fields interested into the topic. The third level was used to narrow the content toward more physical and architectural interpretation of the issue with a set of keywords "DESIGN" or "ARCHITECTURE or "BUILT ENVIRONMENT" or "PHYSICAL SPACE". Those keywords have been selected based also from previous literature reviews and papers collection in the field of Quality Assessment, Healthcare, Architecture and EBD. Using the "title, abstract, keywords" and "title, abstract" search in Scopus and PubMed databases, several articles were collected and stored.

Here some eligibility criteria have been applied in order to separate in-scope from out-of-scope results and avoid biases generated by the selection through keywords. The terminology used is indeed very much adopted also in fields that are not related to Built Environment and

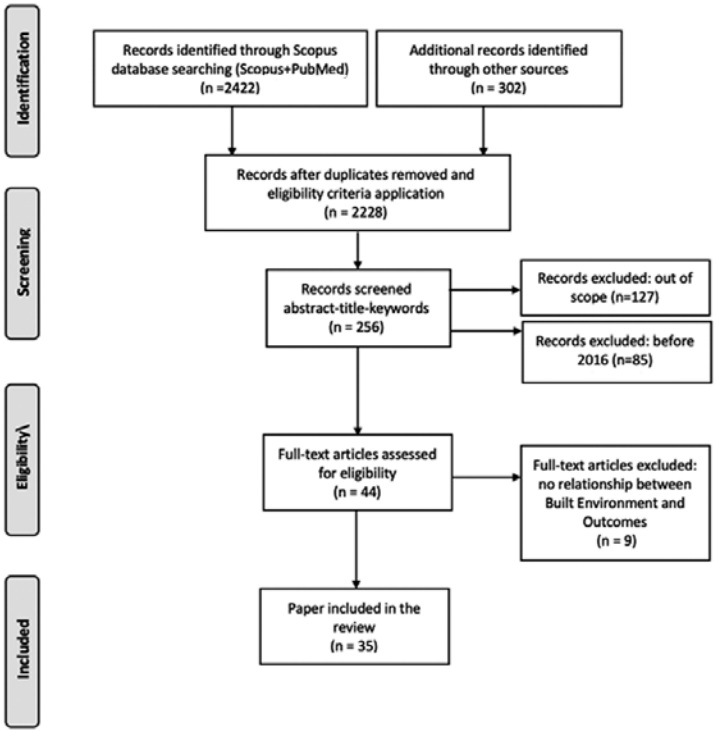

Fig. 2 - The Prisma Flow Diagram shows the process followed for the identification of the 35 papers selected through the Literature Review.

Health-related studies, such as Computer Science (software architecture) and Biology (bone architecture, cells design). Moreover, only peer-reviewed articles published in English after the introduction of EBD theory on Science (29) have been included in the first count, resulting in 2422 works. Due to the novelty and the multidisciplinary nature of the topic, additional information has been gathered from secondary sources such as research centers repositories (34). 302 additional records have been identified with the same set of keywords.

Screening

The initial search, after the removal of duplicates and the application of the aforementioned eligibility criteria, resulted in 2228 papers. Furthermore, titles, abstracts and keywords have then been screened one by one by A.B. and reviewed by A.R. and S.C., in order to discard out-of-scope documents that were not excluded by the filter application in the selected databases.

Eligibility

Titles, abstracts and keywords of the selected papers have been critically read and processed according to some exclusion criteria such as:

• Date of publication: since the last Systematic Literature Review available on similar topics (30) considered articles published until the end of 2015, only contributions from 2016 to March 2018 have been included, in order to acquire information about the most recent trends. 85 records have been excluded.

• Content:

- Focus on hospital: exclusion of papers or documents related to different building typologies;

- Focus on diagnosis and cure spaces: exclusion of papers or documents related exclusively to working spaces;

- Focus on physical qualities: exclusion of papers related exclusively to sustainability issues;

- Focus on regulations: exclusion of papers exclusively related to laws or mandatory technical regulation.

127 records have been excluded, resulting in 44 papers.

Inclusion

Finally, full text of the resulting papers has been assessed for eligibility and 9 of them have been excluded when no relationship between built environment and health were the object of the research. Therefore 35 papers have been included into this review.

Results

Theoretical models

Most of the researches (49%) have roots into the EBD or related Ulrich's theories such as the Supportive Design (2, 35, 36) that focus on environmental features impacting on patients' stress reduction. Another theoretical reference on which papers are built is the Biophilia hypothesis (37) that investigate the natural environment benefits on health (38, 39). Other important theoretical lens through which the occupants' health is read are Accessibility (40) and Usability (41, 42). Well-known environmental psychology theories like Canter's psychology of place (43) are taken as important references both for reviews and empirical studies (44-46). Theories of satisfaction evaluation are used both for patients (47) and for staff related studies (48), while just few of the contributions refer to quality control or management related theories (49, 50).

Methodologies

Among the 35 papers collected 27 (77%) are empirical studies and Post Occupancy Evaluations (POE) while the other 23% (8 out of 35) are literature reviews (narrative, scoping or systematic) showing that the topic is wide and there are several angles through which it is possible to investigate it.

Data collection

Among the experimental papers data are collected mainly throughout structured or semi-structured interviews, questionnaires or observations and there is the trend of using multiple techniques rather than just one in order to have various datasets. Those are made of several information gathered from very different sources; in particular staff (56% of the studies) and patients (48% of the studies) but also external experts (19%), visitors (7%), students (7%) or the environment itself (15%). About 40% of the empirical studies collect data for more than one source (i.e. patients and staff).

