كلية الهندسة بشبرا
FACULTY OF ENGINEERING AT SHOUBRA
ERJ
PRINT ISSN 3009-6049
ONLINE ISSN 3009-6022

ENGINEERING RESEARCH JOURNAL (ERJ)
Volume (52),Issue (4)
October 2023, pp:16-20
https://erjsh.journals.ekb.eg

Literature Review of Post-Occupancy Evaluation in Emergency Departments in Hospitals

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Abstract: Improving efficiency in emergency departments can be achieved through Evidence-Based Design (EBD), which uses data and research to inform facility design and improve patient outcomes. By designing patient rooms that facilitate healing and recovery, or layouts that limit the risk of infection transmission, EBD can help reduce medical errors, infections, and falls in healthcare facilities. One effective way to improve healthcare facilities is through post-occupancy evaluations. These evaluations identify areas for improvement and create more efficient systems that reduce costs, improve patient satisfaction, and enhance the quality of care. By applying evidence-based design principles and evaluations, emergency department operations can become more effective and efficient. The problem with the research is that design criteria are important for hospital efficiency, but emergency departments are sometimes overlooked. Architects must balance patient needs with client satisfaction and cost minimization, which can lead to ED overcrowding due to financing strategies and increasing demand. The research methodology adopted a theoretical review of literature and codes, an analytical study of EBD strategies and tools, and a future quantitative assessment through an applied study and staff interviews.

Keywords: Operational efficiency, Emergency department, Evidence-based design, post-occupancy evaluation, Emergency Department assessment..

1. Introduction

Globally, the need for emergency services in hospitals is increasing due to population aging and epidemics. The emergency department serves as the primary point of care for injured and critically ill patients in countries facing economic hardships, such as Egypt. Efficiency in emergency departments is influenced by various factors, but space design and circulation are the most significant. Emergency department codes and design standards have a significant impact on the design process, which affects the operating efficiency of the department. It is crucial to identify the codes to follow when starting a healthcare facility concept design.

Post-occupancy evaluation (POE) is a critical tool for measuring the operating efficiency of healthcare facilities, identifying design weaknesses, and providing lessons learned for future projects to enhance ongoing projects through redesign or additional techniques.

Evidence-Based Design (EBD) is an approach that uses reliable evidence to inform healthcare architecture design. It aims to enhance well-being, promote healing, reduce stress, and improve safety by incorporating concepts from environmental psychology, architecture, neuroscience, and behavior. It is used to reduce medical errors, infections, and falls in healthcare facility planning, design, and construction.

2. EMERGECY DEPARTMENT

Emergency Departments categorize patients into three groups: walk-in patients with minor injuries, patients with more severe or complex conditions transported by ambulance, and patients requiring resuscitation. Patients are assessed in an assessment room or immediately transferred to the resuscitation or treatment room, and most are discharged after minor treatment, while others may be admitted to the observation room before being discharged. [1].

2.1 Healthcare categories that serve Emergency Departments

There are three types of healthcare facilities: primary, secondary, and tertiary. Primary facilities offer basic services and do not have inpatient care. Secondary facilities offer inpatient care and serve populations of 100,000 to 250,000. Tertiary facilities offer comprehensive medical services and serve as a central hub for the country, serving 1 million people [2].

2.2 General functional requirements for Emergency departments' design

For an emergency department, clear accessibility and visible signs are important, along with nearby parking for patients and doctors, a lounge and toilets for ambulance drivers, and a helicopter landing pad [2]. The department is divided into three sections: Hot for ambulance patients, Cold for walk-ins including gynecology, and Intermediate for both including triage, procedure, laboratory, x-ray, radiology, and observation rooms [1].

Main Emergency department spaces

Based on national & international codes the following table summarize ER spaces.

