

An objective evaluation of emergency plan types using space syntax and users' responses

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KEY WORDS

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ABSTRACT

Emergency departments are the doorstep of any hospital and designed in different plan types due to a multiplicity of factors. As treatment follows a specific medical pattern according to established SOPs, therefore the spatial configuration needs to respond to that pattern. This paper objectively analyzed the three basic plan types of the emergency department for its spatial configuration using space syntax and users' responses. The results of this study demonstrate that the three basic plan types of emergency departments follow a consistency configurational pattern in their syntactic values despite different layout patterns. All three types exhibit not only a very similar space link ratios, integration, and difference factor (DF) but also the internal integration of the order clinical spaces in a consistency way. The results were cross-validated through users' responses for the required spatial pattern through closed-ended structured questionnaires. The results of this study may provide a baseline for the objective evaluation of the emergency department in the future.

1. Introduction

The preferred way to discuss architecture, is in terms of visual styles, but its most far-reaching practical effects are not at the level of appearances at all, but at the level of space [1]. recent studies in the healthcare environment focus on improving the quality of hospital environments through the optimization of floor layout [2, 3, 4, 5]. In architecture, design is a cognitive activity that starts with an abstract idea and then continues to transform into concrete spatial formations. Based on this abstract idea spaces are formulated [6]. This abstract idea is based on two types of knowledge together, scientific or research-based knowledge and intuitions, both to generate ideas and test them subjectively [7]. This means there exists a hidden structure of the configuration of the building. According to Hillier, Hanson, and Graham, "ideas are

objectively present in artifacts as much as they are subjectively present in minds" [8]. many researchers employed space-syntax theory and methodology to objectively evaluate spatial configuration [9-14].

Emergency department has a vital role in providing prompt and effective clinical care to patients [15]. It is the doorway of a healthcare facility responsible for receiving patients with different degrees of urgency and complexity. Improper facility design can lead to numerous problems [16]. The design of hospital facilities should ensure that care operations run efficiently and effectively [17]. Emergency Department is considered to be an extremely complex system [18]. To alleviate these Emergency Department problems, Welch [19] listed a number of factors that could improve the quality of Emergency

Department service. These include among others the architectural design issues. The delivery of effective care cannot be detached from the *structure* of its physical environment, which may support or delay the delivery of care and its results [20]. Ulrich et al [21] identified built environment design variables including floor layout among others as a factor that have an impact on efficient and high-quality care outcomes. Pati et al [22] also concluded that the physical environment can either ease or hinder operations and is rarely neutral to the processes occurring within it. It has been established that enhanced flow in an emergency department reduces stress among staff [23] and minimizes the number of patients leaving before treatment [24]. Space adjacencies in healthcare facilities are of prime importance “The movement of people and goods throughout a healthcare facility can be time-consuming and expensive. Therefore, careful study is necessary to minimize distances for the movement of traffic. It is recommended that during early planning, an evaluation of departmental relationships be performed [25].

Space Syntax has established its role in the evaluation of building designs in applied architectural research [6]. As opposed to conventional building performance tests focused on the physical qualities of a building for instance energy consumption, lighting, costs, etc., Space Syntax offers a valid tool to evaluate building designs with a qualitative and quantitative approach. It offers an opportunity to determine how space and users reciprocally adapt to each other and reorganize themselves [26]. This approach to the reading and understanding of spatial structures reveal possible relations between form and function. As emergency departments are meant to respond to the patient in a life-threatening situation, where the spatial configuration needs to respond to the procedure of treatment. Therefore, an objective evaluation tool of analysis is needed to check whether the spaces created meet the required configuration pattern based on the users' responses.

1.1. Objectives

- I. To objectively evaluate the spatial configuration of the basic three types of the emergency department.
- II. To determine the required spatial configuration of emergency department in terms of frequency of use.

- III. To propose a baseline for the evaluation and design of future design of emergency departments.

1.2. Research Questions

- I. Does plan typology make a significant difference in the spatial configuration of emergency departments?
- II. What are the most used spaces of emergency department?

