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Analysis of Functional Layout in Emergency Departments (ED). Shedding Light on the Free Standing Emergency Department (FSED) Model

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Abstract: The ever-increasing number of hospital Emergency Department (ED) visits pose a challenge to the effective running of health systems in many countries globally and multiple strategies have been adopted over the years to tackle the plight. According to a systematic review of the available literature, of the numerous models of healthcare systems used to address the issue in western countries, the FSED Model has the greatest potential for reducing hospital ED overcrowding as it can reduce the additional load by diverting minor cases, freeing up space for more urgent cases. The aim of the study is to shed light on the Free Standing Emergency Department (FSED) model and compare it with the traditional Hospital Based Emergency Department (HBED) in international contexts. In this study, 23 papers have been collected in a literature review and the main features have been highlighted; 12 case studies have been analyzed from a layout point of view and data have been collected in terms of surfaces, functions, and flow patterns. The percentages of floor areas devoted to each function have been compared to define evolution strategies in the development of emergency healthcare models and analyses. The use of FSED models is an interesting way to face the overcrowding problem and a specific range for functional area layout has been identified. Further studies on its application in different contexts are encouraged.

Keywords: emergency department; hospital design; healthcare planning; case study; free standing emergency department; floor area; data analysis

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1. Introduction

1.1. Background of the Study: EDs and Introduction of the FSED Model

Hospitals are large, complex institutions that continuously evolve [1,2]. Along with the growing need to create user sensitive designs and facilities, Emergency Departments (EDs), have been facing numerous challenges such as overcrowding, increasing patient acuity and deficit numbers of experienced staff leading to extended waiting times, negative impact on the overall efficiency and declining patient satisfaction rates, on a global scale [3,4]. To begin to address crowding, the root of the problem must be determined. There is no single cause and effect scenario; instead, there are many causes depending on the region of the world and the governing healthcare system [5,6]. Being the most vital and complex zone of any healthcare facility, Hospital Based Emergency Departments (HBED) require instantaneous and inventive interventions to address the growing challenges, as the improper functioning of any ED has the potential to adversely hamper the operation of the entire hospital system, which may hinder the delivery of healthcare services to society [7–9].

Among numerous endeavors to find possible solutions to these problems, a new infrastructural model defined as Free Standing Emergency Department (FSED) emerged demonstrating effectiveness in some context. This model has emerged as a promising alternative to the traditional HBED, especially in some regions of the United States (US) (i.e., Texas) and by the Australian healthcare system [10]. The model includes the development of a network of detached centers for emergency care from the main hospital campus for the delivery of emergency services to varied locations with the objective to reduce HBED overcrowding along with ensuring smoother accessibility of these services for the population. Similar to traditional EDs, the FSEDs offer several services like the board-certified emergency physicians, who are capable of treating more emergencies and their activities are available 24 h a day.

According to the American College of Emergency Physicians [11], FSED can be further characterized based on their location and relationship with the closest hospital:

i. Satellite Free Standing Emergency Departments (SFSED);
ii. Autonomous Free Standing Emergency Departments (AFSED);

Satellite facilities are generally affiliated with a parent/referral hospital and usually accept Medicaid/public insurance coverage plans while Autonomous FSEDs are privately owned by healthcare professionals [12]. Reports highlight the rapid and accelerating growth of both FSED typologies in the US [13,14] as well as interest from other countries [10], however, limited information is available on its actual structure, layout and functionality; therefore further research is needed to shed light in this direction.

1.2. Contemporary Challenges of Emergency Departments

Emergency Department (ED) overcrowding is a multifaceted issue that results in higher wait times, poor patient satisfaction, and negative domino consequences throughout the hospital, consequently disrupting the healthcare system and supply chain [5,15]. While crowding is a complicated concept to characterize and was previously limited to anecdotal evidence, it is gaining traction as more attempts are made to objectively quantify the problem in various locations throughout the world; for example, a study by Melissa McCarthy and colleagues showed that ED occupancy rate (total number of patients in the ED divided by the total number of licensed beds) can easily serve as a valid measure of crowding [16]. Overcrowding can be seen as the incapacity of ED staff to provide optimal care to patients as a result of high work overload and could be measured through certain quality indicators, such as wait or treatment times [5].

It is imperative that the ED suffers adverse effects when its primary function—to stabilize the patients—is compromised while functioning as an inpatient unit as well. Despite differences in health systems, ED problems appear of global relevance. Although regional characteristics should influence tailored approaches, good practices and models must be accurately studied in order to shed light on possible solutions to consider. In order to correctly design or plan healthcare facilities, it is important to have reference guidelines, benchmark or checklists to support stakeholders in this direction [17].

Over the previous few years, there has been a steady reduction in ED efficiency due to increased ED visits and its excessive use for non-emergency problems. These steadily increasing numbers have resulted in ED overcrowding, which has a direct effect on its functioning and ultimately results in unfavorable clinical outcomes [15,16]. A possible solution in this direction involves the strengthening of the territorial healthcare network for primary and emergency care [18].

Additionally patient dissatisfaction increases as wait times lengthen and resources become scarce. With the additional constraints of increased patient acuity, a shortage of trained medical professionals, and ineffective triage procedures, it is critical to identify potential solutions or alternative models that can assist in resolving current concerns. As the ED serves as the entry point to the hospital system, problems that arise here have the potential to have a detrimental effect on the entire healthcare system, even in terms of patient satisfaction and patient safety [2,15]. The challenges outlined justifies the need for research in such a specific field of study where data analysis on design interventions can support ED efficiency and eventually reduces issues—such as overcrowding—that can impact the whole quality of healthcare service delivery in various contexts.

1.3. Research Gap and Aim of the Study

An ever-increasing number of hospital ED visits pose a challenge to the effective running of health systems in many countries globally and multiple strategies have been adopted over the years to tackle the plight. Within the current state-of-the-art, the FSED model has emerged with potential for reducing hospital ED overcrowding as it can reduce the additional load by diverting minor cases, freeing up space for more urgent cases.

This approach has been embraced in the US and is under consideration in some western countries [10]; although it is a relevant issue, no standard requirements for location, layout or staffing patterns is present and only few states explicitly allow this model [19,20]. To the best of our knowledge, this specific hospital type is not studied enough and little information is available to start comprehensive, multi-country, wide-sample studies.

Further research is in fact needed to make this model known and recognized in other contexts, such as Europe, and disclose its functional and spatial implications for the hospital planning perspective.

Therefore, the aim of the study is to shed light on the specific features of this model by analyzing and comparing functional layouts of different FSEDs and EDs in various contexts. Through this first explorative study, the objective is to gather in a structured way the relevant information from recent scientific literature and case studies in order to learn about the key features of this model in comparison to traditional ED frameworks.

