

Effects of Indoor Environmental Quality on Occupant Satisfaction in Healing Environments

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Abstract: Indoor environment has a potential impact on health by influencing behaviors, actions, and interactions of patients and their families as well as the health providers. The motto of health professionals since Hippocrates "First, do no harm" seems to be not widely followed in recent times. Unhealthy buildings can cause a lot of illnesses to occupants. Sick building syndrome (SBS) is a poorly understood phenomenon where people have a range of symptoms related to a certain building and there is no specific identifiable cause. The effect of poor indoor environmental quality (IEQ) is not only on physical health of the building occupants, but also on their psychological health. Through extensive review, the paper addresses different factors, which affect both physical and psychological health of occupants in healing environments.

These factors are divided into two main categories; (a) spatial factors, which include the architecture design of the space, views of nature and nature images, indoor plants and landscaping, wayfinding and orientation of the space, pleasant color scheme, the presence of coordinated art objects, furniture layout, and video and virtual reality environments; and (b) environmental factors include air quality and freshness, availability of daylight, thermal comfort, and acoustic quality.

Since hospitals are profoundly different from other types of buildings, the study focused on integrating the aforementioned factors toward an optimal healing environment for children in a state pediatric hospital in Assiut city, which has potential impacts on occupant satisfaction and wellbeing. Based on a comprehensive literature review, the paper also summarizes both negative and positive factors, which provide a point of departure for further investigation and exploration within the field of IEQ in healing environments.

Keywords: *Occupant Satisfaction, Healing Environments, IEQ Factors*

1. Introduction

There are multiple stressful components leads to discomfort while being in healing environments such as (i) psychological fears: worries about illness, isolation from family and friends, fear of medical procedures, lack of familiarity with medical personnel, hospital equipment, and the sterile hospital environment [1], and (ii) physical complaints: eye, nose and throat irritation, headache, fatigue, nausea, dizziness and skin irritation accompanied by symptoms of lack of fresh air, stuffiness, poor temperature control and unpleasant odors [2].

The purpose of this paper is to provide a succinct and systematic review of the existing research in indoor environmental quality (IEQ) in healing environments, in order to achieve the occupant satisfaction and to improve the patients' physical and psychological health during hospitalization

by non pharmacological approaches, which depend on dealing with IEQ factors; both spatial and environmental ones.

The paper begins with the concept of healing environments, which is introduced in Section 2; the paper discusses in the following Section 2.1 the illnesses caused by poor IEQ. Then, In Sections 3.1 and 3.2 the study elaborates both spatial factors and environmental factors respectively, which affects the patients' health. Section 4 describes the possibility of integration of these factors in a state pediatric hospital in Assiut city as a case study, which aimed to reach occupant satisfaction based on the literature review, while Section 5 concludes the paper.

2. Healing environments

The word "healing" comes from the Anglo-Saxon word haelen, which means to make whole. One way to understand the term is

as harmony of mind, body, and spirit. Healing is not the same as curing, which is about fixing problems, eradicating disease, and decreasing symptoms. People can be healed even if they are not cured. For example, those with a chronic disease can learn to be at peace despite their condition. Conversely, people may be cured but not healed [3]. Thus, healing environments are designed to promote harmony of mind, body, and spirit.

Huelat posited whether caregivers, good medicine, beautiful surroundings, and astute diagnoses may make the healing journey a pleasant transition from illness to health, or the journey might be filled with fear, trepidation, confusion, discomfort, and anxiety from being separated from loved ones and familiarity [4].

Zborowsky et al argued that such environments can reduce stress and anxiety, which positively affects our health in a number of ways. Neuroscience is showing that our brain and nervous, endocrine, and immune systems are constantly interacting [3].

Thus, a noisy, confusing hospital room might leave a patient not only feeling worried, sad, or helpless but also might raise his or her blood pressure and heart rate and increase muscle tension. In addition, hormones released in response to stress could suppress the patient's immune system, causing wounds to heal more slowly.

2.1. Sick building syndrome (SBS) and building related illness (BRI)

A variety of expressions have been associated with illnesses caused by poor IEQ, such as sick building syndrome (SBS), building related illness (BRI) and environmental sensitivity. Sick building syndrome varies in a number of ways from building related illness. The symptoms of sick building syndrome are predominantly non-specific, that is they are not readily identifiable to one illness, or one contaminant source [5].