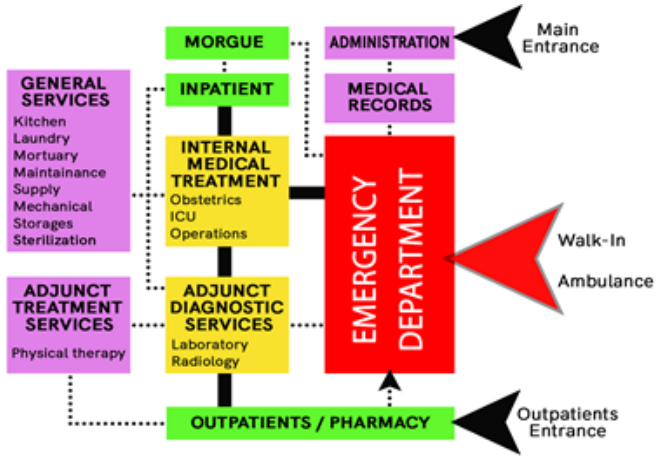

Fig 1. Relations between hospital's components \ the thicker the line the stronger the relationship [2].

TABLE 1. Emergency department main spaces

Space	Action
Entrance	Two entrances: the main entrance for patients who arrive on their own, and the ambulance entrance for patients who arrive via ambulance on a stretcher or chair [2].
Sorting (triage)	An experienced nurse assesses vital signs and transfers patients during the initial examination of a patient [2].
Reception area	To ensure convenience and accessibility for all visitors.
Waiting & services	A comfortable room near the resuscitation area should have a cafeteria, toilets, and a wheelchair-accessible restroom. It should also have comfortable seating options [2][4].
Examination	Directly located after the reception area. Examine patients and give them the diagnosis [3].
Treatment room	A room of at least 12 m2 is required for physical examinations, therapeutic procedures, and minor surgeries such as washing, dressing, stitching wounds [3].
Special treatment	Head and neck assessment/treatment room: equipped to handle patients with ENT, ophthalmic, and dental issues [2][4]. Women/Urology: a specific room for conducting internal investigations on cases that require further examination [2].
Recovery room	A room with two beds, each with an area of at least 18 m2, can be achieved with single or partitioned rooms that are at least 4 m wide for each bed [2].
Observation room	Allow patients to receive additional treatments and clinical observation for up to 24 hours, enabling safe discharge [3].
Isolation room	Enables the swift isolation of potentially infectious patients prior to registration. The suite must be designed to ensure both efficient and safe patient care, with fixtures carefully selected to facilitate activities within the suite [2][4].
Doctors and nurses	Lounges and nursing stations.
Surgical (Resuscitation)	For immediate care of patient [3].
Plastering room	Reducing and casting fractures and dislocations, must contain a sink [2].
Supplementary services	A small laboratory for regular analyses, a diagnostic radiology room, or a small mobile radiology store, and a private pharmacy [2]. Decontamination facilities are used to treat patients during radiation, chemical, or major incidents.
Supporting services	Storage for supplies, stationary supplies, storage of hazardous materials, medical gas storage, linen storage, wheelchair and trolley storage, waste disposal, archive, and interview room [3][4].

3. EVIDENCE BASED DESIGN

Evidence-based design (EBD) is a design approach that uses research evidence to make healthcare facility design decisions. EBD can improve health outcomes by reducing rates of infections [5], medical errors, patient falls, and staff injuries, and can also enhance safety, productivity, and sustainability, and decrease resource waste [6]. EBD involves collaboration between a designer and client to make design based on research evidence and project evaluations [7]. (EBD) is a framework that enables departments to identify service gaps and develop new solutions. It is based on best practices and evidence from previous research and can be used to create new systems or improve existing ones.

3.1 The center of health design (CHD)

A non-profit organization that works alongside clients and interdisciplinary teams to enhance healthcare design. The main goal is to improve healthcare performance, patient satisfaction, staff productivity, and safety [9].

3.2 Evidence based design strategies [10]

1- Identify the main problems of the project, such as outdated technology or increasing demand.
2- Take a collaborative approach that involves leadership and all relevant parties.
3- Keep patients and families in mind when defining goals and assessing outcomes.
4- Examine the long-term cost-effectiveness of design options and investment returns.
5- Use decision-making tools such as SWOT analysis and decision trees to make technical decisions.
6- Use incentives and checklists to motivate the design team and involve end-users.
7- Collaborate with hospital staff to develop new products.
8- Test designs from the patient's perspective, including lighting and energy.
9- Consider the 30–50-year life cycle of the project and its impact on safety and workforce outcomes.
10- Communicate frequently with clinical staff and community members through meetings, newsletters, and webcams.