2. Materials and Methods

The research methodology included a literature exploration and review of relevant papers in the healthcare field and data analysis of international FSED and ED case studies as detailed below.

2.1. Literature Review

The paper investigates the current state-of-the-art by conducting a systematic literature review to catalogue, analyze and critique the concepts pertaining to Emergency Departments, its operation and different triage models identified globally, along with the present challenges faced by health infrastructures. Furthermore, it investigates interventions to tackle them, such as the Free Standing Emergency Department (FSED) Model. Moreover, the model's operation is examined considering current trends pertaining to its success, growth, and distribution pattern, as well as the essential prerequisites for its suitability; such models can be different depending on geographical context and must consider different frame, healthcare policies and insurance regulation, design and education approaches in healthcare design [21]. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria were adhered to throughout the research process. The research materials are retrieved by a search on a set of key words like "Emergency Department", "models of care", "triage", "dedicated health facility", "free standing Emergency Department", "FSED", available from a structured search in databases (Medline, CINAHL, Scopus, PubMed, and Web of Science) to explore peer-reviewed research publications that were aimed at analyzing the issue under consideration. The initial outcome will be a meta-synthesis for the qualitative research conducted.

To achieve most of the information about the topic, a systematic and explicit design for identifying, evaluating, and interpreting the existing body of recorded documents has been considered [22]. For screening, after the removal of duplicates and the application of the eligibility criteria, the initial search resulted in 1174 papers. Furthermore, titles, abstracts and keywords have then been screened one by one, to discard out of scope documents that were not excluded by the filter application in the selected databases. Titles, abstracts, and keywords of the selected papers have been critically read and processed according to some exclusion criteria such as:

- date of publication: Only contributions from January 2000 to December 2021 have been included, in order to acquire information about the most recent trends;
- content focusing on hospital design: papers or documents pertaining to alternative architectural typologies were excluded from consideration;
- exclusion of papers or documents pertaining solely to working spaces in order to concentrate on diagnosis and treatment areas;
- emphasis on physical characteristics; publications that are solely concerned with managerial or clinical issues were excluded;
- regulations as the primary focus: publications that are entirely concerned with the laws or mandatory technical regulations of a given location are excluded;
- concentration on a certain model: publications not connected to HBED or FSED models were excluded;
- no specificity on temporary COVID-19 Emergency Department.

The screening process resulted in 73 papers. After title, keywords and abstract analysis, a total of 37 records were excluded, resulting in the selection of 36 publications. Finally, after full text screening, a total of 23 papers have been included in this review as reported in Figure 1.

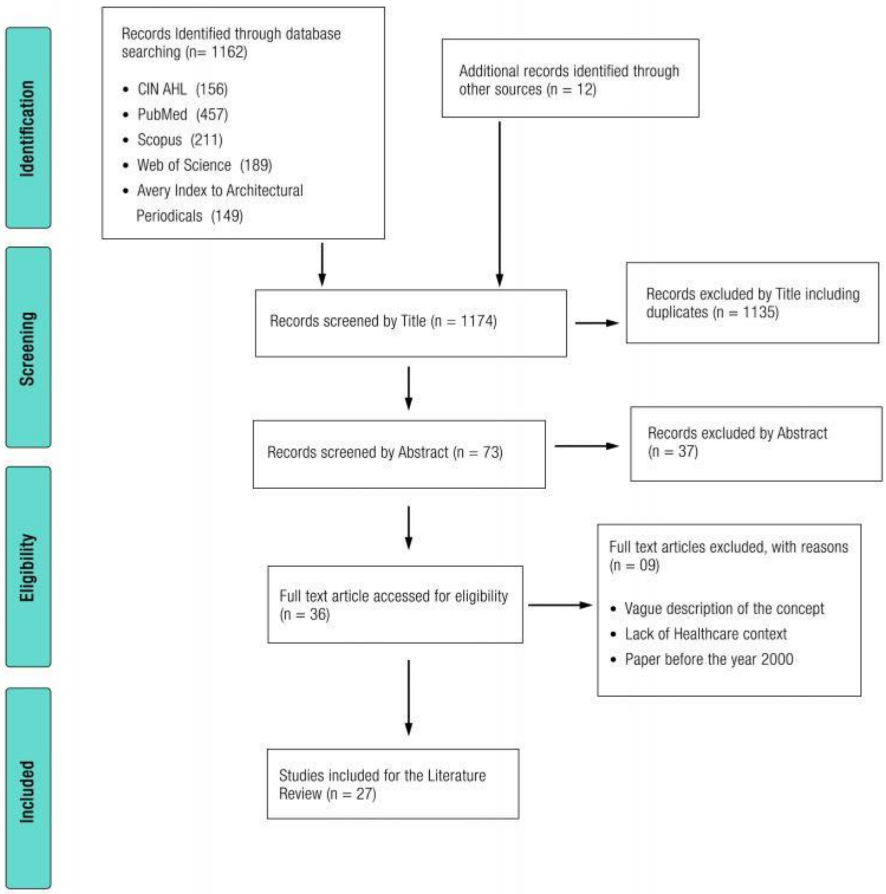


Figure 1. The PRISMA Flow Diagram shows the process followed for the identification of the 23 papers selected through the Literature Review.

2.2. Case Studies Functional Layout Analysis

Following the collection of data and information from the available literature review, it was necessary to examine and study a broad spectrum of practical examples of hospital HBEDs and FSEDs to gain a better understanding of the complex systems of their operation and functioning. US-based satellite and autonomous FSED in conjunction with general EDs in European hospitals and Italian hospitals were subjected to a thorough assessment. Data availability and the capacity to gather information, due also to language issues, resulted in the geographical composition visible in Table 1. Technical plans, sections, masterplan, and design reports have been collected through websites, publications and dialogue with designer and/or hospital managers. For the purpose of greater comprehension, three examples of contemporary case studies were picked for the study of each type previously described. Case studies have been selected among facilities built after 2010, between 70,000 and 500 square meters gross floor area, and where it was possible to collect information about floor plan and functions. Relevant cases where no data were available have been excluded.

Table 1. List of case studies analyzed and criteria of analysis.