Data analysis

The collected data were then analyzed with qualitative (33%), quantitative (26%) or mixed methods (41%) coming from different field of study. Among the qualitative approaches, several authors chosen inductive thematic analysis or content analysis and pattern identification (51), while for quantitative methods descriptive statistics, statistical analyses and multiple regressions are the most common approaches. Mixed methods studies are supported by a combination of the aforementioned methodologies, sometimes enriched by multicriteria analysis (52, 53) or supported by advanced softwares (i.e. SPSS for Machine Learning, Nvivo for qualitative analysis).

Focus

Although researches not focused on hospitals were excluded during the literature search, not all the authors approached this complex building in the same way. Due to its complexity and variety, it is possible to identify three levels of detail in the studies:

1) The building. It includes all the studies that consider the hospital as a whole entity of investigation in its different specifications such as rehabilitation facilities (54), general hospital (27, 40, 47, 50, 55, 56), teaching hospitals (46), pediatric hospital (57), mental health facilities (58);

2) The ward. This level has been investigated in several studies and the focus is either a department (i.e. emergency department) (59-62) or a specific functional area (i.e. hospital circulation zones) (2).

3) The room. This last level is the most used as platform for empirical studies thanks to the possibility of having a clear physical limit and data source similarities (i.e. same typology of patients). Most of those studies are focusing on inpatient rooms (regular, ICU, psychiatric) (36, 63), outpatients (64) or staff break spaces (65).

Geographical origins

Although the approaches are very different, it is possible to clearly state that the topic is not worldwide diffused with the same intensity. The majority of the authors are affiliated to American institutions (34%), followed by Australia and New Zealand (26%) and Canada (17%). In Europe UK and Scandinavia (Sweden and Finland) are the most prolific regions with 4 papers each over 35 (11%). Scholars from Italy, Portugal, Malaysia, Netherland, India and Brazil are starting to approach the topic with 1 or 2 contributions each in the papers collected.

Target

The results of the studies identify a clear target on which the built environment can have impact in terms of health-related benefits. The patients are the target of 22 studies (63%), the staff is present in 43% (15 over 35) of the results, while only 4 papers (11%) concentrate the attention also on the hospital's visitors. Although 8 papers have more than one target category amongst the three, those results clearly highlight the focus of EBD related studies on patients' outcomes.

Outcome

The studies collected have three different typologies of outcome. About half of the papers (49%) conclude with a statement about a specific topic, either assumptions based on the analysis conducted, confirmation or denials of hypothesis or definitions. About one third has the objective of defining a set of design principles or guidelines for the design of built environment able to scientifically improve users' health or wellbeing. The remaining 5 papers (14%) tested or developed structured tools for the evaluation of hospital physical spatial qualities.

EBD analysis

The contents of the papers have been analyzed throughout the Evidence Based Design conceptual framework developed by Ulrich in 2010 (15), after his last literature review on the topic (66). In this paper we assume that this model is able to catch all the possible EBD implications and relationships between Built Environment and users or organizational outcome in the hospital settings. The conceptual framework has been previously shown in Fig. 1 and the results are presented below.

Built Environmental variables

Audio Environment. Audio environment in hospital is a serious issue (15, 67). In addition of prescriptive concerns, in 20% of the papers this topic is highlighted both in terms of noise reduction and in terms of sound enhancement. The design strategies

most used are the use of music (11%), the reduction of equipment noise (6%) or the use of appropriate surface finishing (3%). Music can indeed reduce patients' anxiety (64) and eventually improve their own or their visitors' overall satisfaction (68, 69), while equipment noise significantly impacts the sleep quality (70, 71).

Visual Environment. Visual environment was the first concern of EBD scholars in the 90s (29) and is still top ranked in todays' studies. About 30% of the papers mentioned some kind of benefits that visual environment can give to users. Windows are very important both for natural light and views (20%) because it has been proven that those two features contribute in reducing patient's stress (35, 63) and can eventually have a significant influence on organizational outcomes (38). This relationship between human and nature is enhanced by the presence of gardens that can significantly reduce staff stress (39, 42). Another important feature is the presence of artworks in the facility (3%).

Safety. Safety is today an urgent characteristic and several scholars highlighted that built environment can lower the incidence of nosocomial infections, medical errors, patient falls, and staff injuries (15). From the review emerges that today the most important characteristics are the staff visual access to patients (9%) and the presence of handrails or non-slippery flooring (9%); those features significantly impact the reduction of patient's falls (46, 72, 73) and staff perception of patient's safety (61).

Wayfinding. Hospitals are complex facilities and the wayfinding systems result as fundamental since their preliminary design (74). The signage design (11%) plays a role in enhancing building orientation, reducing also the risk of patient falls (72), while a good floor plan layout supports patient and staff satisfaction (2, 60).

Sustainability. Although sustainability is a very important feature of each building system and is included in the EBD framework, there seems to be no direct interests from todays' EBD scholars in the topic, apart from few punctual issues such as building materials, Heating, Ventilation and Air Conditioning (HVAC) systems and energy efficiency measures (3% each).

Patient Room. The patient room layout is one of the most debated topics (20%) and includes the discussion about single or double-bed rooms (9%), the ability to control light and/or temperature by the occupants (9%) and the presence of acuity-adaptable rooms (3%). The room layout with only one bed has been found to improve sleep quality (71) and the possibility of control on environmental features can enhance the overall sense of privacy especially in children and adolescents (68). Management costs similarities between a 50% or 100% single room designed wards have been also investigated in one of the contributions (75).

Family Support Space. Family or visitor space is important and contribute to the social support (44) especially in terms of waiting (9%), meeting in private (3%) and having the possibility of spending a comfortable night in the patient room (6%).