4. POST-OCCUPANCY EVALUATIONS

Evidence-based design uses post-occupancy evaluations to measure a building's design efficacy, evaluating design decisions in relation to human behavior in a built environment. Binary-choice issues such as acoustics, lighting,

and user-friendliness are evaluated, and research methods such as observation, photography, and surveys supplement traditional design research methods.

4.1 Pebble Project Matrix [11]

Healthcare architecture firms can benefit from hiring a director of research to prepare a research platform, develop hypotheses, and collect clinical-outcomes safety data from hospitals relevant to new units being designed. The Pebble Project research partners use a matrix to ensure uniformity of measurement and reporting, while Lyn Geboy, director of research and education, created a graphic representation of 12 environmental factors that influence outcomes and contribute to a healing environment using small photos to help architects interpret evidence-based design (EBD) data.

4.2 The Centre for Health Design and the Picker Institute toolkit [12]

The Patient Environmental Checklist and Patient Survey are tools designed to assess consumer needs, satisfaction, and quality improvements in healthcare facilities. The checklist evaluates strengths and weaknesses of an existing facility, while the survey collects data on patients' interactions with the built environment. Consumer focus groups are also used to learn about specific needs and generate ideas for future solutions.

4.3 The Corollary to Evidence-Based Medicine [13]

Hamilton and Watkins (2006) present an alternative approach to develop a research agenda for a project, based on the classic text on evidence-based medicine by Straus et al. (2005). The approach includes the following five steps:

1- Translate the need for information into answerable questions.
2- Find the best evidence to answer the questions.
3- Critically evaluate the evidence for validity and applicability.
4- Combine the evidence with clinical expertise, unique biology, values, and circumstances of the patient.
5- Measure the effectiveness and efficiency of the approach and identify areas for improvement.

Evidence-based designers must use critical thinking to draw rational inferences from information that may not perfectly fit their design situation. Evidence-based healthcare projects should demonstrate improvements in clinical, economic, productivity, patient/staff satisfaction, or cultural success measures.

4.4 Facilities and Safety Management (FMS) [14]

It is a management system that ensures a safe and secure work environment for all staff on-board. This covers issues such as medical equipment, health and safety, hazardous materials, disaster preparedness, fire safety, waste management, and hygiene control. It is crucial for the safety of patients and healthcare providers, and it helps ensure the operational efficiency of ER departments. The system manages the facility, building, yard, equipment, and staff (both clinicians and non-clinicians), and is an important part of the safety precautions in place.

4.5 Six Sigma Principles [3]

Six Sigma is a statistical and data-driven approach that reduces process variation and improves overall system performance in manufacturing and service industries. It was developed by Robert Galvin at Motorola and adopted by General Electric in 2000. It has been widely used and approved by the American Society for Quality (ASQ).

Consisted of five steps:

Define: Timeline of the project or system are defined. The process identifies problems, sets goals for improvement, and outlines expected benefits.

Measure: Data is collected and analyzed to fully understand the process and determine process metrics for comparing performance before and after improvements.

Analyze: Data is analyzed using tools and techniques to identify root causes of problems.

Improve: For achieving high operational efficiency in a system, brainstorm potential solutions, simulate each solution, and analyze results based on efficiency, economic benefits, and cost. Apply the best solutions.

Control: During the redesign phase of the Six Sigma process, a control plan is put in place to ensure that improvements are sustained over time. The plan tracks changes made during the redesign and measures efficiency throughout the process.

4.6 Queue Theory [15]

A queue is a group of elements where you add elements to the back and remove them from the front. Queue models are used to describe waiting lines, and there are different representations that will be discussed in the following sub-sections.