Name	Type	Location	Year	Area Sqm
Cap-Rock Emergency Hospital	FSED-Satellite	USA	2018	1928
Clarksville Freestanding Emergency Department	FSED-Satellite	USA	2017	1022
Huston Methodist Emergency care Centre	FSED-Satellite	USA	2014	892
Legacy ER Freestanding Emergency Department	FSED-Autonomus	USA	2013	785
West Texas Emergency Department	FSED-Autonomus	USA	2014	600
Baptist Health South Florida FSED	FSED-Autonomus	USA	2019	1730
Villeneuve-Saint-Georges Hospital	HED-Europe	FRANCE	2012	17,800 (hospital)
New University Hospital La Fe de Valencia	HED-Europe	SPAIN	2010	260,400 (hospital)
Skane University Hospital Malmo	HED-Europe	SWEDEN	2010	25,800 (hospital)
Papa Giovanni XXIII Bergamo	HED-Italy	ITALY	2012	5580
Policlinico di Milano	HED-Italy	ITALY	On Going	70,000 (hospital)
San Raffaele Hospital Milano	HED-Italy	ITALY	2021	6752

The analysis was carried out by studying the user-flow, logistics, the relationship with its surroundings and an understanding of the zoning and its inter-relationship with different functions and its area distribution per function. To compare all the cases with common criteria, six functional macro areas were identified: Patient Care and Stay, Imaging Department, Nurse Station and Spaces, Core Emergency Area, Triage and Waiting Area, and Lounge and Cafeteria. This analysis resulted in a deeper comprehension about the area distribution for different zones in the studied cases.

A department's physical footprint (and the footprints of other functional elements of any building) is determined by the initial functional assumptions, which include factors such as the size of the served area, the number of users, the number of scheduled procedures, access to other healthcare facilities, statistical information on traffic injuries, and so on. Naturally, the aim is not to evaluate an Emergency Department solely on the basis of its area due to different starting conditions. However, the study of the area element is commonly considered in the research and practical environment to be a very valuable tool for assessing the accuracy of a design, and therefore benchmark strategies on this element have been adopted for data analysis [23–25]. The area specification, especially shown as a percentage of the total area, can help to point out several principal relations. It gives a scale for comparing the components with respect to the overall dedicated areas for the functional department. Materials of analysis have been collected from web sources or directly from an architectural/construction firm or hospital organization. The full list of cases that are included in the analysis is reported in Table 1, along with the criteria used for data analysis.

3. Results

3.1. Literature Review

Numerous research papers, on-line journals, publications, ongoing research studies and on-line sources were consulted in order to build the literature review; it was important that the literature review was understood and analyzed before proceeding and bringing out the specific factors for the critical understanding of the FSED model. These sources were selected, keeping in mind the sub-topics of the background study, pre-requisites, ongoing trends, and related subjects that are yet to be discovered. The answers came from the detailed analysis of the selected 23 papers that emerged from the initial search, and is briefly reported in Table 2 and included in Supplementary Materials. The key findings are reported below.

Table 2. Summary of the literature review analysis.

N°	Authors	Title	Year
1	Bąkowski J	Several notes on differences between American and European model of an emergency department. An architect's point of view [26]	2014
2	Buffoli M, Bellini E, Dell'Ovo M, Gola M, Nachiero D, Rebecchi A, Capolongo S	Humanization and soft qualities in emergency rooms [27]	2016
3	Lukens J	Freestanding Emergency Departments: An Alternative Model for Rural Communities [28]	2016
4	Ayers AA	Understanding the Free Standing Emergency Department Phenomenon [29]	2016
5	Schuur JD, Baker O, Freshman J, Wilson M, Cutler DM	Where Do Freestanding Emergency Departments Choose to Locate? A National Inventory and Geographic Analysis in Three States [12]	2016
6	Rismanchian F, Lee HY	Process Mining–Based Method of Designing and Optimizing the Layouts of Emergency Departments in Hospitals [30]	2016
7	Frascio M, Mandolfino F, Zomparelli F, Petrillo A	A Cognitive Model for Emergency Management in Hospitals: Proposal of a Triage Severity Index [31]	2017
8	Brunelle A, Henes M, Hu A, Kosovrasti K, Lambert B, Tavera, A	Freestanding Emergency Departments (FSEDs)—A Stakeholder Study [32]	2017
9	Langlands B, Coleman D, Savage T	Reimagining the ED:Ideas for Shaping the Emergency Department of the Future [33]	2018
10	Hartigan L, Cussen L, Meaney S, O'Donoghue K	Patients' perception of privacy and confidentiality in the emergency department of a busy obstetric unit	2018
11	Burgess L, Kynoch K, Hines S	Implementing best practice into the emergency department triage process [34]	2019
12	Zamani, Z	Effects of Emergency Department Physical Design Elements on Security, Way-finding, Visibility, Privacy, and Efficiency and Its Implications on Staff Satisfaction and Performance [35]	2019
13	Gharaveis A, Hamilton DK, Shepley M, Pati D, Rodiek S	Design suggestions for greater teamwork, communication and security in hospital emergency departments [36]	2019

Table 2. *Cont.*

N°	Authors	Title	Year
14	Sasanfar S, Bagherpour M, Moatari-Kazerouni A	Improving emergency departments: Simulation-based optimization of patients waiting time and staff allocation in an Iranian hospital [9]	2020
15	Ehmann MR, Erin KM., Zakk A, Jordan D, Mustapha S	Emergency Department Ergonomic Redesign Improves Team Satisfaction in Cardiopulmonary Resuscitation Delivery: A Simulation-Based Quality Improvement Approach [37]	2020
16	Gharaveis A, Pati D, Hamilton DK, Shepley M, Rodiek S, Najarian M	The Correlation Between Visibility and Medical Staff Collaborative Communication in Emergency Departments [38]	2020
17	Tindle K, David A, Carlisle S, Faircloth B, Fields JM, Hayden G, Ku B.	Relationship of the Built Environment on Nursing Communication Patterns in the Emergency Department: A Task Performance and Analysis Time Study [39]	2020
18	Nourazari S, Harding JW, Davis SR, Litvak O, Traub SJ, Sanchez LD	Are Smaller Emergency Departments More Prone to Volume Variability? [40]	2021
19	Zhao-Wang Z, Jian Y, Jiatong L,	Generation of hospital emergency department layouts based on generative adversarial networks [41]	2021
20	Douillet D, Saloux T, Ravon P	Adaptation of ED design layout during the COVID-19 pandemic: a national cross-sectional survey [42]	2021
21	Jeong C, Jakobsen HCW	Influence of architectural layouts on noise levels in Danish emergency departments [43]	2021
22	Alowad A, Samaranayake P, Ahsan K, Alidrisi, Karim A	Enhancing patient flow in emergency department (ED) using lean strategies–an integrated voice of customer and voice of process perspective [3]	2021
23	MohammadiGorji S, Bosch SJ, Valipoor S, De Portu G	Investigating the Impact of Healthcare Environmental Design on Staff Security: A Systematic Review [44]	2021

Among the twenty-three papers were sixteen research articles, two reports, one review, one web article, one conference paper, and one book chapter. Most of them (thirteen) have been written by US authors (78%) while the others represent scholars from Italy (two), and other countries (eight).

Of those that were used, seventeen were based on an analysis of literature, data or case studies, while the remaining three used theoretical process and, three were about practical application of strategies.

