An investigation of spatial relationships and operational requirements in hospital emergency departments in Jordan.

By

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Dedication

I dedicated my humble effort to …

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Abstract

This research investigates spatial relationships and operational requirements in hospital emergency departments (EDs) in Jordan. The preliminary literature review identified overcrowding and long waiting times as major challenges. A more detailed review examined current ED design research and guidance on ED design, functions, and operational activities and how the spatial relationships of ED functions influence ED's operational activities. The review revealed limited research in these areas and a lack of detailed design guidance about ED functional and spatial relationships.

This research, therefore, investigates for the first time ED spaces and their functional relationships to explore their influence on operational activities. The research carried out fieldwork in two case study hospitals – one public and one private – in Jordan. A mixed-methods approach was adopted using three data collection methods: interviews, spatial analysis, and direct observations of operation of EDs.

Interviews with hospital designers confirmed that ED design guides do not provide the necessary detailed explanations of ED functions and their spatial relationships. The findings highlighted limitations in stakeholders' engagement during design and a lack in the use of computer-based analytical tools during design. Accordingly, as a first step, this study explored the use of Space Syntax tools as potential design aids to analyse the two case study hospitals. This part of the research found that later changes to the original designs invalidated previous analysis and concluded that spatial analysis alone does not improve the design outcome and may create a false sense of certainty.

Direct observations showed that in practice, the arrangement of the functions and their spatial relationships in the selected EDs hinder departmental workflow. The observations were supplemented by interviews with various ED staff members to understand why the spaces are used the way they are. The findings revealed that current spatial configurations do not support the medical procedures for the ED patients with different medical conditions. Therefore, the current spatial allocation of functions hinders EDs' efficient workflow operation and causes overcrowding and longer waiting times.

The research identified three factors affecting operational activities. First, ED activities depend on the spatial organisation of functions, which in turn depends on medical procedures. Second, behavioural and management aspects both influence operational flow. Finally, the period between when the hospitals were designed and occupied saw an evolution in medical operational requirements supported by technological advances, which undermines the functional allocation of spaces.

This research recommends that ED functions and their operational spatial relationships need to support EDs' complex operational demands to cater to the needs of different users (patients and staff) and their different requirements. Therefore, the spatial organisation of healthcare facilities in Jordan has to evolve by adopting new design strategies, including co-designing with key hospital stakeholders.

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Chapter 1: Introduction and Overview

1.1 Introduction

The design of healthcare facilities, including busy and very demanding EDs, have always been under critical reviews among researchers and policymakers to improve efficiency and maintain safety. Design and operational challenges in these facilities are continuously rising due to many factors, such as the increase in complexity and demands. However, the current coronavirus pandemic has posed unprecedented challenges to the delivery of health services, which require, in return, systemic and radical changes to tackle this unforeseen pandemic safely, effectively and in timely manners. Therefore, the current global challenge of overcrowding and COVID-19 are fundamentally incompatible, where it may be impossible to maintain safe coronavirus measurements in overcrowded environments. Therefore, this research seeks to contribute a solution for overcrowding and long waiting times in ED to inform future designs.

1.2 Research Context and Background

The chapter starts by presenting a preface background for the research, defining the research problem, outlining the research questions, aim and objectives, point out the scope and focus of this investigation, viewing the research design and methodology, and it ends by presenting an outline of the thesis and a summary of the chapters.

1.2.1 Healthcare Facilities

Health care facilities, in general, are not only architectural projects that hold clinical functions and services. Instead, it is a combination of complex interconnected systems which work collectively to meet the overall functional needs of the various activities in the space. Therefore, such sophisticated systems require more attention from the early phases of the design to explore the full range of difficulties associated with such facilities. Among these are the relation between functional distribution and spatial practices (operation) to support the internal flow. Therefore, healthcare facilities' design should respond to these unique practices and demands, including users' various needs which might be lees often considered but equally important (Abdelsamad et al. 2018).

Architects are responsible for designing healthcare facilities that support the workflow by considering the functional environments and their users' needs. Besides, spatial planning in healthcare facilities has critical consideration due to its significance to support the operational requirements. To clarify, the critical relationship between the spatial structure and the functional distribution with the operational protocol also includes the flow and the internal circulation of the various users and their various needs. However, less attention has been given to stakeholders' role regarding the design of their intended facility (Abdelsamad et al. 2018). Also, recent movements in design, promote the integration of all users' preferences and needs as a considerable contribution to the design of their working facility such as Co-designing strategy.

1.2.2 Emergency Medicine

Emergency medicine is the medical domain that mainly diagnoses and treat unforeseen illness or injury. Emergency medicine is not defined by its location; rather, it is practised where it can be practised in various settings, including free-standing and hospital-based Emergency Departments (EDs). Moreover, Access to urgent medical care is vital in most healthcare settings because critical cases may hit unexpectedly, usually outside regular hospital working hours (Schull et al. 2002). Therefore, EDs can be an example of complex settings (Boyle et al. 2012); self-contained health care delivery systems that are extensive in the scope and richness of both their mission and processes. As a result, ongoing research is arguing about the rising demand for the importance of emergency care around the world (Slade et al. 2015).

1.2.3 ED in Healthcare

Emergency departments, as defined by UK Department of Health (2013) - Health Building Note 15-01: Accident & emergency departments, are:

> "Consultant-led 24-hour service with full resuscitation facilities and designated accommodation for the reception of accident and emergency patients".

Healthcare systems, in general, are centred around users and their interaction to provide adequate healthcare services. A successful healthcare system also depends on healthcare facilities' availability (Adler, 1999; Verderber and Fine, 2000; Bloom and Canning, 2003; Bloom et al. 2004). Therefore, Emergency Departments (EDs) are one of the primary and front-line components of almost any healthcare system, where it operates as a vital part of such a complete system (Adler, 1999). EDs efficiency and services' quality significantly impact the entire healthcare system (Adler, 1999; Health Building Note 15-01: Accident & emergency departments, 2013).

Recently, there has been growing research to lower cost and enhance hospitals' productivity, which has been a great challenge (Ingalls 2004). EDs, as a main part of hospitals, are complex, adaptable healthcare systems that run 24/7. Patients arrive at EDs without prior appointment with a range of stable and unstable conditions that has to be treated immediately. Such departments suffer from crowding and their limited budgets (Liu et al. 2014). Also, in EDs, the number of arriving patients may increase in a sudden (Adler 1999). Therefore, improving the functionality and efficiency of EDs without increasing the department capacity, or increasing the budget and hiring more staff is still a significant challenge.

1.2.4 Crowding in Emergency Departments (EDs)

Overcrowding in EDs is considered as a global challenge that hinders the delivery of healthcare services in EDs (Eitel et al., 2010). Overcrowding in EDs usually happens when the department capacity to provide care in a realistic amount of time become insufficient for the size of demand (Bond et al. 2007).

The American College of Emergency Physicians defined crowding as a situation in which the current need for emergency care exceeds available resources in the ED (Crowding - Policy Statement. 2019). The Australasian College for Emergency Medicine (2019) defines overcrowding as when ED functions are hindered to providing emergency healthcare services, which is because the number of patients are more than either the staffing and /or the physical ability of the ED. ED patients are the ones waiting to be seen, the ones undergoing assessments and treatments, and the ones waiting for departure. Therefore, overcrowding happens in hospitals' EDs when the number of patients is more than the staffed treatment beds in the ED, and the waiting time is more than the accepted period. Therefore, crowding can cause poor practices, for example, treatment of patients in nontreatment areas (e.g., hallways) which compromises patients' and families' privacy, increase waiting time for admitted cases, delay in evaluating and treating ED patients, decrease patients and staff satisfaction, and damage the institution's reputation. Also, it compromises patients and staff safety and privacy (Bernstein and D'Onofrio 2009; Moskop et al. 2009), and can cause frustration among staff working in the ED (Derlet and Richards 2000).

Emergency medicine is considered relatively new; it has started in the 1960s and has grown internationally since this time (Zink 2006). However, although it is still a new speciality, crowding manifested after a short time. Overcrowding in ED was on the Time magazine cover in 1990 (Derlet and Richards 2000), and researchers start working on solutions and strategies for overcrowding.

Overcrowding in ED is a significant public health issue (Di Somma et al. 2015; Kelen et al. 2016) as well as an international problem (Derlet and Richards 2000; Hoot and Aronsky 2008; Bernstein et al. 2009; Forero et al. 2011; Pines et al. 2011; Wiler et al. 2011; Morris et al. 2012; Di Somma et al. 2015; Innes 2015). Therefore, overcrowding in ED is associated with significant challenges, for example; Increased morbidity and mortality rates among patients (Sprivulis et al. 2006; Hoot and Aronsky 2008; Hoot and Aronsky 2008; Forero et al. 2011; Guttmann et al. 2011; Shen 2011; Di Somma et al. 2015; Kelen et al. 2016; Crowding - Policy Statement. 2019); increased length of stay for admitted patients (Crowding - Policy Statement. 2019); decreased patients' satisfaction (Guttmann et al. 2011; Maa 2011; Di Somma et al. 2015); violence (Derlet and Richards 2000); decreased physician productivity and efficiency (Derlet and Richards 2000; Crowding - Policy Statement. 2019); increased disability and medical errors (Crowding - Policy Statement. 2019); treatment delays (Derlet and Richards 2000; Sprivulis et al. 2006; Hoot and Aronsky 2008; Bernstein et al. 2009; Morris et al. 2012); increase hospital length-of-stay (Liew et al. 2003; Singer et al. 2011; Verelst et al. 2015); and an increase in associated costs (Krochmal and Riley 1994; Richardson 2002; Huang et al. 2010; Foley et al. 2011).

Research published in 2010 concluded that delays in ED admission for more than 12 hours increased Inpatient Length Of Stay (IPLOS) at an additional annual cost of $2.1 million dollars (Huang et al. 2010). Thus, crowding in ED can negatively impact on many entities, for example, governments (Hughes

2010), insurance companies (Krochmal and Riley 1994), hospitals, healthcare workers (Hoot and Aronsky 2008), physicians (Derlet and Richards 2000), ambulance services (Forero et al. 2011), and patients (Guttmann et al. 2011).

Currently, different solutions and new strategies have been developed in the emergency medical research to reduce crowding and waiting time in ED, also to improve users' flow and patient's throughput (Paul and Lin 2012; Kang et al. 2014; Marino et al. 2015; Carlson 2016; Fulbrook et al. 2017), which results in patient experience of being seen and attended to almost immediately, rather than the typical story of being held in the waiting room for long periods. However, the multifactorial challenge of crowding may still have no satisfactory solution in medical research (Mason 2011; Morris et al. 2012). Although there are many proposed solutions for ED crowding in Emergency care research, the literature lacks robust evidence (Cheng 2016).

On the other hand, inappropriate design of EDs spatial structure and functional relationships (insufficient adjacencies and complex spatial relationships) is a major cause for many problems, including overcrowding. For example, it will result in crowding, increased length of stay, higher mortality, and increase the cost (Krochmal and Riley 1994; Richardson 2002; Huang et al. 2010; Foley et al. 2011; Singer et al. 2011; Di Somma et al. 2015; Verelst et al. 2015; Kelen et al. 2016; Abdelsamad et al. 2018; Crowding - Policy Statement. 2019). Thus, EDs are considered as significantly complex environments (Boyle et al. 2012). Huang et al. (2010) concluded in their research that Improving patient flow in EDs may decrease costs and enhance the quality of care. However, such facilities' design is still lacking development; even in recent years, there are not enough design studies to deal with these difficulties efficiently and in a cost-effective manner (Abdelsamad et al. 2018).

1.2.5 The Jordanian Healthcare System

Jordan is a low-income country located in the Middle East, north of the Arabian Peninsula, west of Asia, Figure 1. The position of Jordan has a critical geographic and political position in the area. Jordan total area is about 92 000 km2, with an approximate total population of 9.5 million (About Jordan: facts about Jordan. 2011; Department of Statistics (DOS) and ICF 2019). Also, Jordanians have a life expectancy of 70 years for men and 76 for women (Petro-Nustas 2002), with about 92% of the total population being educated (Orbach and Delaney 2004). However, the average life expectancy in Jordan might be considered low when compared with other counties such as the UK with life expectance of about 80 years (Marshall et al. 2019).

Jordan's economic situation is facing a recession, where Jordan is highly affected by The Arab Spring and the crises of refugees (Pollack and Byman 2006; Madaeen and Adeinat 2018; OECD 2018). Therefore, such a situation is significantly important for a small country with limited resources and a weak economy. The refugee crises may have negatively affected the country, reducing living standards,

decreasing job opportunities, increasing poverty, and inflation in living cost. Besides, it caused more demand and pressure on the healthcare system. However, although Jordan is a small country with limited natural resources, it is famous for its advanced healthcare services. It is one of the more efficient systems in the area (Oweis and Abushaikha 2004). Besides, it is one of the peoples' main destinations for medical tourism in the Middle East and North Africa (*Medical tourism and healthcare status from around the world* 2016; *The Report: Jordan 2018* 2018).

Furthermore, the Jordanian healthcare system can be divided into three main sectors: Public, private, and donor. The number of hospitals in Jordan reached 106 hospitals with a total capacity of 12081 beds (High Health Council 2017). The public part involves two major public programs: The Ministry of Health (MOH) which account for 38% of total hospitals' beds, And Royal Medical Services (RMS) which account for 20% of total hospitals' beds. Other smaller public healthcare services include university-based programs, such as Jordan University Hospital (JUH) in Amman and King Abdullah University Hospital (KAUH) in Irbid. On the other hand, the private sector has a total of 33% of total beds in Jordan (Ajlouni 2011; High Health Council 2017). Besides, the donor sector is mainly run by the United Nation Relief and Work Agency (UNRWA). It services more than about 1.1 million Palestinian refugees in Jordan whom they do not have Jordanian citizenship (UNRWA 2013).

The hospital beds in Jordan have rated for 18 beds per 10,000 people, which is higher than in other neighbour Arab countries. However, it is still lower than the international rate (Nazer and Tuffaha, 2017). Not to mention, with the recent increase in the population rates and the high influx of refugees to Jordan (Madaeen and Adeinat 2018; OECD 2018), the current bed rate is considered insignificant (Ajlouni 2011; High Health Council 2017).

Figure 1: the map of Jordan (Obtained from google maps by the researcher)

1.2.5.1 EDs in Jordan

Health challenges in Jordan have increased in the last two decades due to different factors such as low financial resources, and the increasing number of refugees from around the Middle East. Therefore, EDs, as a prominent part of the healthcare system, are facing increasing demands that are causing more challenges and putting more pressure on EDs. Furthermore, EDs are considered one of the most critical facilities in Jordanian hospitals, where they suffer from crowding and long waiting times (Al-Refaie et al. 2014; Jahmani 2018).

