

Evidence based design in hospitals

Khalida Lifam

Department of Architecture
College of Engineering
Trivandrum, Kerala
lifam222@gmail.com

Ar. Smitha M.V

Assistant Professor
College of Engineering
Trivandrum, Kerala
smithamv2010@gmail.com

Abstract— Poor hospital design leads to patient and staff stress and an overall decrease in the health care efficiency. 'Evidence based design is the process of basing decisions about the built environment on credible research to achieve the best possible outcomes' (The Center for Health Design, 2008). Evidence indicates that well-designed physical settings play an important role in making hospitals safer and more healing for patients, and better places for staff to work. Design of single inpatient rooms over multi bed rooms, acuity adaptable rooms, proper decentralised nurse stations, effective acoustics, appropriate lighting, better ergonomic design and positive distractions are the main areas of intervention in evidence based research related literature in hospital design. This paper reviews the literature on this relatively new field of design in spatial analysis of hospital areas like lobby area, patient rooms, nurse stations and positive distraction areas. The paper also attempts to establish the relevance of evidence based design methods in hospital design in India.

Keywords— Evidence-based design; hospital design; outcomes; spatial analysis; patient safety; staff safety; infection; hand washing; medical errors; falls; pain; sleep, stress; social support; single rooms; noise; acuity adaptable rooms; positive distraction.

I. INTRODUCTION

Research in the field of healthcare on the impacts of hospital environment has been growing rapidly in recent years. Many scientific studies have collected empirical evidence demonstrating connections between the environmental design of healthcare facilities and outcomes that are important for patients, families, healthcare staff, and healthcare organizations (Ulrich, et al. 2008).

As a result, there is a growing understanding that an appropriately designed built environment can help to improve patient outcomes and create a safe, nurturing, and positive work environment for caregivers (Goertz, et al. 2008).

According to statistics, about 44,000-95,000 patients die each year due to preventable medical errors in the United States hospitals

(Institute of the Medicine, 1999). Of 2,000,000 Hospital-acquired infections a year in U.S.; 88,000 die annually (IOM, 2000). Risk of health care associated infections in developing countries like India is 20 times higher than in developed countries (WHO 2011). These alarming figures indicate that health care industry has not been able to overcome the design faults that cause such common errors.

In the initial years since its inception, EBD had a few database, but the body of evidence has grown rapidly and substantially in recent years. A large number of rigorous researches show strong connection between physical design features and outcomes that can be regarded as scientific evidences. These researches are credible since they are assessed on rigor, quality and degree of control. They are also high impact, psychologically sound and patient centred. Relevance of EBD has increased as the need for better healthcare facilities has grown and become more mandatory.

The study aims at analysing the literature available in evidence based design in hospitals and finding the relevance of its application in Indian context. The objective of the study is to bring out the importance of evidence based design in spatial analysis of hospitals for improving patient safety, reducing stress among staff and improving overall healthcare quality.

In carrying out the intent, the following methodology has been used. Three case studies are done to understand the application of evidence based design features and their implication as well as to understand the condition of hospitals in Indian context. In the analysis of case studies, different spaces in hospitals where the evidences were credible enough were reviewed and analysed. The spaces chosen for study were lobby space, staff work area, inpatient rooms, positive distractions and the overall building layout and location. The following factors such as sunlight, noise, social support, building location, unit and room configuration and layouts, ventilation systems, patient-doctor interaction, privacy, interior material selections and positive distractions were considered in the study.

Overall, this review confirms the importance of improving the healthcare outcomes associated with a range of design characteristics or

interventions both for patients as well as staff well being.

II. BACKGROUND STUDY

In the EBD researches available at present, the research team found rigorous studies that link the physical environment to patient and staff outcomes in three main areas namely improving patient safety, reducing staff stress and fatigue to increase effectiveness in delivering care and improve overall healthcare quality. These areas were further simplified to a number of factors such as effects of nature distraction, sunlight, noise, interior material selection, single patient rooms, floor layout of the nursing units, social support and other positive distractions on patient and staff. Other areas of study include design features that help in reducing patient stay, patient falls, hospital acquired infections and injuries and walking distance among staff.