Among the findings, nineteen reported specific data on ED facility design, while four provided only general consideration on managerial or clinical aspects.

Of the papers analyzed, five provide *Organizational models*, eight papers gave indications about *Functional Layout*, one was mainly related to *Structural and technical features*, and nine described *Design features and amenities*. Therefore, the results are clustered accordingly and the main findings are reported below in the following different sub-sections: (i) organizational model; (ii) functional layout; (iii) structure and technical features; (iv) design features and amenities.

3.1.1. Organizational Models

According to the literature review, five articles addressed aspects related to the organizational field. As a single entity, the performance of an Emergency Department can be compared to that of a whole hospital; this is due to the elements of an Emergency Department being self-contained [23]. In recent times, there are detailed and particular reviews on various aspects of EDs operation, beyond being strictly medical—but also economical, social, management, technical, technological, statistical perspective. The general layout of the Emergency Department (including hospital-based and FSED) and the functional interconnections between its components are seldom examined. Comparing functional patterns for hospital based and free standing Emergency Departments enables the identification of critical distinctions between them and also serves as a precursor to the specification of a general model for determining both solutions and discussing their relative benefits and disadvantages.

It emerged that a small scale ED, both 'Hospital EDs' and 'FSEDs', is better performing in terms of organizational issues, and also patients' wellbeing [23,40].

A broad functioning diagram of the ED has been observed using a collection of selected projects as case studies, for both 'Hospital EDs' and 'FSEDs'. The comparison of the two designs reveals commonalities, but also significant variances. While the average hospital Emergency Department gets between 150 and 200 patients per day, depending on the business model, many FSEDs receive as few as 35 to 40 patients per day, and some private operators are profitable with fewer than 20 [29]. In general, FSED patients are mobile and present with conditions that would be classified as less urgent (urgent or semi-urgent) in a Hospital Based Emergency Department. If it is decided that a critically ill patient presenting to an FSED requires hospitalization, surgery, or specialist treatment, the patient is stabilized and moved by paramedic to a nearby higher-acuity facility.

Economic reasons have resulted in the expansion of a network of 'Free Standing Emergency Departments' (FSED), which have assumed responsibility for the majority of the tasks associated with providing emergency medical care. The team is made up of members from Emergency Departments as well as paramedic rescue squads. As the Emergency Department in the United States has not been fully defined, its activity is typically described as a 'separate part of the hospital equipped with adequate personnel and equipment for the reception and care of patients requiring immediate medical care, regardless of their health or emergency reasons' (American Emergency Department). A similar model of emergency medicine has been proven to be effective across the world in countries such as Australia, Canada, China, United Kingdom, Israel, Japan and others [23]. The 'European' model or the hospital based EDs has also placed the core of Emergency Medicine (EM) at the pre-hospitalization activities, but with minor different preconditions. The EM is based on interdisciplinary cooperation and the rescue teams competences and equipment—'hospital coming to the injured', are highly emphasized by being part of the Hospital but fully independent. The description refers to the organizational model of the emergency system. In general, the ED appears to be a part (ward) of the hospital, with several auxiliary elements (for example, free-standing emergency stations). Currently, this model is found in the majority of European countries [23].

Both solutions have their own set of advantages and disadvantages. It is a decentralized model that can be located at the very micro level, even in rural settings where large infrastructure may not be the most cost-effective solution. In this way, it becomes possible to establish a more dense and widely distributed network of healthcare institutions while also providing quick access to urgent and emergency medical care. For its part, as it typically incorporates medical units that perform medical treatments of a higher degree of complexity, the model nevertheless needs the same state-of-the-art infrastructure and maintenance effort as a traditional hospital Emergency Department. Any model of ED is dependent on a good communication network and its location is very important for the time-dependent reason that every minute is vital for the emergency cases. For example, the maximum estimated time to provide emergency care in case of cardiac arrest is 15 min. Although it is outside the scope of this paper to discuss which model is better suited to provide an emergency coverage (due to different healthcare system requirements and overall related context), the differences have been summarized according to the next following three domains: functional layout, structure and technical features, design features and amenities; finally it is important to note that the use of FSEDs could be crucial in rural areas, where the distance from hospital is often wide [12,28].

According to their geographical context, the ESI (Emergency Severity Index) Model is used in the FSEDs in the United States, the MTS (Manchester Triage System) in hospital-based Emergency Departments in Europe, and an Italian-MTS hybrid triage system that is used specifically in Italian hospital-based Emergency Departments are all examples of different triage models that have been studied (Figures 2–4). As a result of the differing triage systems, the FSEDs in the United States and European hospital-based EDs have quite distinct spatial layouts. In most cases, the Free Standing Emergency Departments (FSEDs) consist of several exam rooms around a central nurse station; however, the Italian Hospital EDs consist of large exam rooms specialized to specific intensities, with a tiny nurse station positioned in or near each room. Both types of Emergency Departments are designed to address different intensities of trauma where the high intensity (ESI 1/Code Red) patients are directed straight to the trauma/shock room through an express entry.

Figure 2. ESI & MTS Triage Systems.

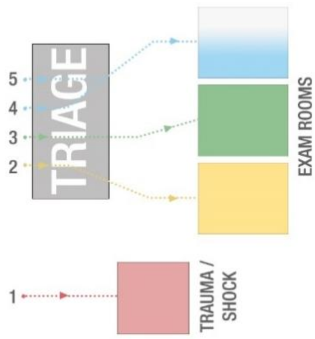


Figure 3. Italian HBED Triage and Layout Organization.

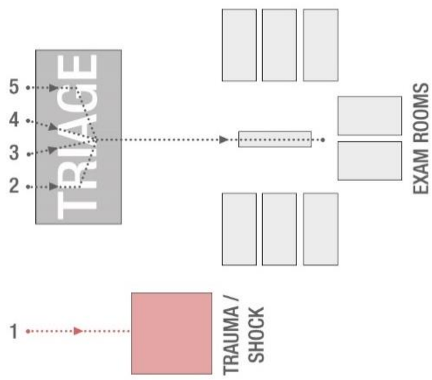


Figure 4. FSED based Triage and Layout Organization.

3.1.2. The Functional Layout

The functional layout includes the internal communication system, internal connectivity and connections to other departments of the hospital as well as the provision of isolated areas of the branch and functional zoning.

The sequence of these steps determines the spatial location of the necessary rooms and areas (room units) and the access path to reach them. The 'sequence of events' takes its origins in the system or from the technological requirements. In most cases, the adoption of a suitable framework for the processes strongly narrows the room for designer's maneuver, though (especially in the case of American FSED solutions) the whole range of possibilities is allowed—this is why the American Free Standing Emergency Department can be designed with more flexibility.