1.2.5.2 Crowding in Jordanian EDs

EDs are considered as one of the most critical facilities in Jordanian hospitals. The most common problems that EDs in Jordan are suffering from is crowding and long waiting time (Al-Refaie et al. 2014; Nasir 2015; Jahmani 2018). Therefore, the literature has shown that research regarding EDs design and its influence on the operation is lacking. Also, overcrowding and long waiting times in EDs in Jordanian hospitals have not been well investigated. This is because little attention might be given to this area of research in countries with low income.

Besides, design resources and guidelines for EDs in Jordan are limited, and there are no formal design codes for EDs, nor the spatial structure of such complex spaces. For example, the Jordanian Engineering Association and the Ministry of Health have no formal and sufficient EDs design resources. Therefore, research might be needed in this area in a Jordanian context. The researcher believes that this research area is neglected and can be considered outdated to suit the Jordanian context and the region's demographical changes. Therefore, research to explore the spatial structure in EDs might be urgent to update the current situation to improve the overall operational aspects of the EDs, which will lead to improving movement and flow. To emphasis, small improvements can impact the whole department; therefore, challenges EDs face, such as waiting time and overcrowding, will be improved. Thus, this study aims to contribute to this growing research area by providing evidence and a better understanding of EDs spatial relationships and how the layout facilitates or hinders users' flow to reduce overcrowding and waiting time in Jordanian Hospital.

1.2.5.3 EDs Design regulation in Jordan

In Jordan, as the context of this research, there are no formal design guidelines for healthcare facilities in general, and EDs in particular other than basic regulations approved by the government and adopted by the ministry of health. These regulations do not provide any design guidance other than formal laws of building. Thus, EDs design and their spatial relationships are neglected and can be considered outdated to suit the region's demographical changes. Therefore, research to explore the spatial structure of EDs and their operational influence might be urgent to provide reliable data, which may contribute to improving the current situation.

1.3 Research Questions

Two research questions have emerged from the problem identified above. Research questions are used to structure the research to provide more in-depth knowledge of the research problems. According to Robson (2011), research questions are used to define the research structure to uncover new knowledge. Thus, research questions were used to guide the research towards discovering new knowledge in the research area. The research question is:

- "What influences does spatial structure have on the operation of EDs?"
- "How can spatial structure improve workflow and reduce overcrowding and waiting time in EDs?"

1.4 Research Aim and Objectives

This research builds on the knowledge that overcrowding and waiting time are a significant challenge in EDs. and the fact that there might be lack of comprehensive explanations of the functional relationships between the different spaces in EDs. Hence, this study aims to provide evidence and a better understanding of EDs spatial relationships and how the layout facilitates or hinder users' flow to reduce overcrowding and waiting time. This research is based on a detailed study of two selected EDs in Jordan. Therefore, five objectives were identified to answer the research questions comprehensively and in the best way possible. Table 1 shows the research objectives and the adopted research methods.

Table 1: Research objectives and methods

	Research Objectives	**Research Methods**
1	To explore EDs spatial design in the literature and design guidance	Literature search
2	To explore actual designers' approaches to EDs spatial design	Interviews with designers
3	To investigate EDs spatial relationships	Spatial analysis
4	To investigate the influence of the spatial structure on EDs' operation: - How EDs are being used and functioning - Why EDs are being used the way users uses them	Field observation Interviews with EDs' staff
5	To compare the findings from the previous four objectives to develop a better understanding of how EDs should be designed to support their operation	Review and analysis

1.5 Scope and focus of the research

Scope: This research explores the impact of EDs spatial design on staff and patient flow during treatment processes. This research is conducted to better understand how spatial practices in EDs in Hospital in Jordan are facilitated or hindered by their current design. The research will contribute to the development of recommendations for future designs to design better EDs.

Focus: This research focuses on the spatial organisation and design of EDs by conducting spatial analysis and carrying out fieldwork in two carefully selected case study hospitals – one public and one private – in Jordan.

1.6 An Overview of the Research Design

This research was divided into four phases to achieve the research objectives. These phases are literature review, data collection, data analysis, and discussion and development of recommendations. To achieve the research objectives, because they addressed different phenomena, different methods, and techniques for collecting and analysing the data were reviewed. A pragmatic (Mixed-Method) approach was adopted, which allows the use of both qualitative and quantitative techniques to achieve the research objectives.

Phase1: Literature review and critical analysis: The literature review is the first phase of the research to explore challenges EDs face when delivering urgent healthcare services. In additions, to review EDs spatial design knowledge from the literature, which include available ED design guidelines and current research. Also, to Identify types of EDs to be used as case studies in this research.

This phase also included arranged face-to-face and phone calls meetings with healthcare designers and medical planners in the field in the study area and the UK. Also, phone calls meetings with senior medical staff in the study area (Jordan). The main reason for these initial meetings was to collect general information about ED design and operation. Also, to collect information about challenges ED might be facing to inform the research in its early stages.

Phase 2: Data Collection: The data collection is the second phase of the research to achieve the research objectives, which involved three major activities: case study, semi-structured interviews, and field observation. This phase includes the following:

1. Case Study: two different EDs were chosen in the study area as case studies to investigate the research questions further. The original architectural drawings were collected for both cases. Besides, as-built measurements were taken to generate drawings for the current settings—moreover, the selected cases were used to achieve objectives three and four. The former was to investigate their spatial relationships using spatial analysis tools. The latter was to investigate the influence of the spatial structure on EDs operation using qualitative techniques.
2. Interviews: semi-structured interviews were adopted in this research to collect qualitative opinions from two sets of participants to achieve objectives two and four—first, specialised healthcare designers and medical planners to explore their approaches to EDs spatial design. Second, staff working in the selected case studies to investigate the influence of the spatial structure on EDs operation.

3. Field observation: field observation was adopted in this research to collect qualitative description and evaluations of the selected case studies to investigate the influence of the spatial structure on EDs operation. Non-participants observation was adopted, which included describing the EDs outdoor settings, describing the EDs indoor settings, and recording staff and users' behaviour.

Phase 3: Data Analysis: The data analysis is the third phase of the research to organise and analyse the obtained data from the data collection phase. This phase involved three major activities: spatial analysis, interview analysis, and observation analysis, which are as follow:

1. Spatial analysis: to analyse the spatial configuration by exploring the spatial structure for the pre- and post-occupancy setting for the selected EDs. This phase is done in two stages:
   A. First, spatial structure development: to explore the spatial structure and identify spatial changes between the pre- and post-occupancy settings. Manual zoning plans were created to highlight the changes in the spatial structure.
   B. Second, Space Syntax Analysis: to explore its outcomes as a syntactic analytical tool to analyse EDs functions spatial relationships. AGRAPH and DepthMap software were used as space syntax tools.
2. Interview analysis: All interviews were transcribed into Arabic first, then translated to English before the coding process. Microsoft Office Word was used for formatting the text before importing the data to NVivo 12 software for analysis. Moreover, to capture all the relevant information related to answer the research questions, a combination of deductive and inductive approaches was adopted to analyse the obtained data from designers and staff. The revealed data were supported with direct quotations.
3. Observational analysis: The analysis process started by critically reviewing the observed data several times to understand the data better, then, the observed phenomena were synthesised to interpret the data into a comprehendible written report that explains the observed activities. The data were presented as a list of points under three predefined headings.
   A. First, a description of the emergency department building and location (outdoor).
   B. Second, a description of the emergency department (Indoor).
   C. Third, recording users and staff behaviour.

   The date was also translated into a 2D as-built floor plan for the observed EDs to better illustrate the data to know the influence of the physical settings on users' behaviours.

Phase 4: Discussion and Development of Recommendations: This phase seeks to compare the research objectives' findings to understand better how EDs should be designed to support their operations.

1.7 Structure of the Following Chapters

The research is arranged into nine chapters, as shown in Figure 2. The content of each chapter is presented below:

- **CHAPTER ONE: Introduction and Background to the Research:** This chapter describes the research background and reason for the research. It also presents the research questions, aims and objectives. Besides, it gives an outline of the research design as well as the overall thesis.
- **CHAPTER TWO: Literature Review:** This chapter presents a general overview of the design of healthcare facilities. It also presents ED design data, including ED spatial relationships, functions, clinical considerations, and recent research on issues around ED design and spaces. Moreover, this chapter presents an overview of design evaluation methods and techniques, including post-occupancy evaluation and space syntax as a tool for evaluating spatial layouts. Finally, it summarises the literature search, highlights limitations and gaps in knowledge, and concludes with a research question, which will guide the research towards discovering new knowledge.
- **CHAPTER THREE: Research Design and Methodology:** This chapter gives an account of the research design and approaches showcased and employed, and the employed data collection and analysis process. Ethical guidelines upheld during this research were also discussed.
- **CHAPTER FOUR: Designers Interview Analysis:** This chapter presents the interviews conducted with healthcare design experts in Jordan to fulfil objective two, exploring actual designers' approaches to EDs spatial design. They were conducted to understand what is important about EDs spatial design and what drives design decisions. It presents findings from the interviews with designers and the resulting themes. The chapter presents a detailed description of the coding process, data reduction, and data display elements of the interview analysis.
- **CHAPTER FIVE: Spatial Analysis:** This chapter presents a detailed spatial analysis of the two selected EDs to fulfil objective three, investigating EDs spatial relationships. Thus, the pre- and post-occupancy configurations of the selected EDs were analysed by applying two different techniques. First, spatial structure development, which is to explore the original design and the development in the spatial structure. Second, space syntax analysis to explore the spatial relationships between the various functions in EDs.
- **CHAPTER SIX: Observation Analysis:** This chapter presents findings from the field observation carried out in the two selected EDs to fulfil the first part of objective four, investigating the influence of the spatial structure on EDs operation. They were carried out to understand how EDs are being used and function by observing users' behaviours and activities. Detailed descriptions of the observed notes are presented.

- **CHAPTER SEVEN: Staff Interview Analysis:** This chapter presents the interviews conducted with staff in the two selected EDs to fulfil objective four, evaluating the influence of the spatial structure on EDs operation. Also, to understand why EDs are being used the way users use them. It builds on the results from the observational studies described in the previous chapter and presents findings from the interviews with healthcare staff and the resulting themes. The chapter also describes the coding process, data reduction, and data display elements of the interview analysis.
- **CHAPTER EIGHT: Discussion and Comparisons:** This chapter discusses and compares the research findings from the preceding chapters to identify the most critical influences on EDs design. Also, to suggest how these influences may be incorporated to improve ED design and operation by reducing overcrowding and waiting time.
- **CHAPTER NINE: Conclusions and Recommendations:** This chapter summarises the achieved research objectives, the contributions to the body of knowledge, the limitation, the recommendations, and the needed future research.

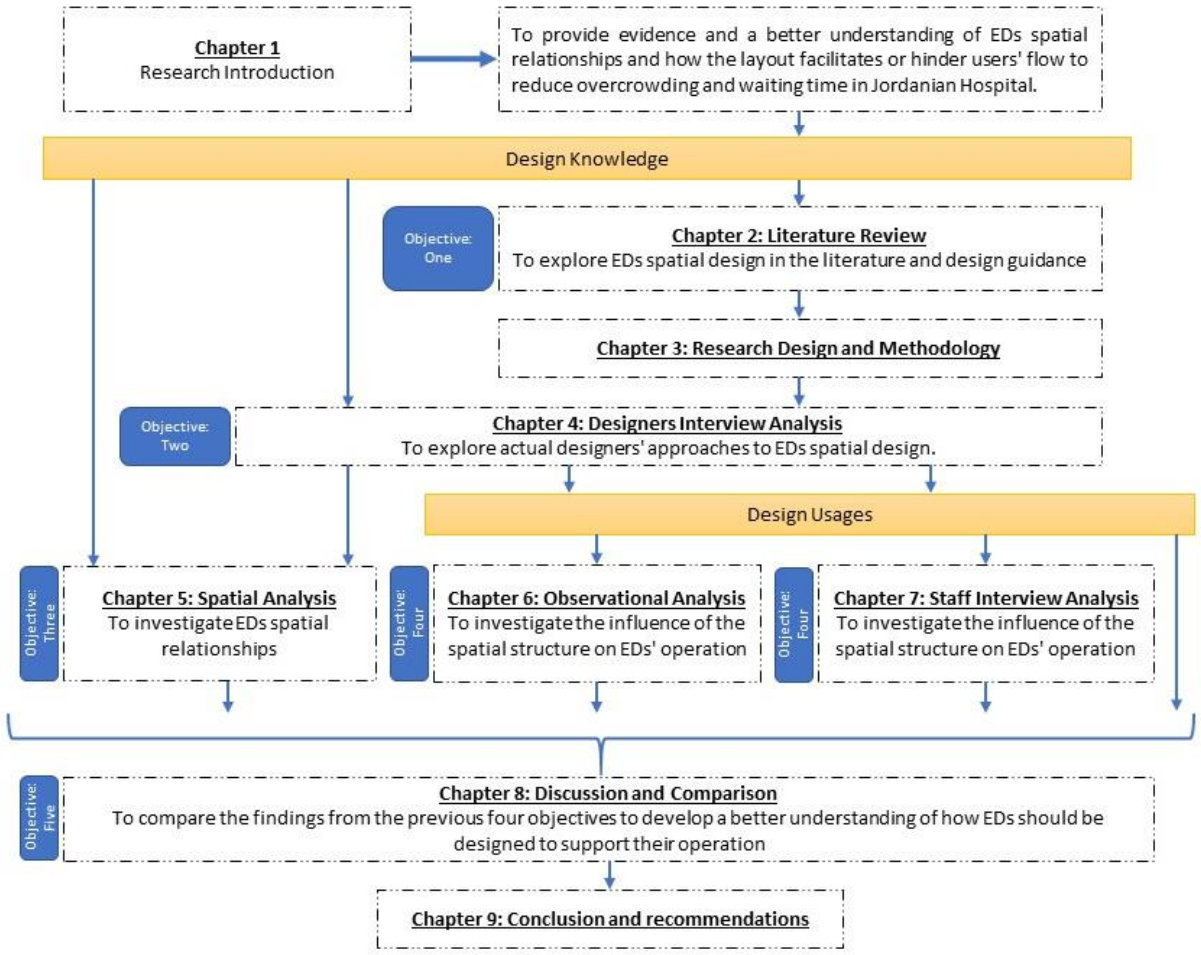


Figure 2: Thesis Structure

1.8 Chapter Summary

This chapter provided an initial introduction and a general background of the study. It presents the problems and the justifications for this investigation, the research questions, aims and objective, and the adopted methodology. It concludes by providing an outline of the thesis. The next chapter provides an overview of EDs design and knowledge, which introduces the literature review chapters.

Chapter 2: Literature Review

2.1 Introduction

This chapter reviews available knowledge and guidance to support the spatial design of EDs. It aims to explore EDs' design guidelines, as well as the current research in EDs design.