Nurse and Physician Support Space. Staff space emerged to be important mainly for staff job satisfaction (73, 42) and stress reduction (39, 76,) thanks to the floor layout (3%), the presence of supplies and storages (3%), the workstation quality (3%) and the quality of space for meetings (6%). Although it might be an important indicator, the quantity of space available is not mentioned in the selected papers.

Finally, considerations about physicians' physical space are not specifically mentioned in the literature collected.

Discussion

Thanks to the EBD analysis of the selected literature, it has been possible to

A. BUILT ENVIRONMENT VARIABLES

1	**Audio Environment**	**7**	**20%**
1.1	Surface finishing	1	3%
1.2	Equipment	2	6%
1.4	Music	4	11%
2	**Visual Environment**	**10**	**29%**
2.1	Window (natural light & view)	7	20%
2.3	Art	1	3%
2.5	Gardens and plants	2	6%
3	**Safety Enhancement**	**6**	**17%**
3.4	Staff visual access to patients	3	9%
3.10	Handrails and non-slippery flooring	3	9%
4	**Wayfinding System**	**6**	**17%**
4.2	Singage	4	11%
4.3	Floor plan	2	6%
5	**Sustainability**	**3**	**9%**
5.2	Building materials	1	3%
5.3	HVAC system	1	3%
5.4	Energy efficiency measures	1	3%
6	**Patient Room**	**7**	**20%**
6.1	Single Vs Multibed	3	9%
6.4	Acuity-adaptable rooms	1	3%
6.6	Control of light and temperature	3	9%
7	**Family support space**	**6**	**17%**
7.1	Confortable waiting room	3	9%
7.4	Overnight bed in patient room	2	6%
7.7	Private meeting room	1	3%
8	**Staff support space**	**5**	**14%**
8.1	Workstation quality	1	3%
8.3	Nursing floor layout	1	3%
8.4	Supplies and storage	1	3%
8.6	Quality of space for meetings	2	6%

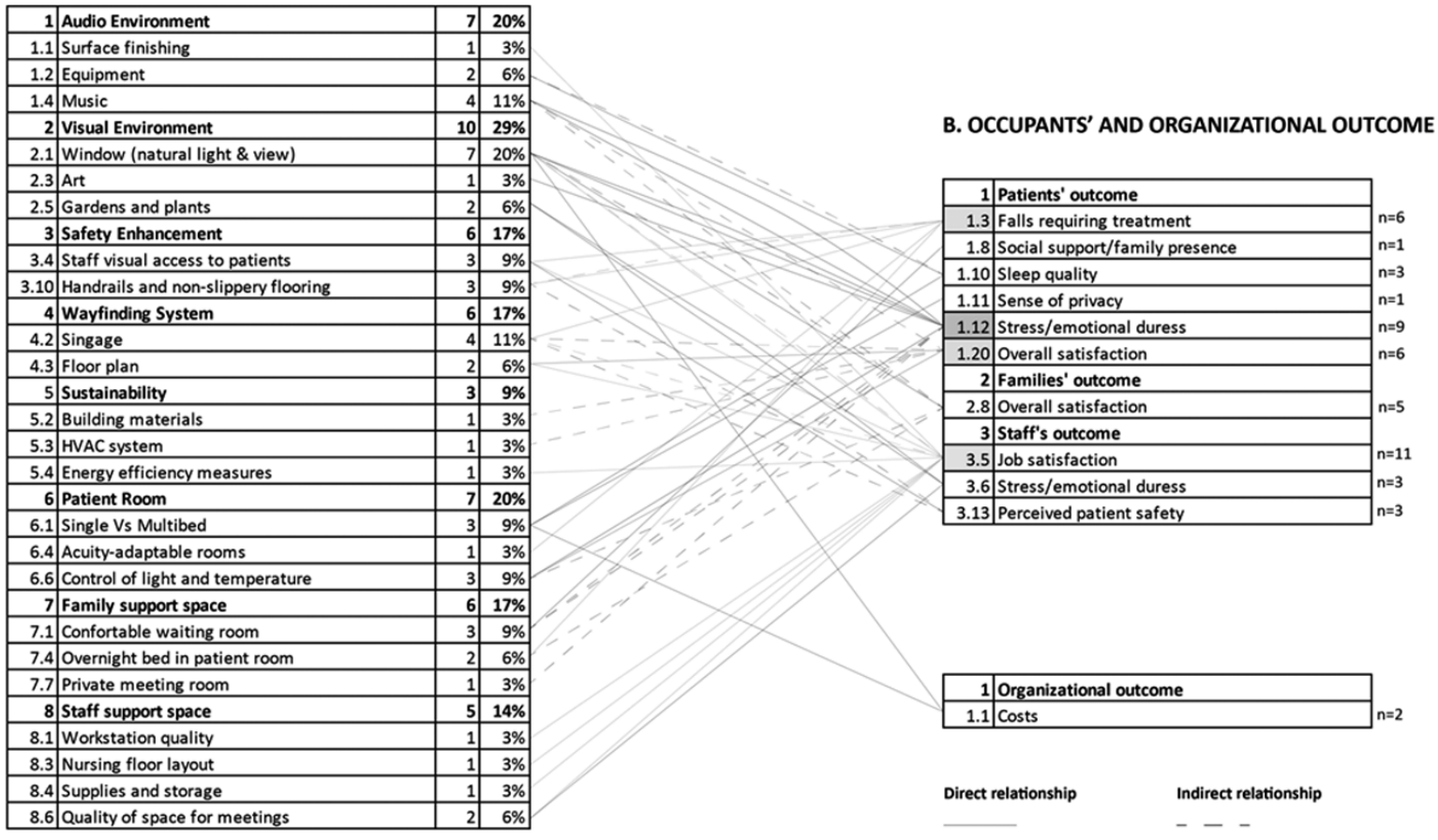

Fig. 3 - Significant relationship between Built Environment variables and occupants' and organizational outcomes with highlighted the 4 outcomes discussed.

identify several hospital users' outcomes that can be affected by built environment characteristics, as shown in Fig. 3. Patients' fall reduction, patients' stress reduction, patients' satisfaction and staff's job satisfaction emerged to be the most significant outcomes and, therefore, are hereafter discussed.

