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The Utilization of Algorithms in the Evaluation of Space Layout Planning in Inpatient Departments

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Abstract:

The evaluation of a health-care building's architectural product is dependent upon its ability to meet the expectations of its many user groups, which encompass patients, patient families, and health-care staff members. This study focuses on the architectural qualities of inpatient facilities, specifically examining how the concept of quality care may be applied to enhance the quality of health-care buildings. The research aims to evaluate the quality concept and components of health-care buildings from the perspective of patient-centered design. employs the isovist theory to examine individuals' perceptions of their environment and investigates the manner in which humans see their surroundings. Indeed, a post-occupancy evaluation process is conducted on three different case studies of inpatient departments, each featuring a different configuration of nursing station layouts. The objective is to investigate the impact of spatial design on the perception of inpatients. the visibility as experienced by users in the day-to-day operation of the hospital.

Keywords:

General Hospitals, Evaluation Process, Algorithms, Space Quality, Spatial Experience.

1. Introduction:

The problem of Space Layout Planning (SLP) as it applies to Architectural Design is of vital significance within the field of architecture. The experienced space planner demonstrates a keen awareness of spatial experience, consistently evaluating the impact of many design elements such as entrance effect, room shape, spatial organization, symbolic qualities, and the interior space and time experience of users when making planning decisions. However, the process of designing a hospital has consistently provided challenges for architects. Architects are faced with a multitude of design requirements when undertaking the design process of a complicated artifact. This encompasses not just addressing the complicated functional and medical demands within healthcare facilities, but also attending to other complex and intangible factors, such as the psychological needs of users.(Alalouch et al., 2016)

The concept of healing architecture relies on the belief that the physical characteristics of a built environment, including its spatial features, can influence the well-being of persons who inhabit the space and the activities that take place inside it. In recent years, there has been a growing interest among healthcare providers in the field of healing architecture. This interest emerges from the acknowledgment that the design and spatial characteristics of hospital environments have a significant influence on the healing process and can contribute to improved outcomes. Consequently, healthcare providers have recognized the potential of

incorporating healing architecture principles to enhance healthcare efficiency and reduce costs. (Ulrich et al., 2008) (Kathrine Frandsen et al., 2012)

The purpose of this study is to provide a methodology to perform post occupancy evaluations on three different case studies of inpatient departments. Each of these departments has a unique arrangement of nursing units. The methodology is based on the isovist theory, which provides a means of analyzing the visual experience within the surrounding environs. The results demonstrate the level of visibility perceived by users throughout the routine functioning of the hospital ward. The primary objective is to optimize the arrangement of nursing stations in order to optimize the therapeutic setting for patients. The anticipated outcome of this improvement in the patient experience is a positive impact on service delivery quality and a resulting increase in hospital turnover rates.

2. Space Layout Planning in Design Process

The development of an architectural floor plan involves the allocation of relationships to a function, followed by the determination of the corresponding geometry and size for this function. During the first stage of the planning process, the establishment of relationships and interactions between different organizational entities assumes a pivotal position. (Lobos & Donath, 2010). Hence, the development of space planning skills primarily relies on a sequence of planning activities that commence with smaller spaces and gradually progress to larger spaces with greater complexity program requirements. Furthermore, encompasses fundamental knowledge regarding space planning, the utilization of planning rules of thumb, guidelines for employing appropriate design approaches, and suggested literature and reference sources for further exploration.(Karlen, 2009)

3-Inpatient Department Layout Planning in General Hospital

By engaging on the design process of a hospital facility, it is essential to take into consideration a multitude of design criteria. These criteria encompass factors such as the size of the hospital, its ownership structure, the range of medical specializations it offers, and the levels of medical care provided to patients. While patients represent the primary user group of hospitals, the development of hospital architecture and planning has mainly been influenced by architects, nursing personnel, and physicians. In order to establish a more precise research framework, a review of the Egyptian design guidelines has been undertaken to determine a comprehensive definition of a general hospital. This investigation primarily centers on the building features and scale of the hospital.

2.1. General Hospital Definition

According to the Egyptian design guidelines the general hospital has defined as the following: General Hospital should be in a separate building, the number of beds should not be less than 15 bed (*Egyptian Design Standards for Hospitals and Health Facilities - Part 1*, 2022).

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2.2. Inpatient Department Layout Planning

The provision of patient care and healthcare services for inpatients in the hospital's inpatient department relies heavily on the nursing units. These units are mainly charged with creating an optimal environment for patient care and ensuring the availability of necessary resources and facilities for them. (*Egyptian Design Standards for Hospitals and Health Facilities - Part 1*, 2022)

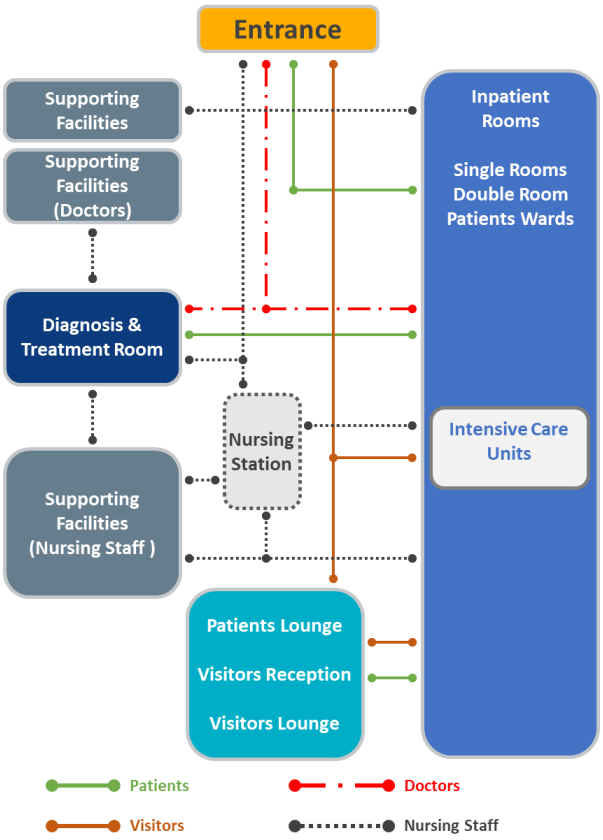

Figure 1: Nursing Unit Zoning
Source: By Researcher, from (*Egyptian Design Standards for Hospitals and Health Facilities - Part 1*, 2022)

2.3. Nursing Units Architectural Layout Typologies

The nursing station functions as the main focal point for nursing care activities within a hospital or long-term care facility. The designated workspace is typically allocated as the principal area for a specific unit. The nursing station commonly includes the unit reception area, as well as designated spaces for maintaining data and conducting charting tasks. The identification of essential components in the design of nursing stations encompasses walking distances, accessibility, visibility, and ease of supervision. (Zborowsky et al., n.d.)

Nursing Units Typologies passes mainly through three phases as the following:

The origins of nurse work areas can be attributed to the late 19th and early 20th centuries, particularly within the Nightingale wards, which were built in a conventional manner. During

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this particular era, nursing units with open wards, where a centrally positioned nursing station was the dominant typology, came into existence. Within each open ward, a strategically placed nursing station was situated at a central location, facilitating the nurses' ability to maintain visual supervision over all of their patients. Nevertheless, the main working area for nurses was located adjacent to the bed of every individual patient., as shown in figure 2. (Hamm, 2011)

Figure 2: Nightingale wards
Source: *(*Johns Hopkins Magazine*, n.d.)*

In the mid-twentieth century, a reconfiguration of nursing units occurred, characterized by the placement of semi-private patient rooms on either side of a central corridor. The unit's work areas were characterized by a prominent, fortress-like workstation located at the heart of the unit, accompanied by a variety of supplementary locations encircling the central nursing workstation. The introduction of enclosed semi-private rooms produced a reduction in patients' visual exposure and prompted a reassignment of nurses away from direct provision of patient care, as shown in figure 3. (Hamm, 2011)