2.2 Healthcare Facilities

The delivery process in healthcare systems is continually changing due to multiple factors that may range from medical services and technological development (Thimbleby 2013). Thus, it has developed into operational systems in large, technologically and advanced healthcare facilities. However, such development has resulted in increased challenges in the delivery services punctually and with the available budgets; consequently, healthcare services has come under a wide range of reviews (Miller and Swensson 2002; Clark 2008). On the other hand, many scholars argue that the designs of healthcare facilities are an essential factor in the quality of the delivered healthcare services (Codinhoto et al. 2008; Tzortzopoulos et al. 2008; Wanigarathna 2014). Tzortzopoulos et al. (2008) point out that designing healthcare buildings is to accomplish various objectives within the healthcare system. For example, to provide proper care services in proper healthcare environments, enhancing operation efficiency, and ameliorating patients' flow and overall experience. Therefore, improving healthcare services delivery can be achieved by having state-of-the-art buildings, efficient layouts and spatial adjacencies, effective support for clinical processes, and improved information system. However, the complexities around the departments' requirements in healthcare facilities and stakeholders' needs may hinder these goals.

2.3 Spatial Relations and Adjacencies

Adjacency is to distribute the spaces depending on the department's frequent interaction needs, its working spatial relations, and prioritising proximity such as close and closer. For example, Van Der Voordt and Van Wegen (2007) believe that the spatial structure of the different functions in a building needs to provide the best support for the various activities through an adequate arrangement for the available spaces. Not to mention, spatial arrangement and adjacency in buildings may impact on its effectiveness, whether it will promote or hinder its functionality.

For instance, Zimmerman and Martin (2001) mentioned that poor relationships between the organisational demands and the spaces would cause an increase in the cost and reduce the organisation's effectiveness. Thus, to create efficient layouts, (Lorenz et al. 2015; Hayward 2016a) argues that it is essential to understand the functional layout and identify the location of the various required spaces that match the formal organisational structure in the preparation stage. As a result, having a suitable adjacency and spatial relations will improve operational productivity and minimise traffic travel distances by incorporating an effective spatial distribution (Neuman 2011; Harrell 2020), resulting in decreasing departmental fragmentation and costs (Frampton and Guastello 2010).

2.4 ED design

The primary purpose of EDs is to receive and provide healthcare services to various patients with various, unpredicted, and urgent medical conditions. These patients are then triaged and stabilised by providing them with acute healthcare service. Thus, the design's role is to accommodate these activities by creating adequate environments to support these procedures.

According to the Australasian College for Emergency Medicine (2014), what characterises EDs and make them unique environments with various design challenges, can be for example: the variety of staff members associated with different models of care; the variety of critical and life-threatening illnesses; the variety of patients with undifferentiated conditions; the high patients turnover; and the variety of patients admission and discharge pathways. Therefore, the design of efficient EDs in proper environments, which support the delivery of appropriate healthcare services, depends on the collaboration between key stakeholders engaged in the building or development procedures. Thus, ED design needs to consider some main requirements (Huddy and McKay 1996; Australasian College for Emergency Medicine 2014), for instance:

- The design of EDs should be practical and supportive for the way patients with different medical conditions are treated.
- The design should also reflect on health professionals' needs to manage and provide care for their patients to improve functionality.
- The spatial relationships in EDs need to support the interaction between the different users, such as staff, patients, family members, and caregivers. Also, they need to support the flow of clinical procedures.
- The design of EDs should be flexible and adaptable due to future changes in emergency care models, which may cause changes and relocate of the clinical treatment spaces. On the same point, it can be seen that the current unprecedented coronavirus pandemic has forced a sudden and dramatic shift in the delivery of healthcare services in ED. Therefore, it would be a critical area of research to further explore spatial and operational flexibility and adaptability in ED without compromising other essential requirements, such as privacy, safety, efficiency and infections control.

As a result, and to create efficient EDs, the various stakeholders need to be engaged in the design process, whom they are part of the decision-making team. For example, and most importantly, staff and caregivers working in the ED (doctors, general practitioners, nurses, administration staff, and technicians) for being highly connected to the ED (Estates and Health 2004; UK Department of Health 2013; Abdelsamad et al. 2018). ED staff, especially caregivers, are the front line soldiers as defined by Huddy and McKay (1996), where they provide significant inputs regarding ED’s unique operational situation and how the department should function. Also, stakeholders can be people who do not work

in the department but connected to it, for example: designers, clinical engineers, medical engineers, healthcare planners, pharmacists, and other non-medical staff (Abdelsamad et al. 2018), as well as patients and public users (Estates and Health 2004). Interpreting stakeholders' inputs in a systematic way will help promote the design outcomes by providing inspiring information to design EDs that support emergency services delivery by creating a successful, efficient, and safe patient care environment. Such environments can adapt to meet future developments in technology, healthcare, and the increased number of patients.

2.4.1 ED Spatial Relationships

Poor design of ED can cause various challenges, such as overcrowding and long waiting time (Abdelsamad et al. 2018) and operational deficiency. As a result, the design has a considerable influence on facilitating and supporting the overall operation in EDs, including clinical process (UK Department of Health 2013). In this case, the operational elements have to be considered in the preparatory phase of the design process, which should be governed by the clinical requirements to create an effective task envelope. Not to mention, it is critically important to create appropriately designed spaces that can provide assessment and treatment to a wide range of patients with different acuity needs. For example, create adequate pathways, which users will take following through the ED, considering users' needs and different staff activities is vital to improve operational efficiency.

2.4.2 ED Functions

As mentioned earlier, the spatial relations in EDs should be governed by the clinical process to support and facilitate the workflow, which will impact the department's overall operation. Thus, Hayward (2016) mentioned that is it essential to identify all required functions in the planning stage, especially major diagnostic and treatment spaces. To emphasise, understanding EDs functions and their spatial relations to support the clinical process is an important pre-design stage, which will aid creating an excellent spatial structure for all the needed functions and services to support user's demands (treatment journeys).

Furthermore, users' journey in EDs may expand to require services from other departments as part of the procedures to fulfil the clinical requirements. However, EDs relationships with other department and clinical areas remain a challenge, which may hinder the ability to practice advanced emergency medicine (Tarawneh 2018). Such relationships can be, for example, with the inpatient department, urgent care units, laboratory, radiology department, operation department or minor operation Theatre, cardiac units, observational units, and pharmacy.

To further understand EDs infrastructure and related functions that need to be included in EDs to support the delivery of advanced healthcare services, data were collected from various resources. For example:

A. Tarawneh (2018) mentions that the infrastructure of EDs consists of different areas to support ED practices. For example, EDs should include clinical areas, clinical support areas, and non-clinical areas. These areas are as the following:

1. **Clinical areas** are divided between patients' areas, patients care areas, and inpatients' facilities. For example:
   - Patients' areas, such as ambulance entrance and its facilities, ambulance equipment storage area, documentation and reception, and walk-in entrance.
   - Patients' care areas, such as triage area, waiting areas (for patients and a separated one for children), resuscitation areas, isolation areas, treatment and diagnostic areas, speciality treatment areas (Eye, ear, etc.), ambulatory areas (minor operation), pediatric treatment areas, interview rooms, quiet rooms, disturbed patients' rooms, patients' toilets (near waiting areas / near treatment area), baby changing and breast-feeding areas.
   - Inpatients' areas, such as observation ward (Clinical Decision Unit (CDU)), chest Pain assessment unit, relative interview room, staff base, showers, and toilets.
2. **Clinical support areas** include reception area, drug preparation area and drug storage, equipment storage, staff base, supply storage, medical gas storage, cleaner's room, clean and dirty utility, security area, and trolly storage area.
3. **Non-Clinical areas**, such as private staff areas (include changing rooms, toilets, and showers), staff rest and dining area. Also, office areas, which include administrative support, multi-person offices, and private offices. Besides, education and training areas include a seminar room, a library with computer access, and a storage area. Finally, support services include a switch cupboard, fire alarm control board, electrical system, IT equipment, and CCTV system equipment.

Moreover, the availability of EDs own clinical spaces, such as ED laboratory, radiology section, and pharmacy, might be governed by many factors. For example, the ED total area and the available spaces, the locations of the ED, and the assigned budget (Tarawneh 2018). Having these functions as part of the ED internal circulation to support the clinical process's requirements may influence the ED workflow and overall operation.

B. Glanville and Howard (1999, p. 17_19) also identified in (Adler, 1999) ED main functions and their spatial relations that need to be included in the department. For example:

1. **Entrances:** EDs should have a private entrance due to the nature of their activities for running 24/7. Also, owing to EDs clinical demands, their traffic should not mix with outpatients and visitors. Besides, there should be a dedicated entrance for ambulance

cases separated from the walk-in entrance due to patients' criticality. A parking slots for ambulances near the ambulance entrance is also required.

2. **Reception and waiting area:** a registration desk is required for walk-in patients, and it needs to overlook the main waiting area. The reception and waiting area need to lead directly to the assessment and treatment area.
3. **Triage:** walk-in patients' needs to be triaged first on arrival for urgencies classification. A triage cubicle should be located near the reception and waiting area.
4. **The exam and treatment areas:** it can be an open space area surrounded by different cubicles. These cubicles will be used for the ambulance and walk-in patients, where some will hold couches. All cubicles should lead to a central working area equipped with a supplies station. Some of the cubicles will be used for specific clinical purposes such as ear, nose, throat, ophthalmic, pediatric cases, and alcoholic and drug patients. Besides, some of these cubicles might be used as a plaster room and a minor operation theatre—also, the need to have dirty and clean utilities and stores.
5. **Resuscitation areas:** they should be fully equipped with direct access to the ambulance entrance.
6. **Areas or rooms for short observation:** patients sometimes might be kept in the ED after assessment for various reasons, such as waiting for an inpatient admission or clinical purposes before patients are discharged. However, an observation area might be hard to preserve due to the high demand for beds in EDs.
7. **Children facilities:** it is argued that a separated treatment area for children is required with a separated entrance and waiting area. Although this is a challenging task to achieve (creating three separate routes for the ambulance, walk-in, and pediatric patients), there is a current pressure to incorporate this aspect.
8. **Pharmacy:** recently, patients are encouraged to use an external pharmacy; therefore, the pharmacy's location is not critical, but it should be easy to find.
9. **Staff private areas:** EDs' staff needs are essential to consider; therefore, rest and changing rooms are required. These rooms need to be located near the ED with sufficient space where staff can change their clothes and take breaks.
10. **Teaching facilities:** these facilities are another essential demand for EDs' staff, such as meeting rooms, seminar rooms, and study areas. They need to be located within or near the department.

Adler (1999) also explains that due to the ED's critical work environment when dealing with various medical conditions with different acuity that may arrive suddenly, it is critical to consider the relationship with other supporting departments. For example:

1. **X-ray:** depending on the total department area, these facilities can be located within the department for a fast process. Alternatively, they can be in a separate department with direct separated access, if necessary, for rapid diagnosis.
2. **Fracture clinics:** can also be the minor operation rooms. They can be accommodated in the department as one of the assessment cubicles or can be included near the department in an intensive treatment unit.
3. **The operational department:** there should direct access between the operational department and the ED.
4. **Orthopaedic and fracture clinics:** these clinics are usually one of the assessment cubicles in the ED, along with a plaster room. Nevertheless, they can be in a different department, where is this case, their relations with the ED are critical.

C. The UK Department of Health (2013, p. 56-63) provides another list of functions to be considered for being accommodated in ED. Equally important, it emphasises that EDs various functions have to be designed and arranged to suit the unique activities and clinical pathways in EDs. For example:

1. **Entrances:** There should be two entrances for EDs; a walk-in entrance, which is the main entrance to the department, and an ambulance entrance for patients arriving by ambulance. The walk-in entrance and the ambulance entrance should not cross paths.
2. **Reception and waiting area:** There should be adequate public services such as toilets, wheelchair toilets, and nappy changing.
3. **Interview room(s):** They are used to talk with patients and their families; therefore, they should be in a quiet area.
4. **Rapid assessment and treatment facilities:** these rooms are for patients' assessment and treatment. Some of these rooms can be used for patients with minor injuries and illnesses, and others for major injuries and illnesses. Some of these rooms should be located near the entrance for easy assessment on arrival. Not to mention, an isolation suite near the entrance might be needed for fast segregation. One of the rooms needs to be designated to deal with ear, nose, throat, ophthalmic and dental problems. Accessible toilets for patients and a store for clinical equipment are needed.
5. **Resuscitation areas:** Unless acuity-adaptable rooms are used, resuscitation rooms are required for patients with critical medical conditions. These areas need to have direct access from the ambulance entrance without going through the main waiting area. The resuscitation area should also be close to the assessment and treatment rooms with direct access for rapid patient transfer. It could be in a closed bay with single patients' rooms or private single patients' rooms. For example:

- Resuscitation rooms need to be able to accommodate the number of required staff and allowed family members. Also, the layout needs to support a 360-degree patient's access.
- Patients in resuscitation rooms may require surgical interventions; therefore, the room should be arranged and equipped according to the performed procedures with the ability to manoeuvre without interpreting the clinical activities. As a result, the selected equipment and fixtures should support efficient care delivery for the various activities that may happen in the room. For example, mobile X-ray machines can be installed, taking into consideration their safety and usability requirements.

Note: Acuity-adaptable rooms can be used for patients' assessment and treatment with various medical conditions from low to high acuity. Acuity in these rooms can be stepped-up/down to suit patients' needs.

6. **Decontamination rooms:** such rooms are required in "category one" emergency departments where the department can receive casualties of radiation, chemical incidents, in addition to major incidents.
7. **Clinical decision units (CDU):** these areas are used after the assessment and treatment phase, where patients might need further assessment and treatment before they are transferred or discharged. These units should meet the requirements of the inpatient ward.
8. **Dedicated children's facilities:** children attending ED may reach up to 30% of the department's patients. Thus, it should be considered in the design stage to create a separated flow system and area for children. Also, a waiting area under staff supervision that is separated from the adults one. On the other hand, large children's facilities may consider having a separate entrance and reception.
    - Children's exam areas should have child-friendly assessment and treatment rooms.
9. **Sitting room for bereaved persons:** these rooms need to have a non-clinical atmosphere for users to feel comfortable. These rooms should be located near the resuscitation area but far from any disturbing sound. Also, they need to be accessible from the resuscitation area without passing the department's public area. Besides, there should be a designated route for bereaved persons to leave without passing waiting and treatment areas.
10. **Staff rest and changing facilities:** such facilities are essential for staff to relax and take a break. Therefore, such rooms should have a window with a nice view, be comfortable, have a comfy furnished, and a telephone. These rooms should be located far from patients' treatment and traffic areas; they should also be near a pantry and other staff facilities. For example:

- Toilets for both male and female staff are required within these facilities and in staff changing rooms. The staff also needs spaces where they can take a shower and change their clothes while on duty.
- Facilities for both males and females are required to be separated.

11. **Teaching facilities:** it is essential to support staff learning, whether pre-arranged or spontaneous meetings. Thus, these facilities should have a seminar room and a library, along with a multifunctional training and education room. A seminar room should be in the ED for different purposes, such as teaching, meetings, conferences, and clinical instructions.
12. **Office accommodation and meeting rooms:** staff offices should be located within the ED. The offices' area should be accessed from a secure single controlled door.

