The Nigerian HealthCare Facilities: Need for Adopting Evidence-Based Design as an Innovative Approach for Improved Health and Wellbeing

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Abstract. As a result of innovative design technological approaches and practices, healthcare design has dramatically improved over the years. This has resulted in the emergence of new domains in the design of healthcare facilities. One facet of these domains is "evidence-based design" (EBD) practices, which have left indelible imprints on healthcare design and the built environment by focusing on end-users. EBD has become a beneficial trend in healthcare design and is predominantly applied in the United States and Europe. However, this design practice has not been significantly utilized in the design of Nigerian healthcare facilities. Therefore, this paper examines the level of awareness, uptake, and prevalence of EBD factors in five selected healthcare facilities (general hospitals) in Lagos and Abuja, Nigeria. It also highlights the function, design aspects, principles, process, and stages of EBD in the healthcare design process. A qualitative research design was adopted for the present study. A structured checklist was distributed to patients (N = 25) and staff (N = 25) to obtain their views on the EBD intervention at selected general hospitals. The researcher's observation was used to collect other additional data. The results show that incorporating EBD elements into the design of healthcare facilities in Nigeria will significantly reduce stress, increase job satisfaction, and improve overall health outcomes.

Keywords: Evidence-based design · Healthcare facilities · Design factor · Wellbeing

1 Introduction

There has been a significant transformation in the design of healthcare facilities in recent years. This includes the application of innovative design approaches that have created

A. D. Mambo et al. (Eds.): InterSol 2022, LNICST 449, pp. 49–65, 2022.
https://doi.org/10.1007/978-3-031-23116-2_4

new domains within the healthcare milieu, such as user-centered design and evidence-based design (EBD) (Reay et al. 2017; Quan et al. 2017), Djukic and Marić 2017). These design approaches take into consideration the needs of users and introduce novel ways of improving the health care landscape. The EBD is one component of this approach, which has been defined as "the purposeful attempt to base design decisions on credible evidence from research in order to improve design outcomes and critically evaluate post-occupancy results" (Zimring et al. 2004). In the same vain, Oladejo et al. (2015), recommends that healthcare facilities require the consideration and measurement of user needs and expectations to achieve optimal design. This can be done by communicating vital information to the design team and others working towards the effectiveness of the organization.

Pioneering establishments and industries have adopted the knowledge of EBD approaches in the last few decades and have integrated them into their context (Smith 2007). This approach has been applied in various building types, however have been widely utilized in healthcare facilities (Hamilton and Watkins 2009). Fundamentally in EBD approach, it is required that design strategies and evidence need to be incorporated into different phases of the building process. To achieve this, the EBD procedure needs to be broken down into steps that would correspond with the conventional design stages.

The Center for Health Design (CHD) documents the EBD process into eight steps, namely: (1) define evidence-based goals and objectives; (2) find sources for relevant evidence; (3) critically interpret relevant evidence; (4) create and innovate evidence-based design concepts; (5) develop a hypothesis; (6) collect baseline performance measures; (7) monitor implementation of design and construction; and (8) measure post-occupancy performance results (CHD 2012; Rashid 2013). Incorporating these steps into practice requires team work between healthcare organizations, researchers, and the design team.

Fig. 1. Integration of the evidence-based design process in project stages (Adapted from CHD 2012; Rashid 2013; Martin 2009)

A schematic wheel showing the stages of integrating the eight-evidence-based design process into various phases of a project from start to finish is show in Fig. 1. It is important for designers to note that adopting EBD approach is not a rejection of creativity but a means to improve their design solutions (Martin 2009). Similarly, Fig. 2. Highlights the integration of EBD steps as it relates to various project designs phase as stated by the Center for Health Design.

