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The Role of the Spatial Configuration of the System Designed for Intensive Care Units in Creating Healing Environment - Iraqi Hospitals as a Case Study

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ABSTRACT

With the continuous development of health sciences and therapeutic technologies, and the increased demand for health services due to the continuous increase in population, the continuous development in lifestyles, and the continuous emergence of new diseases that threaten humanity, the need has led to the need to find solutions that contribute to keeping pace with medical developments while accommodating the patient requirements to find spaces that achieve a healing environment. Without affecting the time and safety of the patient, the study aimed to reveal the role of the spatial configuration of the intensive care unit design system in creating a healing environment. There is an existing relationship between the design patterns of intensive care units and the therapeutic environment. Three types of intensive care units were chosen (Nightingale ward, double corridor, and single corridor). To represent three hospitals in Iraqi governorates. The study used a visual survey, field visits, and a quantitative method using the Space Syntax program. The results based on the analysis of the different models of the configurations of intensive care units showed some indicators about the elements of the care unit achieved for the healing environment, as the study determined the appropriate intensive care unit design for the physical interaction between patients and health care staff in terms of levels (privacy, security, safety and finding the way), thus confirming a direct relationship between the factors of the healing environment, with the spatial configuration of the units that lead to the comfort of patients and staff alike.

1. INTRODUCTION

1.1 Spatial configuration and the healing environment concept

A healing environment is defined as one that reduces stress and encourages the patient's self-healing skills while contributing to the patient's recovery and well-being [1]. The healing environment can so be defined as a place where the body, mind, and soul are healed. It is where illness, healing, death, life, and the healthcare facility that supports these conditions are defined with respect and dignity [2]. The term "healing environment" is used to describe factors that have a psychological and physical impact on the healthcare community. Healing environments should facilitate planning that protects the dignity of patients and enhances their privacy. This can reduce stress, increase comfort, and support recovery and wellness while reaching out to nature can reduce stress and improve outcomes [3].

Healing environments address a wide range of factors surrounding patients and staff in healthcare facilities. It starts with key factors such as air quality, noise control and thermal comfort, and then is optimized to include safety and security privacy. Increase access to nature, access to social support, and reduce environmental stressors [4].

1.2 Literature review

Previous studies that have addressed the role of the physical design of the ICU and the percentage of achieving the healing environment have shown that the most important design feature affects all aspects of ICU services (patient privacy, comfort and safety, staff working conditions, operational efficiency, rotation and movement, logistical support, and family integration) [5]. An ideal ICU should have three areas: patient area, family area, and caregiver area [6].

Studies have focused on the central point in the ICU is the patient's room. The recommend using a single bed instead of multi-bed rooms to enhance patient safety, privacy, and infection prevention. Each room should be equipped to function as an independent area with the necessary space for caregivers and visitors and should provide a therapeutic environment with access to outdoor views [7, 8]. According to the literature, private rooms reduce patient stress and the need to transfer patient's multiple times; given that the mortality rate from infection in the intensive care unit is much higher than in other clinical settings, the use of private rooms is ideal [9].

In ICU patient areas, social support areas are needed to throw families into patient care by providing appropriate space inside or outside the care unit for family members and visitors to provide a therapeutic environment [10].

The nursing station is the main working area of the unit used by nurses or nursing staff supervising health services. Nursing stations include the reception, the registration, and the official registration [11]. The nursing stations are classified into three types (centralized, decentralized, and hybrid nursing stations), each of which has a significant impact on patients and their needs, feeling safe and secure [12].

The approved international standards showed that the number of intensive care unit beds, which determines its ratio to the number of hospital beds, is 13% of the hospital bed capacity, and the minimum number of intensive care unit beds is eight [13, 14]. In addition to thinking about physical design, some standards achieve the healing environment, including security and safety, access to social support, access to nature, and positive distraction. this study showed that the spatial classification of intensive care units plays an essential role in the healing process, directly or indirectly. Thus, providing a healthy and comfortable environment and user satisfaction [10].

The location and spaces size within the ICU through the relationship between them and their functions. Depending on the physical constraints of the space, the designers have implemented different types of layouts and installations that achieve a healing environment such as, Nightingale ward, double corridor, single-corridor, cluster, radial and racetrack are the most common unit layouts in intensive care units [15].

Despite the above studies, a set of specifications of the healing environment in the spatial design of intensive care units were clarified comprehensively and did not clarify the role of the spatial configuration of the design system of the intensive care unit in supporting the healing environment, especially by analyzing the factors (privacy, security, safety and finding way) in particular and their impact on achieving the operational efficiency of the unit and its impact on the behavior of users in particular. In particular, there is a relationship between ICU design patterns and the therapeutic environment for three ICU module types (Nightingale ward, double corridor, and single corridor).

In support of the main research objective, a rigorous evaluation should be carried out using Space Syntax methods to verify the impact of ICU models of selected samples in terms of studying the levels of (privacy, security, safety and finding way) and their impact on the healing environment of the ICU design system in Iraqi hospitals.

1.3 Mixing of the healing environment in the design of intensive care units

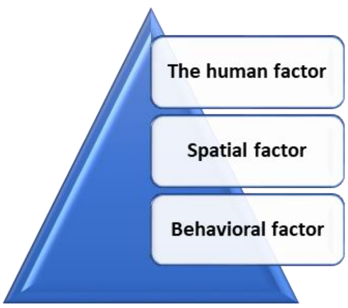


Figure 1. The design elements of the healing environment

The main strategies used in the design of intensive care units were based on patient care and ease of work for medical staff; health care designs were predominantly utilitarian and family visits were limited. This created an inhumane atmosphere for patients. Patients were placed in open wards with common rooms. This design allowed patient care with as few nursing staff as possible. and lack of privacy. With the increase in infection [16], the current trend is toward designing a health system that enjoys the elements of a healing environment, as shown in Figure 1.

The design system supporting the healing environment depends on several elements represented by the following:

***A- The human factor**:* There is a relationship between space and human behavior, many spatial studies indicate the possibility of using the architectural space as a visual guide to determine their direction and the level of visual and auditory vision through:

- *Finding the way:* This is defined as the set of visible points from a certain position, in the case of a polygon that is formed by determining the field of view of the observer in a certain position in space, and if we assume that there is an angle of view (360), the higher the value of the viewing polygon, the more appropriate the field of view and observation, therefore, through the signs in each node, which is an intersection point, facilitates observation and independent control through the use of colors and indicative panels for each unit [17]. These guidelines facilitate people's opportunities from loss and anxiety because these reduce operational efficiency and increase dependence on other people to reach the specified place [18].
- *Privacy insurance*: It is an innate human feeling that a person needs and is at several levels in the design of the intensive care unit; that may be achieved by providing a single-family system for multiple beds; the open system is an obstacle to the patient's healing environment. The greater the visual vision, the greater the transmittance and the opposite of the privacy factor [19]. Reduce patient staff admissions through the availability of visual follow-up of staff to the patient [8].

B- Spatial factor: The study indicates that the elements of the spatial environment when evaluating intensive care units, represented by color, light, aesthetic elements, and the distribution of furniture in spaces, the use of cold finishing materials tends to create an inharmonious atmosphere, increase stress levels in patients [14], combine natural and artificial elements, and create contemporary, creative and symbolic works of art to help patients to enhance the healing environment, and personalize the architectural space [20].

C- Behavioral factor: There is a reciprocal correlation between human behavior and the general organization of space. Space cannot be designed without understanding and recognizing the nature of the user's behavior and their functional requirements. The mutual support between the family and the patient and providing space for family members in intensive care units and family members must be considered as an important member of the health care team where they can provide patients with the emotional support they need to recover [21]. Emotional and positive support from family and friends influences the recovery of intensive care patients [19].

Intensive Care Units (ICUs) lack aesthetic appearance and have a sterile atmosphere and little visual attention has not been incorporated into their design yet, but with many advances in biomedical equipment and monitoring in intensive care units, integrating modern technology and elements of the healing environment to provide the best design [20].

From the above, the most important features of the healing environment and the impact of integrating them into the design system of intensive care units have been clarified, and some of the types of intensive care unit configurations, in particular the types of selected study samples, have been clarified.

1.4 ICU configuration patterns

Many studies have found that the characteristics of the spaces that make up the unit affect the improvement of patient care and the policy of operation of the unit and these spaces include: Patients and medical staff. Its operational patterns are represented by many types, but the study is concerned with three of the most prevalent models, as follows:

- *Nightingale ward:* The unit design consists of large rectangular rooms, with 20–30 beds, one central nursing station, offering large windows and outside views, good monitoring and control, mutual ventilation, natural lighting, low privacy factor, high risk of infection, and long walking distances [21].
- *Double -corridor:* The design consists of two corridors and patient rooms on both sides of the corridor, whether single or multiple rooms, and the design contributes to the good possibility of observation and short distances of staff movement, fewer beds (up to 16-20 beds), private and multiple rooms and large windows with natural light, long corridors, and low risk of infection and safety [22].
- *Single-corridor:* The design contains a single corridor overlooking all patient rooms and central nursing stations and decentralizes the number of beds from previous studies [12-30] with an increase in the length of the corridor and supply rooms, and because of the long walking distances between nursing stations for patient rooms, it increases the need for decentralized nursing stations to monitor and increase control and control and large windows, natural light [23].