The collected data above provides an initial understanding of EDs infrastructure and functions, which to support the delivery of emergency medicine. However, after reviewing the collected data above from different resources (Adler (1999); UK Department of Health (2013); Tarawneh (2018)), in addition to other guidelines for ED design, such as American Institute of Architects (2006); Australasian College for Emergency Medicine (2014); International Health Facility Guidelines (iHFG) (2017); Australasian Health Facility Guidelines (2019), they might be providing almost similar infrastructure regarding EDs main functions. For example, entrances and waiting areas, triage and registration, treatment and exam areas including resuscitation, acute, fast track, and other specialist zones and rooms, also, support areas, services, and staff areas. However, some of these guidelines provide a more detailed description regarding EDs required functions. Furthermore, EDs various functions need to be arranged and linked to facilitate and support the clinical procedures in EDs. Thus, it is essential to understand the different clinical pathway that different patients may take as part of their treatment journey to illustrate their flow in EDs. Further explanations are mentioned in the next section.

2.4.3 ED Clinical Patient Flow

EDs have a unique operational workflow that needs to be accommodated and supported by the spatial configuration. For example, EDs provide urgent healthcare services to various patients with various medical conditions. These medical conditions require different treatment procedures that follow different clinical pathways from arrival until the patient is admitted, referred, or discharged. These operational requirements need to be considered early in the design stage to support the delivered healthcare services (Huddy and McKay 1996; UK Department of Health 2013; Australasian College for Emergency Medicine 2014).

Moreover, Huddy and McKay (1996); and the Australasian College for Emergency Medicine (2014) identify several challenges that clinical user groups encounter during the design process of EDs. For example, and for what might be interesting for this research, neglecting the clinical practices in the

design stage will develop inadequate facilities that have no change in the clinical practices. Thus, staff might be forced to adapt their workflow and operational requirements to their environment. Thus, these clinical procedures need to guide the spatial structure design so the spatial structure, in return, can support and facilitate their flow. As a result, understanding the flow of the different pathways in EDs will inform the design of EDs spatial structure to support operational efficiency.

For example, Laskowski et al. (2009) provide a basic model of EDs assessment and treatment processes. In their model, patients will go through the following possible scenario Figure 3:

1. Patients will arrive either by ambulance or walking to the ED.
2. Usually, ambulance patients and some walk-in patients will require immediate medical care. Thus, they will be taken directly to an assessment and treatment area.
3. Walk-in patients who do not require urgent medical care will be directed to the registration counter, usually overlooking the waiting area.
    - If it were busy by the registration, patients would have to wait for their turn.
4. After registration, patients go to the triage office, which is usually near the waiting area.
    - If it were busy by triage, patients would have to wait for their turn, usually waiting in the waiting area.
    - In triage, a staff member will assess the patients' condition and assign priority depending on the severity of their condition.
5. After triage, patients will be directed to wait in the waiting area before they are called to a treatment room.
6. In the treatment area, patients usually wait for a physician to be treated depending on their urgency.
7. After the treatment is done, patients will leave the department, whether admitted, transferred, or discharged.

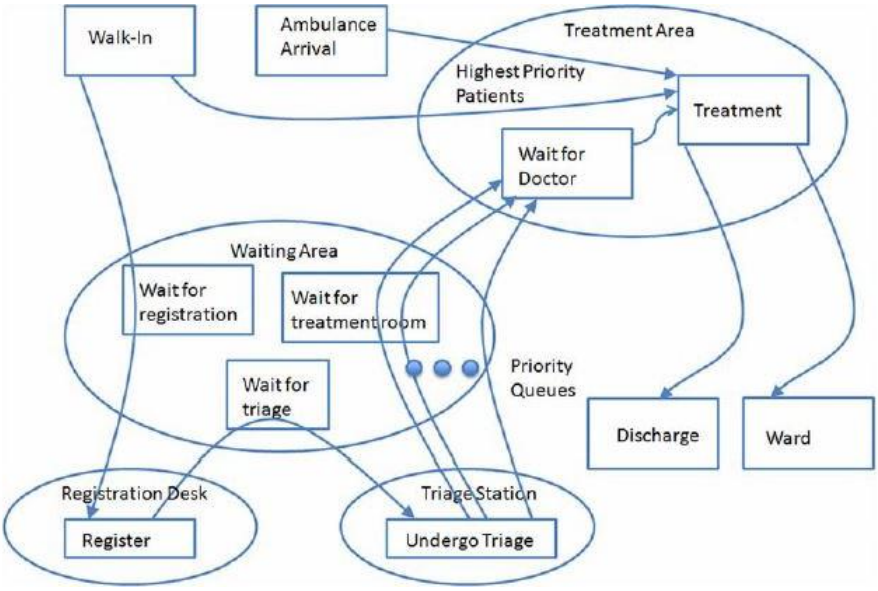


Figure 3: Model of ED treatment processes *(Laskowski et al. 2009)*

On the other hand, the UK Health Building Note 15-01: Accident & emergency departments. (2013) identify more detailed and specialised pathways for various patients' condition. The identified pathways in the British health buildings notes for ED are resuscitation, high dependency, low dependency, front door, or Clinical Decision Unit (CDU) pathways. These clinical pathways are explained below:

A. *Resuscitation pathways*

According to the UK Department of Health (2013), patients with critical medical conditions will be received in the resuscitation area, and then they will go through the following (Figure *4*):

1. The department will be informed in advance about the patient conditions from pre-hospital staff (ambulance, paramedic, doctor).
2. Patients arrive at the ambulance entrance. Alternatively, patients can be transferred from within the ED department, referred from elsewhere such as outpatient, or self-referred. Then the patients will be handed over to the ED staff members.
3. The patients will be taken directly to the resuscitation room where he/she will be provided with initial diagnoses and will be treated depending on the circumstances.
    - The registration may be done before the patient arrives at the bed.
4. The patient then might be discharged, admitted to the hospital, or transferred out.
5. If patients are admitted, they will be moved to Clinical Decision Unit (CDU), then discharged, admitted to the critical care unit, transferred to the operation theatre, or another ward.

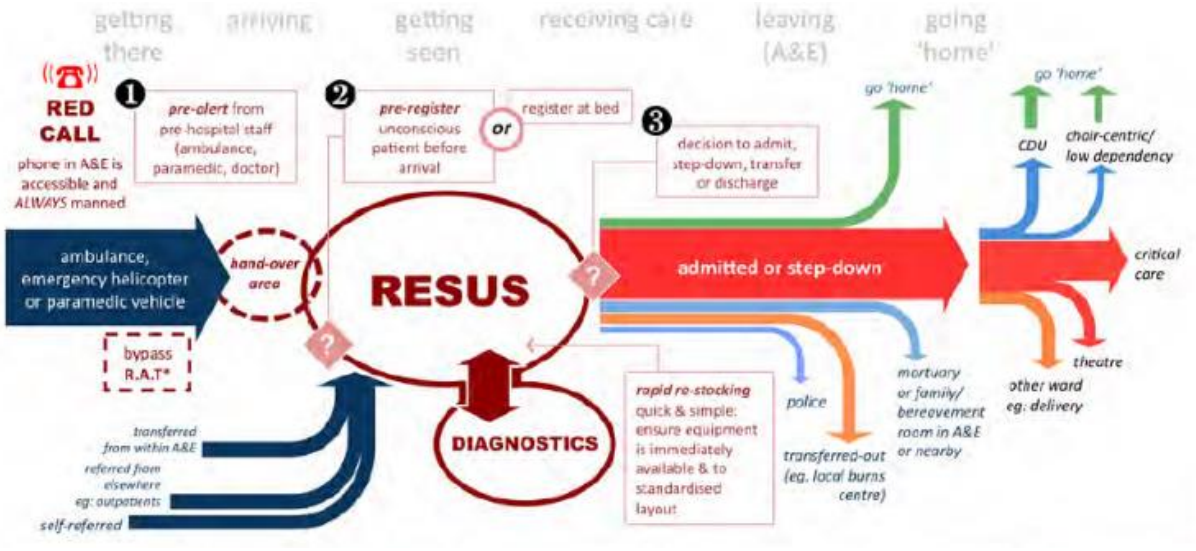


Figure 4: Resuscitation pathway *(UK Department of Health, 2013)*.

B. High dependency pathways

According to the UK Department of Health (2013), patients with critical medical conditions, but not to the point to be received in a resuscitation area, will go through the following (Figure *5*):

1. Patients arrive at the ambulance entrance, usually by an ambulance, where they will be handed over to the ED staff members. Alternatively, it might be a Walk-in patient, referred from elsewhere such as outpatient, or transferred from within the ED.
2. Patients will have a first nurse assessment; they will be booked-in, a brief history and all vital signs to be taken, symptoms and acuity stream determined, and transferred to a trolley.
3. A rapid assessment and treatment (RTA) will occur for ambulance patients at the entrance; then, they will be taken to the high dependency room. In contrast, walk-in patients will be isolated or booked-in to be transferred to the high dependency room.
4. In the high dependency, patients will have a second nurse assessment, such as vital signs and blood samples. These rooms are adaptable acuity rooms where care can be stepped up or down as needed without moving the patient. The Diagnostics area is closed to the high dependency unit: near-patient testing.
    - Assessment and treatment will be performed by an emergency physician, in-hospital specialist doctor, specialised nurse, emergency nurse practitioner, or a GP.
5. The patient then might be admitted, step-up/down, transferred or discharged.
6. If patients are admitted, they will be moved to Clinical Decision Unit (CDU), then discharged, admitted to the general ward, moved to low dependency, or resuscitation.

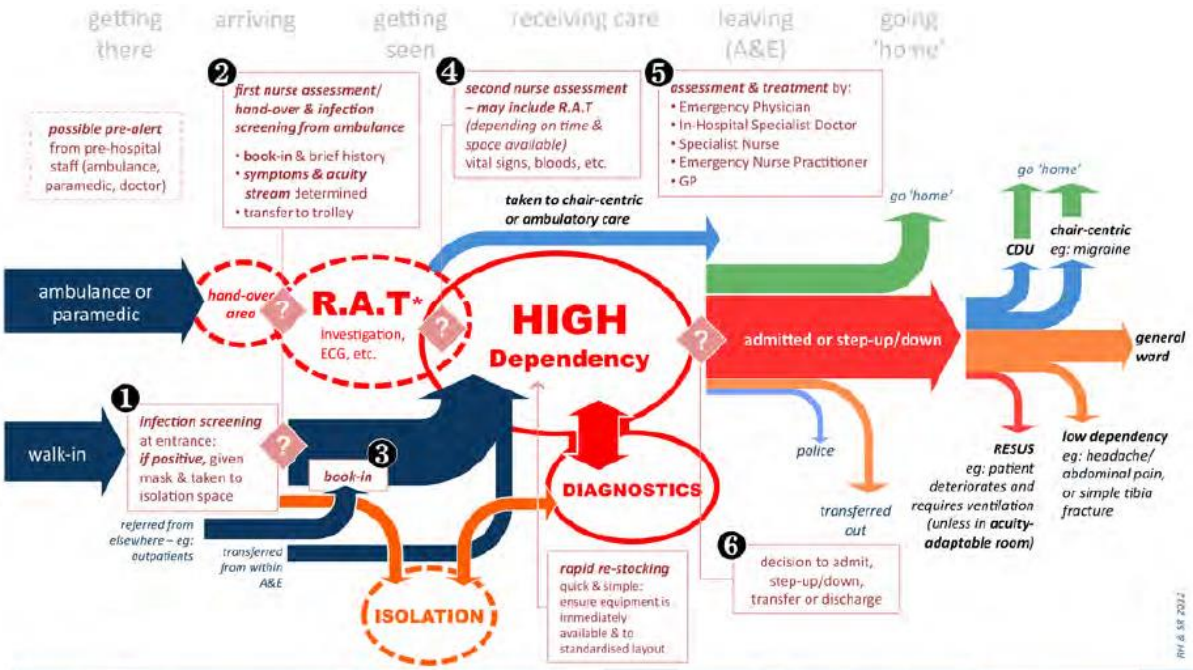


Figure 5: High dependency pathway *(UK Department of Health 2013)*

C. Low dependency pathways

According to the UK Department of Health (2013), low dependency patients require minimal levels of nursing intervention and care, and they will go through the following (Figure *6*):

1. Patients usually arrive through the walk-in entrance or the ambulance. Alternatively, they might be transferred from within the ED or referred from elsewhere, such as outpatient.
2. Patients might be isolated or asked to wait before they are admitted to the department for diagnostics.
3. Patients will have a detailed nurse assessment at this stage; they will be booked-in, a brief history and all vital signs to be taken, symptoms and acuity stream determined, and investigation requested.
4. In the low dependency, patients will have an appropriate investigation in the diagnostic area. For example, X-Ray, CT Scan, and blood test. More intensive investigation and near-patient testing. These rooms are adaptable acuity rooms where care can be stepped up or down as needed without moving the patient.
    - Assessment will be performed by an emergency physician, in-hospital specialist doctor, specialised nurse, emergency nurse practitioner, or a GP.
5. The patient then might be admitted, step-up/down, transferred or discharged.
6. If patients are admitted, they will be moved to Clinical Decision Unit (CDU), then discharged, admitted to the general ward, or be sent to the resuscitation.