Falls reduction

Falls are a serious problem in healthcare facilities, especially in western countries, where they are always more and more inhabited by the elderly people (77). Although data reported that about 40% of falls in US hospitals have the root cause in the physical environment, most of the researchers about falls do not include building features as discrete variables (72). The literature review has been able to highlight several studies that instead focus on specific architectural features able to have direct or indirect impact on the number and seriousness of patient falls. Staff visibility and control of patient is one of the important issues that can contribute to prevent or at least to limit the damages of possible falls. The layout design is very important in this direction because, for instance, keeping doors open is possible only if there is enough space in the corridor (72) as well as the possibility of having different level of acuity rooms, where the most critical ones are closer to the staff areas. Another study found that a new EBD layout, with the presence of handrails and non-slippery floor covering, contributed to a 55% reduction in reported falls despite the increased post-relocation number of beds per unit (73). This result is consistent with occupants' ideas expressed in another study, where flooring materials and flooring irregularities were identified as fall risk factors (46). Since there is rarely a single cause of a fall, there cannot be a single or obvious prescriptive solution to prevent falls in hospitals. Nevertheless, built environment designers have an important role in identifying effective strategies, based on existing evidence, to prevent or mitigate the underlying conditions related to falls.

Patients' Stress reduction

The idea that environmental design has no role in patients' outcomes can no longer be accepted and there is growing evidence throughout the literature from many disciplines about the need to create a healing environment within hospital facilities (38). As Ulrich (35) and Wilson (37) showed in their seminal studies, the relationship with nature is able to reduce blood pressure and muscle tension, increase positive feelings and improve the overall well-being. Recently, scholars pointed out that also indoor environments may lead to stress by affecting individual and/or workplace needs in healthcare settings (42, 65). Based on Supportive Design theory, Andrade argued that the characteristics of the hospital rooms have a significant impact on reported stress and that the presence of positive elements (such as artwork, clock, or phone) explain this room effect. Perceived opportunities for control, access to social support and positive distraction are important but differences may exist among different cultures (36).

Patients' Satisfaction

Patient satisfaction is an important and commonly recognized indicator for measuring the quality in healthcare and several tools and questionnaires exist (78-80). One of the main challenge that today's hospital organizations have to face is the development of a patient-center approach (81), were the patient is not anymore just a user but a customer. Indeed, third-party payers too have recognized that patient satisfaction is an important tool for the success of their organization and are regularly monitoring patient satisfaction levels among their customers (79).

The Literature Review found important researches in this direction, where built

environment related factors can significantly contribute to increase the overall patient satisfaction, thanks to an EBD approach. Young patients have been found to be more satisfied when they were allowed to listen to music while undergoing dental treatment (64). Similarly, in another empirical study of a mental health inpatient unit, the most commonly selected feature emerged to be music panels (68) followed by light and color controls. The possibility to control environmental features of the inpatient room, such as light and temperature, emerged to be significant for patient satisfaction and perception of calmness (63). In addition, sense of control, privacy, innovation, comfort, and a "space to call on my own" (47, 50, 54, 55, 60, 82) are indicators of satisfaction among different sets of patients. Those results show that certain features of the spatial layout and the environmental design in hospital influence outcomes and, the greater is the number of those favorable variables included in the design, the higher patient satisfaction can be expected.

Staff's job satisfaction

As seminal works on job satisfaction states, the psychology of motivation is tremendously complex (48, 83). In recent times extensive research regarding nurse job satisfaction has been undertaken and has been linked to positive patients' outcomes and greater perceived quality of care (84, 85). The environment in which the nurse works has been found to have impact on job satisfaction, but in several papers and reviews it is considered just as the set of relationship and equipment that are present at work, forgetting the importance that the physical assets can have. On the contrary, the undertaken literature review shows that several built environmental features have direct impact on overall staff satisfaction. In an Indoor Environmental Quality (IEQ) comparison between an old and a new hospital, Aalto et al. (42) showed that features, such as surface finishing enhancing the acoustic qualities of the rooms, and the presence of large windows with natural light and natural view, have higher outcome in job satisfaction. Instead, a Pre and Post Occupancy Evaluation study (POE) shows limited direct improvement in job satisfaction but quite a lot in terms of physical demand and patient care quality, both of which are known to indirectly affect job satisfaction (73). Similarly, staff sample from another study demonstrated increased satisfaction and enhanced interprofessional interactions at a new hospital compared to an old one (54). Starting from the statement that a nurse on duty can walk upward of 8 km during an average 12-hr period, with an assignment of four patients, Jiang and Verderber conducted an extensive review of hospital circulation zones, confirming the hypothesis that physical work environment can affect one's overall job performance and job satisfaction (2). The definition of different sequence of public/private, interior/exterior spaces can create dedicated staff corridors, reduce overall noise, and therefore improve occupants' satisfaction. Finally, also soft qualities strategies have been found to be important. Another POE led by Kalantari and Snell (58) showed that color and icon-based wayfinding strategy was perceived as being effective and improving staff satisfaction.