A. Improving patient safety

It was found that that humans have a deep need to connect to nature and that even a brief view of a garden or interaction with a water element, for example, can have immediate physiological benefits in terms of reducing stress and anxiety (Ulrich 1984; Ulrich 1999; Parsons and Hartig 2000). Similarly patients facing windows with medium levels of sunlight and views of nature were found to heal faster than those facing brick walls. Presence of nature elements like greenery and waterfall help in reducing environment stressors, providing positive distraction, faster healing and thus reducing patient stay.

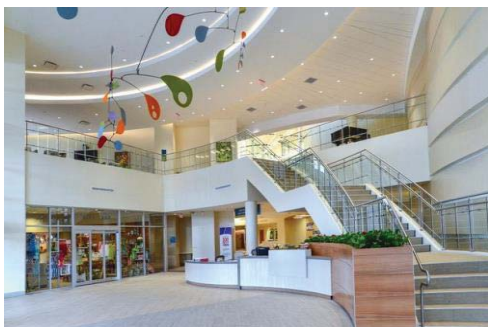


Fig 1. Lobby area with positive distraction spaces (Wellstar Paulding hospital, Indianapolis)

Access to friends and families contribute to physical and mental well being of patients. Single patient rooms with spacious family zones were found to be less noisier, more patient friendly, providing patient privacy and direct family care.

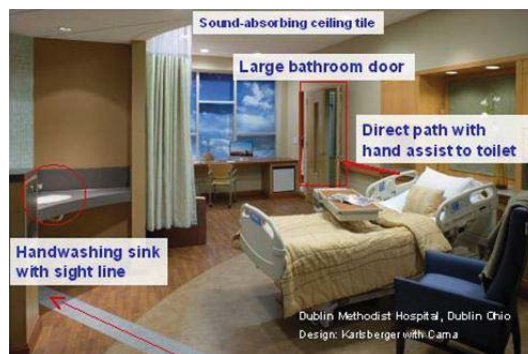


Fig 2. Single patient room with evidence based design features (Dublin Methodist hospital, Ohio)

Patient transfers usually result in waste of time, communication breakdown, medical errors, loss of staff time and productivity(Ulrich, R. S., C. Zimring, A. Joseph, X. Quan, and R. Choudhary. 2004).

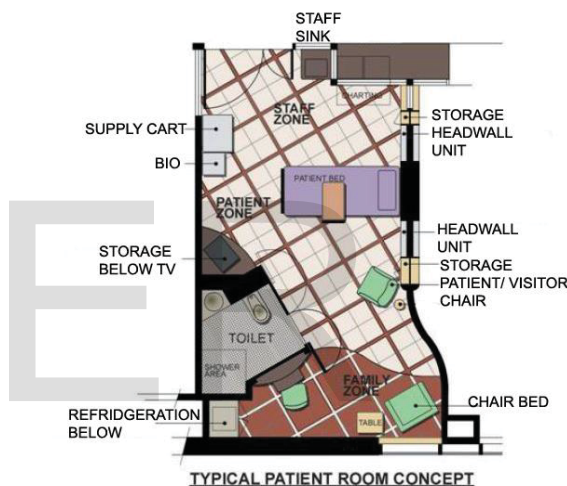


Fig 3. Typical patient room concept (Clarion Methodist hospital, Indianapolis)

In an acuity adaptable room, different levels of care are given in a single room so as to minimize the need to transfer patients as their acuity level changed (Hendrich, Fay, and Sorrells 2004). Patients fall when they get out of bed unassisted. Decentralized nurse stations, single-bed rooms designed to support family presence, providing grab bars to assist patients in reaching toilets, using design features such as night light features were found to decrease the number of patient falls.

Providing clean filtered air and providing alcohol-rub dispensers were found to be highly effective in preventing nosocomial infections.

B. Reducing staff stress and fatigue

It was also found that well ventilated staff areas, with alcohol based hand washing gels reduced staff infections. Single patient rooms fared well in controlling infections than multi-bed rooms

in staff infection control also. Height-adjustable footstools, better monitor placement, and ergonomically designed instrument tables was found to reduce neck and back torsion experienced by nurses as they attempted to obtain an unobstructed view of the operating field and reached for instruments on instrument tables in the operating room. Error rates were reduced when work-surface light levels were relatively high (Buchanan et al., 1991). The selection of interior finishing materials directly impacts the amount of hazardous off-gases, psychological appeal, acoustic quality, energy consumption, and greenhouse gas emission.