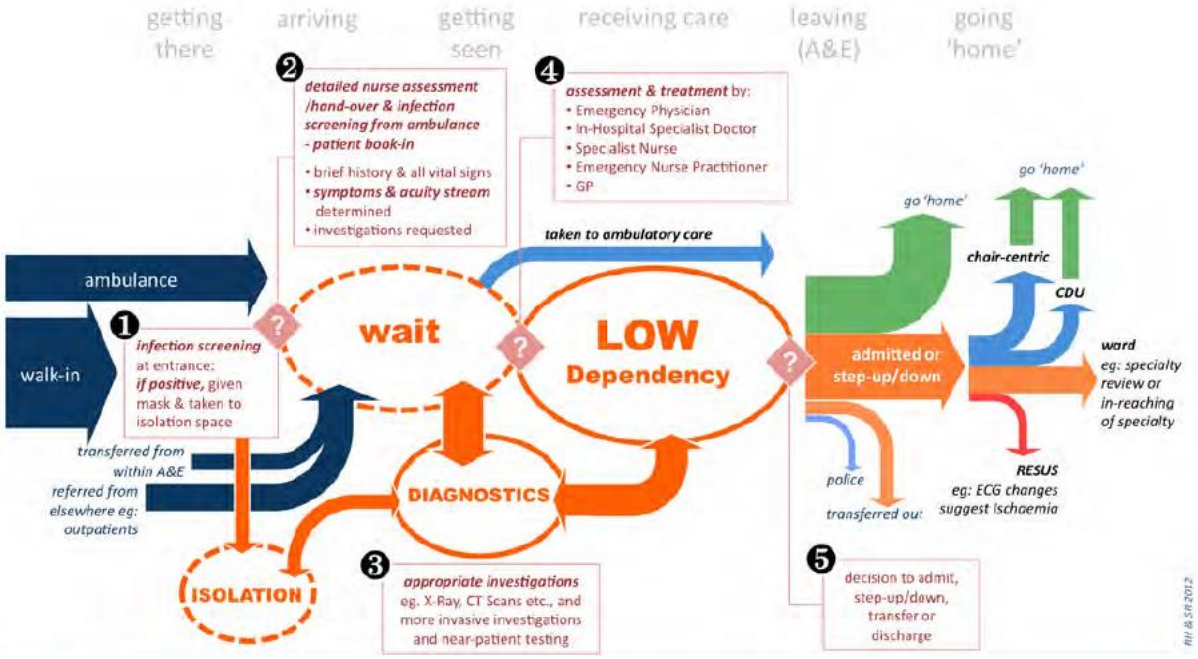


Figure 6: Low dependency pathway *(UK Department of Health 2013)*

D. Front door pathways

According to the UK Department of Health (2013); front door patients are less critical than low dependency patients, where long waiting may occur, and they will go through the following (Figure 7):

1. Patients arrive mainly through the walk-in entrance. At this stage, patients will give initial information before they are asked to wait where they might be redirected.
2. Patients might be isolated or asked to wait before they are admitted to the department for diagnostics.
3. Patients will have a secondary nurse assessment of symptoms and acuity at this stage, they will be booked-in, and investigation requested.
4. Patients will be told to wait in the waiting area, depending on their acuity.
5. After patients are admitted, they will have an appropriate investigation in the diagnostic area—for example, X-Ray, CT Scan, and blood tests. Also, a more intensive investigation near-patient testing. It will happen in chair centric or other appropriate clinical areas.
    - Assessment will be performed by an emergency physician, in-hospital specialist doctor, specialised nurse, emergency nurse practitioner, or a GP.
6. The patient then might be admitted, step-up/down, transferred or discharged.
7. If patients are admitted, they will be moved to Clinical Decision Unit (CDU), then discharged, admitted to the general ward, or resuscitation.

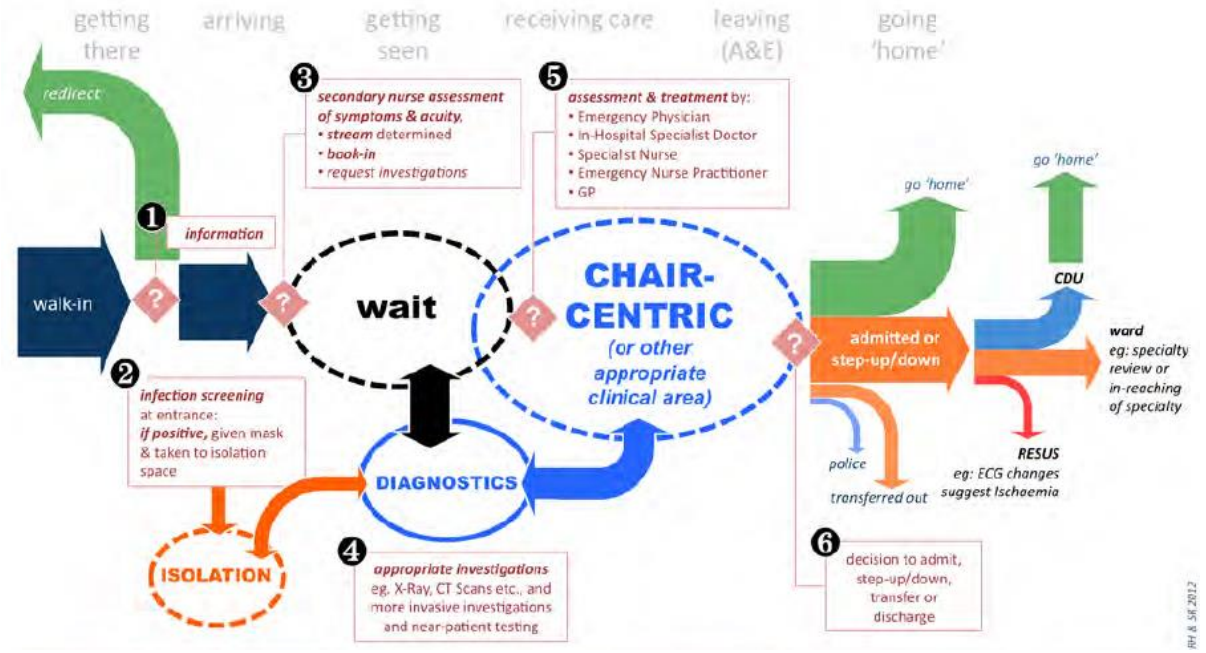


Figure 7: Front door pathway (UK Department of Health 2013)

In summary, after reviewing the above data regarding pathways that users may follow in EDs, additional guidelines for EDs design were also reviewed to explore further ED's clinical pathways. For

example, the American Institute of Architects (2006); the Australasian College for Emergency Medicine (2014); the International Health Facility Guidelines (iHFG) (2017); and the Australasian Health Facility Guidelines (2019). Thus, the UK Department of Health (2013) provides a more comprehensive explanation of various clinical pathways for various acuity levels. However, what seems to be lacking is a comprehensive and more detail explanation of the clinical processes and their relationship with the spatial structure. In other words, how the spatial structure may influence EDs function and operation to fulfil the clinical requirements will determine the efficiency of spatial performance. The main goal of any clinical model of care is to reduce unnecessary steps during different users' journey, such as staff and patients, and to optimise the required time for each step during the journey (Australasian Health Facility Guidelines 2019).

On the other hand, design guidelines in general and ED in this research might require flexibility when proposing design guidance. They can be used for different types of EDs and be adapted in different environments and cultures (Abdelsamad et al. 2018). Also, having these flexibilities will ease spatial development, especially in medical equipment and clinical operations.

2.5 Previous research on issues around ED design and space

Patients flow in EDs is hindered when the demands for ED services, such as triage, diagnostic images, laboratory tests, and speciality consultations, exceed the department physical and/or staffing capacity, which results in overcrowding (Walley 2003; Yoon et al. 2003). This can also be explained by the high percentage of hospital patients who were admitted to the hospital through ED (Dawson et al. 2008). Also, inappropriate facility design can cause many difficulties. In EDs, for example, overcrowding, access block (being refused to enter the ED due to insufficient resources and space) and long waiting times are major problems, which may have massive negative consequences. For example, increased mortality rates, poor care quality, delays in treatment, delays in hospital readmission, an increase in patients' length of stay, long waiting time, an increased number of patients left without being seen (Carter et al. 2014; Yarmohammadian et al. 2017), (further explanations are mentioned in the introduction chapter under heading "1.2.4 Crowding in Emergency Departments").

Several healthcare sector professionals believe that current EDs lack meeting their users' expectations, whether staff, patients and families (Abdelsamad et al. 2018). Thus, Methods for prioritising ED functions and their arrangement and spatial relationships are still debated in the literature. Several scholars have carried out various studies to improve ED operation by improving patient flow and reducing the wasted time to solve EDs main challenges of overcrowding and long waiting times. For example:

- Chan et al. (2014) mentioned that EDs face various problems, such as crowding, access block, high cost, and increased demands for emergency healthcare services. Therefore, they sought to Improve patients

flow by applying lean management as a quality assurance method that focuses on improving the process. It was used to find the non-value-added and time-wasting processes that are hindering patients' flow in EDs. For example, any activities that do not support patients' treatment journey and may cause a delay in receiving their cure are considered waste. Kolb et al. (2008); and Chan et al. (2014) argue that significant waste in EDs can be, for example, waiting time to be seen, waiting time for the next treatment, waiting time for admission bed, and blood testing time, which is a significant cause of overcrowding and long waiting time. However, (Chan et al. (2014) have applied series of lean management work to improve the admission and blood result waiting time. For example, they implemented a structured re-design process, improved communication with medical department, priority admission triage (PAT), and the use of the latest generation of cardiac enzyme testing (blood test) called high sensitivity troponin-T (hsTnT). After implementing the mentioned changes, the waiting time for triage, consultation, blood result, admission, total process time and the total length of stay in the ED were compared for before and after the lean management modifications. The most time-consuming processes were to wait for an admission bed and blood testing result. Therefore, the study concluded that lean management could reduce the wasted time and improve patients flow, which can further improve patients' efficiency, quality, and safety. As a result, Chan et al. (2014), based on a quantitative lean design study, found that redesigning EDs spatial structure can cause a reduction in waiting time. For example: reorganisation the layout of the consultation rooms, increase the number of consultation rooms, relocating treatment areas, **reconstructing the nurse station**, and redesign the signage to improve wayfinding and improve patients' flow. These results agree with Simon and Canacari (2012) were they also argue that reorganising EDs' spatial structure can reduce patients waiting time. Finally, the application of lean management can improve patients flow in the ED.

- Tawfik et al. (2014) used facility layout planning algorithms to improve the physical design of an ED in Malta to reduce overcrowding during disaster situations. They sought to create a new layout that includes major ED spaces without expanding the available area. The new proposed construction layout is created using a computerised relationship layout planning (CORELAP) algorithm, a closeness relationship design. To apply the simulation to improve ED design, they collect ED data, as such, patients' arrival rates, duration of activities, delays time, number of patients in each activity, and ED resources. Moreover, to imitate ED real work, ED real system is represented with specific elements. For example, the basic elements used in the simulation model include ED process flow chart, patients and staff as entities, delays periods, and activities in ED, such as triage, treatment, etc. Also, used resources to perform ED activities, such as beds and equipment, and entry routine activities for staff and patients. Thus, after running the simulation using the collected data, the ED was improved by modifying spaces without increasing the ED total area. For example, relocating beds in the simulated area and increasing or decreasing beds reduces patients' waiting time to be treated. The results also showed a reduction in crowding and an improvement in patient Flow. However, the spatial

relationships between spaces were determined by planners rather than users. Also, using the numeric values of the assigned relationships by CORELAP does not adequately represent the relationships between the spaces. Hence, it may not be appropriate in many layout scenarios because it does not adequately represent that one relationship is much more important than the others. Therefore, they argue that the assignment of suitable user values is needed to create a layout that achieves the closeness rating as relevant as possible.

- Other researchers proposed creating additional services within EDs called Patients Buffer to reduce overcrowding and long waiting times. In the buffer system, the buffer staff will protect the ED staff from disruptive routine matters by efficiently organise waiting periods. Therefore, these services were created to reduce pressure on ED sub-units by creating an extra organised waiting space for ED's patients, which allows patients' movement to be more flexible, thus reducing overcrowding. For example, Kolb et al. (2008) argue that a major cause of crowding in EDs is the waiting time for patients, who they are occupying a bed in the ED, to be admitted to the inpatient unit. Therefore, they proposed a solution to reduce overcrowding in EDs, where they created an extra service within the ED named the Patient Buffer. They tested five-buffer systems in patients flow to reduce pressure on the ED. They interviewed various staff and managers in a local hospital in the US to better understand ED processes to be part of their simulation. As a result, the patients' buffer concept in the design reported a reduction in patients' total length of stay in the ED, increased patient satisfaction, and improved the process flow.
- Welch (2012) listed several factors that could improve ED service quality. Some of these factors included human resources (such as the integration of medical teams), administrational controls (such as establishing express admission units), and architectural design problems (such as the establishment of intake pods zones and discharge kiosks).
- Hayward (2016) Identified some operational issues that cause crowdedness and long waiting time in a selected ED as a case study, for example, shortage of intensive care beds at the hospital, which increases the length of stay for admitted patients waiting for a bed. Also, turnaround time in assessment and treatment areas caused by delays in response from the imaging department, delays in specialist consultations, and the number of admitted patients waiting for a bed to become available in the inpatient department, which all increases patients' turnaround time. The findings were that even minor improvement in the turnaround time in treatment rooms would significantly influence space usages (Hayward 2016a). Therefore, the design team took the approach to improve the turnaround time in assessment and treatment areas before embarking major structural changes. Thus, the leadership decided to use adjacent health clinics to triage, assess, and treat non-urgent patients during the weekends and evenings, where they usually are closed. Also, they reconfigured the treatment areas to become twenty-five good size rooms and cubicles for treatment—moreover, adjacent office spaces were reconfigured to enlarge patients' and families' waiting areas. The result was a temporary

solution where the department will be monitored and re-evaluated in the future. Hayward (2016) also found that creating a holding area for admitted patients waiting for a bed to become available in the inpatients' ward will reduce pressure on the ED. Beside, Hayward (2016) mentioned that a solution for expanding EDs might raise concerns, where such expansion may require more staff to be hired, which will put more pressure due to the limited budget EDs' have and the difficulty in recruiting staff.

- An interesting study was done by Abdelsamad et al. (2018), where they argue that EDs major problems, such as crowding, increased length of stay, and high mortality rates, are caused due to the lack of stakeholders' involvement in the design process. Therefore, they proposed a new hybrid design model based on stakeholders' requirements and the international standards to reassess the major design solutions for ED that would improve the flow within the ED. Also, assign priorities and weights for ED's functional units that need to be included in the department. The new hybrid model was created by combining the requirements of the international standards with stakeholders' needs using quality function deployment (QFD). This model was based on a large survey to collect stakeholders' functional requirements (physicians, nurses, administrators, technicians, clinical engineers, healthcare planners, pharmacists, and non-ED physicians) and international standards requirements. The survey was conducted in two different contexts: Saudi Arabia and Egypt. As a result, the proposed model assigns priorities and weights for ED's functional units; therefore, medical planners (designers) can prioritise and select the ED's required functions based on their weight, which might be required when space and budget are not enough. They also suggested that international design standards should have more structured methods for incorporating stakeholders' views. Furthermore, a certain degree of difference should be allowed depending on the hospital's context to reflect cultural and environmental differences, which what this research seeks to explore in more details regarding the Jordanian context.

  However, the distributed surveys included questions about functions that need to be included in the ED to improve the design, efficiency and enhance patients' satisfaction. These questions were based on a 5-point importance scale. Besides, they relied on experienced healthcare planners, the international standard, and the literature search to translate stakeholders' requirements into design specifications to understand EDs design, functions, and relationships. They stated that it was a challenge to rely on experts to develop the relationship. Although there was no significant difference in respondents' demographic data from both countries, the authors recorded differences in stakeholders' requirements between the two EDs. For example, differences in 75 requirements were nonsignificant, while differences in 9 requirements were significant. Therefore, this may indicate that the operational model and the clinical requirements differ in different contexts. Therefore, the spatial relationships depend on various factors, such as the operational model, type of patients' conditions, and hospital location.