Conclusions

The significant relationships found between (A) Built Environmental variables and (B) users' and organizational outcomes in the recently published scientific literature, confirm that the EBD theory, although developed in the 90s, is both contemporary and relevant. In the last two years most of the paper focusing on hospital built environmental quality consider as outcome four variables showing a growing attention in this direction.

Falls reduction, patient satisfaction, patient stress reduction and staff job satisfaction emerged to be the most important outcomes on which built environment has impact.

Limitations of the research

Certainly, the research has limitations. First, this review did not use two independent reviewers to conduct the study search, selection and evaluation, but only one researcher, supervised by a doctoral advisor, expert on the topic. Then, the selection of this period of time is intentional but might have led to excluding relevant contributions and a statistical significance analysis of the results may be conducted in future studies. Finally, the main challenge in this field is the selection of keywords and terms, because a clear and shared definition of design quality is missing (86).

Further development

The results suggest several promising research gaps that can be further investigated through two main possible research lines. First, the four users' outcomes found to be most relevant, might be further deepened in different fields such as architecture, environmental psychology or hospital management. Second, we suggest testing the results found throughout a statistical significance analysis and in real empirical settings, collecting them in a tool to test the quality of a real case study about hospital built environment. These two research lines will be followed by the authors as well in future works.

Riassunto

Ospedali Evidence Based. Revisione della recente letteratura riguardante l'impatto dell'EBD dell'ambiente costruito sugli utenti e sull'organizzazione dell'ospedale

Introduzione. L'ospedale è un'architettura complessa nella quale interagiscono diverse istanze architettoniche, tecnologiche, sociali e cliniche. Nei sistemi sanitari moderni si registra una crescente attenzione al tema della qualità in termini di processo ed esito, mentre gli aspetti strutturali (fisici) sono spesso poco considerati. Dagli anni '90 la teoria dell' Evidence Based Design (EBD) ha dimostrato che può esistere un rapporto significativo tra l'ambiente costruito e la salute/benessere degli utenti.

Obiettivo. Attraverso un'analisi della letteratura scientifica recente, l'obiettivo consiste nell'individuare quali sono gli impatti sugli utenti e sull'organizzazione a cui possono portare le caratteristiche fisiche dell'ospedale, attraverso un approccio EBD.

Metodologia. È stata condotta una revisione di letteratura attraverso i database Scopus e PubMed per poter identificare i trend principali che riguardano la valutazione della qualità ospedaliera da un punto di vista fisico e architettonico. I risultati sono stati analizzati sulla base del modello teorico EBD di Ulrich.

Risultati. Sono stati inclusi 35 paper pubblicati negli ultimi 2 anni. Le metodologie adottate sono molto differenti e i dati sono raccolti attraverso interviste o osservazioni ed elaborati attraverso analisi qualitative (33%), quantitative (26%) o miste (41%). Il tema è particolarmente attuale in USA, Australia, Canada, UK e nella regione scandinava ma si registrano anche alcuni contributi italiani. Le variabili ambientali che hanno un impatto sugli utilizzatori dell'ospedale (pazienti, staff) e sull'organizzazione riguardano principalmente: le caratteristiche visuali (29%), acustiche (20%) e di layout delle camere di degenza (20%).

Discussione e Conclusioni. Dallo studio emerge che l'ambiente costruito ha impatti significativi principalmente in termini di: soddisfazione dei lavoratori (n=11), riduzione dello stress nei pazienti (n=9), soddisfazione dei pazienti (n=6) e riduzione delle cadute in ospedale (n=6). Gli aspetti organizzativi, invece, sono indagati in soli 2 casi.Nonostante la teoria EBD sia stata elaborata negli anni '90, il tema è molto attuale e rilevante. La diversità dei contributi e le limitazioni della ricerca rendono sfidante una comparazione dettagliata. Successive indagini potranno approfondire ogni singola variabile trovata.

References

1. Latimer HS, Gutknecht H, Hardesty K. Analysis of Hospital Facility Growth: Are We Super-Sizing Healthcare? HERD 2008; **1**(4): 70-88. doi:10.1177/193758670800100407.
2. Jiang S, Verderber S. On the Planning and Design of Hospital Circulation Zones. HERD 2016; **10**(2): 124-46. doi:10.1177/1937586716672041.
3. Mauri M. The future of the hospital and the structures of the NHS. Techne-Journal of Tech-