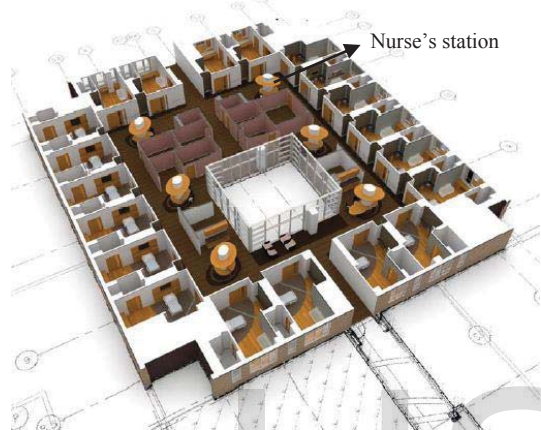


Fig 4. Unit layout showing decentralised nursing station.

Studies suggest that bringing staff and supplies physically and visually closer to the patients helps in reducing the time spent walking. Decentralising helps in providing immediate patient care in times of need, tending to the patients better and reducing nurse fatigue by decreasing the nurse walking time and time spent on searching for appropriate medication.

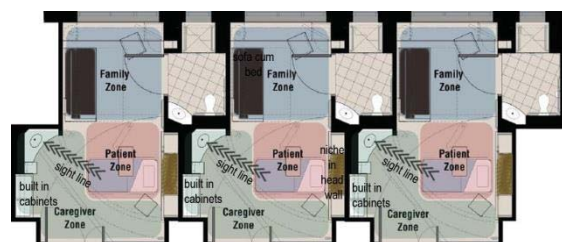


Fig 5. Like handed standardisation of inpatient rooms in Dublin Methodist hospital, Ohio

III. CASE STUDIES

The following literature case studies namely Dublin Methodist Hospital, Ohio and Well star Paulding Replacement hospital, Indianapolis were studied in the International context. In the Indian context, Iqraa International hospital, Kozhikode was chosen as the live case study.

In the analysis of case studies, different aspects such as building layout and location, lobby space, staff work area, inpatient rooms and positive distraction areas were studied.

In analysing the building layout, siting and access were the factors considered. Illumination levels (building envelope), noise reducing features, way finding strategies, seating provisions, interior material finish, positive distractions and legibility were the features considered in the lobby areas. Staff work areas were analysed for its functionality in delivering patient care by means of floor layout, staff walking distance and planning of staff nursing units. Ergonomic features while treating patients, treatment room illumination levels and staff and supply proximity levels were reviewed for ensuring staff safety and reducing work based health issues. Provision of specialised areas such as positive distraction spaces on patient and staff well being were also studied.

In patient bedrooms, the location of patient bed, acoustic treatment, window positioning, number of hand wash sinks, position of toilets, provision of head wall alcoves and acuity adaptable beds were analysed. Positive distraction spaces and their strategic placement throughout the hospital structure were also studied

Dublin Methodist hospital in Ohio provides inpatient and outpatient surgical services in orthopaedics, spine and pain management. The hospital has 94 inpatient beds, 32 emergency department beds, 6 surgery suites and 24 pre and post operative rooms with expansion capacity to 300 beds. It is spread over a total site area of 89 acres in a commercial context.

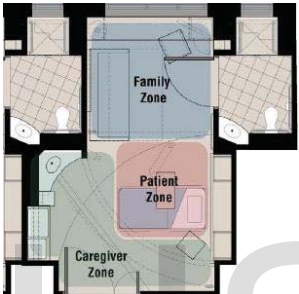

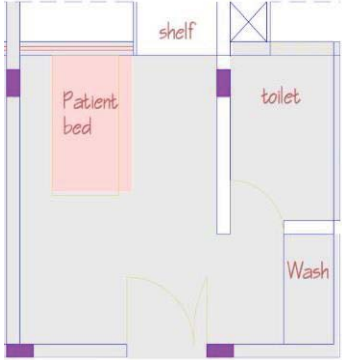
WellStar Paulding Hospital, Hiram is a 52 bedroom hospital (can be expanded to 112 beds) in Georgia designed under the pebble project, providing services in surgery, ear, nose, throat and paediatrics.