Various scholars conducted other studies to improve ED operation, reduce patients' length of stay in EDs, and to reduce pressure on EDs to solve their main challenges of overcrowding and long waiting times. These studies are, for example, creating additional services for EDs to reduce pressure on ED sub-units and accordingly reduce overcrowding, such as Rapid Assessment Zones (RAZ) (Bullard et al. 2012) and Clinical Decision Units (CDU) (Roberts et al. 2010) model as permission alternatives to ED services. A four-hour target was proposed to reduce patients length of stay in EDs (Banerjee et al. 2008; Horwitz et al. 2010). Although it may have some negative consequences regarding the quality of the delivered healthcare services (Mortimore and Cooper 2007; Banerjee et al. 2008; Hughes 2010), these quality measures may have the possibility to encourage changes in ED processes (Horwitz et al. 2010). Producing a conceptual model to partitions crowding in EDs into input, throughput, and output as three interdependent components as part of a proposed framework to tackle ED main problem of overcrowding (Asplin et al. 2003). Increase staffing and resources (Hoot and Aronsky 2008). Create observational units in EDs, such as for patients with chest pain, to reduce the pressure on the ED (Martinez et al. 2001). Facilitate ED patients' accessibility to hospital beds (McConnell et al. 2005; Moloney et al. 2006). Increase ED capacity even if it was not in close proximity to the main ED (Kelen et al. 2001)

In conclusion, redesigning EDs spatial structure can cause a reduction in waiting time and improve operation and flow. However, research about the spatial relationships between EDs various functions is still limited and lack comprehensive explanation to improve spatial performance. To emphasise, EDs have controlled work environments that follow a specific set of routine spatial activities to fulfil the various clinical requirements. For example, the spatial treatment journey that patients with specific medical conditions have to take by moving from one space to another to fulfil the clinical requirements. Thus, they have unique spatial practices, which are considered as the interplay between spatial configuration, organisational configuration, and the configuration of work processes and routines (Koch and Steen 2012). Therefore, no explanations have been found to understand the link between the spatial structure and the operational activities in different contexts. The reviewed evaluations processes in other research papers to illustrate patients' pathways is not thoroughly explained in the reviewed literature and do not reflect on ED's clinical spatial relationships, which depend on various factors, such as patients' acuity, their medical condition, and the adopted medical processes in different contexts. Also, the lack of users' involvement (mainly staff) is identified among the reviewed studies, where some researchers relied on medical planners and expert healthcare designers to understand the clinical requirements and operations. Thus, the researcher agrees with Koch and Steen (2012) argument that it is essential to understand how and where activities occur to find the relationship between spatial configuration and operations, where clinical processes are of EDs main activities. As a result, this research sought to understand EDs operation further and functions

spatial relationships in the Jordanian contexts based on the functionality of two existing case studies. Thus, spatial adjacencies and complexity are the main factors that influence the spatial performance.

2.6 Technology, information, and communications

Healthcare facilities will always be under the direct influence of the ongoing development in information technology, such as the development in data processes and its use in handling patients' records (Francis et al. 1999). Also, the development in information and communications technology systems between the different departments will allow clinicians to access patients' data, reducing wasted time and improving admission and discharge decision time (UK Department of Health 2013). Besides, the constant growth in information technology will change the ways of interaction between patients and healthcare providers, such as video conferences. Francis et al. (2001) believe that remotely medicine and healthcare delivery are awaited to be the future model for healthcare delivery systems. Besides, development in biomedical engineering and medicine will probably change the design and management of healthcare buildings such as hospitals. For example, innovations, such as automated laboratories and surgical units, will probably shift healthcare facilities planning, design standards, and work nature (Francis et al. 1999). Thus, such changes in technology and their impact on space and planning must be considered by healthcare designers (UK Department of Health 2013).

In conclusion, as the focal point of this research, ED would benefit from the technological developments in the healthcare systems and the shift toward a more remotely medicine and healthcare delivery. Such advancements in such critical environments would improve operational efficiency by reducing wasted time in the current sitting due to the current practices. For example, the availability of portable radiology, advanced blood testing machinery, and advanced communication instruments in the ED and with other departments when needed will improve operational efficiency by reducing wasted time. Also, the adaptation to remotely and virtual consultations with patients requiring unurgent ED services would reduce pressure on ED. However, the design might be influenced by the required spaces and their sizes. For example, the functional relationships might be hard to change owing to their criticality when dealing with a different type of patients with various medical conditions., which will be investigated in this research.

2.7 Design evaluation

Architectures are usually complex and may involve many design compromises. Not to mention, that some architects might be working in a vacuum, drawing and creating spaces that may or may not work best for the given organisation. Therefore, conducting a formal analysis and evaluation for the designed organisation will give the privilege to find whether the design decisions made are advisable ones that appropriately alleviate risks (Kazman et al. 2000). Furthermore, building evaluation usually focuses on technical performance, functional performance, and beauty performance (Fronczek-Munter 2013). Thus, evaluating the design will provide an insight into the building experience;

therefore, lessons will be learned, and mistakes are avoided. Nevertheless, in general, architects rarely evaluate buildings in use due to being considered long and expensive process as part of the project. Also, what may discourage architects from conducting evaluations for after occupations is that fees are generally not available for this kind of work and the risk of identifying design deficiencies that could expose architect to insurance claims.

Cold (2012) in Fronczek-Munter (2013) identified three reasons for making evaluation:

- Recognition: to collect a general understanding of space and experience.
- Control: to collect users' experience and use of the space, which to form knowledge.
- Professional information: to collect experts' evaluation, which to discuss and inform.

Also, the British Council for Offices - (BCO) (2007) proposed two reasons to conduction a Post Occupancy Evaluation (POE). First, collect feedback about the workplace's successfulness to support the occupying organisation and the end-users' requirements. Second, to assess if the organisation program requirements were achieved. As a result, evaluating the design after occupation and collecting information on challenges and difficulties that may impact the healthcare delivery services will be advantageous. Thus, it will enlighten stakeholders by influencing their attitudes and increasing their awareness (Hayward 2016) to supporting future improvements.

There are different evaluation methods and tools that can be used for buildings' assessment; one, for example, is Post Occupancy Evaluation (POE), which is the most known evaluation method for buildings (Preiser et al. 2015)

2.7.1 Spatial practices evaluation

According to Hillier (2007), buildings are fundamentally about movement and how it is generated and controlled. However, movement may differ in different settings and for different tasks. For example, Koch and Steen (2012) mention the differences between movement time versus the time spent in each location also, how a specific range of movements and activities are more programmed than others in different environments, which is defined by the organisation and its activities. Moreover, Hillier (2007) defines an organisation as a list of roles and statuses with no necessary relation to a form of space. Although not necessarily how it functions, its description would be the same regardless of its spatial configuration. However, workspaces in any organisation are centred around specific locations and activities in them. Therefore, to find the relationship between spatial configuration and activities, it is essential to understand how and where activities occur (Koch and Steen 2012).

Understanding the workflow in healthcare facilities and how the different functions are connected in the layout, which is governed by the treatment processes, can predict challenges in staff daily walking routines (Yi and Seo 2012), which can be explained through the concept of spatial practices. Spatial

practices can be considered the interplay between spatial configuration, organisational configuration, and the configuration of work processes and routines (Koch and Steen 2012). Therefore, in healthcare facilities, such as EDs, different variables may define spatial practices. For example, different specialisations of workflow among different users for various roles and different responsibilities. Therefore, spatial performance can be evaluated in EDs by understanding the spatial practices. For example, recording the movement to understand the practices correlated with the design and the programme. Thus, it can be done by recording users' movement routines for various activities, which will help identify the importance of understanding the program and its needs. Therefore, in this work, spatial practices can be described as users' movement routine patterns (operation)

2.7.2 Post Occupancy Evaluation (POE)

Zimring and Reizenstein (1980) define POE as "the examinations of the effectiveness for human users of occupied design environments." Preiser et al. (2015) say that POE is "The process of evaluating buildings systematically and rigorously after they have been built and occupied for some time." In POE, users' satisfaction and functional suitability in spaces are its primary considerations (Zimmerman and Martin 2001; British Council for Offices (BCO) 2007), also, whether the primary goal of the organisational program was met (British Council for Offices (BCO) 2007). Therefore, achieving users' needs and functional requirements are the main judgment criteria in POE, where all users' needs are integrated into the design. Because as mentioned by Zeisel (1997), the design process should be recurrent, where it is continually improving with the integration of continuous feedback. POE might be the logical step that needs to be taken as the final stage in a continual design process. Because collecting occupants' experiences after occupation regarding their spaces will help improve the currently occupied areas and guide future buildings' designs (Zimmerman and Martin 2001; Hay et al. 2018). Thus, POE is unique because it generates recommendations based on all stakeholders' experience in the building regarding productivity and well-being (Preiser et al. 2015). According to Preiser et al. (2015, p. 53), there are three degrees of details in POE:

- Indicative approach: this approach will be providing a quick overview of the building's performance. Such an approach can be made by a walk-through assessment, interviews with key employees, meeting with users, and a general inspection.
- Investigative approach: this approach will provide a detailed evaluation of the building. Such an approach can be made by doing a detailed evaluation, surveys, interviews, taking photos, recording videos, on-site measurements, literature research, and exploring state-of-the-art buildings.
- Diagnostic approach: this approach will provide detailed information based on state-of-the-art buildings. Such an approach can be done by an extended and cross-sectional evaluation of performance, explore variables, and literature research.

Traditionally, during the design and programming process of buildings, decisions were made based on general understanding and assumptions about an organisation's functions and how spaces will be used. However, conducting a POE will provide valuable results to support continuous improvement. Consequently, an appropriate POE will produce reliable information to guide decision-makers, where real information will be collected to inform and ameliorate future projects (Zimmerman and Martin 2001). Thus, Zimmerman and Martin (2001) mentioned some benefits of conducting a POE, for example: continuous feedback to support a constant development, enhance the relationships between users and their buildings, services optimisation to suit occupants' needs, reduce wasted spaces and energy, endorse users' needs, and reduce operational cost. Besides, clients would be concerned in POE as a mean to develop their facilities and users' performance (Bordass and Leaman, 2005)

On the other hand, conducting observations might be associated with some difficulties that may compromise the validity and reliability of the obtained results, such as when people are aware that they are being observed and when conducting observations in busy environments like ED. Kumar (2014) mentioned that limitation in observation might also occur, as such, the possibility of observer bias, interruption of observation and incomplete data, and inconsistent interpretations. Therefore, conducting observations to collect reliable empirical data in healthcare facilities are often very demanding, requiring a significant amount of planning and preparation to ensure the reliability of the data collected without disturbing the activities at the examined settings.

2.7.3 Space Syntax as a tool for evaluating spatial layouts

One of the main objectives of this study is to understand the spatial relations of EDs. Therefore, this investigation requires a tool to capture the impact of the spatial structure of a layout on EDs operation as architectural environments. Peponis and Wineman (2002, p.276) stated that "The origin of examining the essential function of the spatial layout is deeply rooted in studies of environment and behaviour". Thus, a syntactic approach can be used to analyse the spatial environment to understand the logic of operation and usages according to measurable spatial attributes of the functional distribution in EDs. Therefore, they assess the validity of using plane base analytical approaches for EDs spatial environments.

Space Syntax was invented and developed at the University College of London (UCL), the Bartlett Unit for Architectural Studies. It represent, quantify, and interpret spatial environments in term of their social relationships (Hillier and Hanson 1997), which might be the only available syntactic approach to investigate the social logic of spaces. Thus, Space Syntax's theory attempts to predict humans' behaviour and social activities from the spatial configuration (Hillier 2007). Moreover, the significance of space syntax theory is that it is a quantitative tool that can capture the relationship between human behaviour and the spatial environment, encouraging the theory's continuous development. Hanson and Zako (2005) stated that space syntax techniques were the first to illustrate a clear systematic

relationship between the spatial structure and the observed functioning in a range of buildings and urban environments in a numerical way.

Also, Space syntax theory, with its analytical techniques, has been applied in various fields, such as urban design, architecture, and interior design. It was also used in anthropology, archaeology, geography, and information technology. Also, the focus of the theory is to evaluate the pattern of predestination movements. Moreover, it was also used for modelling urban traffic, predict the levels of air pollution, and many other aspects (Ratti 2004).

Space syntax claims that relatively simple spatial relationships can determine how people used, occupy, and move through the analysed building or urban environment, studying the spatial structure in an abstracted way (Klarqvist 1993). Therefore, the relationships between spaces in an environment allow the investigation of the environment use and functioning socially. Space syntax has been used in academic research in various fields, mainly in architecture in both building and urban design. Besides, researchers used space syntax to produce evidence that shows high associations between the way spaces are used and space syntax predictions, for example: pedestrian movements patterns in urban areas (Hillier et al. 1987; Hillier et al. 1993; Ozer and Kubat 2007), crime pattern in urban layouts (Hillier and Shu 2000; Nubani and Wineman 2005), commercial land use and values (Desyllas 2000; Min et al. 2007), and traffic assessment tool (Barros et al. 2006). (Hillier and Hanson 1984) argue that in space syntax analysis, spaces that are highly accessible and visible in the environment are likely to encourage social interaction, while segregated spaces may not support social interaction. Also, they argue that space with high integration value is an indication that space is in the centre of the organisation. Besides, integration properties can predict users' behaviours in spaces and determine the design's functional outcomes accordingly. To support this, a number of researchers conducted studies in different urban environment with various scales, and cultures, reported notable correlations between space syntax measures, such as integration, and the number of people in the space (Peponis et al. 1989; Hillier et al. 1993; Peponis et al. 1997; Read 1999).

2.7.3.1 Space syntax analytical techniques

Space Syntax provides a set of theories and technique that can be used to analyse and describe any spatial configurations, mainly when the spatial configurations have a significant influence on humans' affairs, such as in cities and buildings in an objective way (Hillier and Hanson 1984; Klarqvist 1993). Therefore, it allows the researcher to understand the social logic in these spaces. Thus, it is argued that the result of this analysis can predict the relationships between the spatial configuration and the behavioural activities in the analysed space. Hillier et al. (1987) define the spatial configuration as the relationship between, at least, two spaces considering the third space, and at most, the relationship between all spaces in a complex, taking into consideration all other spaces in that complex.

The Syntactic relations for the spatial configuration in Space Syntax can be represented visually or mathematically (Hillier et al. 1987). The former provides justified graphs (Node and connections) that explain the hierarchy of the entire layout. Simultaneously, the latter produces different measures to describe the spaces, such as control, integrations, and connectivity values.

A. Visual Representation in Space Syntax

Floor plans are a valuable source of data that can be used to analyse the main characteristic of architectural spaces. Accordingly, converting the spaces in the layout into an abstract form without considering the geometrical characteristics is useful for analysing the spatial structure. It can be analysed by using circles (nodes) to represent the spaces and lines (syntactic steps) to represent the spatial relationships in the entire layout (Klarqvist 1993). Such analysis can be employed to study the hierarchy of spaces, relations orders and assess the influence of the layout on users (Li and Klippel 2010). It is presented visually in what is called "justified graphs", where they show the total depth of the spaces in the entire layout from one space (Node). Thus, when most the nods are near the bottom of the graph, the system can be described as shallow. On the other hand, when most the nods are far from the bottom of the graph, the system can be described as deep. However, justified graphs produce a static description of the spatial configuration in two-dimensional graphs, while space syntax seeks to capture the dynamic of the social life in space (Bafna 2003).