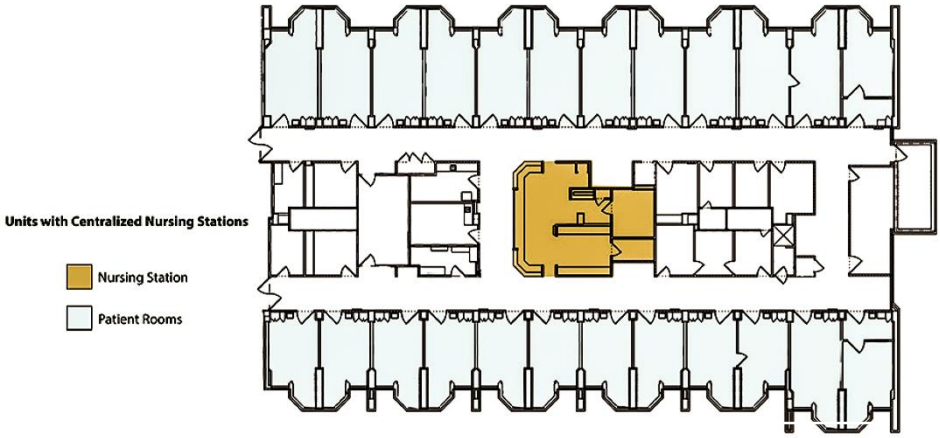

Figure 3: centralized nursing station
Source: (Bayramzadeh et al., 2014)

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During the late twentieth and early twenty-first centuries, there has been a discernible shift towards decentralized nursing work environments. The architectural layout of the units is such that the private patient rooms are strategically positioned along the outer edges of the structure, while the work areas are spaced throughout the central core. Despite the advancements in the current nursing practice model, which involves nurses being in closer proximity to their patients compared to the centralized stations commonly seen in the mid-twentieth century, nurses continue to face the challenge of exerting considerable effort to maintain a consistent standard of care across the entire nursing unit, as shown in figure 4. (Hamm, 2011)

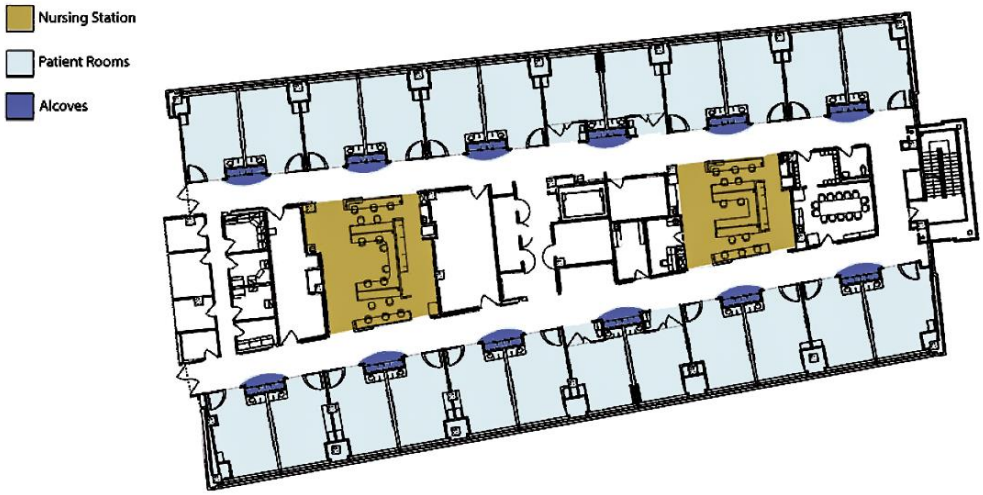

Figure 3: Decentralized nursing station
Source: (Bayramzadeh et al., 2014)

3. The Role of Physical Environment in Healing Environment

The allocation and subdivision of interior space by the space planner play an essential role in determining the fundamental spatial and aesthetic characteristics of the interior environment, whether this decision-making process is done with conscious intent or without explicit awareness (Lobos & Donath, 2010). The indoor environment possesses the potential to have an influence on health outcomes by influencing the behaviors, actions, and relationships of patients, their families, and healthcare professionals. Unhealthy structures have the potential to induce different illnesses among their occupants (Sadek et al., 2013). Along with these studies, the application of Healing Architecture concepts has been applied to hospital design to achieve a good environment for patients and their relatives.

The concept of healing architecture depends on the belief that the spatial characteristics of the built environment can influence the well-being of persons who inhabit the space, as well as the activities and behaviors that take place inside it. Spatial qualities can encompass various factors that influence the operation of a hospital department, such as the distances that staff members need to walk. Additionally, sensory stimulation can have significant effects on individuals' psychological and physiological states, ultimately influencing their overall well-being and the progress of their healing journey. In recent years, there has been a growing interest among healthcare professionals in the field of healing architecture. This interest stems from the

acknowledgment that the design and spatial characteristics of hospital environments have a significant influence on the healing process and can lead to improved outcomes. Consequently, the integration of healing architecture principles has the potential to enhance healthcare efficiency and mitigate costs. (Kathrine Frandsen et al., 2012)
Thus, the healing environment can be defined as an environment in which interaction between patients and staff creates positive health results within the context of the physical surroundings. (Huisman et al., 2012)

4. Role of Evaluation Process in Space Quality Enhancement.

There exists a wide range of approaches and tools employed in the evaluation of facilities, wherein the primary focus is often directed towards the technical performance, functionality, usability, and aesthetic attributes of the building. Two regularly employed evaluation methodologies in the sector include Post-Occupancy Evaluation (POE) and Usability Appraisal. Nevertheless, evaluations of inhabited structures are infrequent. The last phase of building construction is frequently marked by its extended duration and substantial financial investment. As a result, there is a lack of systematic collection of paperwork for finished building projects, leading to the repetition of problems. (Fronczek-Munter & Aneta, 2017)

4.1. Types of Evaluation Methods in Buildings

Evaluation methods can be applied to three different categories of buildings, as shown in figure 5. At where the horizontal axis represents the degree of action and level of creativity within the structure. The inclusion of the vertical axis provides additional contextual information. (Fronczek-Munter & Aneta, 2017):

- **Existing Building:** The purpose of conducting tests in a given facility can be twofold: to assess the current conditions and to use existing knowledge for the purpose of making improvements or achieving radical innovation within the same facility.

- **New Building:** This study aims to assess the extent to which the specified requirements have been fulfilled, while also examining the knowledge gained from analyzing similar existing facilities. Additionally, the study seeks to provide recommendations for improvement and innovation in the design and construction of a new building. This process is an integral component of involving users and fostering a collaborative learning environment.

- **Develop Generic Knowledge:** This study aims to provide a comprehensive documentation of best practice cases pertaining to a given type of building. The objective is to draw inspiration from these cases and foster innovation within the field. Numerous instances will be examined to ensure a thorough analysis.

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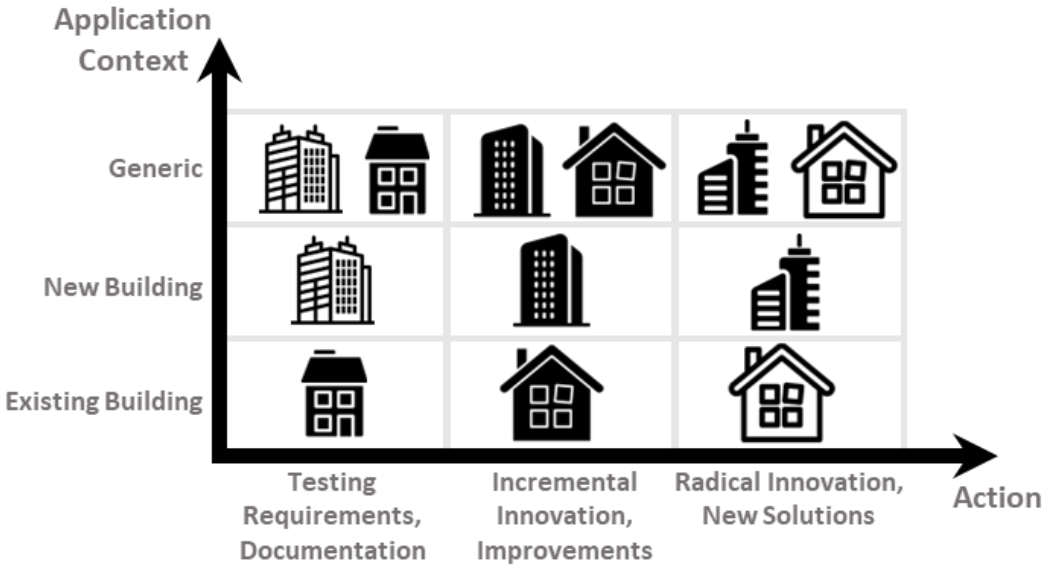