1.5 Research problem

The spatial configuration of intensive care units can play an important role in the healing process, thus creating a healthy, comfortable, and safe environment for patients and medical staff. Based on the results of the data and the study of plans obtained from intensive care units in the region through field research, it was found that the hospital environment was not fully provided in a large group of local hospitals, and research was requested to address this research question and avoid it in future designs. To reach a set of research questions:

-What is the role of the spatial configuration of the ICU design in the realization of the elements of the healing environment?
-What is the design that achieves the healing environment in the intensive care unit system?

2. CASE STUDY

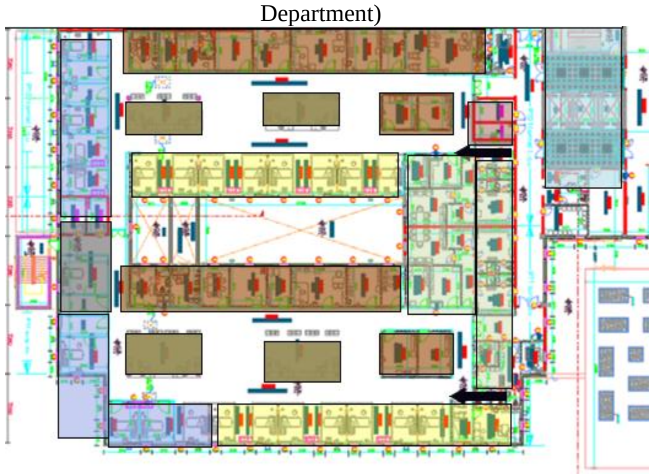
In order to collect information on the spatial composition of intensive care units in the hospital design system, a field survey was conducted for a group of Iraqi local hospitals to collect information about their planning and patterns, and three samples were selected from government hospitals designed according to modern standards for health buildings with different styles and basic health service providers. The survey revealed a large number of hospitals with frequent layouts (Nightingale ward, double corridor, and single corridor). Therefore, three local hospitals representing different types of intensive care units were elected as follows in Table 1:

Table 1. The most important main information about case studies

First Sample	Intensive Care Unit (Najaf Teaching Hospital (Nightingale Ward))

Description: The project is one of the newly implemented buildings (2021-2009), designed according to modern international standards and implemented in more than one governorate (Najaf, Mosul and Muthanna) and the project is located in the Al-Orouba neighborhood in the north of Najaf Governorate. The building consists of four floors and includes [16] operating halls equipped with the latest equipment, classrooms, a central laboratory and an integrated radiology department, in addition to delivery halls, a preterm care unit and two ICUs on the first floor (each unit has 12beds of open system and rooms isolate). The nursing station is located in the central part of each care unit.

A. Intensive Care Unit at Najaf Teaching Hospital Source (Najaf Health Department / Engineering Projects and Services Department)



Building plan

Staff Break		Patients Area	
Services		Station Nursing	
Management Room Meetings		Single beds for patients	

Space coding

Second Sample	Intensive Care Unit (Al-Sadiq Hospital) Double -Corridor

The project is repeated in more than one governorate and is one of six hospitals in (Babylon, Baghdad, Karbala, Basra, Maysan, Nasiriyah). The project is located in the province of Babylon with a bed capacity of 400 beds, surrounding the building A.
General Company: The hospital consists of six floors divided into three units vertically linked functionally (diagnosis, surgery, and inpatient) and the ICU is located on the second floor and consists of several types (surgical, medical, and children, with type open units, single and isolated rooms) of the race track type with a capacity of 24 beds per unit.

B. Intensive Care Unit Diagram at Al-Sadiq Hospital Source (Babylon Health Department / Projects and Engineering Services Section)

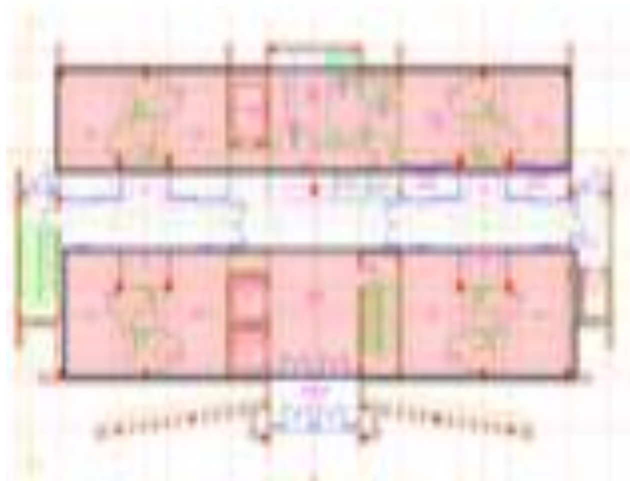
Building plan

Staff Break		Patients Area	
Services		Station Nursing	
Management Room Meetings		Single beds for patients	

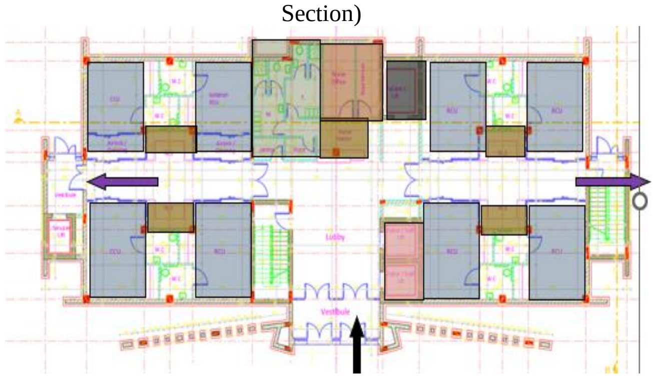
Space coding

Third Sample	Intensive Care Unit at Marjan Medical City in Babylon Single Corridor

The center is located in Marjan Medical City in the Babylon Governorate. The building is at the back of the hospital overlooking the Euphrates River and consists of three floors and connects with the hospital by a bridge corridor. And it is designed according to international standards on several types (intensive care units—surgical, respiratory, medical, and coronary) and consists of 24 beds, on each floor 8 single beds with a single corridor style.



C. Intensive Care Unit plans at Marjan Medical City Source (Babylon Health Department / Projects and Engineering Services Section)



Building plan

Staff Break		Patients Area	
Services		Station Nursing	
Management Room Meetings		Single beds for patients	

Space coding

3. RESEARCH METHODOLOGY

The research methods used in this study were visual surveys, field visits to selected hospitals and quantitative analysis using the Space Syntax method to study the impact of the role of spatial configuration patterns of units on the verification of the hospital environment by studying the spatial suitability characteristics of unit types (privacy, security and safety, and finding the way) as variables of the spatial characteristics of the intensive care unit design system.

First: Previous studies that included a keynote on the role of spatial training for the design of intensive care units on the achievement of the healing environment were reviewed.

Second: Identification of study cases: three samples were selected for several reasons that achieve results and are applicable in healthcare buildings; after that, collect information through field visits to local hospitals and visual surveys of unit plans. Then analyzed by Visibility graph Analysis (VGA), Convex Map Analysis (CMA), and Axial map Analysis (AMA). (Isovist Area Map—IMA), then spatial structure analysis tools were used to measure the study variables (Depth map X10) were used to measure the study variables, and the main indicators were identified in the spatial structure method for all samples of the selected care unit by the VGA communicability values, visual integration, convex integration, convex depth, communicability to the Axial map and Isovist Area Map, and the results were presented in tables and graphs for verification and interpretation.

Third: The results were discussed to explain the impact of the spatial role of intensive care units on the healing environment of the selected samples, and the study methodology concludes the studying the effect of different types of intensive care units to the degree of achieving the elements of the healing environment.

The limitations of the research methodology were mainly the exclusion of some spatial analysis tools (depth Visibility graph Analysis, depth Axial map analysis) due to the nature of the research and its objectives, if the methodology was applied within the design system for intensive care units only.

Figure 2 illustrates the structure of the research methodology used in the study, which began with a review of previous studies dealing with keywords related to the spatial configuration of intensive care units that achieve a healing environment.

3.1 Classification and coding

In order to study, analyze and compare the selected sample, the ICU units under study were classified and codified into a series of different models: in terms of unit type (C1), type of nursing station (C2), and patient family area availability for social support (C3) [2, 10, 11] as shown in Table 2.