B. Mathematical Representation in Space Syntax

Different space syntax measurements could be used to quantify syntactic relationships between spatial components in the spatial configuration. These measures can be local or global. The former does measure the relationships between spaces and their immediate neighbours. The latter measures the relationships between space and all other spaces in the configuration (Hillier and Hanson 1984; Space Syntax – Online Training Platform). For example:

- Connectivity (NCn): measures the number of direct neighbours directly connected to a specific space. For example, corridors may have the highest connectivity values in spatial structure, while stores might have the lowest connectivity values.
- Integration (i): measures the average depth of space to all other spaces in the layout. To explain, integrations value measures the shortest path from one point to all other points in the layout, where the higher the number, the more the space is integrated.
- Control Value (CV): measures the degree to which a space controls access to other spaces directly connected to it, considering any alternative connections that these neighbour spaces have.
- Mean Depth (MD): measures the average depth (or the average shortest distance) from one space to all other spaces in the system.

- Relative Asymmetry (RA): measures the depth of the system from a particular point; therefore, the higher the value, the more the space is segregated, controlled, and has more privacy. While the lower the value, the more the space is integrated, accessible, and has less privacy.

2.7.3.2 Syntactic Maps

Space Syntax can also produce different types of syntactic maps. For example:

A. **Justified graphs:** Justified Graphs produce node and connection graphs by evaluating the entire layout, displaying the hierarchy of spaces and the total depth of each space. Justified graphs are restructured by having a specific space at the bottom of the graph called "the root spaces". In Justified Graphs, spaces that are one syntactic step away from the bottom (root space) are placed on the first level; spaces that are two syntactic steps away from the bottom are placed on the second level, and so on. Thus, they produce a visual image of a layout's overall depth calculated from one of its points (Klarqvist 1993). Different type of spatial layout that can represent syntactic connections between spaces:
   - A tree-like justified graph: most of its nodes (levels) far from the bottom node. Such systems are described as deep, where it has a high mean depth value.
   - A bush-like justified graph: most of its nodes (levels) near the bottom node. Such systems are described as shallow.
   - A ring-like justified graph: the provision of interconnected rings of movement in a layout offers choices for movement routes reducing the depth of space.

   However, justified graphs are limited in capturing the properties of the spatial configuration (Bafna 2003)

B. **Convex maps:** a convex map is another syntactic representation of architectural space. It represents adjacency relationships by reducing the spatial complexity to the fewest and fattest convex spaces. Therefore, in each convex space, all pairs of points are inter-visible. Thus, Spatial adjacency is the fundamental relationship that characterises how structures might be configured in a spatial layout. Any two spaces are considered adjacent when it is possible to access one space directly from another without passing through intervening spaces.

C. **Axial maps:** “Axial lines” or “Lines of Sight” are the longest accessible lines covering all convex spaces in a map or a floor plan to reduce spaces of movement between functions. In axial representations, depth is identified as the change in direction between one axial line and another. Therefore, depth is topological, which has no geometric value. Thus, the number of turns to move between spaces is what is measured rather than metric distances. Moreover, Axial maps have been the most used space syntax technique to describe and analyse urban spaces by configuring their street network (Ratti 2004)

D. **Isovist maps:** represent the visible points that can be seen from a vantage point in an environment. Thus, the perception of the visual environment is linked with a single point (the observer). Therefore, the visual perception will change during any movement in the space due to the change in the observer position (Benedikt 1979). Furthermore, the location of the generating point and its surrounding physical environment control the size and the shape of the generated isovist. However, isovist maps were not used much in architectural research; for example, (Turner 2001) says that there is no clear theoretical framework to used isovist result to explore social issues. Not to mention, it only describes the visual field of a point in the spatial structure, where it does not describe the visual relation for the entire spatial environment (Turner 2001).

E. **Visual maps:** a visual map like **'Visibility Graph Analysis (VGA)** represents the visual access to the entire layout at a time. It is constructed to analysing the reflection of light to calculate the movement patterns of users. To explain, it is used to explore the spatial structure of the entire environment and to explore the differences in behaviours. Thus, It provides modelling and a prediction of how spaces are being used and perceived by its users (Amini Behbahani et al. 2017). Like other space syntax techniques, VGA produce graphs to present the built environment. The Visual Graph Analysis (VGA) contains different types of tests. For example:

   - Connectivity analysis: measures the number of spaces that are visually connected to other spaces.
   - Visual integration: measures the depth of space to all other spaces in the system, revealing the core space in the layout. In a highly integrated space, users usually can see much of the spatial structure and can be seen.
   - Through-vision analysis, which looks at how visual fields varies within an environment.
   - Depth analysis, which shows changes of direction that would take to get from the selected location to other locations.
   - Agent analysis, which indicates patterns of movement, and the frequent use of spaces released from one point.

   In the maps, red colure represents high values, while blue colour represents low values.

2.7.3.3 Space Syntax Tools

Different tools associated with Space Syntax can be used to measure and calculate maps and graphs, such as DepthMap and AGRAPH software.

- **DepthMap:** is an open-source and a multi-platform software developed by Alasdair Turner in 2000 at the Space Syntax Laboratory, The Bartlett School of Architecture, University College London (UCL) (Turner 2001). Then it was developed by Tasos Various and named DepthmapX (2011-2015). It was designed to perform various graphs analyses for the spatial environments on different scale levels, as such, buildings and small urban spaces to cities or states. It is used

to understand the social behaviours in the analysed environment, explore variables that may have significant social influence, and convey how social organisations occupy spaces.

- **AGRAPH:** is an open-access software developed in 2005 by Bendik Manum, Paul Benze, and Espen Rusten at the Oslo School of Architecture (Manum et al. 2009). AGraph software is an application that calculates nodes and connections as space syntax variables to produce Space Syntax graphs. It has a straight forward interface to create models and analysis for nodes and connections, and it also produces printable images (Vrusho and Yunitsyna 2016). This 'node-and-connection model' produces justified graphs with different colours for different values.

2.7.3.4 Space Syntax Criticisms and Limitations

Space syntax theory is a prominent framework that attempts to quantify the relationships between environmental geometry and human behaviour. However, some researchers identified some limitations. For example, (Ratti 2004) argued that there are some inconsistencies in space syntax theory, where Hillier and Penn (2004) responded to these criticisms. This debate is mainly regarding axial lines as one of the most used techniques in space syntax. Following is a summary of this debate.

First, Ratti (2004) argues that space syntax relies on topological representation and discards the matric attributes. Thus, this may cause a fundamental problem in linking the topological and metric attributes in one model. On the other hand, Hillier and Penn (2004) responded in two points to explain that space syntax research uses metric data in the regression model rather than the spatial model. First, they believe that metric factors can significantly change and sometimes, it can contradict with the integration of some spaces. Second, metric factors impact on the boundaries, which may influence the location of the integration. On the other hand, (Steadman 2004) adds to this debate that people tend to take the shortest paths (the least axial lines) to save time, effort, and expense, where axial lines that are linked with the larger number (topologically) of shortest runs have higher integration values. However, in the traditional transport model, people follow the shortest route, weather by metric distance or travel time, rather than only the shortest topological turns as argued in space syntax.

Second, space syntax does not consider 3D information, such as hight, which may affect the density of pedestrian movements. Hillier and Penn (2004) explained that the 3D factor could be considered in the regression model instead of the spatial model. Also, (Hillier et al. 1993) emphasised that the spatial structure is the main driver for pedestrian movement. The other attractions work as multipliers, which is one of the basic assumptions of space syntax. Therefore, variables, such as pavement width and building height, were notable while predicting pedestrian movement; however, the effect of the spatial variables was significantly higher (Penn et al. 1998).

Third, space syntax does not clearly define the boundaries of the spatial configurations, where shrinking or extending the boundaries will change the integration pattern of the spatial structure (Ratti 2004). For example, a regular grid of axial lines has matching integration values; however, when it is

connected to its outside, mismatched integration values might be obtained. This limitation might not be addressed, as far as it may be confirmed, adequately in space syntax literature, where there might be some attempts to reduce the effect of axial maps edge. However, Ratti (2004) suggested using local integration measures instead of global integration ones.

Fourth, Ratti (2004) argues that small changes in the geometry may cause significant changes in the integration values, and accordingly, the movement patterns. He also adds that these geometrical changes, which might not be noticeable, can significantly change the integration values; however, it should not significantly affect movement patterns. Hillier and Penn (2004) argue that, although Ratti's examples might be geometrically similar, they have syntactical differences. Also, they add that even small geometrical changes as these changes may affect the morphology of the urban areas (Hillier 2002) and the behaviours within spaces (Conroy 2001).

Fifth, and with particular reference to axial maps, the process of drawing axial lines might be arbitrary, or subjective, process, where different researchers may produce different axial maps for the same spatial environment, which might be due to the lack of logarithm to generate axial lines automatically (Batty and Rana 2004). Hillier and Penn (2004) argue that the definition of the axial lines can vary depending on a set of questions that may govern the process of creating axial lines. For example, the possibility of extending the lines to make further connections, merging two lines into one, covering all part of the space, and the representation of all rings around the built environment.

Sixth and finally, Ratti (2004) argues that space syntax disregard of land use in axial maps is another limitation. Similarly, (Batty et al. 1998) reported the same issue before. To emphasise, they believe that when the spatial representation is more defined, such as in housing and shopping malls, location and movement are best described regarding users who use these spaces rather than their aggregation by social or any other attribute, where they lose their meaning. Hillier and Penn (2004) argue, based on previous studies (Hillier 1999), that rather than exploring the influence of the land use on the spatial configuration and movements, it would be more suitable to investigate the impact of the spatial configuration and movements on land use.

In summary, Space Syntax might be a useful tool for evaluating and understanding architectural spaces (Dursun 2007; Şalgamcıoğlu 2014). Thus, space syntax will be used to calculate the spatial measures associated with it to analyse the morphology of EDs in the study area. However, the syntactic values, such as integration, control, and connectivity, might not explain the functional relationships to design better EDs, which will be discovered later in this research.

2.8 Conclusion

Healthcare delivery systems have developed into large and advanced healthcare facilities, which increased challenges to deliver healthcare services punctually and within the available budgets. EDs

are part of almost any healthcare system and are one of its primary and front-line components, where a high percentage of hospital patients are admitted through EDs. However, EDs are facing major challenges, such as overcrowding, access block, and long waiting times, which happen when the departments physical and/or staffing capacity become insufficient to meet the demands of their users. Therefore, the design and operation of such critical healthcare facilities are important to avoid problems associated with overcrowding and access block. For example, increased mortality rates, poor care quality, delays in treatment, delays in hospital readmission, an increase in patients' length of stay, long waiting time, an increased number of patients left without being seen. Thus, several ED design guidance and research studies were reviewed to explore the current situation in terms of ED research to tackle these problems. Also, to explore ED design, functions, and operational activities and explore the spatial relationships of ED functions and their influence on ED's operations.

After reviewing ED design guidance and related design references, it becomes clear that although they provide almost a similar list of functions to be included in EDs, they all are limited in providing detailed explanations of their functional spatial relationships, which is determined by the medical procedures and operational activities. To clarify, How EDs different spaces should be spatially connected to support the operational activities and facilitate the overall operational flow is still limited. On the other hand, the UK guidance provides the most detailed and clear illustration diagrams of the different clinical pathways patients follow in EDs, as explained before. Knowing these spatial relationships can help the design process reduce unnecessary steps and optimise the required time for each clinical procedure. Nevertheless, this might be the best option because defining these spatial relationships in the guidelines may be difficult due to the constraints it may impose on diverse populations. Therefore, design guidelines need to have flexibility when proposing design guidance to be applied to different types of EDs and be adapted for use in different contexts. Also, these flexibilities allow future spatial and technical development, especially in the medical equipment area and clinical operations.

On the other hand, the reviewed current research on ED revealed that the current EDs lack meeting their users' expectations, whether staff, patients, and families. Therefore, several scholars have carried out various studies to improve ED operation and reduce patients' length of stay in EDs to solve EDs main challenges of overcrowding and long waiting times. The reviewed solutions are, for example, applying lean management as a quality assurance method that focuses on improving the process by identifying the non-value-added and time-wasting processes that are hindering patients' flow in EDs. Using facility layout planning algorithms to improve the physical design of the ED to improve the flow and reduce overcrowding during disaster situations. Creating additional services within EDs called Patients Buffer to reduce pressure on ED sub-units by creating an extra organised waiting space for ED patients. Similarly, creating rapid assessment zones and clinical decision units in EDs, which will protect ED staff from disruptive routine matters. Four-hour target to reduce patients time in EDs. Producing a

conceptual model to partitions crowding in EDs into input, throughput, and output as three interdependent components. Increase staffing and resources. Create observational units in EDs, such as for patients with chest pain, to reduce the pressure on the ED. Facilitate ED patients' accessibility to hospital beds. Finally, proposing a hybrid model to prioritise ED's functional units needs to be included in the department based on stakeholders' needs and international standards requirements to improve the flow within the ED.

However, research about the spatial relationships between EDs various functions is still limited. No explanations have been found to understand the link between the spatial structure and the operational activities. The reviewed evaluations processes in other research papers do not reflect on ED's clinical spatial relationships, which depend on various factors, such as patients' acuity, their medical condition, and the adopted medical processes in different contexts. Also, the lack of users' involvement (mainly staff) is identified among the reviewed studies, where some researchers relied on medical planners and expert healthcare designers to understand the clinical requirements and operations. Thus, the researcher agrees with Koch and Steen (2012) argument that it is essential to understand how and where activities occur to find the relationship between spatial configuration and operations, where clinical processes are of EDs main activities.

In conclusion, the influence of the spatial structure and functional distribution on EDs operation, as far as it may be confirmed, might not be addressed adequately in EDs design literature. Also, the use of analytical tools, such as space syntax, to understand ED's spatial relationships might also be lacking. In addition, no studies have been conducted in Jordan, despite the fact that Jordan has a large number of hospitals with an outstanding medical reputation that attracts patients from the whole region. Therefore, this is an area that is so important to be investigated by exploring ED spatial relationships from different perspectives to frame a complete picture of the situation. Thus, two research questions have emerged to understand the influence of the spatial structure on ED's operation as further explained in Chapter One: Introductions and Overview

2.9 Chapter Summary

This chapter presents a general overview of the design of healthcare facilities. It also presents data regarding ED design, including ED spatial relationships, functions, clinical considerations, and recent research on issues around ED design and spaces. Moreover, this chapter presents an overview of design evaluation methods and techniques, including post-occupancy evaluation and space syntax as a tool for evaluating spatial layouts. Finally, it summarises the literature search, highlights limitations and gaps in knowledge, and concludes with a research question, which will guide the research towards discovering new knowledge.