Figure 4: Types of Evaluation Methods in Buildings
By: Researcher, Source: (Fronczek-Munter & Aneta, 2017)

4.2. Exploration of Post-Occupancy Evaluation Method

"Post occupancy" refers to the fact that the building was already occupied at the time of evaluation. at the point of evaluation. The origins of the method are in the USA, and it has been used since the 1960s. According to the definition of (W. Preiser & Vischer, 2005), POE is " The procedure of systematically and rigorously evaluating constructed buildings after their completion and occupancy". (Fronczek-Munter & Aneta, 2017)

The British Council for Offices (BCO) assumes two primary objectives for a Post Occupancy Evaluation (POE). The primary objective is to obtain input regarding the effectiveness of the workplace in providing support to both the occupying company and individual end-users. Another objective is to utilize the Principle of Exclusion (POE) in order to evaluate if a project brief, specifically the program of requirements, has been fulfilled. The researchers have recently put forward supplementary objectives for the development of a Proof of Evidence (POE) system. These objectives include acquiring knowledge from sources inside and outside the organization, as well as utilizing this knowledge to inform future briefing processes. (Eurofm et al., 2012; Fronczek-Munter & Aneta, 2017; W. F. E. Preiser, 2001; *Usability of Workplaces-Phase 3*, 2010)

5. Integration of Algorithms in Evaluation Process

Algorithms are often regarded as a recommended methodology for obtaining information or producing solutions to problems through the execution of a finite sequence of steps by a computer program. Therefore, the utilization of a computer program usually involves the execution of an algorithm, with the resulting outputs being mainly dependent upon the input data provided. (Kotnik, 2006; Morsi, 2014)

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5.1. Visibility Analysis Using Isovist

The concept of an isovist is a method commonly employed for the analysis of spatial environments, particularly within the realm of architecture. The utilization of this concept has been observed in the fields of architecture and mathematics. As reviewed by (Turner, 2001), The importance of the concept in architecture seems to be first recognized by (Benedikt, 1979), who defines the isovist as '***the set of all points visible from a vantage point in space with respect to an environment***'. This approach enables them to apply geometric measurements in order to quantify both the size and shape of the isovist. Consequently, the isovist emerges as a valuable method for exploring spatial environments as individuals see and engage with them, thereby facilitating the explanation of various spatial activities (Rajab Alalouch, 2009).

The boundary of an isovist can be categorized into three distinct types. Firstly, there are real surfaces, which refer to surfaces that enclose the field of sight and have the ability to scatter light. Secondly, occluding radial surfaces are the surfaces formed by the radials that define the occluded area. Lastly, region-boundary surfaces are the result of the intersection between the field of sight and the boundary of the environment. The measurement of isovists' size was conducted using the three previously mentioned categories of isovist boundaries. (Benedikt, 1979)

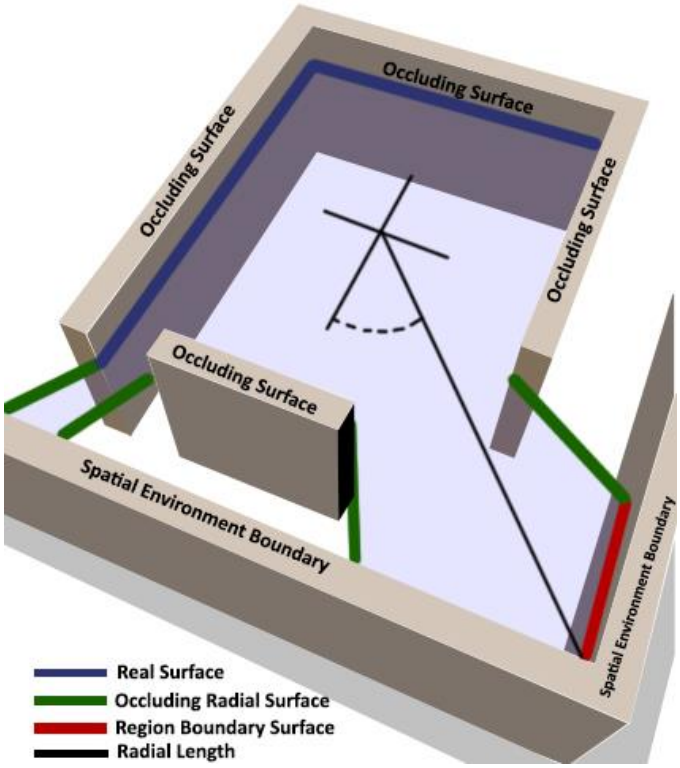

Figure 5: Benedikt's Isovist boundaries and radial of length
By: Researcher, Source: (Rajab Alalouch, 2009)

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5.2. Isovist Field

(Benedikt, 1979) has been found that each individual isovist inside a specific environment possesses a distinct shape and size, and this isovist undergoes alterations in response to the movement of the generating point. Therefore, he argues that in order to measure the spatial environment and get insight into how individuals perceive, navigate, and utilize it, it is imperative to take into account the interrelationship between the isovists within the given configuration. Consequently, the researcher formulates the concept of the "isovist field" for each of his measurements. The Isovist field, as explained by (Turner, 2001) examines the alterations that occur to a specific property (e.g., area, diameter) of an isovist as a result of the movement of its generating point within the configuration. The findings are visually represented through the plotting of contour lines, which effectively illustrate the spatial variations in this property.(Rajab Alalouch, 2009)

6. Case Study: Application of Isovist in Inpatient Department

On three different general hospitals inpatient departments, an analysis has been applied using Decoding Spaces software. The three inpatient departments have different layout configurations, and we are investigating how the spatial configuration affects the users. The analysis was conducted in two approaches: firstly, using isovist field analysis to explore the visual connectivity and how it affects the ease of wayfinding and accessibility to the nursing unit by visitors; secondly, exploring the accessibility from the nurse station to the patients' rooms, ensuring a sense of security for the patients that they are easily observed by the nursing staff with respect to their privacy.

Table 1: Case studies Research Settings

Abbreviation	Hospital Name	No. of Beds	Nursing Unit Configuration	No. of Nursing Units	No. of Beds In Inpatient Unit
H1	Dar El-Fouad Hospital	158	Centralized Nursing Station (Double Corridor)	2	36
H2	As-Salam International Hospital	150	Decentralized Nursing Station (Double Corridor)	3	38
H3	El Sheikh Zayed Al Nahyan Hospital	150	Decentralized Nursing Station (Single Corridor)	3	28

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6.1. Case Studies Overview

In the following figures all of the case studies analyzed into the main zones of the floor Plans of the inpatient departments:

Figure 6: Dar El-Fouad Hospital - Inpatient Department
Source: By Researcher

Figure 7: AS-Salam International Hospital - Inpatient Department
Source: By Researcher

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Figure 8: AS-Salam International Hospital - Inpatient Department
Source: By Researcher

After defining the main zones of the studied floor plans, aspects of space layout planning that affect the spatial experience have been defined according to the target users of the department to start the process of evaluation using algorithms.

The target users have been specified as the following: patients, visitors, patients families, and the nursing and medical staff. In defining the boundaries of evaluation in each case study, two zones have been identified: the whole floor plans of spaces used by the target users, and the circulation paths in the department, which include corridors and lobbies.