2. Methodology

This study used case studies and combined strategies as a research method. Case studies of three basic plan types were used from the plan typologies given by Jenkins and van deLeuv [27] and Margret Peisert [28]. Space syntax methodology was then applied to quantify the spatial configuration of each plan type. The measure of integration, space link ratio, and difference factors were calculated for each case. To determine the spatial configuration of the emergency department, this study used space syntax methods, as an objective evaluation method. As syntactic analysis uses topological distance instead of metric distance, that is different-sized building will have the same syntactic values if its configuration is same and vice versa [29]. In the second step, the response from doctors and nurses working in tertiary-level hospitals were collected in form of email questionnaires for the required pattern of use in the emergency department. A total of 55 responses from doctors and 64 responses from nurses were collected. The analysis of the cases started with justified graphs using AGraph software. Depth map was used for the calculation of integration. The difference factor was calculated by MS Excel program as shown in Table 1.

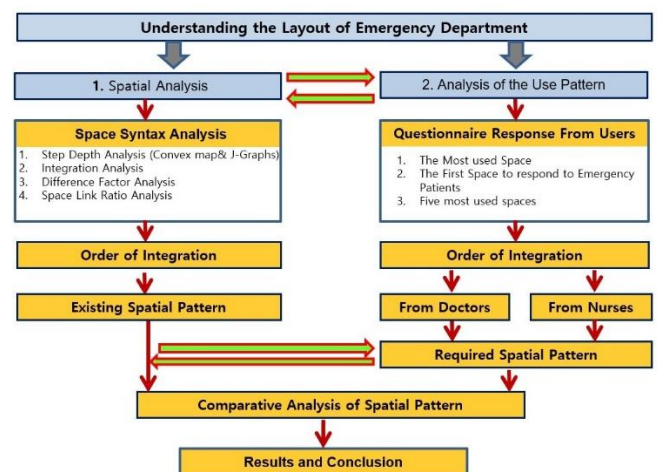


Fig. 1. Conceptual framework

Table 1

Integration, Space-link ratios, and difference factor of three plan types

Plan Type	Space-Link Ratio	Integration			
		Max	Mean	Min	DF
Core Type Area	1.50	1.63	0.88	0.48	0.72
Type	1.19	1.29	0.89	0.36	0.73
Corridor Type	1.20	1.43	0.89	0.37	0.69
Mean	1.30	1.45	0.89	0.40	0.71

3. Emergency Plan Types

Typology in architecture is the comparative study of physical or other characteristics of the built environment into distinct types [29]. Jenkins and van deLeuv [27] and Margret Peisert [28], give the following three plan types for the emergency department. Core type, Arena type, and Corridor type of emergency plan.

3.1 Core Type Plan

Core type plan is organized around a central workspace for emergency department personnel. Ideally, there is a periphery corridor outside the treatment areas from which the patients enter the cubicles [27, 28].

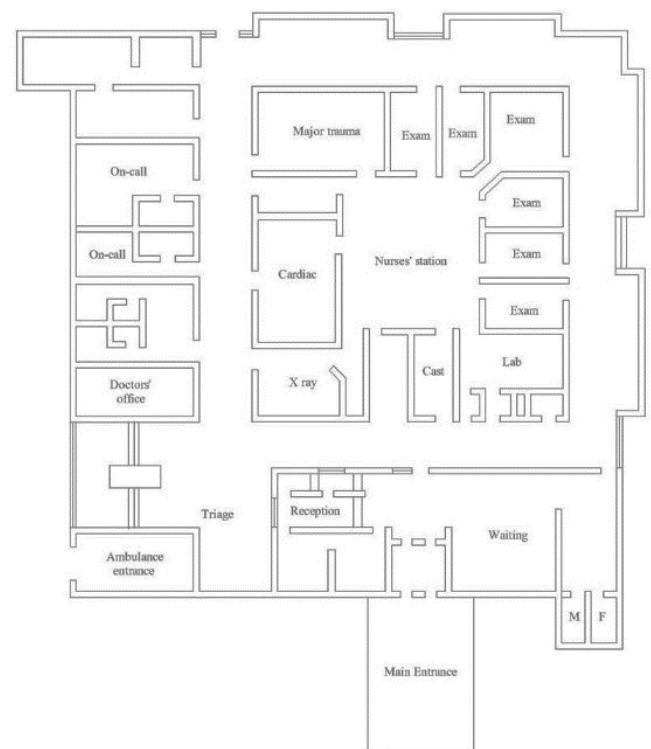


Fig. 2. Core Type Plan for Emergency Department redrawn by authors from Jenkins and van deLeuv [27] and Margret Peisert [28]

3.2 Arena Type Plan

The arena type resembles the core plan type but there is no periphery corridor as in the core type plan. Arena type plan is good for smaller emergency departments. This type provides good view of all the cubicles for the nurses and physicians. Due to the central location of work station, many steps are saved [27].