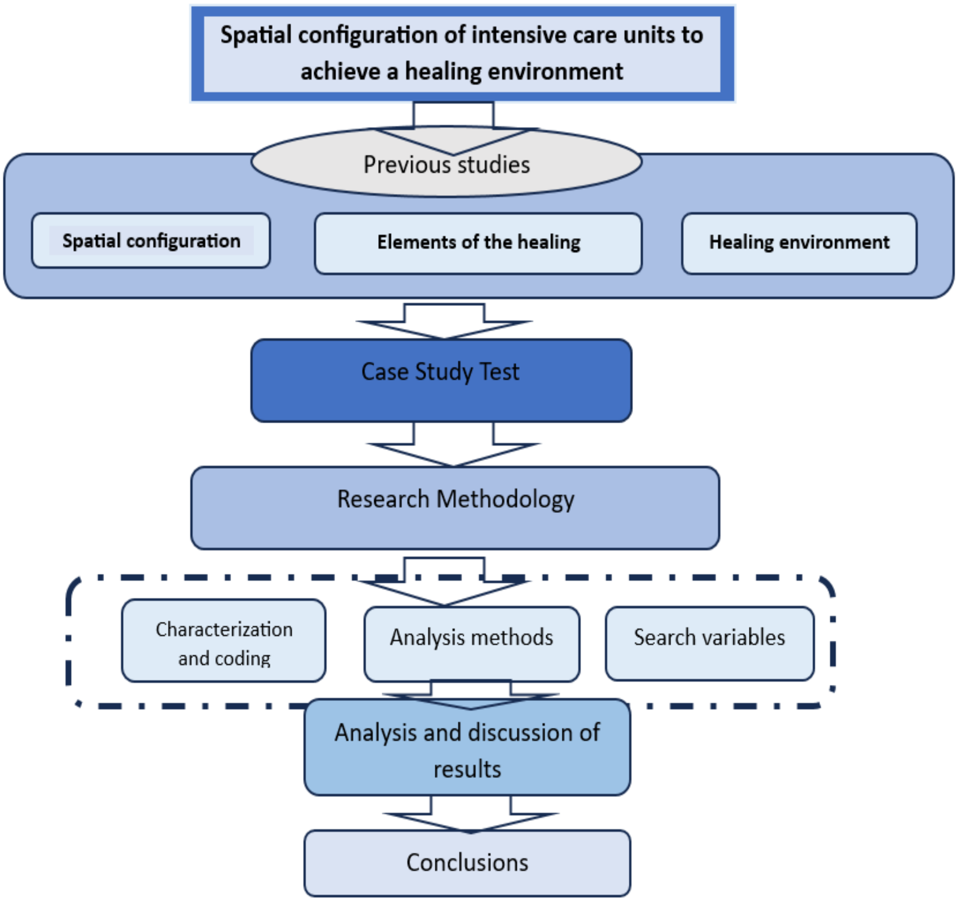


Figure 2. The laborious research methodology of the study

Table 2. The classification and coding of elements

	Elements	Classification and Coding		
1	Unit Type (C1)	Single Rooms C.1.1	Multiple Rooms C.1.2	Multiple and Single Rooms C.1.3
2	Tabs of Nurse Station (C2)	Centralized C.2.1	Decentralized C.2.2	Hybrid C.2.3
3	Family Area (C3)	Inside the Unit C.3.1	Near Unit C.3.2	Outside the Unit C.3.3

4. RESEARCH ANALYSIS AND INDICATORS TOOLS

This study aims to answer research questions related to the role of spatial configuration of intensive care unit design in the success of healing environment elements. The study needs a quantitative analysis tool to reach the best results [3, 24].

The Space Syntax method was used in this study because the previous studies mentioned above dealt with the role of the spatial sequence method and its ability to analyze indicators of mobility, privacy, patient safety and finding a path for the spatial configuration of care units [6]. These studies compared physical and visual accessibility and their association with the perception and behavior of staff in two intensive care units (ICU) for Nightingale ward planners and closed system of (double corridor, and single corridor). The physical and visual potential was measured using spatial analysis techniques of Space Syntax. As in Figure 3 shows the relationship between research variables.

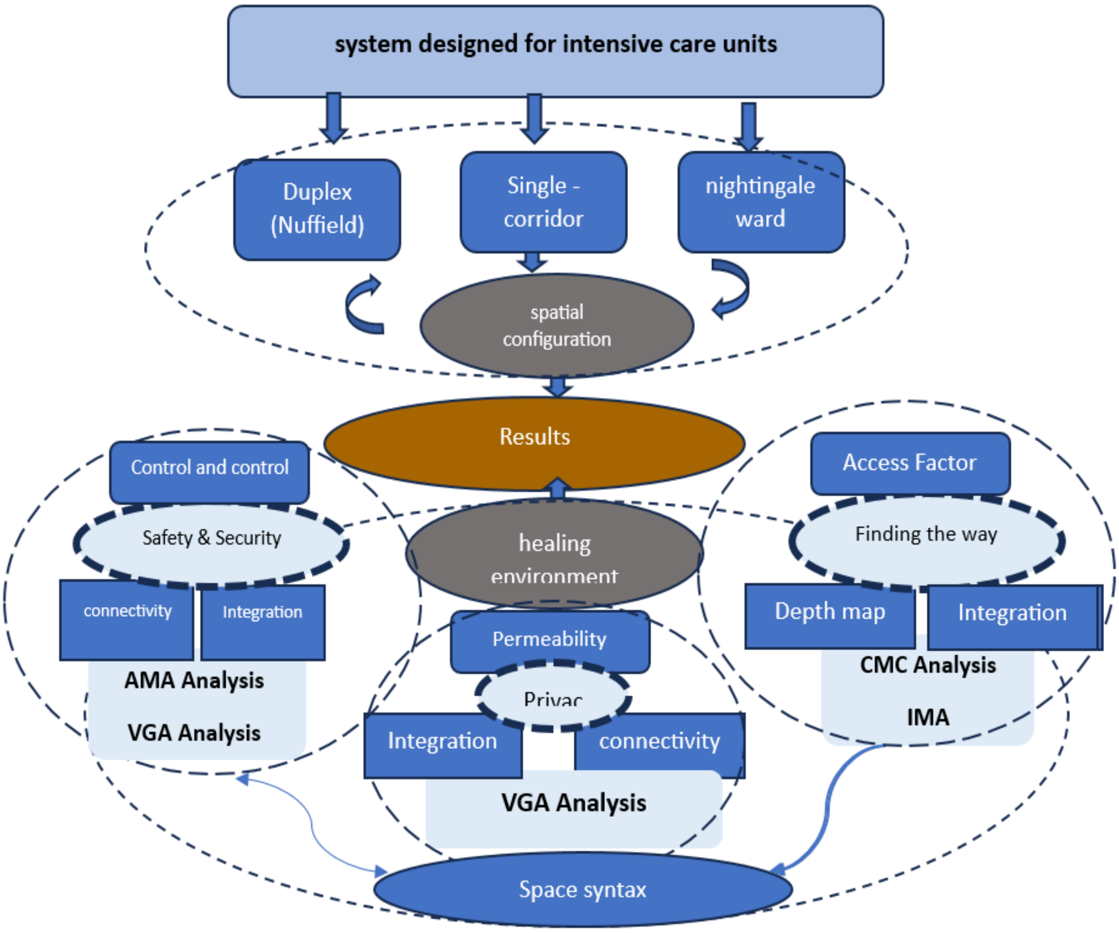


Figure 3. The relationship between research variables
Source: authors

4.1 Space Syntax

A methodology introduced and developed by Bill Hillier and his partners in the seventies, the syntax of space is calculated through the implementation of the Death map x10 program, a complex program that focuses on a series of spatial analyses that provide a clear understanding of the social processes within the included schemes [6].

It is a methodology that deals with the diagram as a series of connected areas (directly adjacent areas or a series of intermediate areas [25]. AutoCAD maps are edited on the same scale and then exported to the chart in DXF format for use in the (Depth map x 10) software and then use spatial grammatical maps to analyze the spatial design system for intensive care units in hospitals elected as case studies for research. The indicators used were connection, integration, and depth, where each indicator provides to achieve the theoretical framework and prove hypotheses, and through the adoption of spatial syntax analysis [26], the following maps can be used as indicators:

- *VGA*

The study relied on the connectivity VGA visibility graph (visual communication) to provide a clear pattern of vision for the selected plans for the study and examine the most visually related areas and whether these areas are within the scope of the nursing area, and the high-contact diagrams provide better control of the staff relative to the patient room and control over the main movement entrance [27]. The outputs of this analysis are represented in the form of colored and gradient areas from red to dark blue. The red, orange, yellow, and light green indicators indicate high-contact areas, while areas indicate the lowest value in blue and dark blue, and high connectivity value indicates more visual communication between points within the space, i.e., more paths and visibility at the level of healthy building spaces [6]. As for the indicators that will be adopted in this study of connectivity and integration of the VGA visibility graph.

- *CMA*

The result of this analysis shows the development of the axes most related between the planning of the intensive care unit design system for the chosen hospital and the depth of the convex to express the depth of the plan such as the most complex and least deep plan has better control by the staff and ease of maintenance and control.

The outputs of this analysis are in the form of colored and gradient areas from red to dark blue, where the highest value areas of the indicators used in this analysis appear in red, orange, yellow, and light green, while the lower value areas of the indicator appear in blue and dark blue. The indicators used in the analysis tool are integration, connectivity, and depth" (Convex map) [28].