Unhealthy buildings cause a lot of illnesses to the occupants. BRI has been defined as illness that the causal factor can be identified clinically [6]. The illnesses are usually characterized by a unique set of symptoms which may be accompanied by clinical signs, laboratory findings, and identifiable pollutants such as hypersensitivity pneumonitis, humidifier fever, asthma, and allergic rhinitis. A variety of symptoms are reported by occupants suffering from BRI; these are listed in Table 1.

Table 1. Symptoms typical of BRI [7]

Affected organs	Symptoms
General	irritability, fatigue, chills
Skin	evanescent rashes, dermatitis
Neurologic	drowsiness, inability to concentrate, headache, forgetfulness
Eye	watering eyes, burning and redness, conjunctivitis
Nose & Throat	runny nose, rhinitis, sore throat, sneezing, dry mucous membranes, nasal congestion
Airway	wheezing, chest tightness, cough, chest pain, shortness of breath
Musculoskeletal	aches and pains
Gastrointestinal	stomach pain, nausea

3. Factors affecting indoor environmental quality (IEQ)

Many studies indicate that there are various factors which have profound effects on occupant satisfaction in indoor environments. These factors should be considered integrated components; the qualities of one factor significantly affect those of another. The caveat is that every IEQ decision should be regarded as having potential positive or negative consequences in each of these factors.

The effect of poor IEQ is not only on physical health of the building occupants,

but also on their psychological health. The study investigates the different factors, which affect both physical and psychological health of occupants in healing environments. These factors are classified into two categories: spatial factors and environmental factors.

3.1. Spatial factors

To promote the speed of postoperative recovery and to achieve satisfaction during hospitalizations, it is important to provide patients with not only the best treatment possible, but also to remove such sources of stress and to counter them with positive distractions, which can affect the perceived waiting time positively [1], [8].

Positive distractions refer to a small set of environmental features or conditions that effectively reduce stress. Distractions can include certain types of music, furniture layout, Indoor plants and landscaping, wayfinding and orientation, color scheme, art objects, views of nature and virtual reality (VR) intervention [9] as explained below.

3.1.1. Architecture design of the space

Design cannot eliminate disease, but it can alter the experience the hospital guests have through their own healing journey. [4]. Architecture design of a space influences users' sensory perceptions and affect staff recruitment and retention, as well as efficiency and productivity [10]. It also influences behaviors, actions and interactions of patients, families, and staff members [11].

Sufficient space in patient rooms and waiting areas provides more opportunities for social contact. Designing patient room with carpets instead of hard surface flooring contributes to expand the length of stay for families and friends. Decentralized nursing stations provide opportunities for patient/staff interactions [11]. The relationship among staff (physicians, nurses) is also affected by design; gardens and lounges encourage positive interactions which can promote greater job satisfaction.

Architecture design of a space can also aid to decrease patient falls; for instance widening bathroom doors gives the opportunity to accommodate a staff person ambulating with the patient.

3.1.2. Views of nature and nature images

Nature images have a remarkable impact on satisfaction of patients in healing environments. In an experimental study to test the effects of specific nature images, on participants experiencing pain, Vincent et al founded that participants with no image experienced greater pain levels in the affective pain ratings than participants who viewed image categories for refuge, hazard, and mixed prospect and refuge [12]. The mixed prospect and refuge image category resulted in significantly less perceived sensory pain sensation, while the hazard image received the highest mood disturbance scores of all groups, despite its highly effectiveness in distracting participants from pain.

3.1.3. Indoor plants and landscaping

The viewing of plants has been considered an effective positive distraction, which may increase positive feelings, block or reduce worrisome thoughts, and promote restoration from stress. Researchers who have assessed the impact of plants on human health have suggested that nature and plant experiences are positively associated with human physical, psychological, emotional, and cognitive health. In addition, viewing plants is linked to pain reduction, less need for analgesics, and fast recovery from surgery [1].

Interior hospital spaces can be made healthier and more comfortable with the presence of living plants. Previous research has indicated that indoor plants reduce sick-building syndrome by removing pollutants, increase relative humidity up to human comfort level, and improve indoor air quality by reducing the quantity of mold spores and airborne microorganisms. Park et al suggested that plant selection should be based on space consideration, sunlight

accessibility, requirements of temperature and humidity, low maintenance, and visual appeal with various colors, sizes, patterns, and shapes [1].