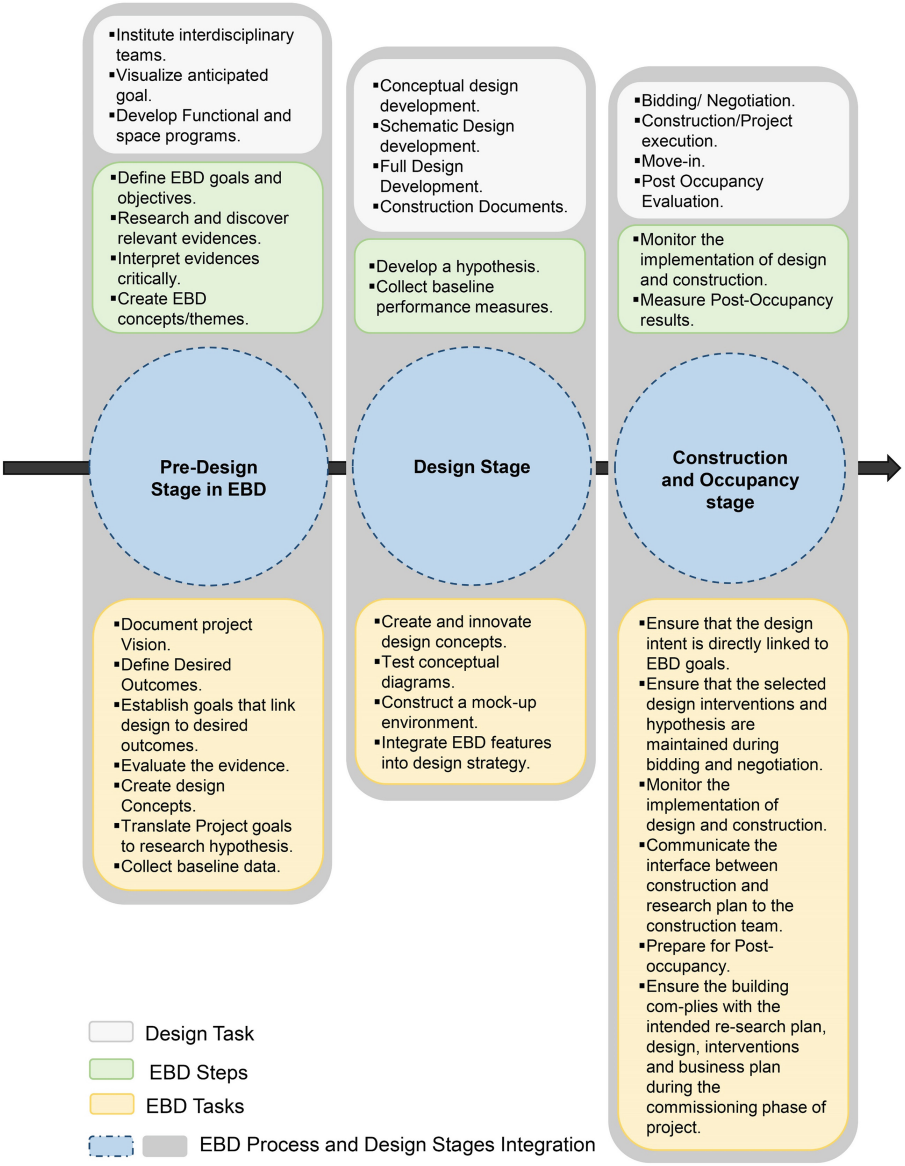


Fig. 2. EBD process and their integration in design stages (Adapted from CHD 2012; Rashid 2013; Martin 2009)

1.1 Describing the Evidence-Based Design (EBD) Concept in Healthcare Settings

The EBD concept was adapted from evidence-based medicine (EBM), which is a medical practice approach that emphasizes the use of evidence from well-designed and conducted research to improve decision-making. EBM is "the conscientious, explicit, and judicious use of current evidence in making decisions for clinical treatments and outcomes of patients" (Sackett et al. 1996). This involves gathering reliable imperial evidence from research and using the evidence to develop the basis for clinical procedures and treatment programs (Molzahn 2007; Sackett et al. 1996, 1997).

However, the origins of evidence-based design (EBD) can be traced all the way back to the 1860s, when the provision of fresh air was cited as the first canon for linking the physical environment of a healthcare facility to improved patient and staff safety, wellness, and satisfaction. With the advances made in EBD and technology development in the 1970s, there was a gradual shift that transformed the healthcare landscape into a "medical machine" that promoted social, physical, and psychological wellness.

The EBD approach is based on gathering data from research and project evaluations in order to design therapeutic spaces that are restorative for patients and healthcare workers, encourages family involvement and improves staff performance, (Smith 2007), as well as to improve the design, management, and policymaking of healthcare facilities (Sigma Theta Tau 2010). Studies have shown that patients who looked out into a brick wall experienced less discomfort when exposed to a view of nature from their hospital rooms, consumed less pain medication, and were discharged sooner than those who looked out onto a brick wall (Ulrich 1984; Malenbaum et al. 2008).

Similarly, Mackrill et al. (2017) stated that a well-designed healthcare environment can improve patients' and staff's experiences as well as have a positive impact on their physical and mental status. To achieve these positive impacts, a range of non-pharmacological approaches have been employed in healthcare settings. For instance, therapeutic gardens and healing gardens as non-pharmacological interventions have been shown to improve wellness and reduce the levels of pain, agitation, and anxiety of patients in healthcare settings (Gillis and Gatersleben 2015; Jiang 2014).

1.2 Describing the Therapeutic Environment

Patients, their families, and healthcare workers frequently perceive healthcare settings as stressful. However, if they are structured to promote beneficial physiological, psychological, social, and behavioral effects, they can be therapeutic (Iyendo et al. 2016; Linden et al. 2016; Uwajeh et al. 2019) (see Fig. 3). Previous research has backed up this theory, demonstrating the necessity to create healing settings that increase user experience (Ghazali and Abbas 2017; Iyendo 2017; Altimier 2004). Other effective interventions include art therapy (Kometiani 2017), music therapy (Goldstein 2016), music medicine (Iyendo 2016), and horticulture therapy (Detweiler et al. 2012). While the advantages of healing environments have been explored, there is still a need to delve more into the specific elements of these environments.

Both patients and caregivers benefit from therapeutic surroundings because they foster a shared environment that promotes self-healing. In other words, the healing environment should mirror the patients' values, beliefs, and philosophies. Hence, the

integration of EBD strategies into the healthcare environment has created a sustainable and ecological healthcare ecosystem (Anåker et al. 2017) that improves clinical outcomes (Ulrich et al. 2008; Iyendo 2016), economic performance, and job satisfaction (Pati et al. 2008).

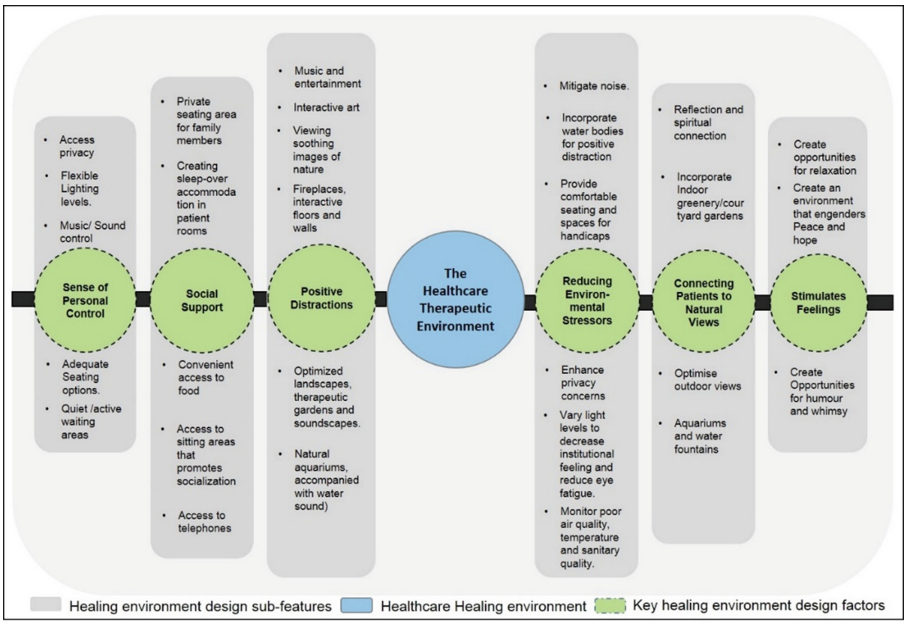


Fig. 3. A model for understanding the therapeutic environment (Adapted from Linden et al. 2016; Uwajeh et al. 2019).