- *IMA*

It is one of the analysis tools in the design of intensive care unit design systems as one of the spatial factors to analyze the characteristics of spatial suitability through the analysis of the spatial configuration of the care unit, which is defined as the sum of all points that can be seen from a given point (nursing station), a space that is supposed to get a 360-degree field of view. If a polygon is formed by determining the field of view of the observer and is also known as the term (field of view), the higher the value of the polygon field of view, the more appropriate the field of view, which indicates the possibility of observation, observation and thus facilitates monitoring and control of nursing stations and patient rooms [29].

- *AMA*

Adopting this tool in the analysis of the integration and connectivity index, the connection was measured to show the most correlated axis layout between the plans of the elected care units. Measuring the integration axes of the units to provide a clear view of the paths and more integrated schemes reduces walking distances for staff and patients and makes it easier to maintain staff response time to patients and accessibility. Therefore, the outputs of this analysis appear in the form of color maps, and the higher-value parts of that indicator indicate red, orange, and yellow, while the colors blue and dark blue indicate the lowest value [30], and the integration and communication indicators that are axial to the analysis of the Axial map will be adopted in the research.

Spatial suitability measurement: Since this study requires a measure by which the level of privacy, road finding, safety, and security can be measured based on the features of the connectivity, visual integration, integration, and depth of the convex map, analysis of the Isovist Area Map and analysis of the axial integration shown in Figure 3, three levels of "good," medium, and weak as shown in Table 3.

Table 3. Measures for the level of privacy, security, safety and road finding

Volume	Privacy	Safety & Security	Finding the Way
Good	Area has a lower average value of connectivity and integration of visual vision and transmittance [1, 2]	Area has an average value of the highest integration and depth [5, 6]	The area has an average value more coaxial integration and visual connectivity [5, 6]
Medium	Area has an average connectivity and integrity value of optical vision and transmittance [3, 4]	Area has an average value of integration and depth [3, 4]	Area has an average value of coaxial integration and optical connectivity [3, 4]
Weak	Area has the highest average value of connectivity and integration of optical vision and transmittance [5, 6]	Area has an average value of less integration and depth [1, 2]	Space has a lower average value coaxial integration and optical connectivity [1, 2]

4.2 Results and analysis

Space Syntax analysis was performed for selected samples using (VGA), (AMA), (CMA), and (IMA) and the analysis begins to accurately interpret the results by measuring the connectivity, visual integration, integration, and depth of the convex map, analysis of the Isovist Area Map, and analysis of the axial integration of each sample separately, and the analysis was initiated in order to interpret the results correctly. The analysis was performed as shown in Table 4, with the upper limit values specified in red, the middle values in orange, and the lower limit values in green.

Table 4. The results of the spatial suitability analysis for selected samples

Selected Samples					A	B	C
	Unit Type (C1)				C.1.2	C.1.3	C.1.1
	Tabs of Nurse Station (C2)				C.2.1	C.2.3	C.2.3
	Family Area (C3)				C.3.2	C.3.3	C.3.2
Study indicators	Vocabulary	Variable name	Analysis method	Space Syntax epithets	Arithmetic mean	Arithmetic mean	Arithmetic mean
	Privacy	Permeability	VGA	Connectivity	787	547	353
			VGA	Integration	9.49	6.2	6.35
	Safety & Security	Clarity of vision	CMA	Integration	1.566	1.060	2.25
			IMA	Vision	433	83.31	535
			CMA	STEP DEPTH	1.73	2.93	2.72
	Finding the way	Accessibility	AMA	Integration	4.10	3.63	3.59
			VGA	Connectivity	787	547	353

4.3 Privacy factor

Privacy is one of the characteristics of spatial suitability of spaces, so the greater the visual vision, the greater the permeability, which deals with privacy inversely, and the data that analyzed the privacy factor included the type of unit with single or multiple or multiple patient rooms (C1) and the location of nursing plans in terms of quantitative analysis [19]. The Visibility graph Analysis (VGA) of the intensive care units showed the selected samples through connectivity analysis if the sample (A) achieved the highest visual vision connectivity value of (787) and is inverse to privacy if the unit has a spatial organization of the open type (Nightingale ward), it achieves the lowest degree of privacy, followed by sample (B) with a medium degree of visual vision connectivity with a value of (574) and sample (C) with the lowest values of selected samples with a value of (353) if it achieves high levels of privacy and a level of visibility connectivity lower than the double aisle type Duplex (Nuffield) with single rooms and decentralized nursing stations as in Table 5.

While the (VGA) analysis of the selected samples showed through the analysis of the integration of visual vision , the sample (A) achieved the highest value of visual vision integration with a value of (9.49) and the result of visual vision connectivity is close if it is inversely proportional to privacy if the unit has a spatial organization of the open type (Nightingale ward) achieves the lowest degree of privacy, followed by sample (C) with a medium degree of visual vision integration with a value of (6.35) and sample (B) the lowest integration values of (6.2).

If this difference can be justified by the values of visual communication and integration between samples, because the sample (A) is less deep and has many points of direct visual contact within the space because it is of the open pattern, so the establishment of a high visual extension and space for patient communication with the staff and thus increases the level of permeability and reduces the level of privacy verification while the sample (C) achieved a lower level of permeability and a higher privacy factor because it is of the style of single rooms and hybrid nursing stations, while the sample (B) achieved an average degree of Achieve the level of privacy of being from a multi-family system, dual-aisle and central nursing stations.

If it achieves high levels of privacy as shown in Table 5 and Figure 4.

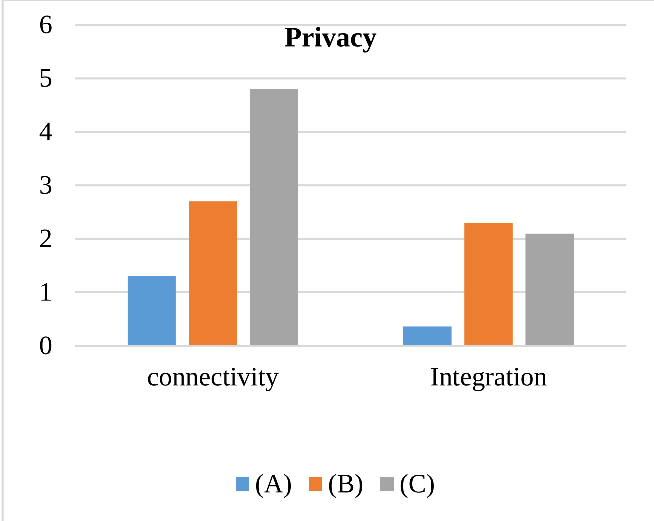
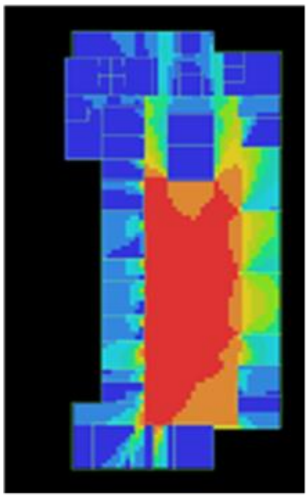
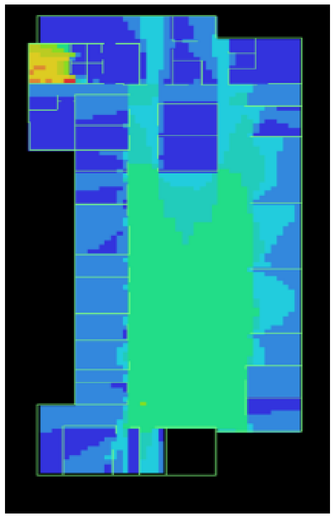
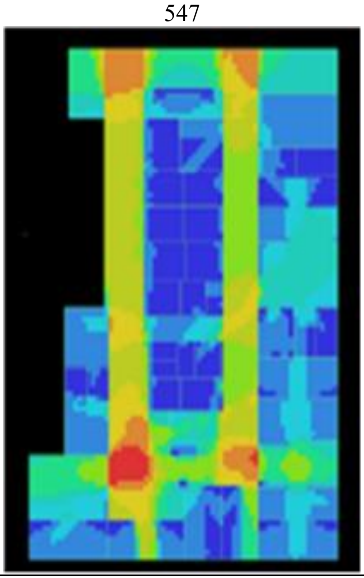
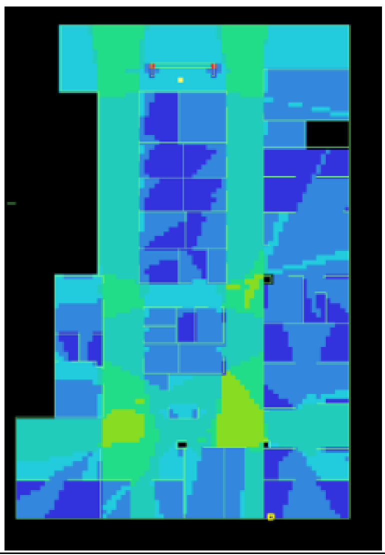
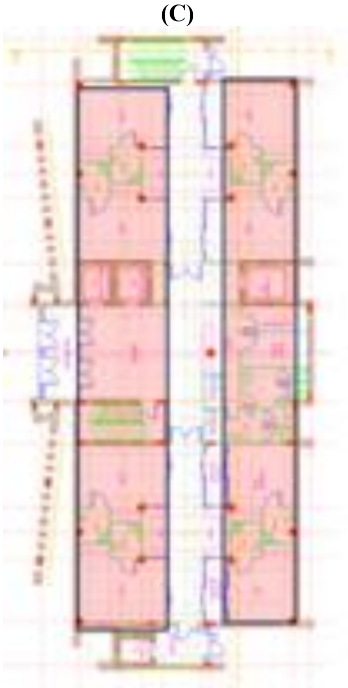
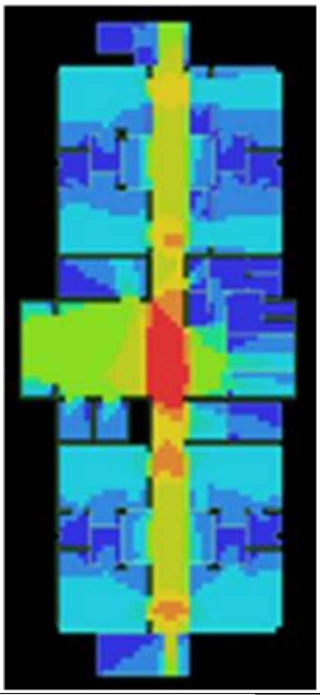
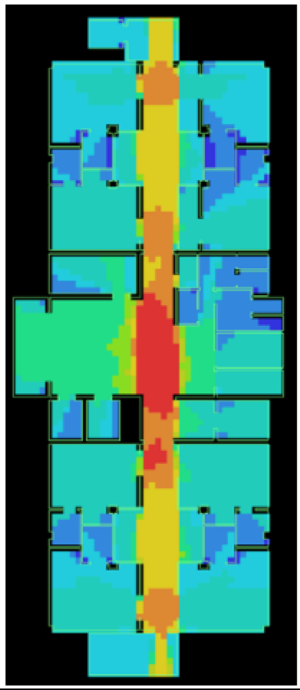