The layout of an ED can have a crucial impact on patients that pass through it, for example, from the acoustic point of view [34,43]. Furthermore, the localization of specific parts of the structure can provide a significant role in the management and number of staff, and decrease the average waiting time of patients [3,9,37,38].

The enhancement of ED design helps nurses and physicians to benefit from supportive environments. A study has shown that an efficient placement of the clinical units yields remarkable improvements in the distances traveled by patients [30].

In the case of the HBED, the functional arrangement can be described as a 'functional passage', i.e., all the basic ED elements are arranged on the axis of internal communication, connecting the triage area to the hospital access, which is a one-way flow of patients, from the processing admission area, through the triage area, treatment areas (therapy and observation) to the hospital. The sequence allows the separation of several zones dedicated to various medical procedures, according to the identified potential life risk. The flow of patients through targeted areas (i.e., as follows: resuscitation/observation/intensive care/operating suite/hospital bed ward) makes it possible to filter them out.

The American model has a slightly different approach: as the central system, with combined therapy and observation area (treatment area/cubicles) located in the inner hub supported by an extensive nurse station. Other areas of the department are in the radial arrangement in relation to the central zone. Such organization of the patients' flow forces all the movement towards the center, without any significant diversity in the relevance of the ED zones. However, unlike HBEDs, the FSEDs:

- Lack trauma level verification by the American College of Surgeons;
- Do not receive patients via ambulance diversion or transfer;
- Do not have overnight beds or intensive care capabilities (mostly);
- Lack inpatient referral or admissions capabilities; and
- Do not have the resources to deal with large influxes of patients from natural and/or man-made disasters.

Considering the fact that there are numerous acceptable variants of the solution: changes in the geometry of the layout, variants of the communication axes, etc.; the diagram (Figure 5) represents a possible functional model and would mostly change in its composition with different settings, but the organizational structure remains almost the same.

Furthermore, the shape of spaces has a crucial role in terms of the efficiency of spaces and it emerged that rectangular areas must be preferred [41].

According to Douillet et al., during the first wave of the COVID-19 pandemic, all EDs adapted, but many of the changes such as the creation of different paths and access recommended for the organization of ED could not be implemented. That is due to the ED architecture constraining adaptive capacities as the flexibility of spaces was not provided in the project preliminary phases [42,45].

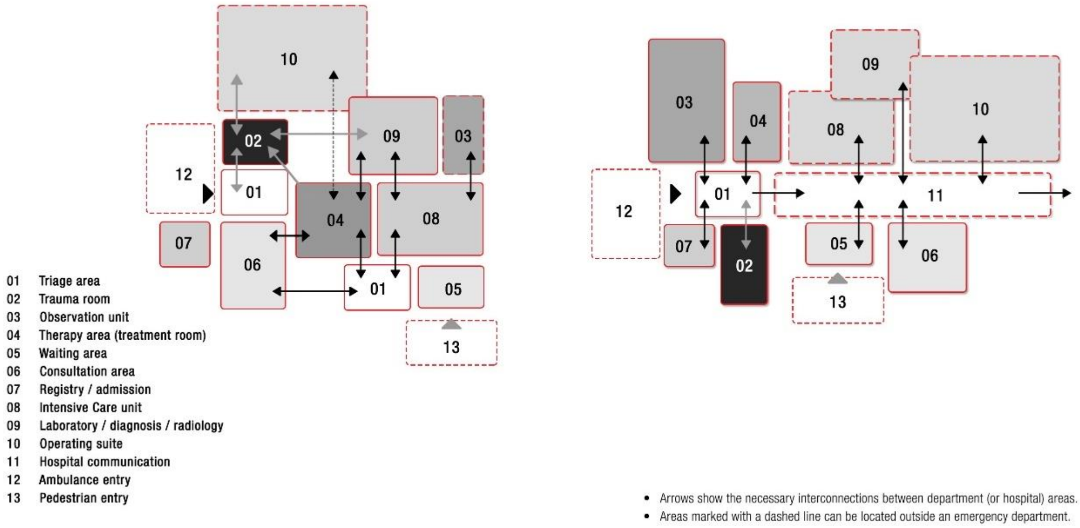


Figure 5. Schemes for the FSED (left) and Hospital ED (right) model for the Emergency Department, redrawn from [29]. Arrows show the necessary interconnection between department/hospital area; areas marked with dashed lines can be located outside the boundary of the emergency department area.

3.1.3. Structural and Technical Features

This category includes the technical infrastructures, the installation systems and the issues related to safety (i.e., fire safety, evacuation).

While technological means undoubtedly have a considerable impact on the quality of any designed or created environment, they do not dictate (at least not considerably) any distinct operational solutions. The modular and structural grids used in healthcare facility architecture, as well as the arrangement of construction elements, are typically based on a multi-span grid (i.e., a system of modular structural blocks repeated across both axes of reference). This is a solution that is typical for healthcare facility architecture. Additionally, the grid establishes the location of the building's infrastructure (heating and ventilation system, plumbing, installation of medical equipment and others). Its size and span (distance between structural elements) enable the installation of nearly any functional system element. Concerning safety, each country has its own set of local legal standards (though of course there are some common elements). The law prescribes methods and solutions for ensuring, among other things, fire safety, appropriate access to the building, and evacuation. Although architecture may appear to be the most essential component of a building to the user or an outside observer, it is frequently merely a 'packaging' for the functioning. Certainly, it is vital, as it contributes to the interior's quality, a sense of satisfaction, comfort, and well-being. For example, an algorithm (TAEM, triage algorithm for emergency management) has been made by Frascio et al. in order to easily determine which ED is more suitable to host different injured patients, using a multicriteria assessment method [31]. Such approaches allow the avoidance of long lines and long waits in emergency rooms in case of serious emergency situations, in which there are many injured.

3.1.4. Design Features and Amenities

FSEDs can also differentiate themselves from their hospital-based counterparts in terms of the patient experience. Hospital EDs have a reputation for long wait times, busy staff, and crowded, uncomfortable waiting rooms [33]. Whereas national studies reflect average three-hour wait times in the nation's ERs, FSEDs focus on getting patients out within 60 to 90 min. In addition, FSEDs are typically located in upscale retail developments and have fashionable decor, conveniences like Wi-Fi and exam room cable television, gourmet coffee and refreshment bars, children's play areas and pediatric-themed rooms.

The atmosphere is more reminiscent of a boutique hotel lobby or day spa than the “sterile” or “clinical” environments associated with hospitals [29].

The design of spaces can have an impact on patient’s well-being and also on the quality of patients care [39]. For example, features like physical environment attributes (i.e., layout, location, ambient conditions, equipment) can have substantial impacts on both patients’ comfort [34,35,38,44,46] and staff satisfaction and performance [32].