1- Single Server Single Stage Queue
Represents a single server, single queue system with a "first come, first served" service order. This model is exemplified by private doctor clinics.
2- Multiple Server Single Stage Queue
Represents a system with multiple service centers where customers form a single queue and go to an available service center to receive service. This model is exemplified by a bank.
3- Single Server Multiple Stage Queue
Represents a single service center providing a multi-stage service to customers waiting in a queue, such as a car wash center. The service is provided in successive stages and serves a single queue of customers/cars.
4- Multiple Server Multiple Stage Queue
Represents a system with multiple service centers, each with multiple stages, where customers form a single queue and are dispatched to a center. This model is exemplified by the Department of Motor Vehicles (DMV).

4.7 Electronic Health Record [3]

Hospital information systems, including electronic medical records and Real-time Locating Systems, can improve efficiency and reduce costs. Patient flow consists of specific activities, such as assessing health status and taking vitals, during a patient's treatment journey.

4.8 Computer simulation modeling

- MedModel software programmer: designed for simulating healthcare systems, importing layout drawings, and analyzing historical patient records to drive the model. Model verified and validated through graphical display and comparison to real data. Existing and improved layout models were evaluated by generating and evaluating alternatives while considering realistic constraints [17].
- Arena Software: is the latest technology for hospital administration and is used by admin staff to manage patient records and hospital resources. The technology can also be used by admin staff to monitor patient flows and evaluate patient satisfaction. The software can help improve patient [3].

4.9 Time series analysis [16]

Time series analysis is a useful tool for examining variations in time series data. It can help identify the causes of variations in performance and efficiency, allowing for better planning of responses to future events.

4.10 Process mapping [16]

It is a diagram that illustrates the care processes and roles involved in an Emergency Department (ED), including doctors, nurses, and support staff.

4.11 Flow redesign [16]

Flow redesign is a helpful method for emergency departments to enhance their efficiency and patient care by improving processes and workflows, optimizing resources, and enhancing overall flow.

4.12 Emergency Department Operations Efficiency" (EDOE) [16]

This framework allows to measure effectiveness and performance, track changes and trends, and make data-driven decisions to improve operational efficiency.

4.13 Lean manufacturing [3]

A production method that reduces waste while improving efficiency and product quality. It can be used in various industries, such as healthcare operations and emergency department design.

5. CONCLUSION and Recommendations

Emergency departments are often very busy, and a poorly designed system can cause many problems, especially during peak times. Therefore, investing time and money in improving the efficiency of emergency departments is essential. Several steps can be taken to achieve this, including conducting a thorough analysis of available data, and utilizing evidence-based design principles. By using these principles, more efficient systems can be created that reduce costs, enhance patient satisfaction and quality of care, and help ensure a smoother flow of patients and staff during peak times. It is recommended to use data to create assessments and checklists can help identify problems in the emergency department. These issues can be addressed by implementing new techniques or redesigning the department.

TABLE 2. Post-Occupancy evaluation methods

Method	Type	Usage
Pebble Matrix	Clinical-outcomes safety data	A matrix to ensure uniformity of measurement and reporting.
Picker Institute toolkit	Patients and staff survey	Assess consumer needs, satisfaction, and quality improvements in healthcare facilities.
The Corollary	Research agenda	Draw rational inferences from information that may not precisely fit their design situation.
FMS	Management system	Ensures operational efficiency in emergency rooms by managing facilities, equipment, staff, and safety measures.
Six Sigma	Statistical and data-driven	Reduces process variation and improves system performance in manufacturing and service industries.
Queue Theory	Model	Used to describe waiting lines, and there are different representations
Electronic Health Record	Data base system	Used to improve efficiency and reduce costs.
Computer simulation modeling	Simulation software models	Existing and improved layout models were evaluated by generating and evaluating alternatives while considering realistic constraints.
Time series analysis	Data base system	Help identify the causes of variations in performance and efficiency, allowing for better planning of responses to future events.
Process mapping	Diagram	A graphical representation.
Flow redesign	Method	improving processes and workflows, optimizing resources, and enhancing overall flow.
EDOE	Framework	measure its effectiveness and performance, track changes and trends over time, and make informed decisions.
Lean manufacturing	Production method	Reduces waste while improving efficiency and product quality.

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