3.1.4. Wayfinding and orientation of the space

Wayfinding problems in hospitals are costly and stressful and have particular impacts on outpatients and visitors, who are often unfamiliar with the hospital and are otherwise stressed and disoriented. Informational handouts, information desks, you-are here maps, directories and signages along the way are critical wayfinding aids. Previous studies found that people who used signs found their destination faster than those who only used maps [9].

Much of the cost of the wayfinding system in a study conducted at a major regional hospital in the US was the hidden costs of direction giving by people other than information staff, which occupied more than 4,500 staff hours, the equivalent of more than two full-time positions [13].

Directional signs should be placed at or before every major intersection, at major destinations, and where a single environmental cue or a series of such cues (e.g. change in flooring material) convey the message that the individual is moving from one area into another.

3.1.5. Pleasant color scheme

Color is definitely a perceptive characteristic of primary importance when it involves in designing an environment's visual appearance. There are multiple ways that color can be introduced within an environment: from the color of the architectural surfaces (walls, floors, ceilings) to the color of elements of furniture, from fabrics to linens, through the use of colored lighting.

Choosing chromatic solutions for the healing environments depends on different variables starting from patient's age, moving through patient's pathology, and type of activity that is performed in the

environment, ending with the user whether he/she is family or staff.

On the one hand, it is necessary to create a varied color panorama within confined environments in order to reach conditions of wellbeing. It is also important to use chromatic solutions that support an emotional state that is coherent with the type of activity that is performed there [14]. Further, colors can influence the perception of time; in rooms where monotonous activities are performed, the use of a chromatic palette having cold shades gives the impression that time passes more quickly. Color can also be effectively used to assist people with orientation and wayfinding. There are many possible uses of this visual attribute in such context.

On the other hand, the color of the patient's skin tone is an important chromatic piece of information. It is therefore necessary to guarantee proper vision for diagnostic purposes. Yellow, green and purple distort skin tone. These colors must therefore be avoided in those environments where it is important for the staff to be able to clearly see the patient's skin (for example the nursing station and the patient's room). Blue must also be avoided in cardiology wards because it makes diagnosis difficult [14].

3.1.6. Presence of coordinated art objects

Although the exact amount of time patients and families wait in hospitals and clinics varies, there is general agreement that the waiting periods are perceived as long, uneventful, and stressful. However; the adverse effects of waiting can be soothed more effectively by improving the attractiveness of the waiting environment than by shortening the objective waiting time [8].

The assumption that all types of paintings and other visual art are positive distractions for patients is not commonly accepted. Ulrich et al found that art work should be chosen carefully as interviews with patients indicated strongly negative reactions to artworks that were ambiguous, surreal, or

could be interpreted in multiple ways [9]. The same patients, however, reported having positive feelings and associations with respect to nature paintings and prints.

3.1.7. Furniture layout

Furniture and equipment in the patients' residential environments often support their comfort and function, while in a hospital environment it could be a source of danger because of the patient's unfamiliarity with them. Therefore, concerns have to be brought to furniture layout as it has been identified to be the primary cause of patient falls in the healthcare settings [15]. Furniture arrangements have also shown a significant effect on social interactions at waiting areas, rooms, and lounges in health care settings [11].

Furthermore, ergonomic characteristics of furniture and equipment can cause long-term muscular or nerve injury due to poor bodily positioning or muscle use [10]. As a way to support patients' functions, designing furniture should be based on achieving ease in handling, flexibility, and modularity, in addition to safety, hygiene, and lack of toxicity [14].

3.1.8. Video and VR environments

Video and VR methods expose persons to interesting and distracting environments. Several studies examined the effects of video and VR methods in controlling pain, pulse rate, and anxiety, showing significant evidence in decreasing pain intensity, pain unpleasantness, and time spent thinking about pain [16]. VR presentations should be personalized to patient characteristics such as age, gender, and ethnicity.

3.2. Environmental factors

There has recently been heightened recognition that environmental factors can influence health, which in turn affect the satisfaction of patients [16]. Air quality and freshness, availability of daylight, thermal comfort and acoustical quality are the important factors of IEQ in healing environments, which affect occupant

satisfaction. Below are short explanations of the four elements.