Figure 4. The levels of privacy of selected samples

Table 5. Represent the privacy factor for selected samples

Samples	Type	Visibility Graph Analysis (VGA) Connectivity	Integration
(A) 	Nightingale ward	787 	9.49 
(B) 	(Double corridor)	547 	6.1 

(C) 	Single -corridor	353 	6.35 

Note: 

4.4 Finding the way

It is one of the indicators of comprehensiveness, which represents one of the characteristics of the spatial suitability of the investigator's space for the healing environment and represents the number of pivotal steps that must be taken from any point to reach the other points and the closer the points to each other and the fewer distances between them, refers to the increase in the values of integration between spaces and accessibility and finding the way easier any space connected and integrated and easy access to social support [30] and the location of the family area within the unit (C3) and showed the graph (AMA) Axial map Analysis through the indicators of Axial integration if the sample (A) achieved the highest level for being spatially organized of the open type if it achieved the fastest access factor with a value of (4.10), followed by the ratio of the average value of integration for the sample (B) by (3.63) and the care unit that achieved the lowest integration value for the sample (C) with a value of (3.59) with similar values as in Table 6. In the analysis (VGA) of the connectivity index, sample (A) achieved the highest connectivity value of visual vision with a value of (787), followed by sample (B) with an average degree of connectivity Visual vision with a value of (574) and sample (C) is less valuable in the selected samples with a value of (353). Therefore, the higher values of visual vision connectivity indicate the possibility of visual and physical connectivity and the possibility of finding the cadre way to better configure.

This case can be justified by the values of the Axial map analysis integration and the connectivity of the *Visibility Graph Analysis* between the samples, because the sample (A) is shallower and contains many visually integrated paths that directly intersect between the points within the space because they are of the open type and central nursing stations mediate the unit, so the access factor is faster than the two previously mentioned samples, thus increasing the connection factor and the speed of response to the patient, reducing the walking distances of the staff, and increasing the efficiency of health care and the environment supportive of recovery.

The spatial unit as shown in Table 7 and Figure 5.

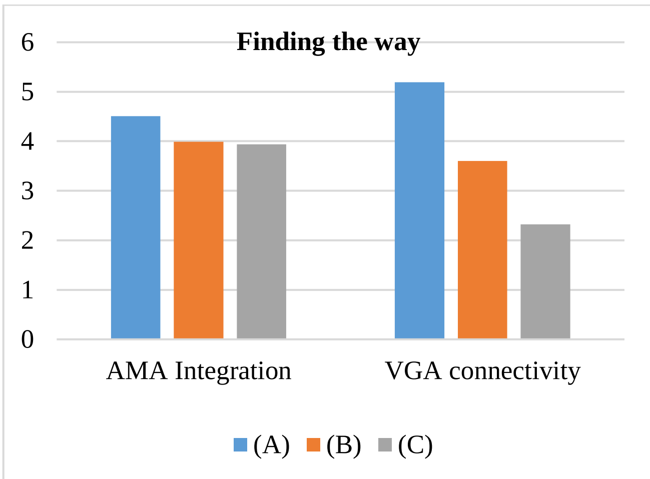
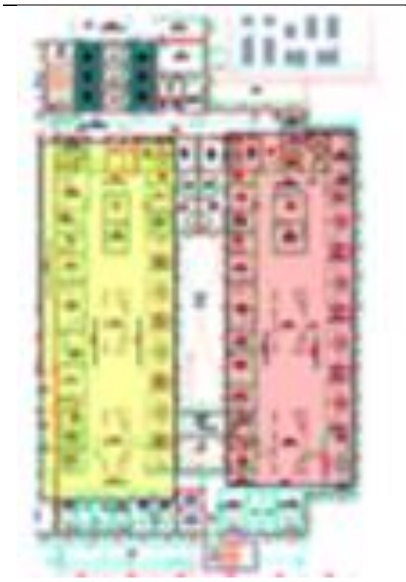
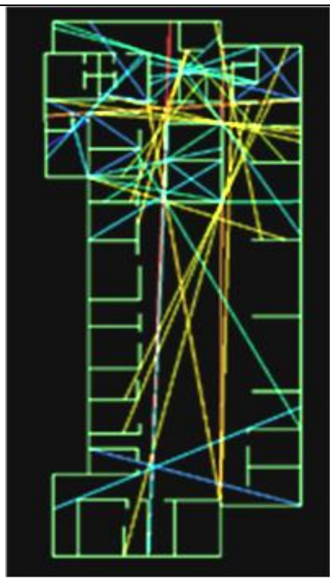
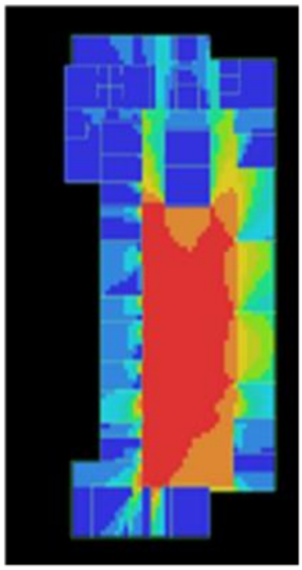
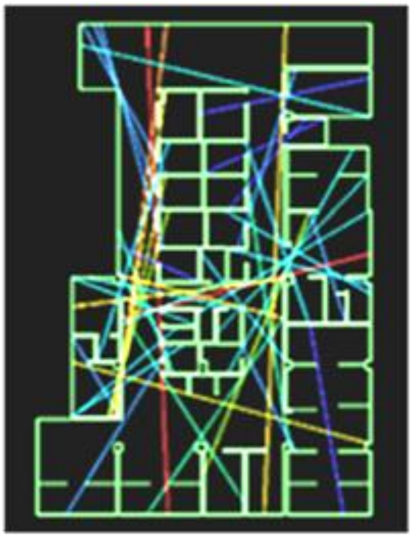
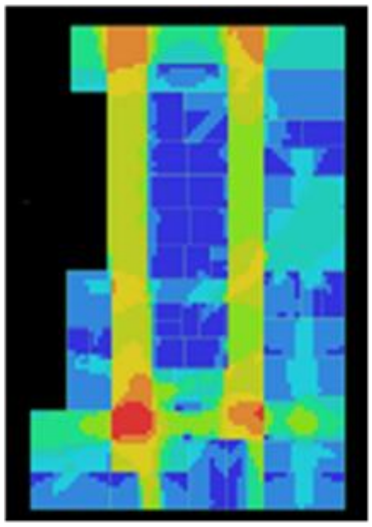
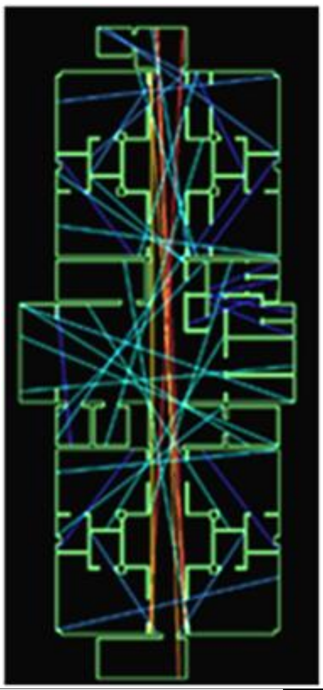
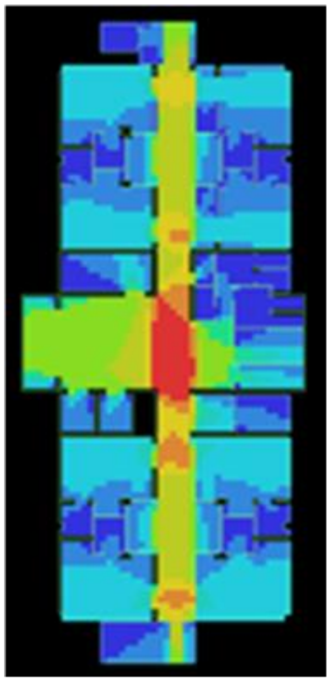