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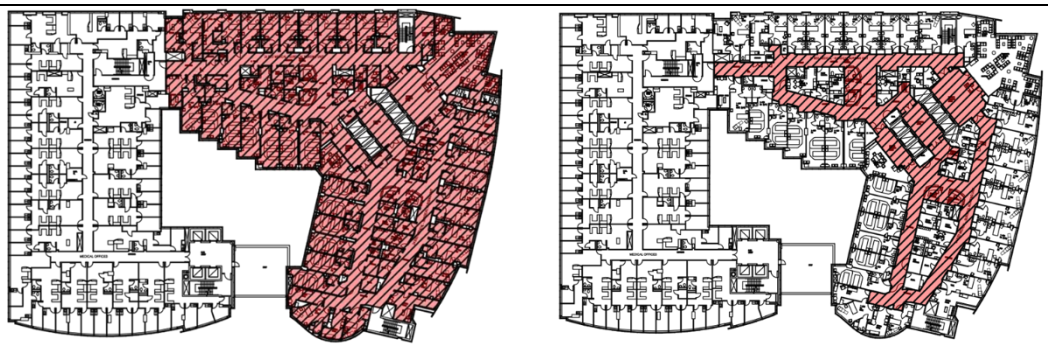
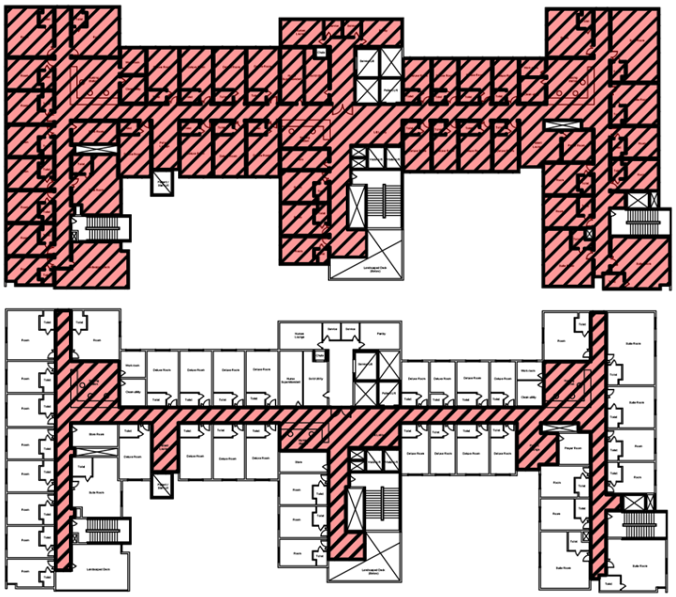
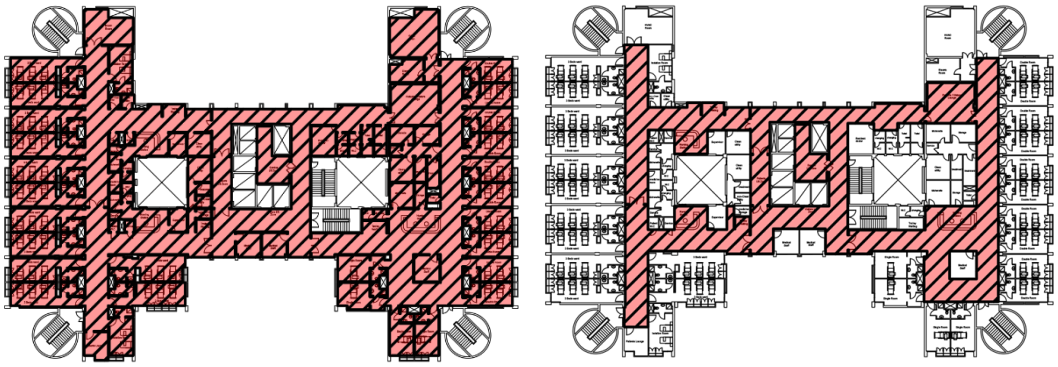
Table 2: Space Definition in The Case Studies

H1: Dar El-Fouad Hospital	
H2: AS-Salam International Hospital	
H3: El Sheikh Zayed Al Nahyan Hospital	

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6.2. The Evaluation Process: A workflow Map

The study primarily centered on the translation of elements derived from the existing literature review pertaining to space layout planning in hospital facilities. Additionally, it aimed to assess the factors that impact the quality of space for both patients and medical personnel. The evaluation process employed in the research will be constrained to the subsequent factors, as shown in figure 10:

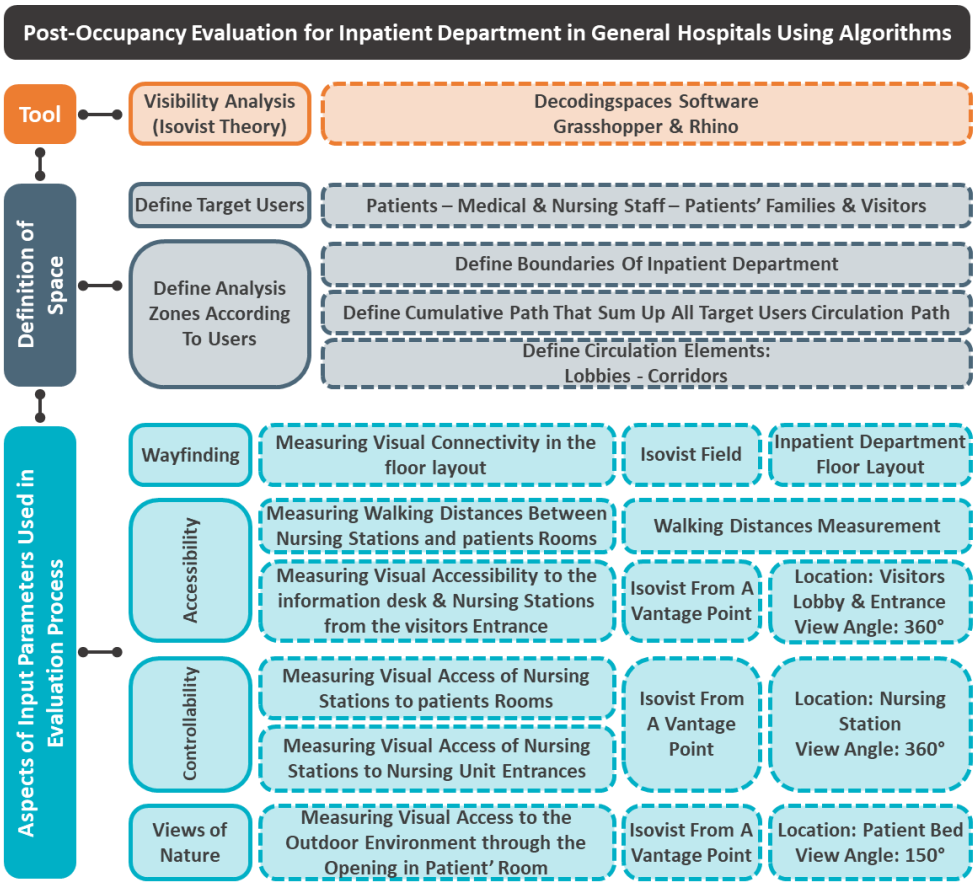

Figure 9: Evaluation Process Workflow Map
Source: By Researcher

6.3. Using Algorithms in the Evaluation of Space Layout Planning

The evaluation has been conducted based on the previously mentioned aspects, as clarified in the following explanation:

- **Wayfinding Analysis**

A 2D Isovist Field analysis generated using Decoding Spaces Software, which is a Grasshopper Add-on linked with Rhino, is applied to the three case studies inpatient department floor plans. The analysis is conducted by dividing the floor plan into a grid of points and determining the visibility of each point to all other points and to the architectural components present in the plan, including walls, columns, and the external outline of the building. Increased closeness

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between points results in enhanced visual connectivity, hence facilitating greater spatial connectedness and improved accessibility for various users, as shown in figure 11.

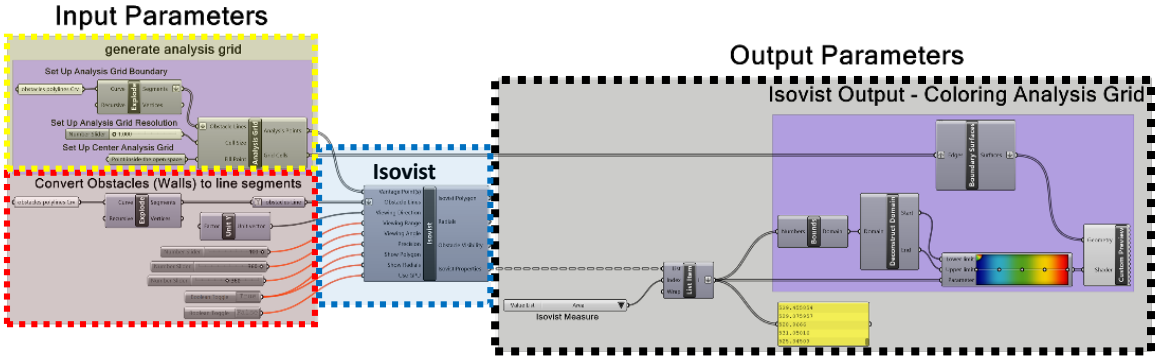

Figure 10: Isovist field Grasshopper Definition Using Decodingspaces Software
Source: By Researcher