3.2.1. Air quality and freshness

There is increasing concern within the scientific community about the effects of the indoor air quality (IAQ) on health. There is also a growing public awareness of the risks associated with poor indoor air quality in the different environments. The accumulation of chemical pollutants, such as volatile organic compound (VOCs), poses a significant hazard [17]. A century ago, the off-gassing of pollutants from synthetic building materials was not a problem. Rather, the overriding concern was to prevent the spread of infectious diseases. The LEED (Leadership In Energy And Environmental Design) certification program for sustainable new and renovated buildings has been criticized on these grounds. The recent report *The Green Building Debate: LEED Certification: Where Energy Efficiency Collides With Human Health* notes that many of the building materials in use today contain chemicals considered to be hazardous by the World Health Organization (WHO). WHO mentioned that poor air quality increases the risk of nosocomial infection [18].

3.2.2. Availability of daylight

The quality and quantity of daylight exposure and artificial lighting is associated with several patient and staff outcomes in healthcare settings. Access to daylight is important for both staff and patients. For patients, it has been found to improve health outcomes such as depression, agitation, sleep, circadian rhythms, as well as reducing intake of pain medication and for certain types of patients, it also may reduce length of stay. For staff, access to daylight contributes to higher satisfaction due to its impacts on visual performance and psychological state of a person by regulating the circadian rhythm [10], [19]. Therefore, site planning and the orientation

of healthcare facilities should be carefully considered to ensure sufficient daylight and avoid situations where some buildings block light for others.

3.2.3. Thermal comfort

Thermal comfort in hospitals is one of the most important factors in the designing phase for architects and engineers. A hospital is a 24 hour and 7 day operation space with a strict indoor air requirement. Creating a thermal comfortable environment can be helpful in stabilizing moods of patients and can also assist in the healing process. In addition, the comfortable environment can reduce the length of patient stay in hospitals. A thermal comfortable environment has a great influence on the satisfaction of indoor building occupants [20].

Thermal comfort can be defined as “the condition of mind which expresses satisfaction with the thermal environment” (ASHRAE Handbook 2005). The predicted mean vote (PMV) is a seven point thermal sensation scale for assessing thermal comfort in a special zone. There are six variables which affect the PMV. They can be divided in two main parts: personal factors (clothing value and activity value) and environmental factors (air temperature, mean radiant temperature, air velocity and relative humidity). PMV value according to the ASHRAE thermal sensation scale ranges from -3 to +3 as follows 3: hot, 2: warm, 1: slightly warm, 0: neutral, -1: slightly cool, -2: cool, -3: cold. For estimating thermal comfort satisfaction of people, predicted percentage dissatisfied (PPD) is used. It is considered if 80% of occupants are satisfied it would be good; that is, PPD less than 20% is acceptable [20]. Comfort range is between 25C and 27.7C and the acceptable range would be 23.8C to 29C.

3.2.4. Acoustic quality

Hospitals are noisy places with numerous sources of noise, and historically they have been designed with sound-reflecting

surfaces that worsen acoustic conditions and enable noises to echo and propagate over large areas. Healthcare providers perceive higher noise levels as stressful and sufficiently high to interfere with their work [21].

Certain environmental interventions have been found effective for reducing noise in hospital settings, including installing high performance sound-absorbing ceiling tiles, eliminating or reducing noise sources (e.g., adopting a noiseless paging system), and providing single-bed rather than multi-bed rooms [19].

4. Assiut university pediatric hospital as a case study

Significant correlations between the enhancement of several spatial factors and the occupant satisfaction had been indicated in two clinic waiting areas in Weill Cornell Medical Center, New York city [8]. At the same city, Becker et al also pointed out positive correlations between more attractive environments and occupant satisfaction in Presbyterian Hospital [22]. With the regard to environmental factors, Kotzer et al found out that design and operational changes to light, noise, temperature, aesthetics, and amenities in Children's Hospital Colorado, Anschutz Medical Campus had a remarkable influence on post-occupancy evaluation of the built environment [23].

The research adopted different approaches based on the previous field studies in order to enhance the facility of Assiut University pediatric hospital in Egypt. This hospital faces various significant challenges despite of being slightly new. The study focuses on the department of diagnostic imaging as being one of the crucial departments that create much apprehension, fear of the unknown, and expectancy of pain and discomfort.

Based on the literature review in Section 3, the department has been redesigned to integrate the aforementioned factors in order to achieve the patient satisfaction and wellbeing.