Figure 5. The diagram to find the way for the selected samples

Table 6. Finding the way factor for selected samples

Samples	Type	Axial Map Analysis (AMA) Integration	Visibility Graph Analysis (VGA) Connectivity
(A)		4.10	787

 (B)	Nightingale ward	 3.63	 547
 (C)	Double - corridor	 3.59	 353
	Single - corridor		

Note: 

4.5 Security and safety factor

Previous studies indicated the importance of the security and safety factor in the spatial design of intensive care units that achieve a healing environment. The models were analyzed by studying the type of central nursing stations, decentralization, and hybrid (C2) The analysis of (Convex Map Analysis (CMA) and Convex Integration. Convex integration is one of the indicators of spatial suitability of spaces to show the most correlated and integrated axis planning between the plans of the design system for intensive care units to know the depth of the plan, such as the most complex and least deep plan, which has better control by the staff and achieves the security and safety factor. Sample (C) achieved the highest value of convex integration with a value of (2.25), while sample (A) achieved the average value of (1.566), and sample (B) achieved the lowest values of axial integration and the least correlated by (1.060). While the convex depth achieved the highest depth value of the sample (B) with an average value of (2.93), the average value of the convex depth of the sample (C) (2.72) and the lowest convex depth of the sample (A) with an average value of (1.73) if the sample (B) achieved the deepest scheme and the higher safety factor.

Isovist Area Map (IMA) analysis is one of the spatial factors in the design of intensive care unit design systems, and is defined as the sum of all points that can be seen from a given point (nursing station) with a 360-degree field of view, assuming that Isovist Area of the field of view has a higher value, if a polygon is formed by determining the observer's field of view in a specific position in space, and monitoring thus facilitating monitoring and control of nursing stations Patient rooms if sample (C) is achieved. The highest value of the Isovist Area is (535), while sample (A) achieved an average value of (433), while sample (B) achieved the lowest value of the Isovist Area by (83.31).

This difference can be justified by the values of integration and depth of the convex map and the analysis of the polygon map between the samples, because the sample (C) is less complex and has many points of direct visual contact within the space because it is of the single corridor style with single rooms and hybrid nursing stations (central in the middle of the unit with small stations near the patient rooms) and the small size of the unit compared to the rest of the samples. Therefore, the establishment of a high visual extension and space for patient communication with the staff and thus increases the level of security and safety, as the separation does not provide safety for patients and staff and the lowest value of the sample (B) because it is more complex and contains the largest number of turns and distant points with the increase in the size of the unit, as in Table 7 and Figure 6.

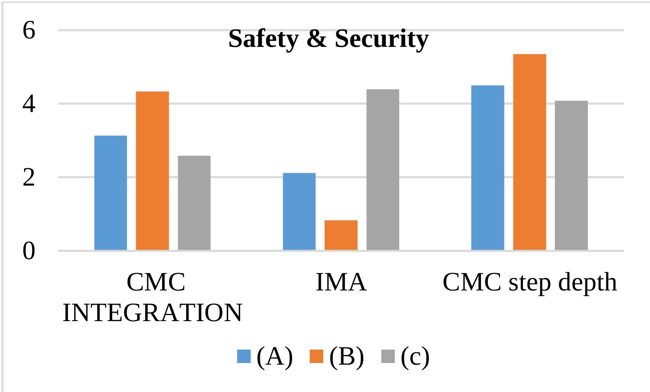
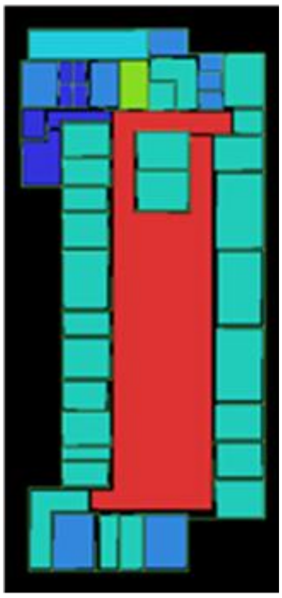
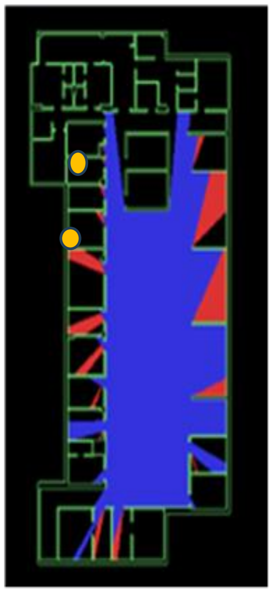
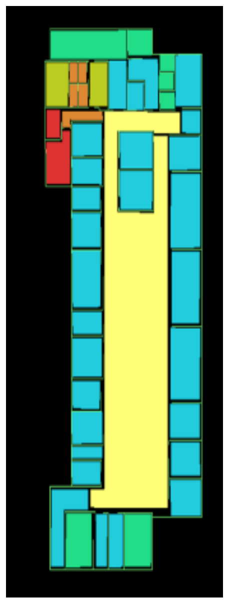
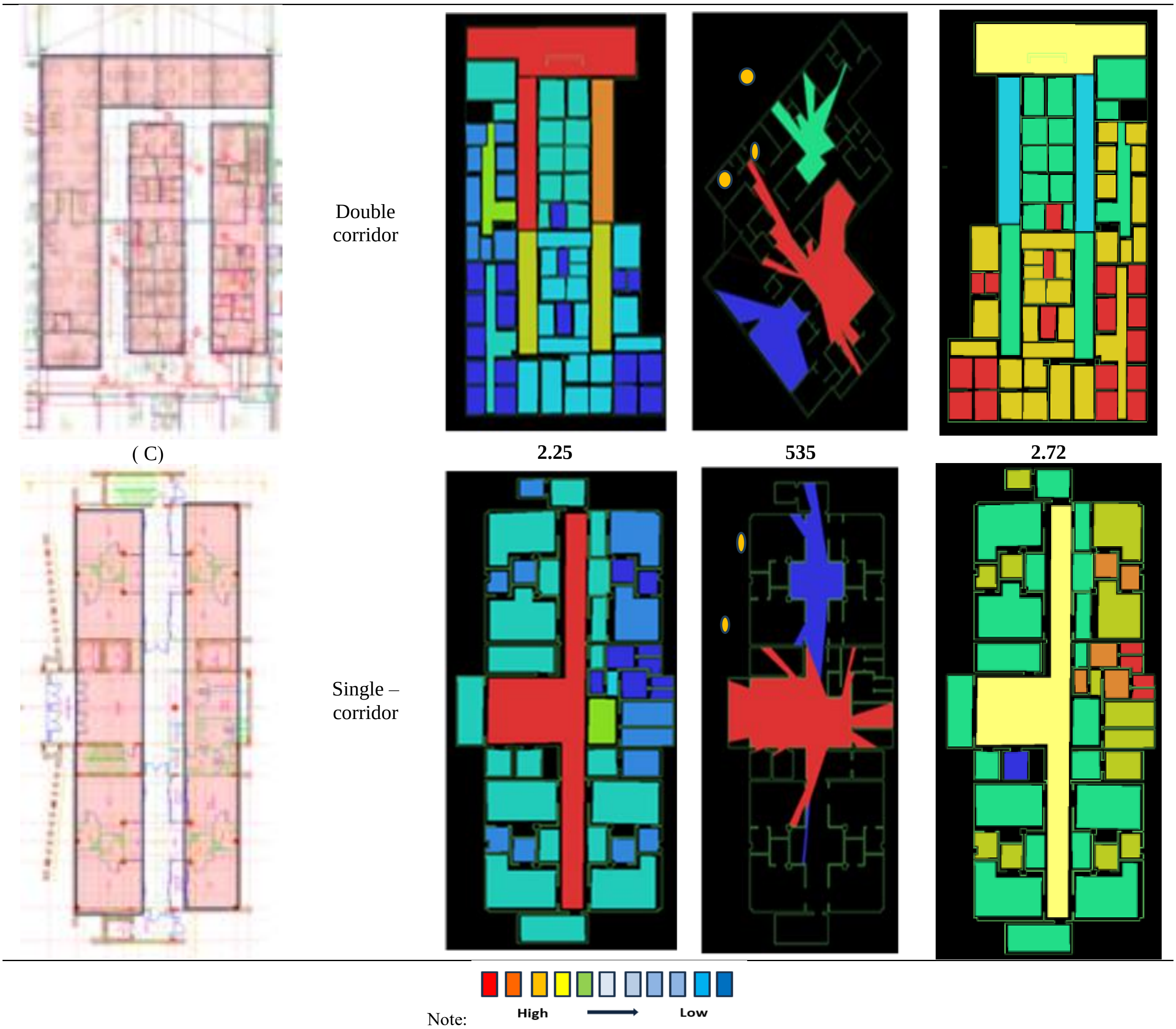
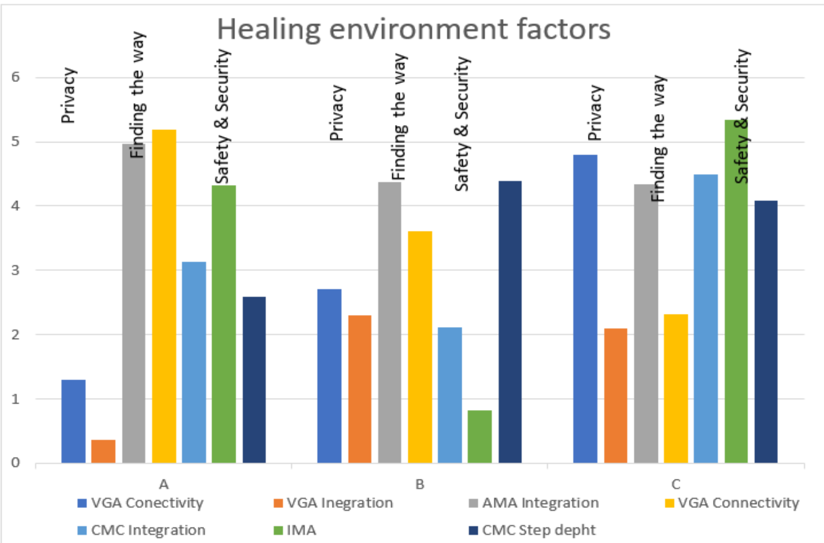