2 Research Methods

A qualitative research design was adopted for the present study. A structured checklist was distributed to patients (N = 25) and staff (N = 25) to obtain their views on the EBD intervention at selected general hospitals in Lagos and Abuja, Nigeria. Twenty-two males (N = 22) and twenty-eight females (N = 28) participated in the study. The researchers also collected additional data through observation. The authors designed the structured checklist employed in this investigation. To ensure content validity, items were adapted from prior relevant studies (CHD 2012; Iyendo et al. 2016) and modified to fit within our current investigation.

The information was gathered over an eight-week period in September and October 2021.The checklist covered four sections, including demographic characteristics of respondents; the staff and patients' awareness of EBD factors; the staff rating of EBD factors; and the patient rating of EBD factors.

3 Literature Review of Related Works

As shown in Fig. 4, the Center for Health Design (CHD) categorizes health and design strategies for improving healthcare environments into fourteen (14) major topics: behavioral and mental health; clinical design; communication; emergency department throughput; healthcare reform; impact on ageing; infection control; noise; patient-centered medical home; perception of cleanliness; population health; patient-centered-driven design; safety; and technology.

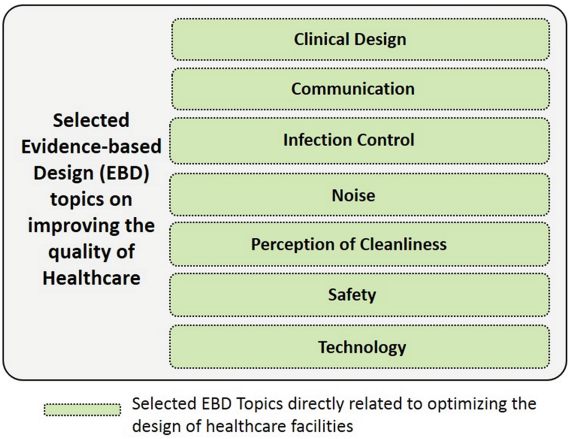


Fig. 4. Main EBD topics on healthcare improvement (Adapted from CHD 2012)

3.1 Clinical Design

The various physical aspects of healthcare environments can either positively or negatively impact patient experiences. For example, when considering an ambulatory design, renovation, or improvement to the physical space, what a patient goes through from the time they enter a community clinic to the time they leave the building or clinic parking lot should always be considered during the design process. Significant evidence demonstrates that user-centered data acquired from evidence-based studies has been used to improve the physical environment and patient safety in hospitals through architectural design (Selami Cifter and Cifter 2017; Ulrich et al. 2008; Calkins and Cassella 2007; Dettenkofer et al. 2004), improved staff outcomes (Bayramzadeh and Alkazemi 2014; Weinel 2008; Miller et al. 2006; Chhokar et al. 2005; Keir and MacDonell 2004; Nelson et al. 2003) as well as other factors, including Landscape, gardens and nature-based views (Iyendo et al. 2016; Beyer et al. 2014,Thompson et al. 2014; Lottrup et al. 2013; Ulrich et al. 2008; Kearney and Winterbottom 2005; Ulrich 1984), Table 1 presents studies that highlight the positive architectural impacts of well-designed clinical environments and their effect on user's outcome.

Table 1. Studies on EBD interventions related to Clinical Design.

EBD factor(s) and references	Findings	EBD Interventions
Design impact: Selami Cifter and Cifter 2017; Reay et al. 2017; Ulrich et al. 2008; Calkins and Cassella 2007; Dettenkofer et al. 2004)	• Patients may experience stress in inadequate design clinical settings that restrict them privacy • Inadequately constructed and located nursing stations might increase nurses' stress levels and degrade care quality • Stress-free hospital surroundings promote patient well-being and the healing process	• Patient-care unit floor design should have corridors structured around a central nursing station, where medications and charts are centrally situated to prevent staff fatigue and maximise time for treatment • Private patient rooms enable greater operational and administrative freedom and have a beneficial therapeutic impact on patients • Infections such as influenza, tuberculosis (TB), measles, and chickenpox can be prevented by housing patients in single rooms
Improved staff outcomes: (Bayramzadeh and Alkazemi 2014; Weinel 2008; Miller et al. 2006; Chhokar et al. 2005; Keir and MacDonell 2004; Nelson et al. 2003)	• Using ceiling-lift technology for patient handling increases patient safety and dignity • Staff stress levels are increased in intensive care units by blinking lights, alarms, and equipment noise	• When comparing ceiling lifts to floor lifts, evidence indicates that caregivers sustain less musculoskeletal injuries • Lifting and transferring patients using a ceiling lift places less strain on the trunk and shoulder muscles than lifting and transferring patients with a floor lift • The installation of assistive equipment helps to reduce back injuries among healthcare workers
Landscape, gardens, and nature-based views: (Iyendo et al. 2016; Beyer et al. 2014; Thompson et al. 2014; Lottrup et al. 2013; Ulrich et al. 2008; Kearney and Winterbottom 2005; Ulrich 1984)	• Patients undergoing heart surgery reported feeling less anxious and stressed when shown a landscape scenario with trees and water bodies • Residents of hospitals prefer windows with abundant views of nature over those with limited views of nature • In healthcare, exposure to nature can help alleviate symptoms of sadness, anxiety, and stress • Patients who recover in a hospital with a view of trees have shorter hospital stays, use less pain medication, and have better outcomes than patients who recover in a hospital with a view of a brick wall	• Garden design that incorporates water bodies, natural noises such as bird song, and the sound of the breeze results in healing spaces that contribute to overall wellbeing • Introduce indoor plants to detoxify the air and to reflect, diffract, or absorb certain frequencies of sound • Certain plants are said to be as good as carpeting in reducing high-frequency sounds in rooms with hard surfaces • Integrating natural green or land-scape aspects into the healthcare ecosystem to improve patient outcomes and to foster a positive atmosphere for visitors and healthcare providers • Relaxing nature scenes might help deflect unpleasant thoughts

3.2 Communication

There are several examples of the consequences of poor communication in the literature: avoidable hospital admissions (Vermeir et al. 2015; Garåsen and Johnsen 2007) and readmissions (Walraven et al. 2002; Moore et al. 2003). Hospital admissions have been observed to be reduced when interventions to increase communication and coordination are implemented (Peikes et al. 2009). Other avoidable problems of inadequate communication in healthcare have been shown to have an economic impact. These include unnecessary testing, polypharmacy-inappropriate referrals, and recurrent recommendations for concerns that were not satisfactorily addressed during the first visit. (Gandhi et al. 2000; Epstein 1995).