An important way to assess and define space of ED is the involvement of users, as hospital is a complex structure used by different people with different cognitive and physical conditions; the design must take into consideration the provision of wellbeing, and create a pleasant environment [47].

The literature review provided general information about the FSED hospital layout, seldom providing guidelines for architects [36], and therefore the consultation of a selection of case studies is important if we are to understand in detail how this model is incorporated in real practice.

3.2. Case Studies Analysis

The critical space-functional analysis of the 12 studied cases (Figures 6 and 7) gave a detailed idea about unique yet salient features of these Emergency Departments and the overall flow of spaces with its set of dedicated functions for every zones. It is interesting to see how the policies and the triage systems affect the floor layouts of the designed spaces in different contexts and geographies. It can have similar functions and the same purpose, i.e., to deal with the emergency cases, yet the arrangement of spaces can vary significantly. What works best is dependent on the specific scenario, but the different typologies under study can be a solid base to define what suits the site the best. The following section underlines the key features of the studied cases and discusses the main aspects that emerged during the study. The specific result for each case study is reported in Figures 8–11 while a detailed summary of the most important features is described in the following sub-sections.

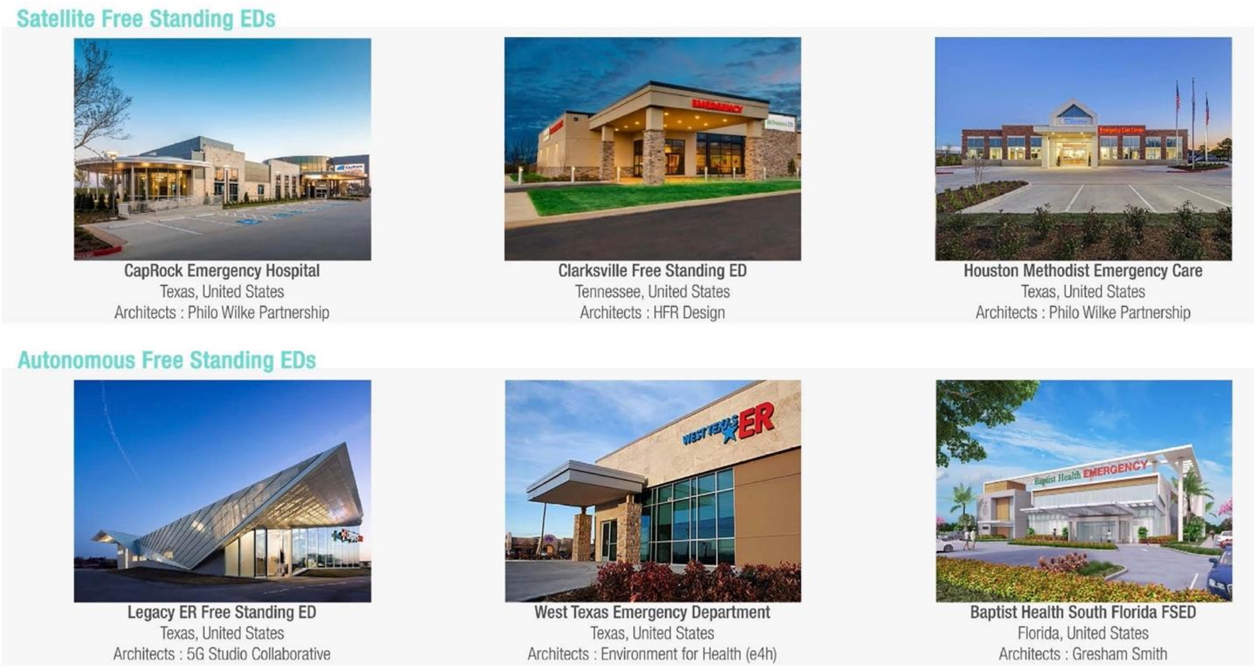


Figure 6. FSED Case studies Analysis.

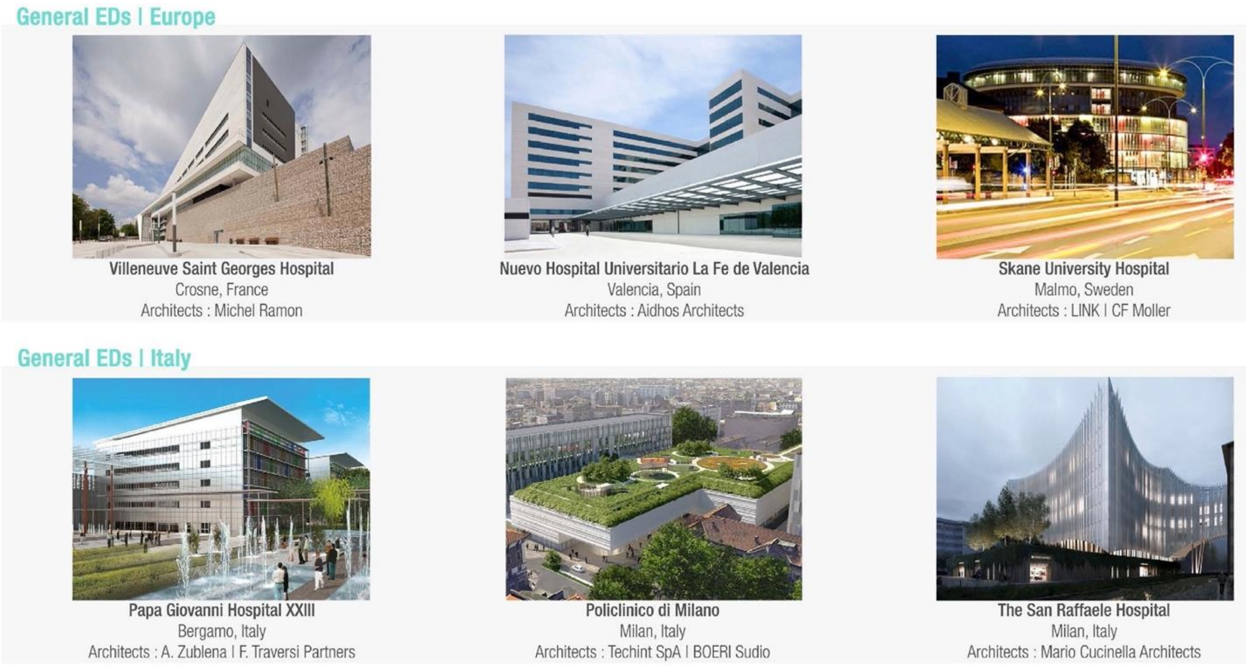


Figure 7. HBED Case studies Analysis.