Iqraa International hospital is a 315 bed hospital, with the expertise of senior consultants, high quality nursing staff providing services like orthopaedics, gynaecology, paediatrics, nephrology, rheumatology cardiac care etc.

IV. CASE STUDY ANALYSIS

TABLE 1: COMPARITIVE ANALYSIS OF CASE STUDIES

Criteria	Dublin Methodist hospital ,Ohio	Well star Paulding Replacement hospital ,Indianapolis	Iqraa International Hospital, Calicut
Facilities	<ul style="list-style-type: none"> •24-hour emergency department, intensive care beds and private rooms, women’s health services (including obstetrics), inpatient and outpatient surgical services in orthopaedics, spine and pain management. •94 inpatient beds,32 emergency department beds , 6 surgery suites and 24 pre and post operative rooms with expansion capacity to 300 beds 	<ul style="list-style-type: none"> •Emergency services for adults and children, chest pain center, telemetry, surgery, GI and bronch services, along with ear, nose, and throat care. •56 beds, with the ability to expand to 112 beds, 40 emergency exam and paediatric emergency exam rooms, 4 surgical suites,6 intensive care units. 	<ul style="list-style-type: none"> •Services such as orthopaedics, gynaecology, paediatry, nephrology, rheumatology cardiac care etc. It also has a full fledged Cath lab, Coronary care center (CCU) and diabetic center. •315 inpatient beds.
Building layout	<ul style="list-style-type: none"> • Located in a commercial area in Central Ohio •Well connected by roads and can be easily accessed by patients, visitors and staff. •Located centrally in the east west axis site 	<ul style="list-style-type: none"> •Located to the south of main highway 278 in Hiram •Site oriented in east west direction. 	<ul style="list-style-type: none"> •Located at Malaparamba , Calicut. •Situated alongside the Kozhikode- Mysore National Highway 212 •Site oriented in the north south direction
Building materials	<ul style="list-style-type: none"> •Glass atrium •Continual slip resistant solid surface flooring •Onsite granite blocks •Carpets 	<ul style="list-style-type: none"> •Brick within 500-mile local radius. •Recycled aluminium metal windows. •Green roof to reduce water runoff. •Exposed stain concrete floors •Low VOC paints •Bamboo handrails •Glass atrium with exterior louvers - deflect sunlight in summer. •External stacked stone cladding. 	<ul style="list-style-type: none"> •Laterite •Concrete blocks •Vertical sweeps of glass.
Lobby area	<ul style="list-style-type: none"> •Large sweeps of transparent glasses-natural daylight. •Spill over cafes •Waterfall wall •Sloping canopy •Seating perches •Way finding strategies. •Electronic kiosks. 	<ul style="list-style-type: none"> •Eight story glass atrium-focal point, easy way finding. •Computerized physician order (CPOE) component-stops illegible handwriting. •Positive distraction elements. •Decentralised seating space. 	<ul style="list-style-type: none"> •Single storey high lobby area-reception desks, cash kiosk and the waiting areas. •Confusing - lacks proper signage •Seating along the perimeter.- not flexible and cannot be rearranged. • Lit from one side, ventilation is by means of fan. •Lacks interesting features or positive distraction areas.
Patient bedrooms	<ul style="list-style-type: none"> •Segregated family zone, patient zone and staff zone. 	<ul style="list-style-type: none"> •Large exterior window with views of nature settings 	<ul style="list-style-type: none"> •Single patient rooms: 19.2sqm. •1.8 m wide windows.