nology for Architecture and Environment 2015; **9**: 27-34.
4. Astley P, Capolongo S, Gola M, Tartaglia A. Operative and Design Adaptability in Healthcare Facilities. Techne-Journal of Technology for Architecture and Environment 2015; **9**: 162-70.
5. Joachino C, Sileno L, Tresalli G. Le analisi a sostegno della programmazione degli investimenti in edilizia sanitaria. Nota di sintesi. Ires Piemonte, 2017, Available on: https://www.ires.piemonte.it/images/Ricerca/Sanita_edilizia/materiali/2017_IRES_Edilizia_NotaSintesi.pdf [Last accessed: 2018, Nov 19].
6. Mutti A, Bucci R. Il Sistema Ospedale dalla programmazione alla manutenzione. Roma: Carocci Editore, 2018.
7. Resconi C. La sicurezza in ospedale Strumenti di valutazione e gestione del rischio. Vol 1. INAIL, 2012. Available on: https://www.inail.it/cs/internet/docs/alg-la-sicurezza-in-ospedale-fascicolo-1.pdf [Last accessed: 2018, Nov 19].
8. Henriksen K, Isaacson S, Sadler BL, Zimring CM. The Role of the Physical Environment in Crossing the Quality Chasm. Jt Comm Qual Patient Saf 2007; **33**(11): 68-80. https://doi.org/10.1016/S1553-7250(07)33114-0.
9. Eisen S, Ulrich RS, Shepley MM, Varni JW, Sherman S. The Stress-Reducing Effects of Art in Pediatric Health Care: Art Preferences of Healthy Children and Hospitalized Children. J Child Health Care 2008; **12**(3): 173-90. doi:10.1177/1367493508092507.
10. Zhao Y, Mourshed M. Design indicators for better accommodation environments in hospitals: inpatients' perceptions. Intelligent Buildings International 2012; **4**: 199-215. doi:10.1080/17508975.2012.701186.
11. Buffoli M, Capolongo S, di Noia M, Gherardi G, Gola M. Healthcare Sustainability Evaluation Systems. In: Capolongo S, Bottero M, Buffoli M, Lettieri E, eds. Improving Sustainability During Hospital Design and Operation. Green Energy and Technology. Springer, 2015: **23**-9. doi: https://doi.org/10.1007/978-3-319-14036-0_3.
12. Clancy CM. Designing for Safety: Evidence-Based Design and Hospitals. Am J Med Qual 2008; **23**(1): 66-9. doi:10.1177/1062860607311034.
13. Sadler L, Blair L, Berry L, et al. Fable Hospital 2.0: The Business Case for Building Better Health Care Facilities. Hastings Cent Rep 2011; **41**(1): 13-23. doi:10.1002/j.1552-146x.2011.tb00093.x.
14. Capolongo S. Social aspects and well-being for improving healing processes' effectiveness. Ann Ist Super Sanita 2016; **52**(1): 11-4 doi: 10.4415/ANN_16_01_05.
15. Ulrich RS, Berry LL, Quan X, Parish JT. A Conceptual Framework for the Domain of Evidence-Based Design. HERD 2010; **4**(1): 95-114. doi:10.1177/193758671000400107.
16. Coppola L, Ripamonti E, Cereda D, Gelmi G, Pirrone A, Rebecchi A. 2015-2018 Regional Prevention Plan of Lombardy (Northern Italy) and sedentary prevention: a cross-sectional strategy to develop evidence-based programmes. Epidemiol Prev 2016; **40**(3- 4): 243-8. doi: 10.19191/EP16.3-4. P243.091.
17. Davidoff F, Haynes B, Sackett D, Smith R. Evidence Based Medicine. BMJ 1995; **310**(6987): 1085-6. doi:10.1136/bmj.310.6987.1085.
18. Donabedian A. The methods and findings of quality assessment and monitoring: an illustrated analysis. J Healthcare Qual 1985; **7**(3): 15. doi:10.1097/01445442-198507000-00011.
19. Farnè S. Qualità Operativa: Ottimizzare per Competere e Raggiungere l'Eccellenza. Milano: Franco Angeli, 2010.
20. Donabedian A. An Introduction to Quality Assurance in Health Care. Oxford: Oxford University Press, 2003.
21. Roberts JS, Coale JG, Redman RR. A history of the Joint Commission on Accreditation of Hospital. JAMA 1987; **258**(7): 936-40. doi:10.1001/jama.1987.03400070074038.
22. JCI. Standard Joint Commission International per l'Accreditamento degli Ospedali. JCI, 2014. Available on: https://www.jcrinc.com/assets/1/14/EBJCIH14I_Sample_Pages.pdf [Last accessed: 2018, Nov 20].
23. Nicklin W, Dickson S. The Value and Impact of Accreditation in HealthCare: A Review of Literature Literature Review. Accreditation Canada 2009. Available on: http://www.hadassah.org.il/media/1902067/t hevalueandimpactofaccreditationinhealthcarearevie.pdf [Last accessed: 2018, Nov 20].
24. Jaafaripooyan E, Agrizzi D, Akbari-Haghighi F. Healthcare Accreditation Systems: Further Perspectives on Performance Measures. Int J Qual Health Care 2011; **23**(6): 645-56. doi:10.1093/intqhc/mzr063.
25. Anthes E. The Office Experiment: Can Science Build the Perfect Workspace? Nature 2016; **537**(7620): 294-6. doi:10.1038/537294a.