3.3 Infection Control

In most institutions today, healthcare-associated infections and other easily transmissible diseases are a substantial concern. Implementing some of the most current healthcare design best practices can help to mitigate their impact. As seen in Table 2, EBD findings and interventions from research literature, case studies, interviews, and other materials to provide an overview of the topic of infection control are highlighted (Prussin and Marr 2015; Allegranzi and Pittet 2009; Ulrich et al. 2008; Ulrich and Wilson 2006; Griffiths

Table 2. Studies on EBD interventions related to Infection Control.

EBD factor(s) and references	Findings	EBD Interventions
Infection Control: [Prussin and Marr 2015; Allegranzi and Pittet 2009; Ulrich et al. 2008; Ulrich and Wilson 2006; Mineshita et al. 2005; Griffiths et al. 2005; Blanc et al. 2004; Conger et al. 2004; Sehulster et al. 2004)	• Showers, sinks, aerators, faucets, and toilets are all common places for pathogenic bacteria to congregate • Faucets should not be directed directly into the sink trap, as this may result in splashing • In healthcare environments, patients, employees, and visitors often carry pathogens from ill patients or other airborne sources • In patient rooms, placing sinks near the entrance encourages hand washing, but placing them away from the bed prevents splashes from reaching the patient • Environmental services personnel's work can be made easier and faster by designing rooms with furniture and surfaces that can be easily cleaned with only one or two products	• Using a variety of control methods during the construction or remodelling process, such as effective filters, appropriate ventilation systems, and air change rates • Installation of high-efficiency particulate air filters in acute healthcare settings, particularly ambulatory care facilities and operating rooms, is recommended to remove particles as small as 0.3 μm in diameter, such as (Aspergillus spores), 2.5 μm to 3.0 μm in diameter • Infection transmission between patients and caregivers is reduced by placing hand-washing basins with continuous impermeable surfaces near staff mobility pathways • Healthcare facilities should keep cold water below 68°F (20 °C), hot water above 140°F (60 °C), and circulate hot water with a minimum return temperature of 124°F (51 °C)

et al. 2005; Mineshita et al. 2005; Sehulster et al. 2004) (Blanc et al. 2004; Conger et al. 2004).

3.4 Noise

Noise has an impact on the safety and health of patients and is a significant component of their experience. Patients frequently complain about noise levels while in the hospital, but there are a variety of treatments that can help to create a healthier and more comfortable environment (Iyendo 2016; Iyendo 2017; Iyendo et al. 2016; Hofhuis et al. 2012; Gardner et al. 2009; Akansel and Kaymakçi 2008; Ulrich et al. 2008; Cmiel et al. 2004; Baldock 2003; Mazer 2012; Orellana et al. 2007) (Table 3).

Table 3. Studies on EBD interventions related to Noise.

EBD factor(s) and references	Findings	EBD Interventions
Noise: [Iyendo 2016; Iyendo 2017; Iyendo et al. 2016; Hofhuis et al. 2012; Gardner et al. 2009; Akansel and Kaymakçi 2008; Ulrich et al. 2008; Cmiel et al. 2004; Baldock 2003; Mazer 2012; Orellana et al. 2007)	• Noise is associated with medical and nursing errors, as well as tracking and monitoring activities • Patient anxiety can be exacerbated by noise from physicians' and nurses' paging devices • Ambient noise contributes to sleep deprivation and confusion, which can result in increased prescription use and patient constraint • Noise has a significant impact on employee stress and irritation levels, perceived job pressure, burnout, and emotional tiredness • Noise impairs memory, aggravates agitation, aggressive behaviour, sadness, and anxiety, and exacerbates communication difficulties	• Utilizing sound-absorbing materials to reduce noise can assist in minimising distractions, reducing stress and medical mistakes, and improving sleep and general staff job performance • Implementation of new technologies to mitigate the noise generated by physicians' and nurses' paging devices, as well as fall alarm sensors put on patient beds • The use of pleasant natural sound interventions, such as singing birds, soft breeze, and ocean waves, indicated advantages that contribute to patients' and staff's reported restoration of attention and stress recovery • When compared to silence, listening to calming music has been demonstrated to lower stress, blood pressure, and post-operative trauma

3.5 Perception of Cleanliness

In terms of infection prevention, environmental cleanliness has an impact on patient experience, satisfaction, perceived service quality, and real service quality. To achieve specified degrees of cleanliness, an interdisciplinary strategy is required, which includes building design, operational and regulatory modifications, personnel education, and organizational culture changes (CHD 2012).

3.6 Safety

The design industry and healthcare owners have often taken distinct approaches to safety. Designers frequently consider fire and life safety, whereas healthcare owners and caregivers may consider safety in terms of serious reportable occurrences and hospital-acquired disorders. However, adverse outcomes such as healthcare-associated infections, prescription errors, damage from patient handling, self-harm (or aggression against others), security breaches, and falls can all be exacerbated by poorly built and operated hospital environments. Healthcare safety is complicated and necessitates a methodical approach that includes a grasp of organizational aspects, people, and the often-overlooked environment (CHD 2012).

3.7 Technology

Healthcare facilities can improve diagnosis and treatment, as well as patient outcomes, by utilizing cutting-edge technologies such as electronic health record systems, robotic surgery, remote video connections, and pharmaceutical safety systems. These advances can support cost-effective and efficient patient-centered care, all of which should be carefully integrated into the details of the layout and design. Recent studies reveal the advantages of medical robotics, wearables, and autonomous systems in healthcare during the novel coronavirus pandemic. Robots, for example, might be employed to help limit the spread of COVID-19 or assist in large-scale COVID-19 screening. By allowing frontline healthcare providers to assess, evaluate, monitor, and treat patients from a safe distance, digital health solutions, such as telehealth and telepresence technologies, can greatly minimize the risk of infectious disease transmission (Tavakoli et al. 2020; Parimbelli et al. 2018; Weinstein et al. 2014). The healthcare system has been able to conduct emergency minimally invasive surgeries using telerobots, lowering the risk to the physician during the pandemic. For example, Intuitive's daVinci Surgical Robot has been widely adopted in hospitals around the world (See Fig. 5). A clinician controls the daVinci's patient-side manipulators through a surgical console. While the surgical console is usually situated in the same operating room as the patient, plastic sheets or tents might be utilized to totally segregate the surgeon from COVID-19 patients with minimum changes to existing clinical practice (Tavakoli et al. 2020).