	<ul style="list-style-type: none"> •Large accessible windows •Spacious family zone- provision of sofa cum bed and a working table with computer and wifi facilities. •Patient zone-lifting bed ,access to internet, nurse call in facilities and direct sight line to nurse’s station and family zone •Niches within the head wall- medical records of the patients. •Sinks in the sight line of the patients for easy access. •Like handed standardisation- reduce medical errors and staff stress. 	<ul style="list-style-type: none"> •42” TV-for ordering meals, communication between patients and physician and family members •Hand-washing sinks- hand-wash monitoring system that uses radio-frequency identification technology. •Standardised patient rooms •Equipment storage area •Ceiling mounted patient lift equipment in the ED bariatric rooms •Touch-less infrared water faucets, self-flushing toilets and hands-free drinking fountains. 	<ul style="list-style-type: none"> •Separate patient and family zone •Wash basins hidden from entry. •Bed positioning such that patient sight line is directed towards blank wall. •Marble flooring •No acoustic treatment. •Single door-opening inside •Toilet door hidden from view •Commode placed first, spacious shower area. 
<p>Staff working areas</p>	<ul style="list-style-type: none"> •Decentralized staff work areas- reduce nurse walking time •Roof top staff relaxation areas •Nurse perches-In the line of sight of patient room. •Sound-absorbing ceiling tiles and flooring •Workspace arranged alongside the windows 	<ul style="list-style-type: none"> •In-room computer charting terminals and mobile handheld tablet devices •Decentralisation-“charting alcoves” outside patient rooms •Decentralised patient care supplies- 80% of nursing supplies within a 6 second reach 	<ul style="list-style-type: none"> •Staff areas located at meeting point of blocks. •Staff-patient in the ratio 1:6 •No complete view of all patient rooms.
<p>Areas for positive distractions</p>	<ul style="list-style-type: none"> •Eight courtyard and rooftop gardens-restorative garden, inspiration garden, labyrinth garden. •Waterfall walls, hard scaped areas in lobby •Huge trees in lobby •Spill over side walk cafe •Pebble covered waiting perch in lobby 	<ul style="list-style-type: none"> •Wall murals near paediatric ward •Well lit atrium space. •Waiting areas-eye catching features. 	<ul style="list-style-type: none"> •Absence of such areas except for a coffee kiosk in the main lobby •Audio visual simulation-TV provided in cardiac waiting area. •No separate spiritual areas found.

and staff nurses on their preferences on spaces in hospitals like lobby area, inpatient rooms, nurse’s station and positive distraction areas. Factors considered in formulating the questionnaire were the effect of sunlight, noise, ventilation, positive distractions, social support and the layout of patient rooms.

V. PRIMARY SURVEY

A survey was conducted at Iqraa International hospital, Kozhikode with a questionnaire assisted interview of patients, doctors

Evidence-based practice is a systematic process of reviewing the best available research

evidence and then incorporating clinical experience and patient preferences into the mix (J.Houser and K.S Oman, 2011). Same is true for evidence based design. The above statement which emphasises on the importance of patient preference forms the basis of this survey.

The aim of the survey was to understand and to find out if the evidences obtained by EBD researches done in global context were valid and consistent with the patient preference in Kerala. Patient preference rather than patient adaptation to a given hospital environment is crucial in attaining the needed shift in perspective of the healthcare decision makers and the architects involved in hospital design. Survey was implemented as a tool in better understanding of the present day condition of hospitals in Kerala context and to get an insight into the patient doctor relationship prevailing here. Such an understanding is vital in establishing the feasibility of EBD guideline application in Kerala context.

A. Patient survey

The inpatients were interviewed based on self administered questionnaire in 40 single patient rooms, constituting 16% of the total inpatients coming to the hospital for treatment daily. The patients were chosen such that 6 patients were interviewed from each department to ensure equal and holistic sample size showing a fair distribution of the inpatients admitted per day. Of the 40 patients interviewed, 18 were males and 22 were females.

- Lobby space

Of the 40 patients interviewed on the quality of lobby area, it was found that 60% of the patients found the front lobby friendly, 27% found it noisy and tiring, and 13% found it fearful. A few patients felt that noise in lobby area was only normal since that was expected in a hospital setting. A few of them had no specific feelings on the quality of lobby area. The survey showed that the patient perception of space was greatly determined by the ease with which they could get treated and the experiences of encounters they had in the lobby. Majority of the patients, nearly 63 % who were taken in through the lobby felt the lobby was well lit whereas the rest 37 % disagreed. 74 % of the patients felt lobby was well ventilated whereas 26% others disagreed. Most of the patients were unhappy with the seating provided in the front

lobby and felt it was insufficient. Some of them felt that the element of privacy was missing as the lobby area was heavily crowded. 70 % of the patients agreed to uncomfortable and insufficient seating in the lobby area.