26. Ciaramella A, Tronconi O. Qualità e prestazioni degli edifici. Come valutarle e misurarle: un modello di rating. Il Sole 24 Ore Norme & Tributi, 2011.
27. Anaker A, Heylighen A, Nordin S, Elf M. Design Quality in the Context of Healthcare Environments: A Scoping Review. HERD 2016; **10**(4): 136-50. doi:10.1177/1937586716679404.
28. McCullough C. Evidence Based Design for Healthcare Facilities. Sigma Theta Tau International, 2010.
29. Ulrich RS. View Through a Window May Influence Recovery from Surgery. Science 1984; **224**(4647): 420-1. doi: 10.1126/science.6143402.
30. Elf M, Nordin S, Wijk H, Mckee KJ. A Systematic Review of the Psychometric Properties of Instruments for Assessing the Quality of the Physical Environment in Healthcare. J Adv Nurs 2017; **73**(12): 2796-816. doi:10.1111/jan.13281.
31. Fink A. Conducting Research Literature Reviews: From Paper to the Internet. SAGE Publications, 1998.
32. Pati D, Lorusso LN. How to Write a Systematic Review of the Literature. HERD 2017; **11**(1): 15-30.
33. Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 2009; **6**(7): e1000097. doi:10.1371/journal.pmed100009.
34. Center of Health Design (CHD). Available on: https://www.healthdesign.org [Last accesses: 2018, Nov 20].
35. Ulrich RS, Robert FS, Barbara DL, Fiorito E, Miles MA, Zelson M. Stress Recovery during Exposure to Natural and Urban Environments. J Environ Psychol 1991; **11**(3): 201-30. doi:10.1016/s0272-4944(05)80184-7.
36. Andrade CC, Devlin AS, Pereira CR, Lima ML.Do the Hospital Rooms Make a Difference for Patients' Stress? A Multilevel Analysis of the Role of Perceived Control Positive Distraction, and Social Support. J Environ Psychol 2017; **53**: 63-72. doi:10.1016/j.jenvp.2017.06.008.
37. Wilson E. Biophilia. Cambridge (Mass): Harvard University Press, 1984.
38. Minton C, Batten L. Rethinking the intensive care environment: considering nature in nursing practice. J Clin Nurs 2016; **25**: 269-77, doi: 10.1111/jocn.13069.
38. Nejati A, Rodiek S, Shepley M. Using Visual Simulation to Evaluate Restorative Qualities of Access to Nature in Hospital Staff Break Areas. Landsc Urban Plan 2016; **148**(April): 132-8. doi:10.1016/j.landurbplan.2015.12.012.
40. Awang NA, Chua SJL, Ali AS. Building condition assessment focusing on persons with disabilities' facilities at hospital buildings. J Design and Built Environment 2017; Special Issue: 73-84.
41. Alexander K. The application of usability concepts in the built environment. J Facilities Management 2006; **4**(4): 262-70.
42. Aalto L, Lappalainen S, Salonen H, Reijula K. Usability evaluation (IEQ survey) in hospital building. Int J Workplace Health Manag 2017; **10**(3): 265-82. https://doi.org/10.1108/IJWHM-03-2016-0014.
43. Canter D. The Psychology of Place. London: The Architectural Press, 1977.
44. McLaughlan R. Psychosocially Supportive Design: The Case for Greater Attention to Social Space Within the Pediatric Hospital. HERD 2018; **11**(2): 151-62.
45. Merchant S, O'Connor M, Halkett G. Time, space and technology in radiotherapy departments: how do these factors impact on patients' experiences of radiotherapy? Eur J Cancer Care 2017; **26**(2). doi: 10.1111/ecc.12354.
46. Melo S. The role of place on healthcare quality improvement: A qualitative case study of a teaching hospital. Soc Sci Med 2018; **202**: 136-42 https://doi.org/10.1016/j.socscimed.2018.03.003 .
47. MacAllister L, Zimring C, Ryherd E. Environmental Variables That Influence Patient Satisfaction. HERD 2016; **10**(1): 155-69. doi:10.1177/1937586716660825.
48. Andrade CC, Lima ML, Devlin AS, Hernández B. Is It the Place or the People? Disentangling the Effects of Hospitals' Physical and Social Environments on Well-Being. Environ Behav 2016; **48**(2): 299-323.
49. Akao Y, Mazur GH. The leading edge in QFD: past, present and future. International J Qual Reliabil Manag 2003; **20**(1): 20-35. https:// doi.org/10.1108/02656710310453791.
50. Wood LC, Wang C, Abdul-Rahman H, Abdul-Nasir NSJ. Green Hospital Design: Integrating Quality Function Deployment and End-User Demands. J Clean Prod 2016; **112**: 903-13. doi:10.1016/j.jclepro.2015.08.101.