3.2.1. Area Analysis for Dedicated FSED Zones

While analyzing the case studies for the FSEDs, several zones were identified like the core emergency areas, triage spaces, etc., for drawing comparisons to get a general idea about the ranges, within which it usually varies. A total of six FSEDs were studied and a range of surfaces in terms of percentage of functional area on the total square meters of the facility have been highlighted. The results are briefly presented below with a range of findings as in benchmarking activities such an approach could be more informative, rather than just the average of very different values.

The Triage system plays a vital role and has its influence over the flow of the users and room placements and overall organization of functions and zones. Most of FSED case studies allocated 10% to 12% of the total surface to the triage and waiting functions, except two of them, who scored higher than 20%. The Core Emergency Area accounted for 12–23% of the total surface. Only one FSED had space for Patient Stay and accounted for about 16%. The Nurse Station space was very variable depending on the different FSED: a group of cases ranked between 8% and 16%, while two of them were up to 25%.

The Imaging and Diagnostic area was instead considerably coherent among the different cases scoring between 9% and 11% with only one case that reached 16% of the total area. Finally, Lounge areas for Staff were between 2% and 5% with one exception, who reached 10% of the total surface. The remaining space is dedicated to distribution, technical and logistic spaces that are not considered in this analysis as it is outside the scope of the paper.

The complete list of FSED results is reported in Figure 8 and a comparison is provided in Figure 9.

3.2.2. Area Analysis for Dedicated HBED Zones

While analyzing the case studies for the Emergency Departments (EDs) from the General Hospitals, several zones were identified like the core emergency areas, triage spaces, etc., for drawing comparisons to get a general idea about the ranges, within which it usually varies. A total of six EDs (three from European countries and three from Italy specifically) were studied comprehensively and a range of surfaces in terms of percentage of functional area on the total square meters of the facility have been highlighted. The results are briefly presented below with a range of findings as in benchmarking activities such an approach could be more informative rather than just the average of very different values. Most of the HBED case studies allocated 12% to 16% of the total surface to the Triage and Waiting functions, except one recently designed, who scored 5%. The Core Emergency Area accounted for 19–30% of the total surface. None of them had space for Patient Stay internally as they are all hospital based.

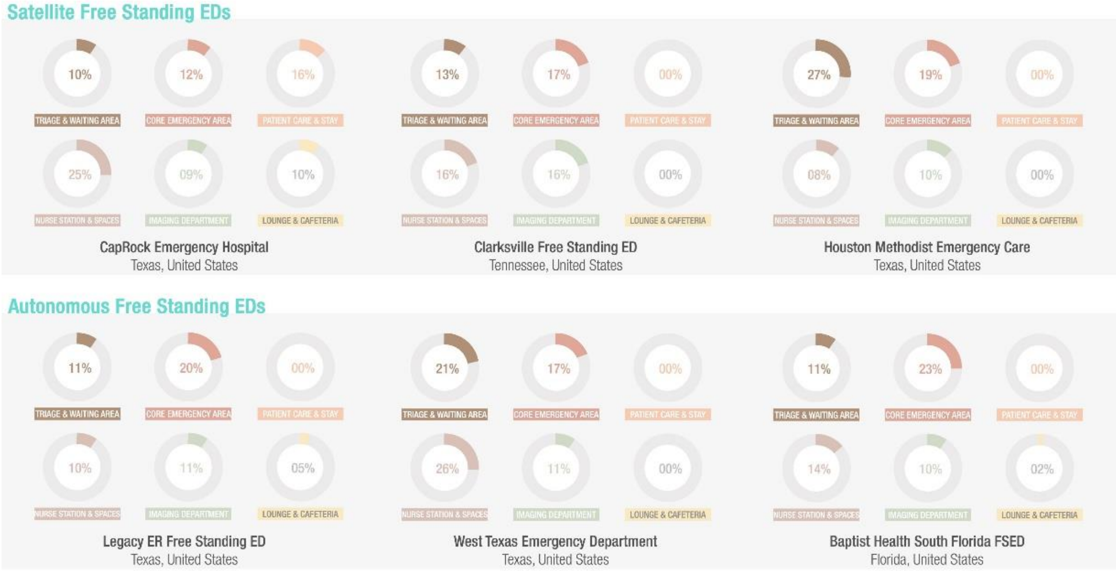
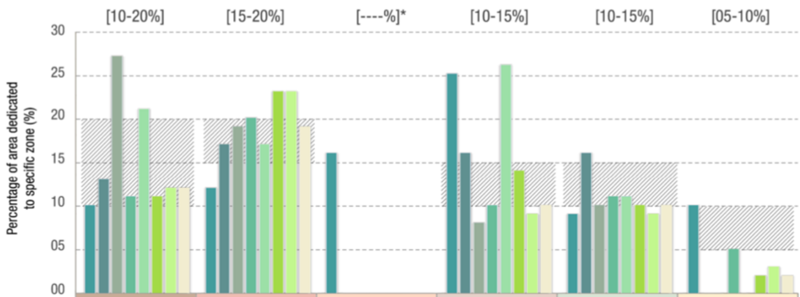


Figure 8. Results from the data analysis of FSED Functional areas.



	Triage & Waiting	Core Emergency Area	Patient Stay	Nurse Station	Imaging & Diagnostics	Lounge & Cafeterias
Cap Rock ER	10	12	16	25	09	10
Clarksville FSED	13	17	00	16	16	00
Houston Methodist FSED	27	19	00	08	10	00
Legacy ER	11	20	00	10	11	05
West Texas ER	21	17	00	26	11	00
Baptist Health S. Florida _Prototype 01	11	23	00	14	10	02
Baptist Health S. Florida _Prototype 02	12	23	00	09	09	03
Baptist Health S. Florida _Prototype 03	12	19	00	10	10	02

* the zone for patient care & stay is not taken into consideration while data cumulation due to the absence of data

Maximum Area Value (%) for each Zone
Minimum Area Value (%) for each Zone

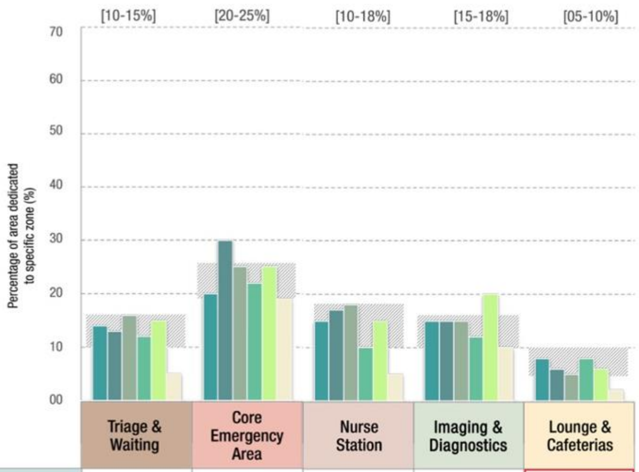
Figure 9. Cumulative Area Graph for Dedicated FSED Functional areas. The sixth case study is reported three times as this FSED had three layout options that are slightly different.