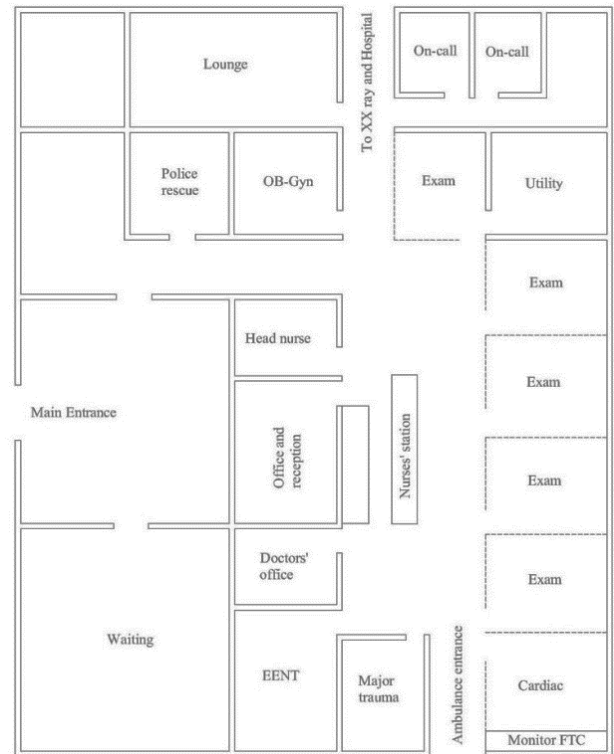


Fig. 3. Arena Type Plan for Emergency Department redrawn by authors from Jenkins and van deLeuv [27] and Margret Peisert [28]

3.3 Corridor Type Plan

The corridor plan type permits many variations, as required according to the size of the department. The treatment rooms line on both sides of the central corridor. Larger emergency departments may find this type as the desirable plan, especially if there is a separation of the various services. Generally, this plan has only one entrance for both ambulance and ambulatory patients [27]. This type of plan, or its modification in a circular form, provides the highest degree of freedom for emergency department personnel [27].

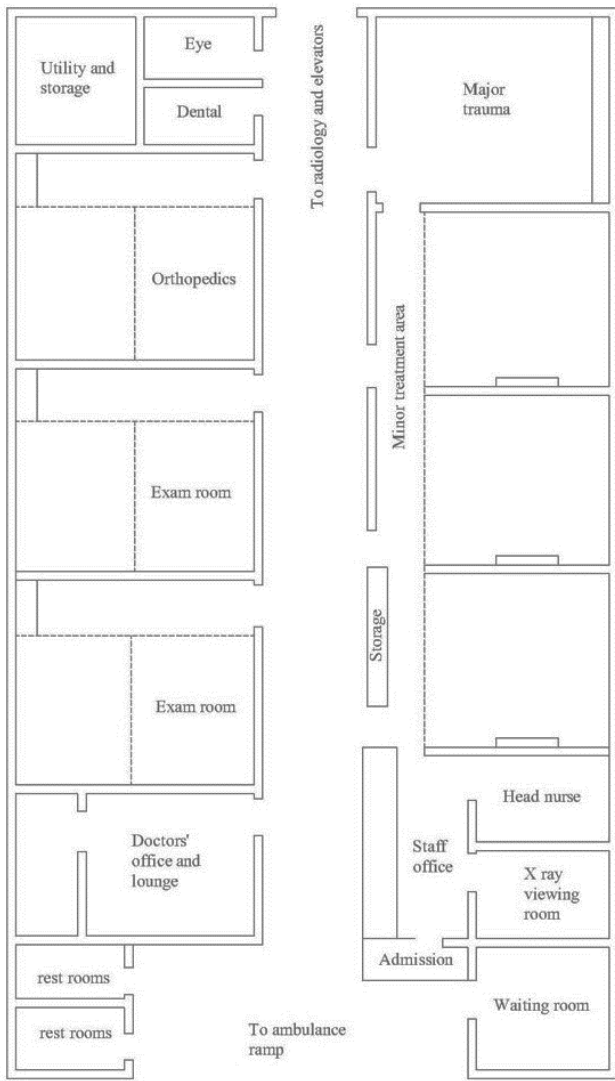


Fig. 4. Corridor Type Plan for Emergency Department redrawn by authors from Jenkins and van deLeuv [27] and Margret Peisert [28]