Figure 6. The safety & security verification ratios of the selected samples

Table 7. The safety & security factor for selected samples

Samples	Type	Convex Map Analysis (CMA) Integration	Isovist Area Map (IMA)	Convex Map Analysis (CMA) STEP DEPTH
(A)		**1.566**	**433**	**1.73**
	Nightingale ward			
(B)		**1.060**	**83.31**	**2.93**





Sample (A) (nightingale ward)	Sample (B) (double corridor)	Sample (C) Signal -corridor

Figure 7. The measurements of healing environment factors

As shown in Figure 7, the measurements of privacy, security, safety, and finding the way can be determined according to the above values of connectivity, visual integrity of the graph, convex integral, step depth of the convex map, *Isoviet Area Map* of view, and integration of the axial map. The sample (C) above showed a level of privacy compared to the average level of privacy for the sample (B) and the lowest level for the sample (A). As for the road-finding factor, sample (A) achieved the highest level of integration and finding the road, and the average finding the way for the sample was (C), and the weak level of finding the way for the sample (B). As for the level of security and safety, sample (C) achieved an excellent level compared to the average level of safety and security for sample (A) and the weak level was for sample (B); in comparison, this sample had the lowest level of safety and security.

The results show that the different values of connective integration, optical integration, convex integration, depth, the polygon of viewing angle, and axial integration of different spaces lead to various measures of privacy, security, and safety levels, and finding the way between the analyzed samples. Therefore, the results of these studies can be used to draw important conclusions.

5. RESULT AND DISCUSSION

The characteristics of the spaces that make up the unit affect the improvement of patient care and the operational policy of the unit: There are many operational models, but this study will focus specifically on the three most common models: (Nightingale ward, Duplex Corridor, single corridor).

The results showed an analysis of these different models the ability of some spatial configurations of the unit to achieve the healing environment , the sample (c) single-pass pattern achieved the highest results achieved for the healing environment in terms of privacy factor due to the lowest value of the permeability factor, because the privacy factor is inversely proportional to the permeability and pattern of single rooms (C.2.3), and the highest value of the security and safety factor and the system of hybrid nursing stations (C.2.3) leads to increased monitoring and control by the nursing unit on patient rooms and an average value to find the way compared to the rest of the samples with social support through the integration of the family area within the unit (C.3.1) while the samples (A) recorded the average values compared to the models, and the sample (B) achieved the lowest values that achieve the healing environment in terms of privacy, security and safety factor because the spatial organization of the double corridor type with patient rooms of the single and multiple type (C.1.3) and central nursing stations only with a lower field of view, and control and maintenance of security and safety at a lower level than the rest of the samples as shown in Figure 8.

The results showed that the intensive care unit sample (C) with a single corridor had the highest levels of achieving the healing environment due to the small number of patient rooms, which is 8 beds, which leads to a short corridor and increases the factor of finding the way, with a single room style, achieving high rates of privacy and user satisfaction and decentralized nursing stations, which increases monitoring, security, and safety and reduces the number of times to enter patient rooms due to the increase in visual supervision.

While the sample (A) achieved the average values of the level of verification of the healing environment with an open pattern of 12 beds , this is due to the achievement of low privacy rates because it has a multifamily system and is served by a central nursing station in the middle of the unit The control rate is high with an increase in the possibility of infection and the values of finding the road are high because the schemes are highly integrated and easy to access.

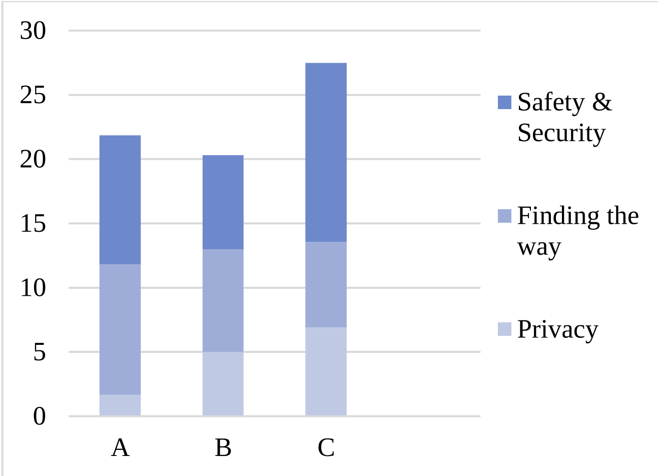


Figure 8. The analysis of healing environment factors based on Space Syntax evaluation

While the sample (B) with a double aisle pattern achieved the lowest values to achieve the healing environment with an increase in the sample size because the unit has [24] beds, so the design of the unit contributes in terms of a central location for nursing stations to monitor patient rooms well, but remote rooms have weaker monitoring rates with the use of a multi-bed system and fewer rates of visual and auditory privacy and the fact that the plan has depth, which leads to finding the road more difficult

The results were represented by the following paragraphs:

- Preference for single-bed patient rooms based on research evidence, which takes a parallel path to previous literature and studies, which provide special spaces for the patient and medical supplies, which helps the comfort of the patient, facilitates the work of the staff, reduces the number of times entering the patient's rooms and increases the privacy factor.
- The spatial configuration pattern of the Nightingale ward type allows higher visual vision and integration of spaces and central nursing stations the site controls the patient rooms overlooking them with increased supervision and a higher access factor and reduce walking distances for nursing staff and medium ratios of the safety and safety factor as it increases the rates of transmission of infection As for the privacy factor, it achieves the lowest level of selected models because it has a multi-family open system and a high level of permeability and lack of privacy.
- The spatial configuration pattern of the double corridor type helps that the services and nursing stations are medium from the unit, which makes the walking distances medium and the access factor medium access while lower ratios for the level of safety and safety because the unit has turns, intersections and distant points with the increase in the size of the unit in general, and the composition also contributes to monitoring patients close to both sides well, preferably the design of hybrid nursing

stations to increase the factor of monitoring, security and safety and achieve medium levels of the privacy factor for a multi-family design.

- The spatial configuration pattern of the single corridor type is suitable for single patient rooms to increase the privacy factor and reduce the levels of space permeability, and is commensurate with the hybrid design of nursing stations because the central nursing station site is ineffective to monitor all patient rooms sufficiently to achieve the factor of security and safety with easy access staff to care for patients effectively and achieve efficiency health care and a supportive environment for healing.

Based on the analysis of the different models of intensive care unit configurations, the results showed some indicators about the elements of the care unit achieved for the healing environment, the study determined the appropriate intensive care unit design for physical interaction between patients and health care staff in terms of the type of single rooms to increase privacy and in terms of the types of hybrid nursing stations for monitoring and controlling patients , and achieve connectivity and integration of spaces and reduce the size of the unit to achieve the access factor. Increase the depth of the unit chart and increase the sample size, thus confirming a direct relationship between the factors of the healing environment with the spatial configuration of units that lead to the comfort of patients and staff alike.