It's usually tough getting kids to go willingly to hospitals; they always have fears and worries about such environments. That's exactly the perception that the new design for the diagnostic imaging department tries to counteract.

The functional distribution of the department areas were designed according to the actual sequence of activities performed within them as illustrated in Figure 1. The intention was to create an optimal healing environment for children, that has a welcoming and friendly atmosphere with a home like surroundings.

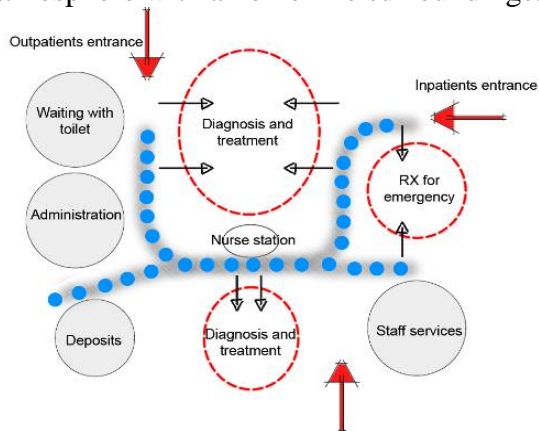


Fig. 1. The actual sequence of activities in the department of diagnostic imaging.

To avoid high spatial density, the waiting area is divided into two areas to promote moderate social interaction. These areas are designed to be a livable space with the presence of a playing area observed directly by the patient's family to emphasize relax mode for the child by reassuring him/her. In order to encourage children to serve themselves, shelving and furniture that contains toys designed to be opened and directly reveal their contents like what shown in Figure 2.

The centerpiece of the diagnostic imaging area is the corridor that funnels patients to the respective area for diagnosis. Moving to this corridor is a sign to the child that the operation will start shortly, that's why a strategy of positive distraction was used to lead the patient's thoughts far from the contingent negative situation.

Along the path, a colorful "natural scene" with environmental graphics is designed to

accompany the child from the beginning of the corridor through abstracting leaves in a shape of small scattered circles that continue to grow along the path to create the main scene in the middle of the corridor which is surrounded by a short time waiting chairs.



Fig. 2. Shelving toys in the waiting area [14].

As the variation of colors is a fundamental characteristic of the natural environment, a varied color panorama is created within the corridor environment in order to reach conditions of satisfaction, whereas intense colors were used in handrails and doorframes to create accents and conditions of chromatic contrast which aids in the visual organization of the environment.

Regarding the orientation of the space, the path is designed to be perceived by wayfindings and signs on the flooring. The placement of images and figures with a strong orientation towards the directions guide kids to their destination without the need to ask as displayed in Figure 3.

The medical equipments offered in the diagnostic imaging department are the ultrasound, endoscopy, traditional x-rays, magnetic resonance (NMR), and computerized axial tomography (CAT scans).

The variety of the procedures performed results in the use of large and highly sophisticated equipments which have a strong emotional impact on patients, therefore techniques to "screen" this equipments are embedded in the design.