The Nurse Station space was considerably coherent, accounting for 10 to 18% of the total HBED surface, and with only one case, which scored 5%.

The Imaging and Diagnostic accounted for 10–15% of the total surface except one case who scored 20%. Finally, Lounge areas were between 2% and 8%. The remaining space is dedicated to distribution, technical and logistic spaces that are not taken into account in this analysis as it is outside the scope of the paper.

The complete list of HBED results is reported in Figure 10 and a comparison is provided in Figure 11.

Figure 10. Results from the data analysis of HBED Functional areas.



	Triage & Waiting	Core Emergency Area	Nurse Station	Imaging & Diagnostics	Lounge & Cafeterias
Villeneuve Saint Georges Hospital	14	20	15	15	08
New University Hospital La Fe de Valencia	13	30	17	15	06
Skane University Hospital	16	25	18	15	05
Papa Giovanni XXIII Hospital	12	22	10	12	08
Policlinico di Milano	15	25	15	20	06
San Raffaele Hospital	05	19	05	10	02

Maximum Area Value (%) for each Zone
Minimum Area Value (%) for each Zone

Figure 11. Cumulative Area Graph for Dedicated HBED Functional areas.

4. Discussion and Conclusions

4.1. Research Outlooks

The qualitative and quantitative study conducted in the form of a literature review, case studies analyses, and a detailed area comparison of dedicated FSED and Hospital ED zones, revealed certain key findings that set the basis of structured knowledge about this hospital type. These preliminary findings are important for the possible structure/framework of design guidelines and, eventually when exploring adaptation of the FSED model in other context.

By emphasizing the model's duality (the presence of both strengths and shortcomings), there is contention in the literature about whether FSEDs can provide prospective benefits such as reduced waiting times and reduced travel distance for emergency care, while others have argued that FSED may result in an increase in overall health care spending. Decision-makers and third-party payers may wish to consider altering the way these institutions are managed in order to account for patient acuity. The standalone model for serving emergencies in the neighborhood scale can be an excellent alternative to avoid the long waiting hours in the HBEDs for minor to an intermediate level of emergencies. The model might also tackle, in a more capillary way, possible emergency outbreak situations such as the ongoing pandemic of COVID-19, but no specific evidence has been found on this aspect. The understanding of the model's functionality in itself can suggest that such facilities might be able to become a containment unit for a neighborhood in times of emergency situations and can relieve a lot of working stress on the hospitals, where beds can be then spared for serious cases and diversion of the rest to these units.

The analysis conducted made it evident that when studying an emergency department model from a different geographical context, it is important to evaluate the characteristics of alternative triage systems and the resulting spatial layouts in order to assure its viability and workability. When designing the functional and spatial layout of a new emergency department, it is indeed beneficial to consider inter-departmental connections, as well as the movement patterns of the users, to get a sense of the sequence and flow of spaces. The exam areas that are designated for varying intensities are typically located in close proximity to the triage area and nurse stations.

It is common practice for ED facilities to situate the Imaging and Diagnostic Department adjacent to the central emergency area, with a secondary access point available from the waiting zone. Certain FSED facilities offer extra services such as an on-call specialist doctor, laboratory analysis, and other extended medical services, however, they are subject to change depending on the size, location, and demographic demand of the particular context in concern. It has been noted that the triage and core emergency areas, respectively, account for 12–20% and 16–22% of the total floor area in FSEDs, whereas they, respectively, account for a range of 8–15% and 20–28% of the total floor area in HBED. As a result of the greater size of the facility, the main emergency area in the hospital EDs is also larger. Areas dedicated to nurse stations and ancillary spaces fall in the range of 15–25% for Free Standing Emergency Department, while a lower ratio is highlighted (10–18%) for Hospital based Emergency Departments, which makes the former slightly more efficient and comfortable from the perspective of staff.

It is observed that the percentages of space given to family lounges, waiting rooms, and cafeteria/restaurant facilities differ from one another as these services are optional and are frequently amended according to the size of the facility in consideration. Only a few FSED examples provide inpatient care and longer-term care services, again depending on the size and location of the facility; as an alternative, the patient is transferred to a nearby larger hospital or the parent/referral hospital in the case of a Satellite FSED, depending on the facility size and location.

The range identified in the study and the general design and operation strategies emerged from the literature review can be an important starting point for understanding this model and eventually identify the possible adoption of strategies for the ED design or refurbishment in different contexts.

4.2. Conclusions

In order to meet the increased demand and improve service quality, additional interventions are required in the healthcare sector and new organizational and physical models need to be explored. Findings from this study help to identify and focus on the characteristics of two different healthcare infrastructures devoted to emergency care, while providing a detailed account of the challenges faced by EDs in various contexts. The literature review and the case studies analysis provided an overview of the emergency healthcare system, which intuits the Emergency Department's components from triage systems to operational models. Lessening difficulties, such as congestion and access blockage, while effectively rejuvenating the concept of care for all in the built environment are all supported by the available evidence. With the success of the US-based Free Standing Emergency Departments, this research paper shed light on the FSED model providing early data and key findings on the understanding of the functional and spatial definition in comparison to the traditional Hospital Based ED model. The collection of detailed data from both typologies is relevant for practical and academic implications to further deepen the topic and support decision makers in developing strategies to face Emergency Department issues.

This explorative study sheds light on the specific features of FSED in comparison to ED and positions itself as a starting point for future studies on wider samples and a possible attempt at the adaptation of the model in other contexts, so they may be adjusted to meet the specific triage protocols, where the movement patterns and flow of areas for different facility users are addressed.

4.3. Research Limitations and Future Developments

The main research boundary is represented by the limited number of cases that have been included in the study. In fact, the case studies sample is not meant to represent a significant percentage of the overall number of FSED nor HBED cases worldwide, but it is the basis for the explorative study to collect important key features. Each case has indeed been analyzed in detail in terms of floor plan, functional area, construction parameters and verified with the support of the architectural office and/or the hospital managers. As such, we are confident that the results can inform future developments or studies on a wider and more comprehensive sample. Additionally, the analysis is concentrated into two specific geographical contexts, and subsequently focused on the areas where data collection was more feasible (i.e., Texas for USA and Italy for Europe); therefore it is still too early to generalize from those results, but they represent a concrete first step in filling the knowledge gap with regard to FSED and supporting future research in this direction, with both practical and academic implications. On one hand, decision makers and practitioners can find relevant insights to design and plan future facilities, while from the academic perspective, the study fills a knowledge gap and allows the future comprehensive analysis on possible FSED model interpretation or application.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/app12105099/s1, Table S1: Full list of papers collected; Table S2: Full analysis of case studies.

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