Finally, the results of this study raise a number of questions for future research:

How do spatial configuration patterns in the design of intensive care units affect patient and staff behavior and affect the operational efficiency of the care unit? Is there a relationship between ICU patterns and unit size with increasing the number of beds to achieve ICU that supports the hospitalization environment? How can some of the architectural functional requirements in the ICU design system be linked to the software requirements and modern technology of the building to provide a hospital environment and ensure the well-being of patients and staff?

6. CONCLUSIONS

Intensive Care Units (ICUs) are a design system of different size and complexity, which can be small units or specialized buildings within a hospital. The spatial configuration of intensive care units varies depending on their spatial and functional characteristics. The design of hospitals has undergone many changes since the modern movement towards needs-based architecture to achieve a healing environment, the idea of a hospital environment is based on supporting patient well-being and comfort. Therefore, the role of spatial formation in providing a healing environment was investigated.

The results show an analysis of these different conditions in relation to the achievement of different degrees of healing environment factors for different spatial formations. In this study, three different models of spatial configuration were selected as case studies to interpret, analyze and evaluate the results, with a focus on intensive care units in Iraqi hospitals. The results were supported in a quantitative way by analyzing the results of Space Syntax. Therefore, it can be concluded that there is a direct relationship between the spatial configuration model of intensive care units and the therapeutic environment.

Engineers and designers can benefit from the results of this study in the design of future hospitals and especially in the development of intensive care unit design systems. This can have a positive impact on the hospital environment and thus improve the satisfaction of patients and medical staff.

The results of this study put forward recommendations for future research, including:

- When designing and developing hospital intensive care units, it is preferable to incorporate hospital environment standards.
- Designers must be fully aware of all the criteria that define the design process, especially those related to the psychological and social aspects of patients and staff.
- This study recommends, large intensive care units divided into smaller groups of units, single room systems can be used to enhance privacy, and hybrid nursing station systems are used, i.e. moving from central nursing stations to decentralized nursing units distributed in the form of cavities near patient rooms to increase monitoring, increase the security and safety factor, and integrate spaces to increase the access factor and response speed to provide patient comfort, reduce walking distances for staff, and achieve a healing environment in the unit.

The findings can contribute to addressing deficiencies in the design of intensive care units in existing hospital buildings on the one hand, and providing data for the design of intensive care units in future hospital buildings on the other.

REFERENCES

[1] Rashid, M., Khan, N., Jones, B. (2016). Physical and visual accessibilities in intensive care units: A comparative study of open-plan and racetrack units. Critical Care Nursing Quarterly, 39 (4): 313-334.

[2] Real, K., Fay, L., Schadler, A.D. (2018). Using systems theory to examine patient and nurse structures, processes, and outcomes in centralized and decentralized units. HERD: Health Environments Research & Design Journal, 11(3): 22-37. https://doi.org/10.1177/1937586718763794

[3] Cadenhead, C.D. (2014). Architectural design of critical care units: A comparison of best practice units and design. Pediatric Critical Care Medicine, pp. 17-32. https://doi.org/10.1007/978-1-4471-6362-6_3

[4] McCullough, C. (2010). Evidence-Based Design for Healthcare Facilities. Renee Wilmeth.

[5] Lu, Y., Zimring, C. (2012). Can intensive care staff see their patients? An improved visibility analysis methodology. Environment and Behavior, 44(6): 861-876. https://doi.org/10.1177/0013916511405314

[6] Rafeeq, D.A., Mustafa, F.A. (2020). Evidence-based design: The role of inpatient typology in creating healing environment, hospitals in Erbil city as a case study. Ain Shams Engineering Journal, 12(1): 1073-1087. https://doi.org/10.1016/j.asej.2020.06.014

[7] Cadenhead, C.D., Anderson, D.C. (2009). Critical care units: Trends in winning designs. World Health Design, pp. 72-77. https://www.dochitect.com/wp-content/uploads/2009/02/2009_SCCM-ICU-Article-WHD.pdf.

[8] Lester, B.M., Hawes, K., Abar, B., Sullivan, M., Miller, R., Bigsby, R., Lagasse, L.L. (2014). Single-family room

care and neurobehavioral and medical outcomes in preterm infants. Pediatrics, 134(4): 754-760. https://doi.org/10.1542/peds.2013-4252
[9] Halaby, T., Naiemi, N.A., Beishuizen, B., Verkooijen, R., Ferreira, J.A., Klont, R., Vandenbroucke-Graul, C. (2017). Impact of single room design on the spread of multi-drug-resistant bacteria in an intensive care unit. Antimicrobial Resistance & Infection Control, 6: 117. https://doi.org/10.1186/s13756-017-0275-z
[10] Rubert, R.L., Long, D., Hutchinson, M.L. (2016). Creating a healing environment in the ICU. In Critical Care Nursing (Vol. 3).
[11] Fay, L., Real, K., Schadler, A.D. (2017). Shifting landscapes: The impact of centralized and decentralized nursing station models on the efficiency of care. HERD: Health Environments Research & Design Journal, 10(5): 80-94. https://doi.org/10.1177/1937586717698812
[12] Cai, H., Zimring, C. (2012). Out of sight, out of reach: Correlating spatial metrics of nurse station typology with nurses' communication and co-awareness in an intensive care unit. In Proceedings: Eighth International Space Syntax Symposium, pp. 1-16.
[13] Office of Construction & Facilities Management. (2011). Medical/surgical inpatient units & intensive care nursing units. Design Guide. https://www.cfm.va.gov/til/dguide/dginpatientnu.pdf.
[14] WBDG Participating Agencies. (2013). DoD space planning criteria chapter 120: Occupancy rates. https://www.wbdg.org/dha/mhs-dod-space-planning-criteria/120.
[15] U.S. Department of Veterans Affairs. (2022). VA-PG-18-9: Space planning criteria 102-intensive care patient care unit (IC PCU). https://www.cfm.va.gov/til/space/spChapter102.pdf.
[16] Bates, V. (2018). 'Humanizing' healthcare environments: Architecture, art and design in modern hospitals. Design for Health, 2(1): 5-19. https://doi.org/10.1080/24735132.2018.1436304
[17] Yun, Y.W., Kim, Y.O. (2007). The effect of depth and distance in spatial cognition. In Proceedings of the 6th International Space Syntax Symposium, Istanbul, pp. 1-13.
[18] Nijhuis, J. (2017). Healing environment and patients' well-being. Master's thesis. Wageningen University.
[19] Pachilova, R., Sailer, K. (2015). Size and complexity of hospitals matter for quality of care: A spatial classification of NHS buildings. In Proceedings of the 10th International Space Syntax Symposium, London.
[20] Thompson, D.R., Hamilton, D.K., Cadenhead, C.D., Swoboda, S.M. (2012). Guidelines for intensive care unit design. Critical Care Medicine, 40(5): 1586-600. https://doi.org/10.1097/ccm.0b013e3182413bb2
[21] The Stationery Office. (2008). Health Building Notes 4: Inpatient Accommodation Options for Choice. Crown.
[22] Zadeh, R.S., Shepley, M.M., Waggener, L.T. (2012). Rethinking efficiency in acute care nursing units: Analyzing nursing unit layouts for improved spatial flow. HERD: Health Environments Research & Design Journal, 6(1): 39-65.
[23] Hamilton, D., Watkins, H. (2008). Evidence-Based Design for Multiple Building Types. Wiley.
[24] Montello, D.R. (2007). The contribution of space syntax to a comprehensive theory of environmental psychology. In Proceedings of the 6th International Space Syntax Symposium, Istanbul.
[25] Zook, J., Nanda, U., Renner, K. (2019). ICU as informational interface: A model for data-driven ICU design. In 12th International Space Syntax Symposium, Beijing, China.
[26] Jiang, B., Claramunt, C. (2002). Integration of space syntax into GIS: New perspectives for urban morphology. Transactions in GIS, 6(3): 295-309. https://doi.org/10.1111/1467-9671.00112
[27] Haq, S., Luo, Y. (2012). Space syntax in healthcare facilities research: A review. Journal of Healthcare Design, 5(4): 98-117. https://doi.org/10.1177/193758671200500409
[28] Omer, I., Goldblatt, R. (2017). Using space syntax and Q-analysis for investigating movement patterns in buildings: The case of shopping malls. Environment and Planning B: Urban Analytics and City Science, 44(3): 504-530. https://doi.org/10.1177/0265813516647061
[29] Ossmann, M., Bafna, S., Zimring, C. (2020). Isovist connectivity: Measuring the potential for concurrent targeted surveillance and general awareness. In 12th International Space Syntax Symposium, Beijing, China.
[30] Alansari, A.E. (2022). Wayfinding implementations: An evidence-based design approach to redesign college building. International Design Journal, 2(1): 6. http://doi.org/10.21608/idj.2022.209701