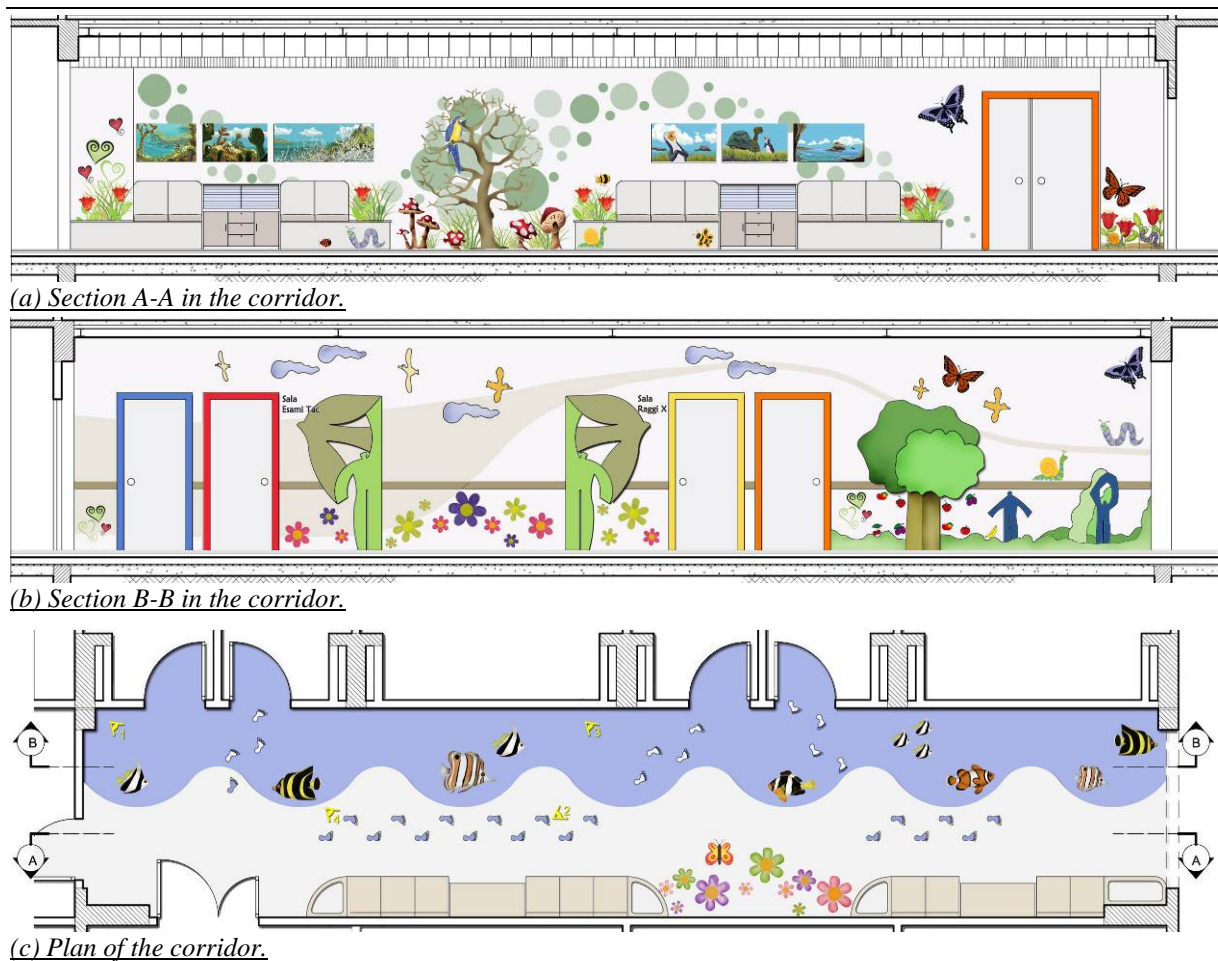


Fig. 3. The architectural drawings of the centerpiece corridor in the diagnostic imaging department.

Following on that the interesting studies conducted by Philips “Ambient experience”, which is indicated in Figure 4 to create environments that can be personalized by means of the control of light, color, music, and images that can be projected in the procedure room.



(a) G. Salesi pediatric hospital, Ancona, Italy.



(b) Laughlin memorial hospital, Greeneville, Tennessee, USA.

Fig. 4. Screening the equipments to alleviate the sensation of strong emotional impact [16].

The new department's interior finishes are proposed to be selected with the intent to minimize harmful impacts on the indoor environment and to protect the health of patients. Radiation protection products are suggested to be used in doors, windows and walls. Furthermore, low VOC paints are preferred to be used on the walls and in the adhesives for flooring which contributes to raise the quality of indoor air. Slippery floors (Granite or Ceramic) also should be avoided; which can add significantly to patient falls [24]. The study suggests other flooring materials, such as synthetic rubber, polyethylene, and polypropylene to reduce immediate health impacts on patients and staff.

Figure 5 shows three dimensional simulated shots for the interior design of the main corridor, which connects patients from the public waiting area to the procedure rooms in the department of diagnostic imaging.



Fig. 5 (a) Shot 1

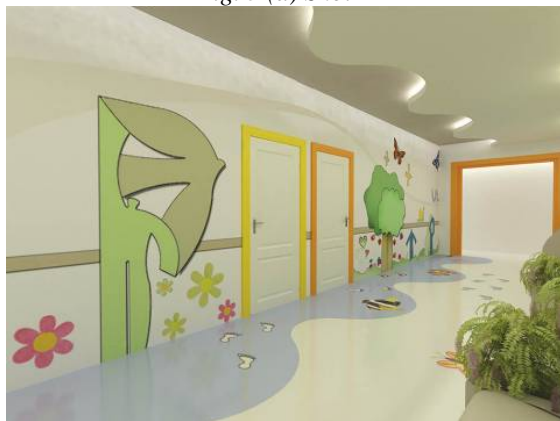


Fig. 5 (b) Shot 2



Fig. 5 (c) Shot 3



Fig. 5 (d) Shot 4

Fig. 5. Simulated shots of the case study.