- Patient room

Majority of the patients were happy with the quality of sunlight entering their room. 93% felt their room was well lit whereas 5% disagreed. A very few (1 out of the 40 interviewed) found the room over lit. More than half the patients interviewed preferred looking out of the windows for nature views whereas the rest 42% felt comfortable in their present bed positioning. While many of them welcomed the idea of looking out of the window, some felt that they were happy with the positioning since they were familiar and used to the present bed positioning.

Noise level was found to be one of the major environment stressors in EBD literature. Of the 40 patients interviewed, 45% felt that their room was noisy, partly because of the canteen in the basement level and the howling of dogs in the neighbourhood. However, only a few patients felt that it affected their sleep pattern. In fact, a very few loved the noise and chatter of their family members.

Providing family space in patient room is an important EBD consideration. Family space bring in a sense of security and respite to the ailing patients. Of the patients interviewed, 39% found the family space comfortable whereas 61% disagreed. Some of them felt a single cot was insufficient for an obese family member. While 55% patients were comfortable with their toilet positioning, 45 % toilet was farther away. A few aged ones also felt the need for grab bars.

B. Staff nurse and doctor survey result and analysis

- Infection control methods

15 doctors 25 staff nurses were surveyed on understanding the need for infection control methods and importance of distraction areas for them. 67% of the staff and doctors always washed their hands before attending to a patient. 33% of patients washed their hands sometimes. 77% of the staff nurse and doctors felt that increasing the number of hand wash sinks will increase their hand washing habits whereas 18% said that they do not know. A few doctors felt that increasing the use of touch free alcohol based gel sanitiser dispenser would be more effective and easier in infection control than increasing the number of patient sinks.

- Nurses and walking distance

77% of the staff nurse and doctors agreed that they have to walk a lot to attend to a patient whereas 23% disagreed. While most of the nurses thought most of their time is spent walking, doctor's disagreed. More than 50% of the nurses interviewed had work related problems like back pain, muscular cramps and swollen feet since they get engaged in activities that require them to be on their feet constantly.

- Positive distractions

Of 38 % of the nurses and doctors who take break often, 61 % felt that positive distractions would improve their treatment experience.35% of the interviewers did not know if positive distractions would be helpful. A majority of them felt it was not applicable and practical in Indian context.

Majority of the nurses and doctors felt that decentralised nursing units will reduce nurse walking time, improve care towards patients and help in tending to patients faster. A few had apprehensions that it would increase stress on nurses since they are separated from each other.

The authors note that the qualitative nature of this research limits the extent to which the results can be generalized, particularly because the research setting was located in a regional area. The future researches should focus on a range of geographical locations and bigger sample size to better understand patient, nurse and doctor preference on these spaces and their implication in real hospital design.

VI. INFERENCES

The hospital reviewed in Kerala context was not consciously designed based on EBD, however a few design features (illumination level in patient rooms) were found to be consistent with EBD. Design interventions like welcoming lobby area, view of nature from patient bed and staff decentralisation units are necessary with regard to EBD principles as well as patient preference. Similarly increasing infection control measures like gel dispensers can decrease the cases of nosocomial infections. Minor design characteristics like standardised rooms, medical charting near head walls, sink within direct level of sight of the patient and providing grab bars till toilets can reduce patient and staff stress and can be adopted in Kerala context without apprehensions. However, a few interventions pose a number of difficulties like high initial capital requirements in administering the EBD features, unrealistic and high end means of treatment (introducing positive

distraction areas) beyond middle class patient's affordability. Some of the doctor's have apprehensions on the materialisation of an EBD hospital since they find the features far fetched. With India's developing economy and increasing investments in healthcare sector in Kerala, these apprehensions can be put to rest.

VII. GUIDELINES

A. Lobby

- Lobby areas should exude a community scale so that the patients feel at ease at the whole hospital setup and the services provided. Since lobby areas form the first impression, even the massing should be such that emotions such as intimidation are not felt by the patients. Vertical massing should not be blown out of proportion.
- Lobbies should be well lit and well ventilated and designed considering the maximum possible patient inflow.
- Positive distraction areas like landscapes, waterfalls, nature paintings, spill over cafes, library rooms etc. should be provided in close proximity to the lobby area. These areas should have clear visibility from maximum number of important function areas in the hospital.