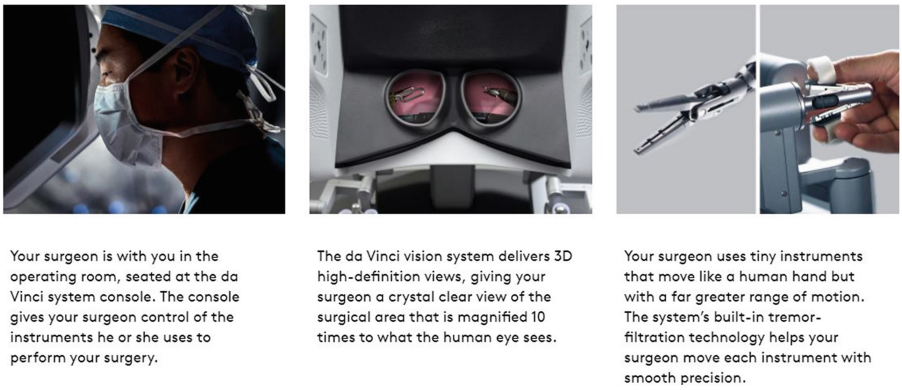


Fig. 5. The daVinci surgical robot by intuitive (da Vinci Systems 2021).

4 Results and Discussion

4.1 Socio-Demographic Characteristics of the Respondents'

Combined data on the distribution of respondents by gender indicates that 22 (44%) are male and 28 (56%) are female (Fig. 6).

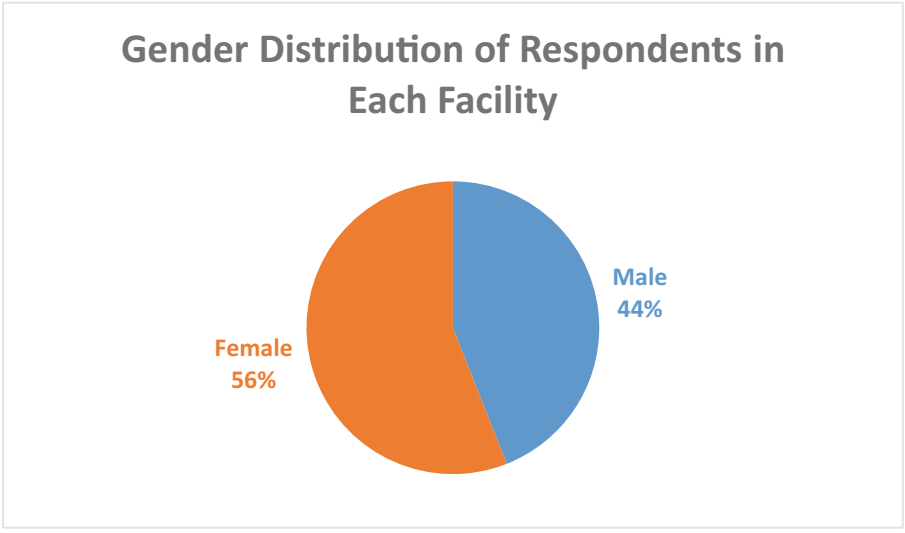


Fig. 6. Gender distribution of respondents in each institution.

4.2 Staff and Patient Awareness of EBD Factors in the Selected Hospitals

Table 4 presents the level of awareness about EBD among staff and patients. The findings found that just a small percentage of staff (10%) in each of the five hospitals reported

being aware of EBD in hospitals. This was especially noticeable among employees who traveled outside of the country and visited hospitals in other countries, such as the United Kingdom and the United States. On the contrary, most patients (90%) stated that they were unaware of EBD in their hospitals. This is because EBD is not implemented at the hospitals where they are admitted.

Table 4. Checklist for staff and patient awareness of EBD Factors in the selected healthcare facilities

EBD Factors	Number of Respondents	Classification of response	Awareness level (%)
Staff	25	Aware	10%
Patients	25	Oblivious	90%

4.3 Staff Rating of EBD Factors in the Selected Hospitals

Considering the extent to which the selected hospitals use EBD, most of the staff (90%) claimed that noise levels within the hospitals were a major complaint and concern, followed by "safety" (84%) and lack of "infection control" (66%). The findings also revealed that most hospitals (70%) did not comply with EBD factor requirements and that technology was used inefficiently (68%) (Fig. 7).