51. Elo S, Kyngäs H. The qualitative content analysis process. J Adv Nurs 2008; **62**(1): 107-15.
52. Capolongo S, Buffoli M, di Noia M, Gola M, Rostagno M. Current scenario analysis. in: Capolongo S, Bottero MC, Buffoli M, Lettieri E, eds. Improving Sustainability During Hospital Design and Operation: A Multidisciplinary Evaluation Tool. Cham: Springer, 2015: 11-22. doi: 10.1007/978-3-319-14036-0_2.
53. Buffoli M, Capolongo S, Bottero M, Cavagliato E, Speranza S, Volpatti L. Sustainable healthcare: how to assess and improve healthcare structures' sustainability. Ann Ig 2013; **25**(5): 411-8.doi:10.7416/ai.2013.1942.
54. Alvaro C, Wilkinson AJ, Gallant SN, Kostovski D, Gardner P. Evaluating Intention and Effect: The Impact of Healthcare Facility Design on Patient and Staff Well-Being. HERD 2016; **9**(2): 82-104.
55. Barnes S, Torrington JM, Lindquist KP. Does the design of hospitals meet the needs of older people? An evaluation of three acute-care settings. HERD 2018; **11**(2): 177-88.
56. Capolongo S, Gola M, Di Noia M, et al. Social Sustainability in Healthcare Facilities: A Rating Tool for Analyzing and Improving Social Aspects in Environments of Care. Ann Ist Super Sanita 2016; **52**(1): 15-23. doi: 10.4415/Ann_16_01_06.
57. McLaughlan R, Pert A. Evidence and speculation: reimagining approaches to architecture and research within the paediatric hospital. Med Humanit 2018; **44**: 146-52.
58. Kalantari S, Snell R. Post-Occupancy Evaluation of a Mental Healthcare Facility Based on Staff Perceptions of Design Innovations. HERD 2017; **10**(4) 121-35.
59. McCusker J, Minh Vu TT, Veillette N, et al. Elder-Friendly Emergency Department: Development and Validation of a Quality Assessment Tool. J Am Geriatr Soc 2018; **66**(2): 394-400. doi:10.1111/jgs.15137.
60. Buffoli M, Bellini E, Dell'Ovo M, et al. Humanisation and soft qualities in emergency rooms. Ann Ist Super Sanita 2016; **52**(1): 40-7. doi: 10.4415/ANN_16_01_09.
61. Pati D, Pati S, Harvey TE. Security Implications of Physical Design Attributes in the Emergency Department. HERD 2016; **9**(4): 50-63.
62. Anåker A, von Koch L, Sjöstrand C, Bernhardt J, Elf M. A comparative study of patients' activities and interactions in a stroke unit before and after reconstruction-The significance of the built environment. PLoS ONE 2017; **12**(7). doi: https://doi.org/10.1371/journal.
63. Schreuder E, Lebesque L, Bottenheft C. Healing Environments: What Design Factors Really Matter According to Patients? An Exploratory Analysis. HERD 2016; **10**(1) 87-105.
64. Jayakaran TG, Rekha CV, Annamalai S, Baghkomeh PN, Sharmin DD. Preferences and choices of a child concerning the environment in a pediatric dental operatory. Dent Res J 2017; **14**: 183-7.
65. Nejati A, Shepley M, Rodiek S, Lee C, Varni J. Restorative Design Features for Hospital Staff Break Areas: A Multi-Method Study. HERD 2016; **9**(2): 16-35.
66. Ulrich RS, Zimring C, Zhu X, et al. A Review of the Research Literature on Evidence-Based Healthcare Design. HERD 2008; **1**(3): 61-125.
67. Hurtley C, ed. Night Noise Guidelines for Europe. Copenaghen: WHO Regional Office for Europe, 2009. ISBN 978 92 890 4173 7.
68. Trzpuc SJ, Wendt KA, Heitzman SC, Skemp S, Thomas D, Dahl R. Does Space Matter? An Exploratory Study for a Child-Adolescent Mental Health Inpatient Unit. HERD 2016; **10**(1): 23-44.
69. Harte JD, Sheehan A, Stewart SC, Foureur M. Childbirth Supporters' Experiences in a Built Hospital Birth Environment: Exploring Inhibiting and Facilitating Factors in Negotiating the Supporter Role. HERD 2016; **9**(3): 135-61.
70. Ramm K, Mannix T, Parry Y, Gaffney MP. A Comparison of Sound Levels in Open Plan Versus Pods in a Neonatal Intensive Care Unit. HERD 2017; **10**(3): 30-9.
71. Pyrke RJL, McKinnon MC, McNeely HE, Ahern C, Langstaff KL, Bieling PJ. Evidence-Based Design Features Improve Sleep Quality Among Psychiatric Inpatients. HERD 2017; **10**(5): 52-63.
72. Taylor E, Hignett S. The SCOPE of Hospital Falls: A Systematic Mixed Studies Review. HERD 2016; **9**(4): 86-109.
73. Copeland D, Chambers M. Effects of Unit Design on Acute Care Nurses' Walking Distances, Energy Expenditure, and Job Satisfaction: A Pre-Post Relocation Study. HERD 2017; **10**(4): 22-36.
74. Capolongo S, Bellini E, Nachiero D, Rebecchi A, Buffoli M. Soft qualities in healthcare: Method and tools for soft qualities design in hospitals' built environments. Ann Ig 2014; **26**: 391-9.

75. Maben J, Griffiths P, Penfold C, et al. One size fits all? Mixed methods evaluation of the impact of 100% single-room accommodation on staff and patient experience, safety and costs. BMJ Qual Saf 2015; **0**: 1-16. doi:10.1136/bmjqs-2015-004265.
76. Jiang S, Powers M, Allison D, Vincent E. Informing Healthcare Waiting Area Design Using Transparency Attributes: A Comparative Preference Study. HERD 2017; **10**(4): 49-63.
77. Morse JM. Preventing Patient Falls.2.ed. New York: Springer. ISBN:9780826103895.
78. Ware JE, Snyder J, Wright MK, Davies AR. Defining and measuring patient satisfaction with medical care. Eval Program Plann 1983; **6**: 247-63.
79. Prakash B. Patient Satisfaction. J Cutan Aesthet Surg 2010; **3**:151-5. doi: 10.4103/0974-2077.74491.
80. Buffoli M, Bellini E, Bellagarda A, di Noia M, Nickolova M, Capolongo S. Listening to people to cure people: The LpCp – tool, an instrument to evaluate hospital humanization. Ann Ig 2014; **26**(5): 447-55. doi: 10.7416/ai.2014.2004
81. Origgi L, Buffoli M, Capolongo S, Signorelli C. Light wellbeing in hospital: research, development and indications. Ann Ig 2011; **23**(1): 55-62.
82. Freihoefer K, Zborowsky T. Making the Case for Practice-Based Research and the Imperative Role of Design Practitioners. HERD 2017; **10**(3): 66-82.
83. Herzberg F. One more time: How do you motivate your employees? Harv Bus Rev 1987; Sept-Oct: 5-16.
84. Hayes B, Bonner A, Pryor J. Factors contributing to nurse job satisfaction in the acute hospital setting: a review of recent literature. J Nurs Manag 2010; **18**: 804-14.
85. Alfonsi E, Capolongo S, Buffoli M. Evidence based design and healthcare: an unconventional approach to hospital design. Ann Ig 2014; **26**(2): 137-43. doi: 10.7416/ai.2014.1968
86. Anaker A, Heylighen A, Nordin S, Elf M. Design Quality in the Context of Healthcare Environments: A Scoping Review. HERD 2017; **10**(4): 136-50.

Corresponding Author: Andrea Brambilla, Department of Architecture, Built Environment, Construction Engineering, Politecnico di Milano, Via E. Bonardi 9, 20133 Milan, Italy
e-mail: andrea1.brambilla@polimi.it