4. Simulation and Results

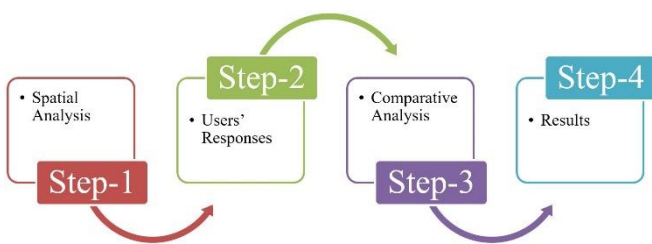


Fig. 5. Procedure of analysis

The syntactic values show a very regular pattern of consistencies across the three plan types of the emergency department. For instance, the mean integration value of the sample is 0.89, and the range is from 0.88-0.89 of integration values. This consistency is also present in the difference factor where the mean value is 0.71, and all the cases are very consistent with its mean value.

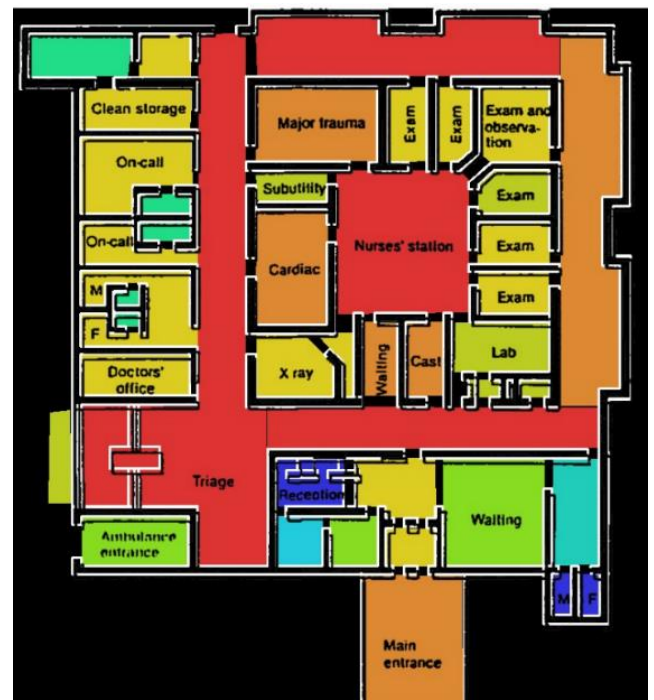


Fig. 6. Convex map Analysis of Core Type Emergency Department

The order of individual clinical spaces was investigated, as shown in Table 2 below. First It was found that the Nurses' station (N.S.) is the most integrating space in all clinical spaces, it takes on the 1st value of integration in case-1 to case-3. Secondly, trauma gets the 2nd, 4th, and 2nd value of integration from case-1 to case-3 respectively. The Examination rooms are located on the 5th, 2nd/3rd, and 5th value of integration case-1-case-3. it is obvious that case-1 to case-3 exhibit the syntactic consistency to the deepest level. This type of underlying consistencies means that they can be grouped into one category on the level of spatial structure.

Table 2

Order of the most integrated spaces based on space syntax analysis

#	From the Most Integrated to Segregated					
	1	2	3	4	5	6
1	NS	Trauma	Cast	Xray	Tri	Exam
2	NS	Exam	Exam	Trauma	Tri	
3	NS	Tri	Trauma	Dr.	Eye/Dental	Exam