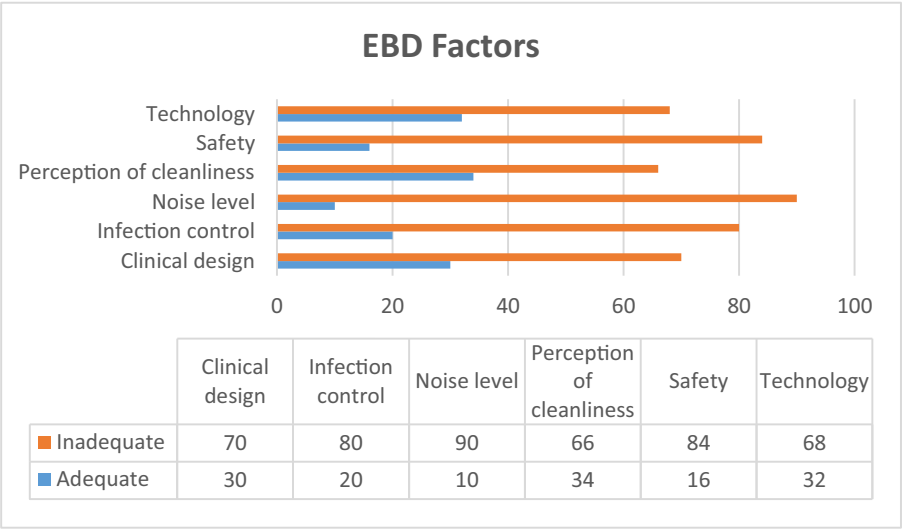
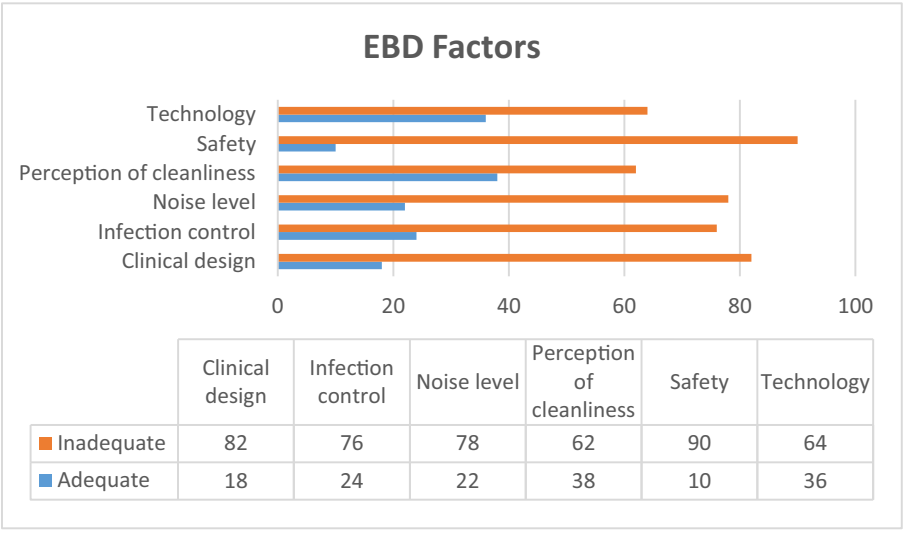


Fig. 7. Checklist for staff rating of EBD Factors in the selected healthcare facilities

4.4 Patient Rating of EBD Factors in the Selected Hospitals

As provided in Fig. 8, in terms of patient perceptions of EBD use, results from the five hospitals studied revealed that most patients (90%) believe that a lack of safety is their primary issue, which could be attributable to ineffective staff care. This is unsurprising given that most patients concur that hospital designs (82%) are inadequate, and noise levels (78%) within hospitals remain a significant patient complaint, followed by a lack of infection control (76%). A slight majority (64%) believed that technology was underutilized in hospitals and that it should be fully employed to improve health and well-being.



	Clinical design	Infection control	Noise level	Perception of cleanliness	Safety	Technology
Inadequate	82	76	78	62	90	64
Adequate	18	24	22	38	10	36

Fig. 8. Checklist for patient rating of EBD Factors in the selected healthcare facilities

5 Conclusion

The results of our research show how patients and staff in Nigerian general hospitals feel about the use of EBD. It also yielded important data for increasing patient knowledge and insight into the use of EBD. The staff and patients' ratings on EBD factors revealed that safety issues should be prioritized, followed by noise levels, infection control, and clinical design. According to our findings, both patients and staff believe that proper implementation or application of EBD in Nigerian hospitals would improve their health and well-being as well as the hospital physical environment for better outcomes. As a result, more research is needed to determine how much EBD factor support patients and staff should receive, as well as how much they should rely on other aspects of EBD factors for productive outcomes.

5.1 Limitations and Directions for Future Research

Although our study was limited to only five hospitals, this appears to be a restriction in terms of the findings' wider transferability and generalizability. Nonetheless, because our research is based on real-life staff and patient experiences, it adds to the empirical research findings that are useful for informing EBD practice in hospital settings. There is also a lack of thorough statistical analysis. We have argued, however, that interpretive research, such as this investigation, is not suitable for extensive statistical analysis because it is based solely on reporting perception. Nonetheless, a longitudinal and ethnographic study in which a researcher spends a significant amount of time observing staff and patients' perceptions and ratings of EBD factors in use in various Nigerian hospitals would be beneficial in providing richer insights into how EBD affects patients' health and wellbeing, as well as staff performance in general.

References

Akansel, N., Kaymakçi, Ş: Effects of intensive care unit noise on patients: a study on coronary artery bypass graft surgery patients. J. Clin. Nurs. **17**(12), 1581–1590 (2008)

Allegranzi, B., Pittet, D.: Role of hand hygiene in healthcare-associated infection prevention. J. Hosp. Infect. **73**(4), 305–315 (2009)

Altimier, L.B.: Healing environments: for patients and providers. Newborn Infant. Nurs. Rev. **4**(2), 89–92 (2004). https://doi.org/10.1053/j.nainr.2004.03.001

Anåker, A., Heylighen, A., Nordin, S., Elf, M.: Design quality in the context of healthcare environments: a scoping review. HERD: Health Environ. Res. Des. J. **10**(4), 136–150. (2017). https://doi.org/10.1177/1937586716679404

Baldock, C.: More attention must be paid to sleep. Bri. J. Nursing **13**(6), 296 (2003)

Bayramzadeh, S., Alkazemi, M.F.: Centralized versus decentralized nursing stations: An evaluation of the implications of communication technologies in healthcare. HERD: Health Environ. Res. Des. J. **7**(4), 62–80 (2014)

Blanc, D.S., Nahimana, I., Petignat, C., Wenger, A., Bille, J., Francioli, P.: Faucets as a reservoir of endemic Pseudomonas aeruginosa colonization/infections in intensive care units. Intensive Care Med. **30**(10), 1964–1968 (2004)

Calkins, M., Cassella, C.: Exploring the cost and value of private versus shared bedrooms in nursing homes. Gerontologist **47**(2), 169–183 (2007)

CHD (Center for Health Design).: Evidence-Based Design Accreditation and Certification. Author, Concord, CA (2012). http://www.healthdesign.org/edac/about

Chhokar, R., Engst, C., Miller, A., Robinson, D., Tate, R.B., Yassi, A.: The three-year economic benefits of a ceiling lift intervention aimed to reduce healthcare worker injuries. Appl. Ergon. **36**(2), 223–229 (2005)