a. H1: Dar El-Fouad Hospital

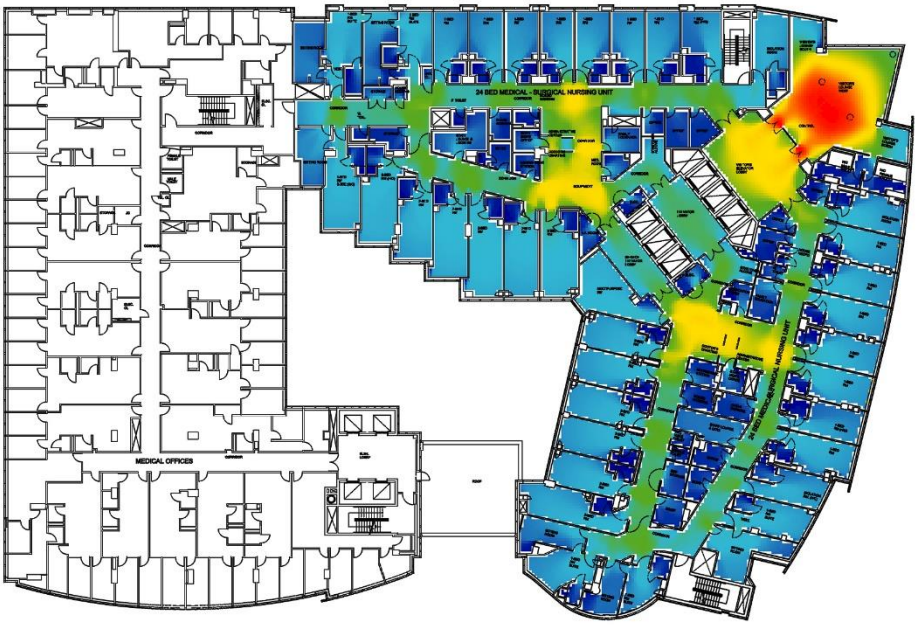

Figure 11: H1 - Isovist field Analysis for Wayfinding
Source: By Researcher

For **H1: Dar El-Fouad Hospital**, as shown in figure12, The visitor's lounge exhibits an increased level of visual connectedness. In addition to the presence of strong visual connectivity in the visitor's reception and lobby, as well as in the lobbies of each nursing unit situated in close proximity to the nursing stations, there is also direct connectivity established with the lobby designated for patients and medical staff. The distribution lobbies appear to provide

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effective visual connectivity to the corridors as well. The inpatient department has a good way of finding behavior for all users, as the allocation of the information desk for visitors' guidance is placed in the most visually connected zone and is easy to find.

b. H2: AS-Salam International Hospital

Figure 12: H2 - Isovist field Analysis for Wayfinding
Source: By Researcher

For **H2: AS-Salam International Hospital**, as shown in figure 13, The visual connectivity within the inpatient department is low, particularly in areas where corridors intersect, indicating difficulties in wayfinding for department users. However, the strategic placement of nursing stations in zones with higher visual connectivity values may aid in regulating accessibility to patient rooms.

c. H3: El Sheikh Zayed Al Nahyan Hospital

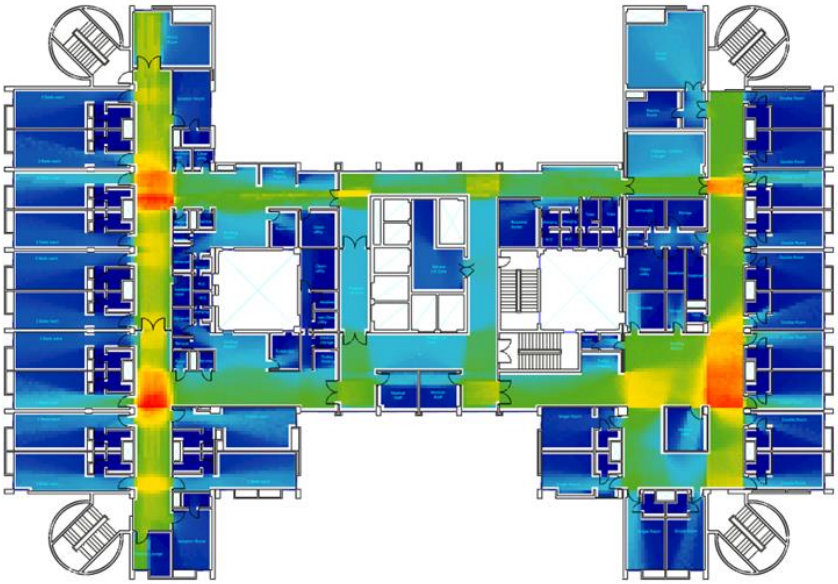

Figure 13: H3 - Isovist field Analysis for Wayfinding
Source: By Researcher

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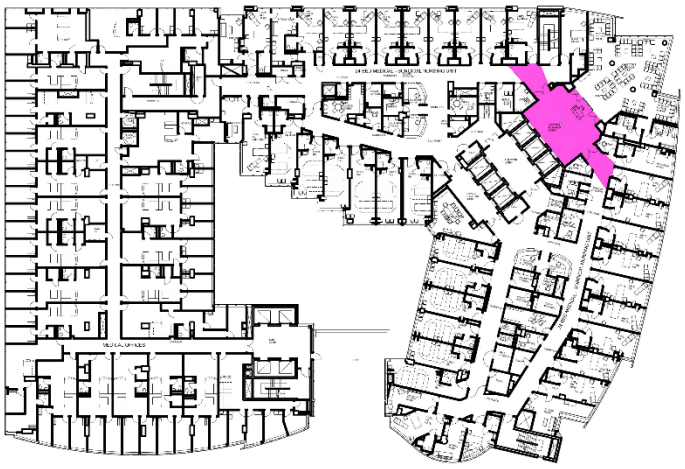
For **H3: El Sheikh Zayed Al Nahyan Hospital**, as shown in figure 14, The visual connectivity values exhibit a low level in the entrances of the inpatient department, as well as in front of two out of the three existing nurse stations. The nursing station is positioned in a manner that allows for effective visual connectivity, enhancing communication and observation. Similarly, the corridors exhibit favorable visual connectivity from the distribution lobbies. However, this layout negatively affects wayfinding behavior within the department due to the divergent allocation of nursing stations, which also serve as information desks for visitors, and the location of the elevators lobby.

- **Accessibility Analysis**

An 2D Isovist from a vantage point analysis generated using Decoding Spaces Software, which is a Grasshopper Add-on linked with Rhino for measuring the visual access from the visitor's lobby to both of nursing stations and information desks, is applied to the three case studies inpatient department floor plans.

For **H1 & H2**, there is good and direct visual access from the Visitors Lobby or visitors entrance. For **H3: El-Sheikh Zayed Al Nahyan Hospital**, The visitors lobby is an open unenclosed area that lacks an information desk and is immediately linked to the entrances of the nursing units. The lack of visual access from the visitors' lobby to the nursing stations, despite their close proximity, negatively impacts the ability of visitors to navigate within the department and find their intended destination efficiently.

Table 3: Accessibility Analysis (Visual Access from The Visitor's Lobby)