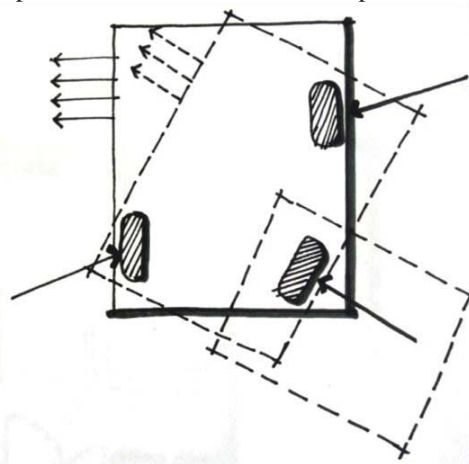


Fig 6. Positive distractions in lobby areas- better healing, helps to orient and reduce confusion

B. Patient rooms and toilets

- A patient room should have segregated patient zone, staff zone and spacious family zone. The three zones should be designed seamlessly for efficient patient-staff-family interaction.

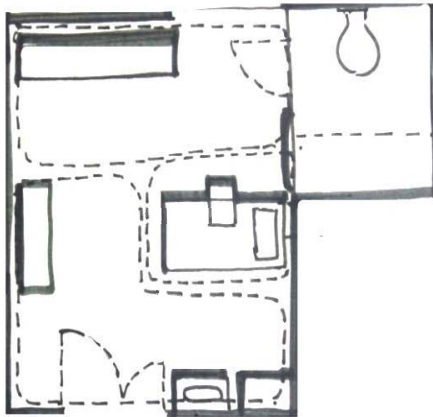


Fig 7. Segregation of spaces in patient room.

- Lifting bed in patient room should be positioned so as to allow direct sight lines to the nature views through the windows. These windows must be openable. Patients need not be in direct contact with the openings. Curtains of flattened seams can be used for covering the window openings to reduce glare and for getting diffused light.
- Touch free alcohol based gel sanitiser dispensers should be placed near entry to the patient room to increase hand washing habits among doctors, nurses as well as family members and to reduce infection risks.
- All the rooms should be standardised so that the nursing staff find it easier in dealing with patients and reducing medication errors.
- Toilets in patient rooms should be designed close to the patient bed so as to reduce patient falls. Grab bars should be provided from patient room to toilet door. These folds up bars should continue within the toilet. Night light feature extending from the floor to the toilet door should also be considered to assist patients in using toilets at night.

C. Staff areas

- Staff area should be decentralised to ensure day and night care to every single patient. Decentralised work spaces must be located right outside the patient room or innovations like nurse 'perches' must be designed for every six patient rooms. These areas should be such that they have direct sight line to the patients.
- Pass through nurse servers should be placed in every patient room so that these can be filled from the nurse station and will help save a life in critical condition.

- Staff recreation areas like rooftop gardens and other positive distraction areas should be designed to decrease staff stress.

D. Positive distraction areas

1. Positive distraction areas such as courtyards, roof gardens, spill over cafes, libraries etc should be provided at intervals in the hospital to reduce stress among patients and staff.
2. Therapeutic gardens are found to have healing effect on patients.

VIII. CONCLUSION

Though most of the results of primary survey were in accordance with EBD preferences, apprehensions were found in the patient as well as doctor expectation on the feasibility of the EBD principles since higher construction costs would mean increased per capita treatment cost and an average middle class patient would not be able to afford the treatment costs.

The survey results conducted at Iqraa International hospital show that interrelation between patient care and design features are not considered and an understanding that patient treatment outcomes are a part of the hospital design is completely disregarded. The same mental outlook is seen in the patients as well. Patients were seen to adjust expectations to meet the reality of the situation.

As Martin Luther King Junior states" Our lives begin to end the day we become silent about things that matter". The same is true with evidence based design. Especially in a populous country such as India where a staggering number of patient deaths occur daily due to medication errors and infection rates, applying research outcomes on fields of design has more meaning and significance. This paper is intended to make the evidence more accessible to practitioners, and to identify needs and directions for future research in the Indian context.

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