Cmiel, C.A., Karr, D.M., Gasser, D.M., Oliphant, L.M., Neveau, A.J.: Noise control: A nursing team's approach to sleep promotion: Respecting the silence creates a healthier environment for your patients. Am. J. Nurs. **104**(2), 40–48 (2004)

Conger, N.G., et al.: Mycobacterium simiae outbreak associated with a hospital water supply. Infect. Control Hosp. Epidemiol. **25**(12), 1050–1055 (2004)

da Vinci Systems, I.: Robotic-Assisted Surgery as a Minimally Invasive Option (2021). https://www.davincisurgery.com/

Dettenkofer, M., Wenzler, S., Amthor, S., Antes, G., Motschall, E., Daschner, F.D.: Does disinfection of environmental surfaces influence nosocomial infection rates? A systematic review. Am. J. Infect. Control **32**(2), 84–89 (2004)

Detweiler, M.B., et al.: What is the evidence to support the use of therapeutic gardens for the elderly? Psychiatry Investig. **9**(2), 100–110 (2012). https://doi.org/10.4306/pi.2012.9.2.100
Djukic, A., Marić, J.: Towards socially sustainable healthcare facilities–the role of evidence-based design in regeneration of existing hospitals in Serbia. Procedia Environ. Sci. **38**, 256–263 (2017)
Epstein, R.M.: Communication between primary care physicians and consultants. Arch. Fam. Med. **4**, 403–409 (1995)
Gandhi, T.K., Sittig, D.F., Franklin, M., Sussman, A.J., Fairchild, D.G., Bates, D.W.: Communication breakdown in the outpatient referral process. J. Gen. Intern. Med. **15**(9), 626–631 (2000)
Garåsen, H., Johnsen, R.: The quality of communication about older patients between hospital physicians and general practitioners: A panel study assessment. BMC Health Serv. Res. **7**(1), 1–7 (2007)
Gardner, G., Collins, C., Osborne, S., Henderson, A., Eastwood, M.: Creating a therapeutic environment: A non-randomised controlled trial of a quiet time intervention for patients in acute care. Int. J. Nurs. Stud. **46**(6), 778–786 (2009)
Ghazali, R., Abbas, M.Y.: Paediatric wards: Healing environment assessment. Asian J. Environ.-Behav. Stud. **2**(3), 77–87 (2017).
Gillis, K., Gatersleben, B.: A review of psychological literature on the health and wellbeing benefits of biophilic design. Buildings **5**(3), 948–963 (2015). https://doi.org/10.3390/buildings5030948
Goldstein, B.: The Secret language of the heart: How to use music, sound and vibration as tools for healing and personal transformation. Hierophant Publishing (2016)
Griffiths, W.D., Bennett, A., Speight, S., Parks, S.: Determining the performance of a commercial air purification system for reducing airborne contamination using model micro-organisms: A new test methodology. J. Hosp. Infect. **61**(3), 242–247 (2005)
Hamilton, D.K., Watkins, D.H.: Evidence-based design for multiple building types. John Wiley & Sons (2009)
Hofhuis, J.G., Langevoort, G., Rommes, J.H., Spronk, P.E.: Sleep disturbances and sedation practices in the intensive care unit: A postal survey in the Netherlands. Intens. Crit. Care Nurs. **28**(3), 141–149 (2012)
Huisman, E.R.C.M., Morales, E., Van Hoof, J., Kort, H.S.M.: Healing environment: A review of the impact of physical environmental factors on users. Build. Environ. **58**, 70–80 (2012)
Iyendo, T.O.: Exploring the effect of sound and music on health in hospital settings: A narrative review. Int. J. Nurs. Stud. **63**, 82–100 (2016). https://doi.org/10.1016/j.ijnurstu.2016.08.008
Iyendo, T.O.: Sound as a supportive design intervention for improving health care experience in the clinical ecosystem: A qualitative study. Complement. Ther. Clin. Pract. **29**, 58–96 (2017).
Iyendo, T.O., Uwajeh, P.C., Ikenna, E.S.: The therapeutic impacts of environmental design interventions on wellness in clinical settings: A narrative review. Complement Ther. Clin. Pract. **24**, 174–188 (2016)
Jiang, S.: Therapeutic landscapes and healing gardens: A review of Chinese literature in relation to the studies in western countries. Front. Architect. Res. **3**(2), 141–153 (2014). https://doi.org/10.1016/j.foar.2013.12.002
Kearney, A.R., Winterbottom, D.: Nearby nature and long-term care facility residents: Benefits and design recommendations. J. Hous. Elder. **19**(3/4), 7–28 (2005)
Keir, P., MacDonell, C.: Muscle activity during patient transfers: A preliminary study on the influence of lift assists and experience. Ergonomics **47**(3), 296–306 (2004)
Kometiani, M.K.: Creating a vital healing community: A pilot study of an art therapy employee support group at a pediatric hospital. Arts Psychother. **54**, 122–127 (2017). https://doi.org/10.1016/j.aip.2017.04.012
Mackrill, J., Marshall, P., Payne, S.R., Dimitrokali, E., Cain, R.: Using a bespoke situated digital kiosk to encourage user participation in healthcare environment design. Appl. Ergon. **59**, 342–356 (2017). https://doi.org/10.1016/j.apergo.2016.08.005

Malenbaum, S., Keefe, F.J., Williams, A.C., Ulrich, R., Somers, T.J.: Pain in its environmental context: Implications for designing environments to enhance pain control. Pain **134**, 241–244 (2008). https://doi.org/10.1016/j.pain.2007.12.002

Martin, C.S.: The challenge of integrating evidence-based design. Health Environ. Res. Des. J. **2**(3), 29–50 (2009)

Mazer, S.E.: Creating a culture of safety: reducing hospital noise. Biomed. Instrum. Technol. **46**(5), 350–355 (2012)

McCullough, C.S. (Ed.): Evidence-Based Design for Healthcare Facilities. Sigma Theta Tau. (2010)

Miller, A., Engst, C., Tate, R.B., Yassi, A.: Evaluation of the effectiveness of portable ceiling lifts in a new long-term care facility. Appl. Ergon. **37**(3), 377–385 (2006)