H1: Dar El-Fouad Hospital	

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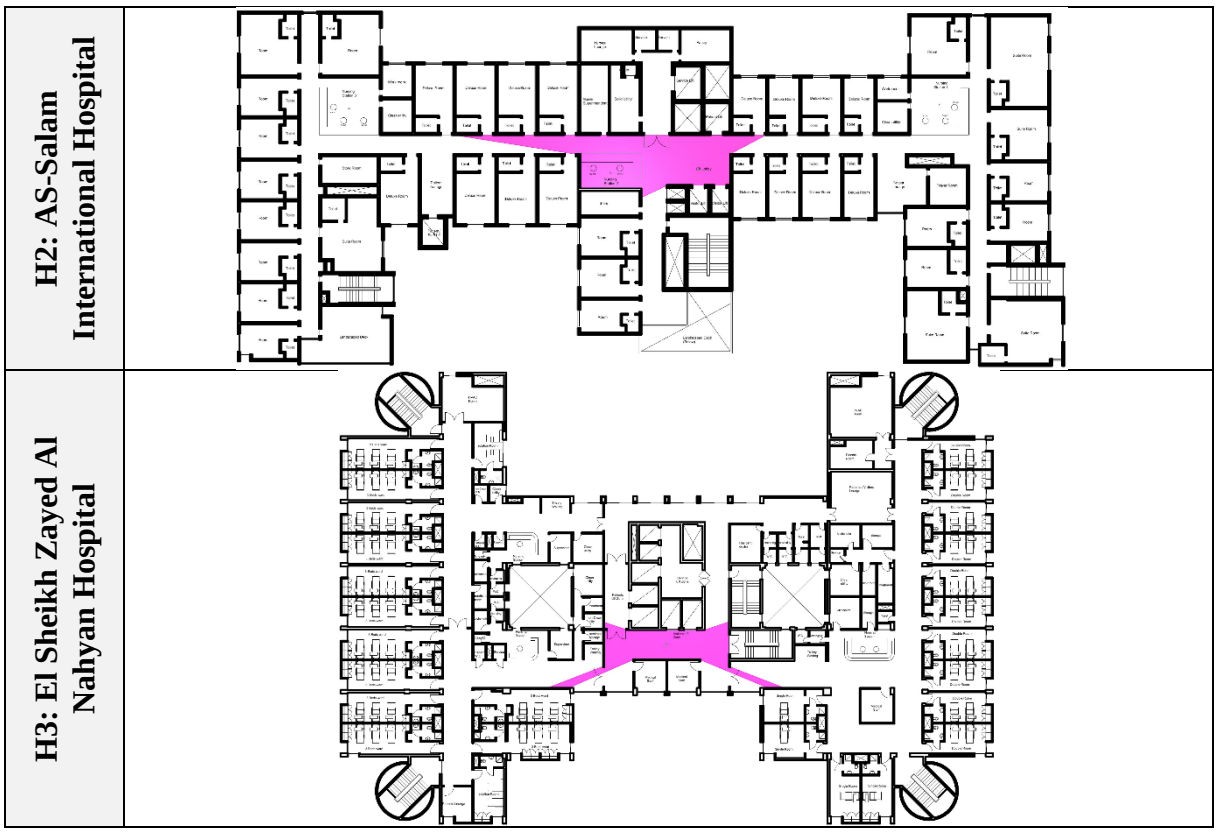

Also, using a grasshopper definition for measuring the walking distances from nursing stations to the patients' rooms, explore how the layout configuration affects the distance between them based on allocation of nursing units as a starting point of nursing staff movement to the patients' rooms., as shown in the following figure 15.

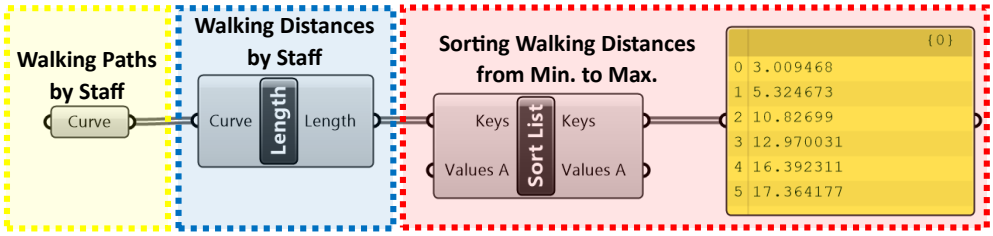

Figure 14: Walking Distances Measurements Using Grasshopper
Source: By Researcher

The walking path is defined as a path between starting and ending points; the starting point is specified from the midpoint of the entrance to the counter of the nursing station, and the ending point is the center of each door of the patients' rooms. The walking path is drawn in the center of the corridors of the nursing unit to get the most precise values possible, taking in consideration all possible rooms passes through this path, as shown in the following:

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a. H1: Dar El-Fouad Hospital

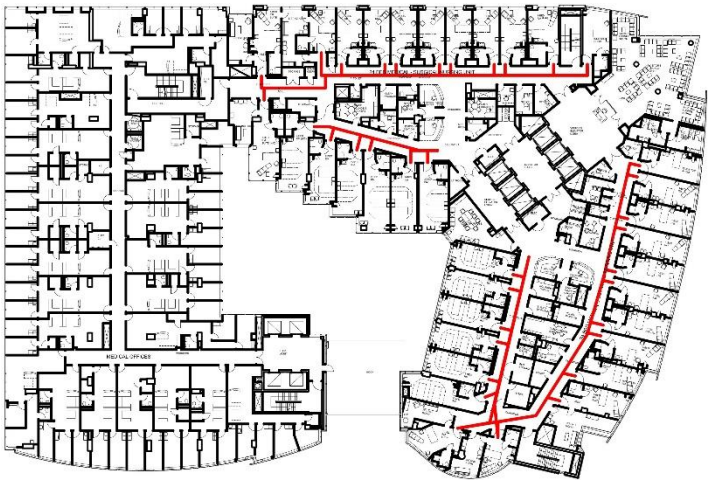

Figure 15: H1 - Walking paths Definition Analysis for Accessibility
Source: By Researcher

Table 4: H1 - Walking Distances Measurements

Walking Distance	Nursing Unit 1		Nursing Unit 2	
	N1-S1 (m)	N1-S2 (m)	N1-S1 (m)	N2-S2 (m)
Minimum	1.77	3.00	4.42	2.07
Maximum	27.55	17.36	27.86	32.65
Average	14.09	11.00	16.25	14.35

b. H2: As-Salam International Hospital

Figure 16: H2 - Walking paths Definition Analysis for Accessibility
Source: By Researcher

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Table 5: H2 - Walking Distances Measurements

Walking Distance	Nursing Unit 1 (m)	Nursing Unit 2 (m)	Nursing Unit 3 (m)
Minimum	1.42	5.50	1.92
Maximum	18.30	16.35	18.14
Average	8.12	10.29	11.39

c. H2: As-Salam International Hospital

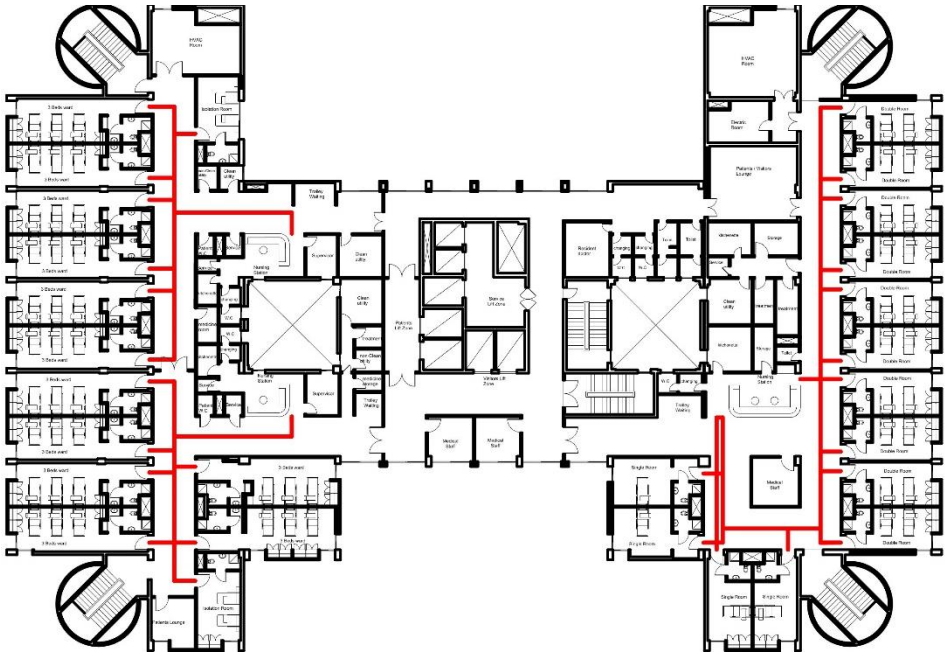

Figure 17: H3 - Walking paths Definition Analysis for Accessibility
Source: By Researcher

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Table 6: H3 - Walking Distances Measurements

Walking Distance	Nursing Unit 1 (m)	Nursing Unit 2 (m)	Nursing Unit 3 (m)	
			N3-S1	N3-S2
Minimum	13.53	13.50	5.77	3.09
Maximum	23.27	23.86	18.67	23.95
Average	17.77	18.14	12.25	12.28