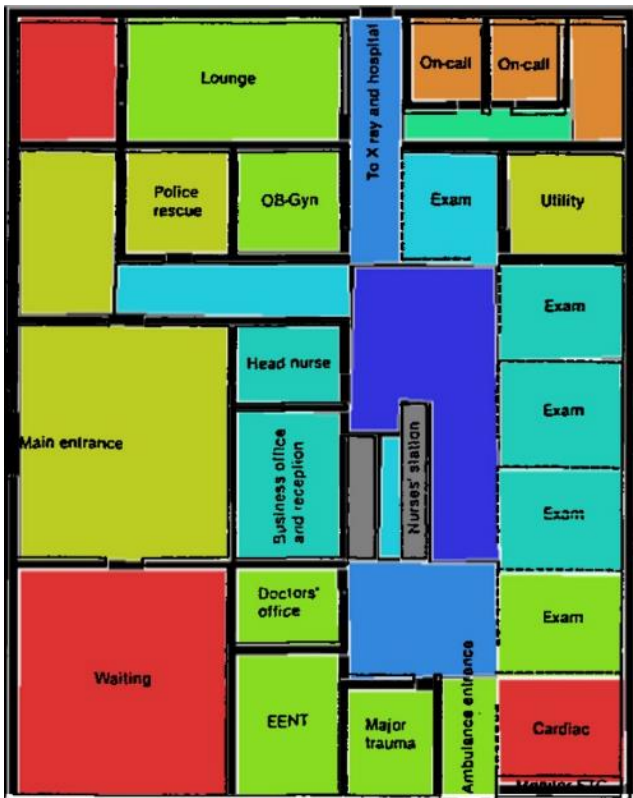


Fig. 7. Convex map analysis of arena type emergency department

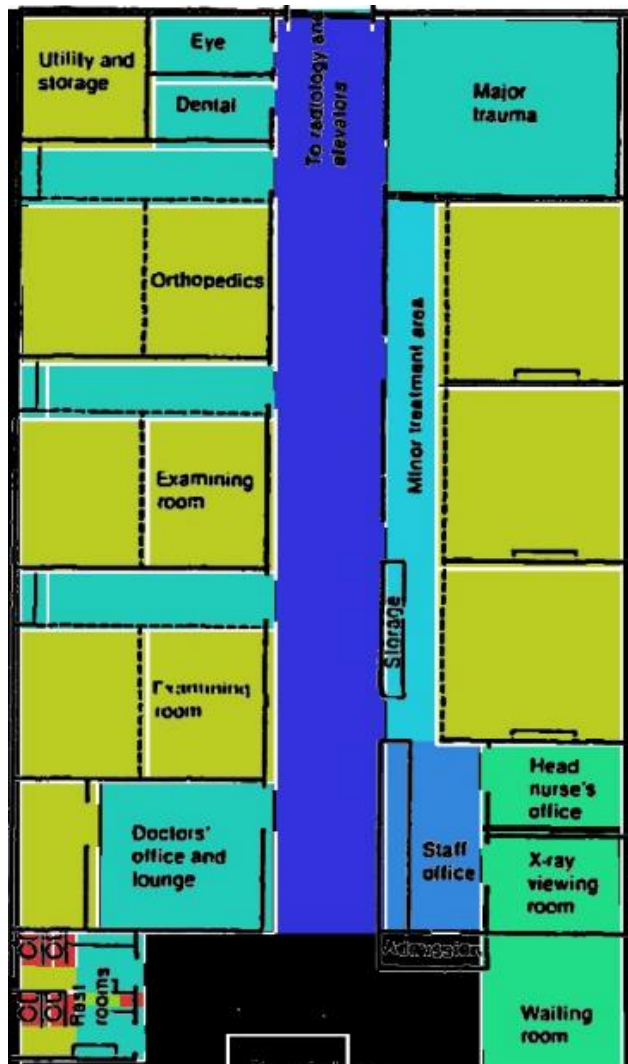


Fig. 8. Convex map analysis of corridor type emergency department

To evaluate the required configuration pattern of the emergency department, responses from the users of emergency departments, i.e., doctors and nursing staff, were collected in the form of a questionnaire with five questions by post with a return envelope and online links shared.

Due to the busy work schedule of emergency doctors and nurses, this method of collecting users' responses was selected to give them the necessary time to respond at their ease. A list of spaces in the emergency department was provided to the doctors and nurses of emergency departments. The response shows, that Triage, examination, Trauma, and nurses' station (NS) were the four primary clinical spaces given priority by both doctors and nurses.

Each emergency department was sent ten questionnaires of which five were for doctors and five for nurses (the content of which were the same for both). A total of 111 responses were collected of which 34 were by post and the remaining online. The response rate was about 72 percent (54 responses out of 75) from doctors and 76 percent (57 responses out of 75) from nurses. To find out the five most important clinical spaces emergency department, A list of spaces in the emergency department was provided to the doctors and nurses. Below is the response of doctors and nurses.