Mineshita, M., Nakamori, Y., Seida, Y., Hiwatashi, S.: Legionella pneumonia due to exposure to 24-hour bath water contaminated by Legionella pneumophila serogroup-5. Intern. Med. **44**(6), 662–665 (2005)

Molzahn, E.J.: Revealing Attributes of Supportive Healing Environments in Interior Design: Staff Perceptions in Healthcare Design. Doctoral dissertation. Colorado State University Libraries, Colorado (2007)

Moore, C., Wisnivesky, J., Williams, S., McGinn, T.: Medical errors related to discontinuity of care from an inpatient to an outpatient setting. J. Gen. Intern. Med. **18**(8), 646–651 (2003)

Nelson, A., Lloyd, J., Menzel, N., Gross, C.: Preventing nursing back injuries: Redesigning patient handling tasks. AAOHN J. **51**(3), 126–134 (2003)

Oladejo, E., Umeh, O., Ogbuefi, J.: An examination of impact of tertiary healthcare facility design on user needs and satisfaction in South East Nigeria. J. Environ. Earth Sci. **5**(5), 35–43 (2015)

Orellana, D., Busch-Vishniac, I.J., West, J.E.: Noise in the adult emergency department of Johns Hopkins Hospital. J. Acoust. Soc. Am. **121**(4), 1996–1999 (2007)

Parimbelli, E., et al.: Trusting telemedicine: a discussion on risks, safety, legal implications and liability of involved stakeholders. Int. J. Med. Informatics **112**, 90–98 (2018)

Pati, D., Harvey Jr. T. E., Barach, P.: Relationships between exterior views and nurse stress: An exploratory examination. HERD: Health Environ. Res. Des. J. **1**(2), 27–38, (2008). doi:https://doi.org/10.1177/193758670800100204

Peikes, D., Chen, A., Schore, J., Brown, R.: Effects of care coordination on hospitalization, quality of care, and health care expenditures among Medicare beneficiaries: 15 randomized trials. JAMA **301**(6), 603–618 (2009)

Prussin, A.J., Marr, L.C.: Sources of airborne microorganisms in the built environment. Microbiome **3**(1), 1 (2015)

Quan, X., Joseph, A., Nanda, U.: Developing evidence-based tools for designing and evaluating hospital inpatient rooms. J. Inter. Des. **42**(1), 19–38 (2017). https://doi.org/10.1111/joid.12091

Rashid, M.: The question of knowledge in evidence-based design for healthcare facilities: Limitations and suggestions. HERD: Health Environ. Res. Des. J. **6**(4), 101–126 (2013)

Reay, S., Collier, G., Kennedy-Good, J., Old, A., Douglas, R., Bill, A.: Designing the future of healthcare together: prototyping a hospital co-design space. CoDesign **13**(4), 227–244 (2017). https://doi.org/10.1080/15710882.2016.1160127

Wouden, H.: Evidence-based medicine. Tijdschrift voor praktijkondersteuning **10**(1), 11–12 (2015). https://doi.org/10.1007/s12503-015-0008-9

Sackett, D.L., William M.C. Rosenberg, J.A. Muir Gray, Haynes, R.B., Richardson, W.S.: Evidence-based medicine: What it is and what it isn't: It's about integrating individual clinical expertise and the best external evidence. BMJ: Br. Med. J. **312**(7023), 71–72 (1996)

Sehulster, L.M., Chinn, R.Y.W., Arduino, M.J., Carpenter, J., Donlan, R., Ashford, D., et al.: Guidelines for Environmental Infection Control in Health-care Facilities. Recommendations from CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC).

American Society for Healthcare Engineering/American Hospital Association, Chicago, IL (2004).
Selami Cifter, A., Cifter, M.: A review on future directions in hospital spatial designs with a focus on patient experience. Des. J. **20**(sup1), S1998–S2009 (2017)
Smith, J.: Health and nature: The influence of nature on design of the environment of care. In: The Center for Health Design, pp. 1–19 (2007)
Tavakoli, M., Carriere, J., Torabi, A.: Robotics, smart wearable technologies, and autonomous intelligent systems for healthcare during the COVID-19 pandemic: An analysis of the state of the art and future vision. Adv. Intell. Syst. **2**(7), 2000071 (2020)
Ulrich, R.S.: View through a window may influence recovery from surgery. Science **224**(4647), 420–421 (1984). http://www.jstor.org/stable/1692984
Ulrich, R.S., Wilson, P.: Evidence-based design for reducing infection. Public Serv. Rev. Health **8**, 24–25 (2006)
Ulrich, R.S., Zimring, C., Zhu, X., DuBose, J., Seo, H. B., Choi, Y.S., Joseph, A.: A review of the research literature on evidence-based healthcare design. HERD: Health Environ. Res. Des. J. **1**(3), 61–125, (2008)
Uwajeh, P.C., Iyendo, T.O., Polay, M.: Therapeutic gardens as a design approach for optimising the healing environment of patients with Alzheimer's disease and other dementias: A narrative review. EXPLORE (2019)
Van der Linden, V., Annemans, M., Heylighen, A.: Architects' approaches to healing environment in designing a Maggie's Cancer Caring Centre. Des. J. **19**(3), 511–533 (2016). https://doi.org/10.1080/14606925.2016.1149358
Van Walraven, C., Seth, R., Austin, P.C., Laupacis, A.: Effect of discharge summary availability during post-discharge visits on hospital readmission. J. Gen. Intern. Med. **17**(3), 186–192 (2002)
Vermeir, P., et al.: Communication in healthcare: a narrative review of the literature and practical recommendations. Int. J. Clin. Pract. **69**(11), 1257–1267 (2015)
Watkins, N., Keller, A.: Lost in translation: Bridging gaps between design and evidence-based design. HERD: Health Environ. Res. Des. J. **1**(2), 39–46 (2008).
Weinel, D.: Successful Implementation of Ceiling-Mounted Lift Systems. Rehabil. Nurs. **33**(2), 63–66 (2008)
Weinstein, R.S., et al.: Telemedicine, telehealth, and mobile health applications that work: opportunities and barriers. Am. J. Med. **127**(3), 183–187 (2014)
Zimring, C., Joseph, A., Choudhary, R.: The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity. The Center for Health Design, Concord, CA (2004)