Among the three cases, **H2** has the lowest values in walking distances for nursing staff from nursing stations to patients' rooms. In comparison to the two hospitals that share the same layout configuration, which are **H2 and H3**, **H2** has the higher number of rooms, which are 38 rooms, relative to **H3,** which has only 28 rooms, which indicates that the allocation of the nursing stations in **H2** is better than **H3**. As referred to in the following table:

Table 7: Walking Distances Measurements in All Case Studies

Walking Distance	H1	H2	H3
Minimum	1.77	1.45	3.09
Maximum	32.65	18.30	23.95

- **Controllability**

An 2D Isovist from a vantage point analysis generated using Decoding Spaces Software, which is a Grasshopper Add-on linked with Rhino for measuring the visual access from the nursing stations to patients' rooms entrances targeting for full observation to all rooms, is applied to the three case studies inpatient department floor plans, as shown in figure 19:

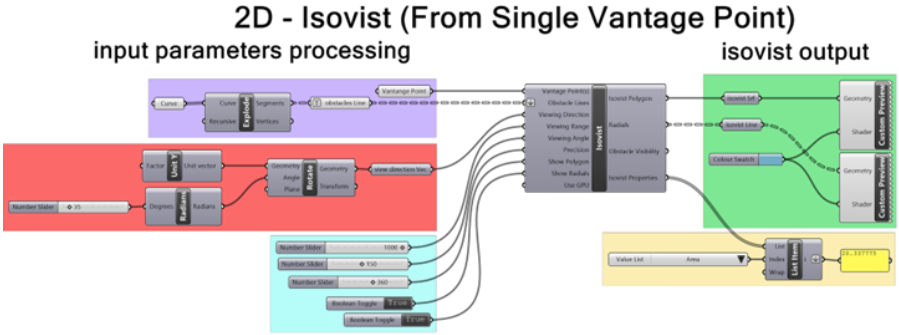

Figure 18: 2D - Isovist Grasshopper Definition Using Decodingspaces Software
Source: By Researcher

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a. H1: Dar El-Fouad Hospital

Figure 19: H1-2D Isovist Analysis for Controllability
Source: By Researcher

In **H1**, it was found that out of the total 18 rooms in Nursing Unit 1 at Dar El-Fouad Hospital, only 6 rooms were utilized, representing a percentage of 33.33%. In the context of Nursing Unit 2, a total of 18 rooms were observed, out of which 7 rooms were included in the analysis. This corresponds to a percentage of 38.88%. Nevertheless, it is worth noting that while the nursing stations in concern possess great visual access to the patients' elevator lobby and service elevator lobby, they do not have any means of access to the visitors' lobby entrance.

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b. H2: AS-Salam International Hospital

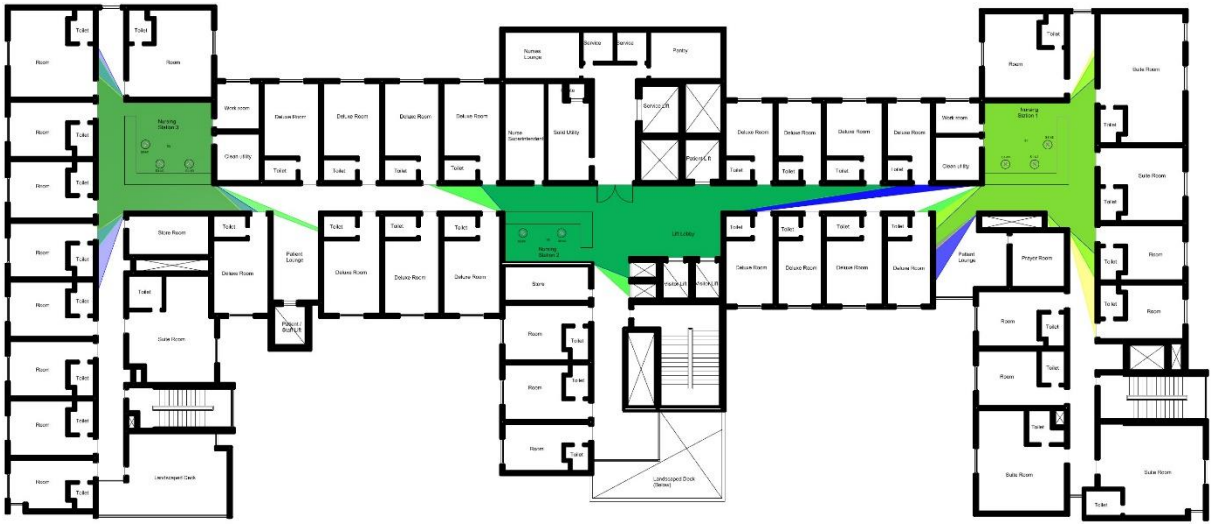

Figure 20: H2-2D Isovist Analysis for Controllability
Source: By Researcher

In H2: AS-Salam International Hospital, Nursing Unit 1, it was noticed that out of a total of 10 rooms, 4 rooms, representing 40% of the total, were under observation. In the context of Nursing Unit 2, a total of 6 rooms were observed out of the total number of 19 rooms, resulting in a percentage of 31.57%. In Nursing Unit 3, a total of 4 rooms were observed out of a sample size of 9 rooms, resulting in a percentage of 44.44%. The nursing units possess favorable visual access to all entrances of the nursing units, with the exception of the service elevator in nursing unit 3.

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c. H3: El-Sheikh Zayed Al Nahyan Hospital

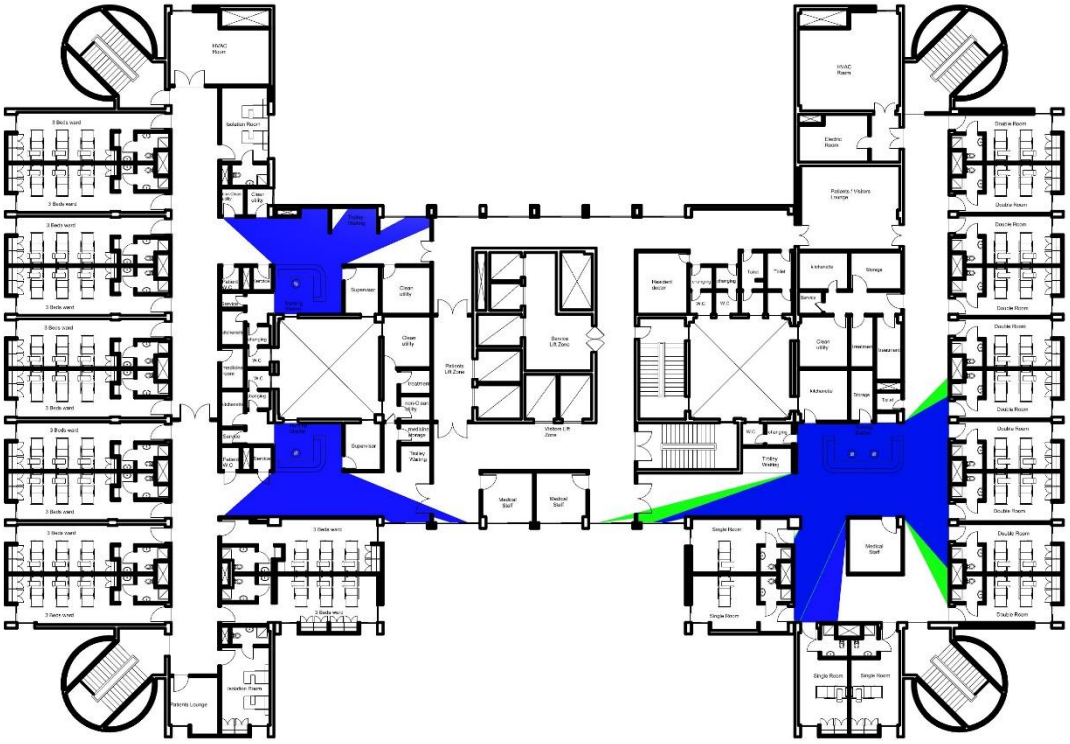

Figure 21: H2-2D Isovist Analysis for Controllability
Source: By Researcher

In Nursing Unit 1 of H2: AS-Salam International Hospital, it was noticed that there are no occupied rooms out of a total of 7 rooms, resulting in a percentage of 0%. In the context of Nursing Unit 2, it was noticed that out of a total of 7 rooms, none were found to be occupied, resulting in a percentage occupancy rate of 0%. In Nursing Unit 3, a total of 8 rooms were observed out of a sample size of 14 rooms, resulting in a percentage of 57.14%. The nurse stations possess favorable visual access to the entrance of the nursing units, similar to all other nursing units. However, there is a lack of control over the elevators lobbies, as there is an absence of information desks in front of any of them to facilitate monitoring of entry to the inpatient department.