5. Conclusion

Health in the built environment especially in hospitals is a complex issue that must be balanced with numerous others issues during the design and construction of a building. Architects are well positioned to advance the quality of indoor environments through their selection of building materials, finishes, furnishings, views and orientations, as well as through the design of the building systems. The study addresses both spatial and environmental IEQ factors which affect the occupant satisfaction in healing environments. Both negative and positive influential factors of wellbeing and satisfaction in indoor environments are summarized in Figure 6.

The case study of Assiut university pediatric hospital serves as an example of how slightly interventions can make a potential difference in the quality of indoor environment, which in turn has a great influence on occupant satisfaction.

The positive results of actual field studies conducted in similar environments act as indicators of success. However; the need to take onsite measures and occupant feedback should be taken into consideration in the future work.

It is also hoped that this study will illuminate the topic of IEQ and provide a point of departure for further investigation and exploration within the field of IEQ in healing environments.

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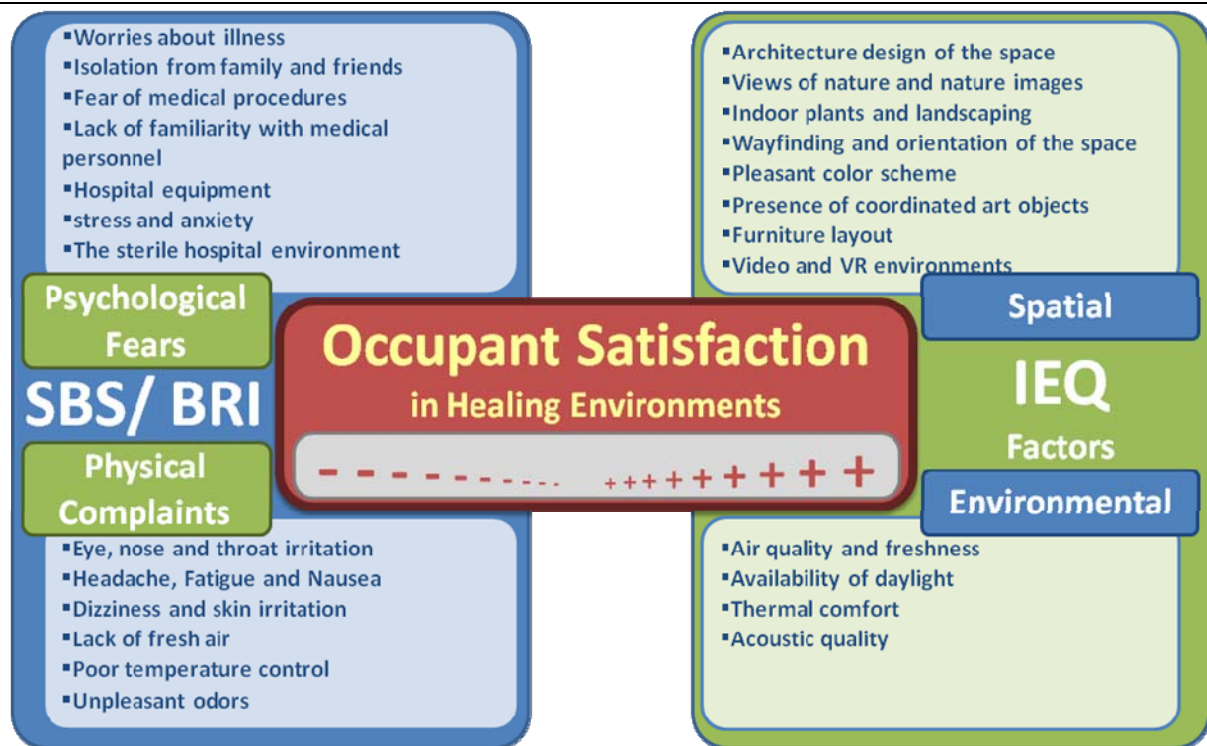


Fig. 6. Factors affecting occupant satisfaction in healing environments.

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