The response shows that Triage, Examination room, trauma, and nurses' station (NS) were the four primary clinical spaces given priority by both doctors and nurses.

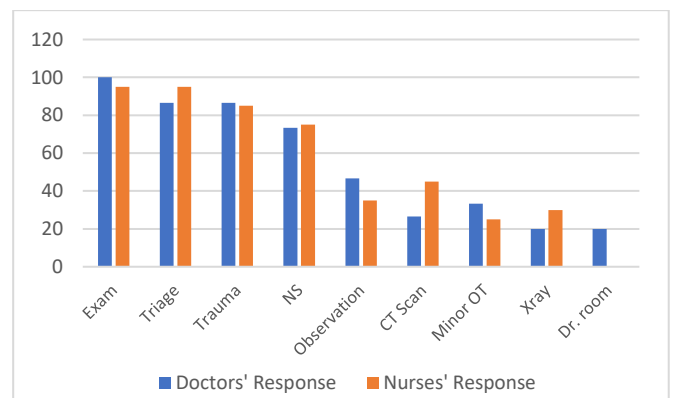


Fig. 9. Order of the most used spaces of the emergency department (Users' Responses)

Fig. 9 shows the average response of the users of emergency departments, where the most used space is the emergency patient treatment area Examination 97.50 percent of the user picked it as one of the five

most important spaces, followed by triage, trauma and Nurses' station with 90.38, 85.83, 74.17 percent average selection rates, respectively.

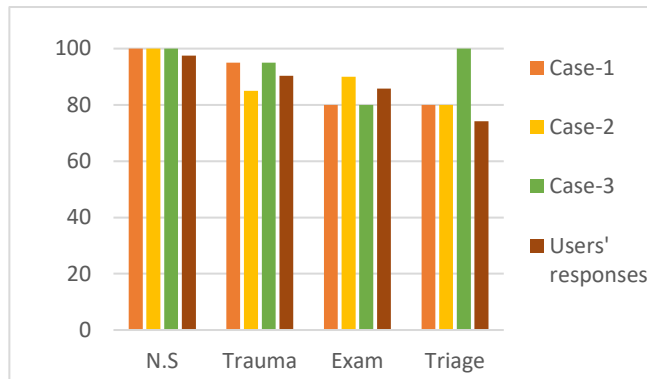


Fig. 9. Comparison of users' responses and simulation results for the most used spaces of emergency department.

Fig. 10 shows the correlation between simulation results and users' responses. From table 2, the four most integrated spaces are Nurses' station, trauma, examination room, and triage occupying the first five values of integration in all three cases. The most integrated spaces generally have easy access and more movement. This cross-validated from users' responses through questionnaire. Fig. 9 above shows the response from doctors and nurses. The same four spaces were selected as the most used spaces of emergency department by both doctors and nurses.

5. Conclusion and Discussion

Emergency departments are planned in different plan types due to multiple factors, ranging from the size of the facility, site, context, and healthcare systems. One of the primary concerns of selecting a specific plan type over the other gives rise to the question of performance differences. In architecture, plans are generally evaluated based on expert opinion, which is subjective in nature. Therefore, this study used space syntax to evaluate and quantify the spatial layouts which are objective in nature. The results of this study demonstrated that the plan type of emergency department follows a consistence Configurational pattern in their syntactic values although the layout patterns are quite different. All three types exhibit a very similar syntactic pattern; that is not only a very similar space link ratios, integration, and difference factor (DF) but also the internal integration order of the clinical spaces are in consistence way. As in architectural planning, the spaces are laid out according to their functional relationships and hierarchy. The integration values of these plan types, exhibit that the clinical spaces follow a consistence logic in their layouts.

Based on the above it can be concluded that:

With different sizes and different shapes, this consistency means an established medical culture that exhibits itself only at a deeper level. The results of this study may provide a baseline for the objective evaluation of the emergency department.

6. Recommendations

Based on the above syntactic simulations and users' responses of emergency department, the following are recommended:

- I. The four primary spaces of emergency department (Nurses' station, trauma, triage, and Examination room) as detected through simulations and users' responses shall be given primary consideration in the planning of any emergency department.
- II. The secondary spaces with limited access were found to be Minor O.T, Observation room, X-ray, CT Scan, and Dr. room, these spaces shall be connected indirectly with public access.
- III. An early simulation of emergency department plans through space syntax is recommended for improved functional efficiency.

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