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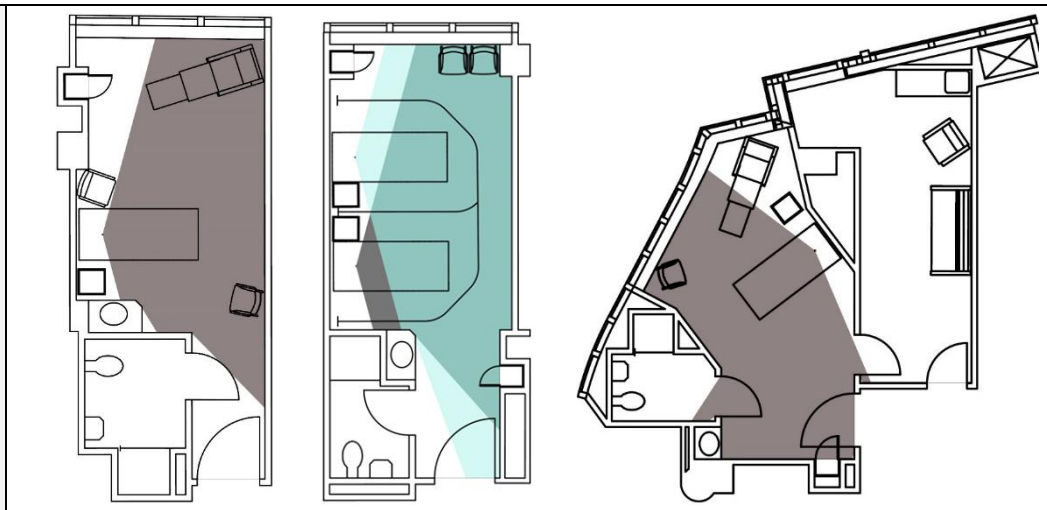
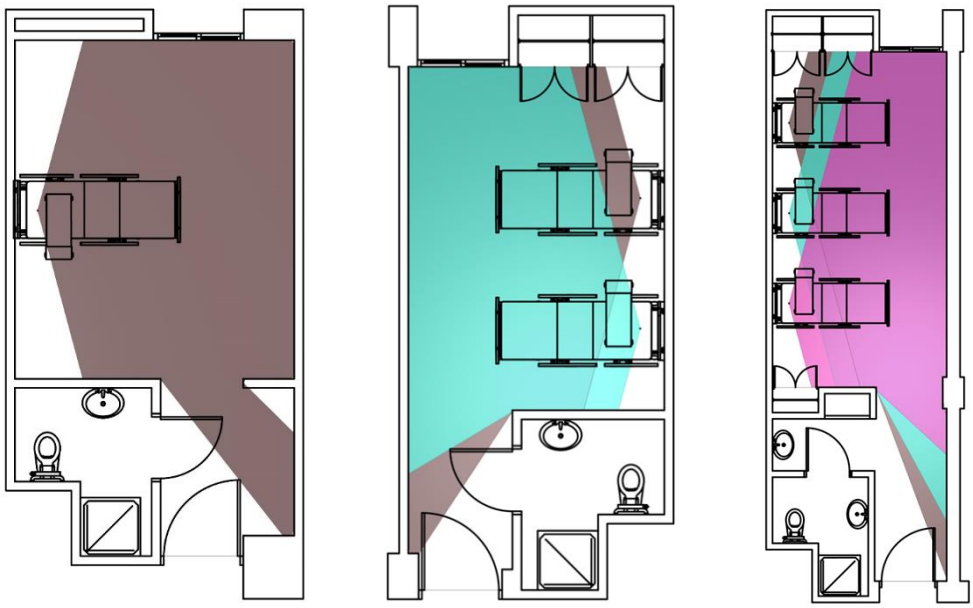
- **Views of Nature Analysis**

An 2D Isovist from a vantage point analysis generated using Decoding Spaces Software, which is a Grasshopper Add-on linked with Rhino for measuring the visual access to the outdoor environment through the openings in patients' rooms. The patients' rooms were studies with its different typologies, measuring the visual area included from the patient head in the bed for each room typology.

Table 8: Views of Nature Analysis

H1: Dar El-Fouad Hospital	
H3: El Sheikh Zayed Al Nahyan Hospital	

In **H1 & H3**, it is observed that all three types of rooms show good visual access due to the presence of architectural openings that connect them with the outer environment. Both the double-bed room and suite room offer patients the advantage of visual access and control over

the room door. This feature enhances the patient's sense of privacy, as they have complete visibility and authority over their room, enabling them to identify others who may enter. This level of control is not present in the single room typology. But in H3, all the room typologies have no visual access to the room entrance, which decreases the feeling of privacy for the patient because he has no visual access to and control over his room and knows who can access it.

The following table provides a summary of the evaluation approach utilized for the three case studies, focusing on their space layout planning characteristics and the aspects of evaluation that have been developed:

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Table 9: Inpatient Departments Space Layout Planning Evaluation Framework Using Algorithms

Evaluation Aspect			H1	H2	H3
Layout Configuration Typology			Centralized Nursing Station (Double Corridor)	Decentralized Nursing Station (Double Corridor)	Decentralized Nursing Station (Single Corridor)
No. Nursing Unit			2	3	3
Total No. of Rooms			36	38	28
Wayfinding [Visual Connectivity at Nursing Units Lobbies & Info. Desks (or Nursing Stations)]			High Visual Connectivity at Visitors Lobby and in front of Nursing Stations	Good Visual Connectivity in front of Nursing Stations	Low Visual Connectivity in front of Nursing Stations and Visitors Lobby
Accessibility	Visual Accessibility From Visitors' Lobby to Info. Desk or Nursing Stations		Good & Direct Access to The Info. Desk	Good & Direct Access to The Nursing Station	No Visual Access to Any Info. Desk or Nursing Stations
	Walking Distance	Min.	1.77 m	1.45 m	3.09 m
		Max.	32.65 m	18.30 m	23.95 m
Controllability	Visual Accessibility from Nursing Stations to Patients' Rooms (percentage of Covered Rooms)		13 Rooms Out of 36 Rooms 36.11 %	14 Rooms Out of 38 Rooms 36.84 %	8 Rooms Out of 28 Rooms 28.57 %
	Visual Accessibility from Nursing Stations to Nursing Unit Entrances		No Visual Access to The Visitors Entrances, But To patients' and Services Entrances	Visual Access to Elevators Lobbies to The Unit Entrances	Visual Access to The Three Entrances
Views of Nature	Single-Bed Room		Access to Architectural Opening In the Room	-	Access to Architectural Opening In the Room
	Double-Bed Room			-	
	3 beds Patients' Ward		-	-	
	Suite Room		Access to Architectural Opening In the Room	-	-

7. Conclusions & Discussions

This Research discusses, firstly, the definition and role of space layout planning in the design process and how it could affect the spatial experience of the users. Followed by understanding the essential guidelines that should be fulfilled to create a floor layout for the inpatient department in the general hospitals. Discussing the concept of a healing environment in hospital facilities that is translated to creating a good physical environment for the patients. that has the potential to enhance healthcare efficiency, reduce costs, and increase the rate of turn-over in hospitals. Based on these approaches, the post-occupancy evaluation process is explained and how it can be used to improve existing environments for users while also avoiding repeating the problems found in similar future projects. Integrating algorithms in the evaluation process, Isovist theory was used in conducting visibility analysis on the case studies.

The analysis was applied to three Different configurations of nursing unit layouts in the inpatient department of three different general hospitals. For exploring how the location of nursing stations within the nursing units could affect the visual connectivity within the whole department, achieving ease of wayfinding and accessibility to the department from the other departments staff as well as the users. and the mutual visibility between the patients and the nurse stations concerning the feel of security that he has observed by the nursing staff with respect to his privacy that only the patient rooms are observed well from the nursing station. The use of software is supposed to make the process of post-occupancy evaluation for the different departments easier than the typical use of researcher in-site observation and surveys and interviews with the different groups of users, however essential they are in some cases, but the software could conduct a quick analysis to explore the main problems in the study cases.

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