Chapter 3: Research Design and Methodology

3.1 Introduction

This research started by exploring potential problems EDs might be facing. Overcrowding and long waiting times were identified. Therefore, this study aims to provide evidence and a better understanding of EDs spatial relationships and how the layout facilitates or hinders users' flow to reduce overcrowding and waiting time in Jordanian Hospital. Therefore, it seeks to explore EDs spatial relationships and the influence of the spatial structure on operations.

Moreover, to answer the research question and achieve this research's aim, several objectives have emerged based on the functionality of two existing EDs in Jordan. First, to explore EDs spatial design in the literature and design guidelines. Second, to explore actual designers' approaches to EDs spatial design. Third, to investigate EDs spatial relationships. Fourth, to investigate the influence of the spatial structure on EDs' operation. As a result, a complete picture of ED design and operation should be unfolded by comparing the findings from the previous objectives to develop a better understanding of how EDs should be designed to support their operation.

Thus, a suitable research design will be framed for this research, including selecting appropriate methodology and methods to rigorously perform this investigation. Therefore, this chapter describes the research design and methodology for this investigation, and details the philosophical paradigms, approaches, strategies, and methods adopted in this study and why they were chosen. It also illustrates the adopted data collection strategies and analysis methods to address the research questions, aims, and research objectives. Also, it shows the ethical regulations that were upheld throughout this research.

3.2 Reviewing Research Models and Paradigms

An early description of academic research by author James Snyder defines academic research as "a systematic inquiry directed toward creating knowledge" (Wang and Groat 2013, p.8). It is also the art of a systematic scientific investigation seeking new knowledge on a specific topic (Kothari 2004). Consequently, it is believed that researchers in different fields, including architecture, are encouraging a more combinatory approach to research whereby various methods from different paradigms are integrated into a single study (Wang and Groat 2013). Because each particular research strategy brings with it strengths and weaknesses, combining methods may offer appropriate checks against the weakness in each one, while together allowing the benefits to supplement each other (Greene and Caracelli 1997; Heppner et al. 2008; Wang and Groat 2013). In general, most research projects are usually a combination of multiple objectives. Thus, this research investigates several objectives to explore the influence of the spatial structure in the ED on its operations, which will be explained more later in the chapter.

Moreover, researchers usually begin their investigations with 'knowledge claims' or 'paradigms'. Corbetta (2003) defines a paradigm as the orientation that stimulates and leads a given science.

Neuman (2014) defines it as the integration of assumption, various beliefs, models, and techniques for collecting and analysing the data. In particular, different researchers, such as, Guba and Lincoln (1994); Crotty (1998); Della Porta and Keating (2008); Wang and Groat (2013); Creswell (2014); Kumar (2014); Bryman (2016); Kivunja and Kuyini (2017); and Creamer (2018), argue that Epistemology, Ontology, Methodology and Axiology/Interpretation, hold the essential knowledge claims, values, consumptions, norms, and beliefs.

Moreover, pragmatism as an epistemological school of thought focuses on understanding the research problem to develop a problem-solving approach instead of holding to the philosophical positions (Tashakkori and Teddlie 2010; Dures et al. 2011; Morgan 2014). Therefore, it gives researchers a choice to adopt suitable methods and techniques to collect and analyse the data that meets the research aim to better understand the problem (Creswell 2014). Furthermore, it is a philosophical position that uses a combined/mixed approach, which allows the use of multiple techniques whether in a sequel or parallel order, in part of or the whole research stages depending on the research needs (Creswell 2014; Saunders et al. 2019).

3.3 Justification for the Selected Paradigm

The chosen paradigm was based on the research questions, aim, and objectives developed from the research problems and the study's rationale. Objectives one sought to explore EDs spatial design knowledge from the literature. Objective two sought to explore healthcare designers' perception of EDs spatial design and operation. Objectives three sought to understand the spatial relations of EDs. and objective four sought to investigate the influence of the spatial structure on EDs usages and operation. Therefore, the adopted research methods have developed from different paradigms. Furthermore, a paradigm that allows using combined/mixed research methods to address the research problem will be more suitable for this research. As a result, pragmatism was selected to drive this research's philosophical orientation due to its flexibility to use different methods.

3.4 Research methodology and methods

A research methodology is a broad framework that supports the basic principles related to a paradigm for specific research (O'Leary 2017). Kothari (2004) defines research methodology as a systematic inquiry that seeks to solve a research problem. At the same time, Crotty (1998, p.3) defines research methods as the process and strategies adopted to collect and analyse the research data. While the research design is about planning and executing the research (Punch 2014). The research methodology provides the strategies and techniques to execute the research. The following are three common research methodologies: quantitative, qualitative, and combined - mixed method with associated techniques and methods.

3.4.1 Quantitative Approach

A quantitative approach is about collecting factual data to examine the relationships between the facts. It includes variables and numbers measured and analysed in a statistical means (Denzin and Lincoln 2000). In social science research, the quantitative approach can usually be used to test questions or hypotheses against a list of variables (Crotty 1998; Blaikie 2003). In general, in quantitative approach, experimental and survey design strategies can be used for data collection, for example, questionnaires, structured interviews, and structured observations (Saunders and Lewis 2012).

In this research, experimental methods as a type of quantitative approach seek to discover the effect of manipulating independent variables on a dependent variable (Rose et al. 2015). For example, experimental methods measure the outcomes of one independent manipulated variable against a dependant variable in a controlled environment; therefore, it seeks to examine the influence of treatment on the outcomes. This approach can be used when the researcher can demonstrate the cause and effect of the variables (dependent and independent) (Thomas 2013). For example, simulations studies can be performed using an experimental method since they create an artificial environment and a numerical templet to represent the process which needs manipulation and control (Kothari 2004).

3.4.2 Qualitative Approach

Qualitative research method tries to understand participants' comprehension of the world. It is used to explore, comprehend, and capture participants' experiences, thoughts, behaviours, and emotions when or before they experience a phenomenon (Saunders et al. 2012; Suter 2012; Wang and Groat 2013) or the research problem (Creswell 2014). This type of research is mainly used in humanities, sociology, and anthropology research (Creswell 2014). It is usually associated with the interpretative philosophy (Denzin and Lincoln 2000; Fellows and Liu 2008). Moreover, it is mainly helpful for researchers to identify the critical variables for the study. Many qualitative researchers rely on their skills to collect meaningful information. Therefore, the final qualitative report can be flexible since it is based on interpreting the meaning of the data (Creswell 2014).

3.4.3 Mixed-Method Approach

Many researchers tend to adopt quantitative techniques more than qualitative or vice versa. However, a mixed-method approach uses qualitative and quantitative methods to involve different strategies (Creswell 2014). Thus, it comes in the middle to provide a full understanding of the research problem by integrating strengths in qualitative and quantitative approaches and neutralising their weaknesses (Creswell 2014). Adopting a mixed-method approach can help increase the depth, meaning, accuracy, and validate the results from both quantitative and qualitative methods (Kumar 2014). A mixed-method approach is also beneficial for studies with multiple objectives, which will help make generalisations and share finding (Kumar 2014).

Mixed methods approach can be used in different phases during the research, whether in the data collection, data analysis, interpretation, and dissemination. The finding from the adopted different methods can be used to compare, confirm, or contradict the research's claims (Kumar 2014). Targeting different samples and various groups of people during the data collection stage would help validate the findings and better understand the research problem.

3.4.3.1 Choosing a Mixed-Method approach

Creswell (2014) says that the advantages of using a mixed-method approach should not be thought of as principles of mixed methods. However, this combination should focus on developing better results than when using a mono-method. Thus, Creswell (2014) mention three different integrations of the mixed-methods approach. These are:

1. Merging the results obtained for the two approaches (qualitative and quantitative) to solve the research problem. In this way, data in the two approached were collected separately to allow a comparison of the results. Thus, contradictions or similarities will be revealed; therefore, it has a parallel sequence.
2. Starting with the quantitative approach, where the obtained results will be used to investigate the research problem further using a qualitative approach. In this way, the quantitative methods will lead the qualitative one; therefore, it has an explanatory sequence.
3. Starting with the qualitative approach to explore the participants' views where the obtained results will be used to investigate the research problem further using a quantitative approach. In this way, the qualitative methods will lead the quantitative one; therefore, it has an exploratory sequence.

Bryman (2016) argues that using a mixed-method approach requires more time and resources. Therefore, the researcher must allow sufficient time and enough financial resources. This type of research also requires various skills due to the use of different techniques, tools, and software during the data collecting and analysis phases (Kumar 2014).

3.5 Research Design

Research design aims at answering the research questions rigorously, objectively, precisely and in an economical way as possible by following specific and logical investigation strategies (Wang and Groat 2013, p.122; Kumar 2014). Heppner et al. (2008) explain research design as an investigation map or a structure that includes a list of procedures to conduct a research project. In another way, it is the description of the chosen approach to combine the different component of the research in a coherent, reasonable, and logical way. Thereby, the research problem can be addressed efficaciously. Based on the previous definitions, a mixed-methods approach was chosen based on the research questions, aim, and objectives, which allow the combination of different research methods from different paradigms to seek a solution for the research problem.

The next section summarises the framework for conducting this research. It will explain the data collection phase and how the data will be used and analysed to understand ED's spatial design better.

3.6 Research Framework and Conducted Phases

When conducting research, different steps need to be declared in an early stage of the investigation (Kumar 2014). Therefore, after identifying the research problem and form the research design, the researcher needs to structure a plan for the data collection, analysis, explanation, and evaluation phases. Figure 8 illustrates the research design for the entire process.

This research was divided into four phases to achieve the research objectives. These phases are literature review, data collection, data analysis, and discussion and development of recommendations. To achieve the research objectives, because they addressed different phenomena, different methods, and techniques for collecting and analysing the data were reviewed. A pragmatic (Mixed-Method) approach was adopted, which allows the use of both qualitative and quantitative techniques to achieve the research objectives. Following are the conducted different phases in this research to answer the research questions:

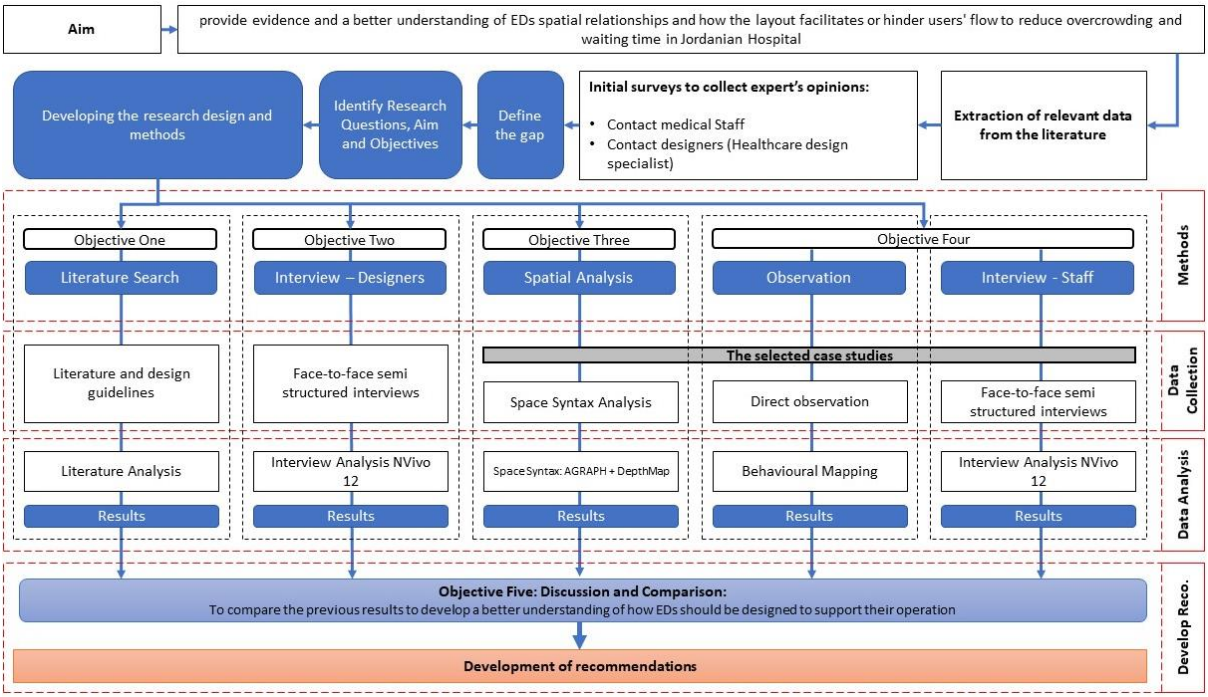


Figure 8: Research Flow Chart

3.6.1 Literature review

The literature search is the first phase of the research; it started in the introduction chapter to explore challenges EDs face when delivering urgent healthcare services. In addition, to review EDs design knowledge from the literature, including available ED spatial design guidelines and current research. Also, to Identify types of EDs to be used as case studies in this research.

The data have been extracted from various sources, including highly ranked peer-review journals and databases, Google Scholar search, trusted websites, books, and EDs design guidelines. A thorough search using keywords for EDs like "Emergency departments", Accident and Emergency", "Emergency Rooms", "Emergency Wards", and "Casualty Departments". Also, A thorough search using keywords like "Healthcare Design", "EDs in Healthcare", "Healthcare Design in Jordan", "EDs challenges in Jordan", "EDs Design Regulations in Jordan", "EDs Challenges", "EDs Crowding/Crowdedness and Waiting Time", "EDs Design", "EDs Spatial Structure/Layout", "Spatial Adjacencies", "EDs Functions", "EDs Clinical Procedures", "Triage", "Technology in Healthcare", "Technological Development in Healthcare", "EDs Design Guidelines and regulations", "Design Evaluation", "Post-Occupancy Evaluation", "Spatial Structure Analysis", "Space Syntax Analysis", Space Syntax in Healthcare facilities", "Space Syntax in EDs".

Furthermore, the researcher contacted healthcare designers and medical planners in the study area and the UK. Also, the researcher contacted senior medical staff in the study area (Jordan). Data were collected over arranged face to face meetings and phone calls to collect initial and general information about ED design, usages, and challenges ED might be facing. The main purpose of collecting these data was to inform the research in its early stages. Thus, no records of these data are available.

The search revealed that crowding and long waiting time are a significant challenge in ED, which cause many problems, as mentioned in the introduction chapter. Furthermore, the influence of the spatial structure and functional distribution on EDs usages and operation to improve efficiency, as far as it may be confirmed, might not be addressed adequately in EDs design literature. Also, the use of analytical tools, such as space syntax, to understand ED's spatial relationships might also be lacking.

3.6.2 Data Collection

The data collection is the second phase of the research to achieve the research objectives, which involved three major activities: case study, semi-structured interviews, and field observation. Further and detailed explanation for the collected data is mentioned below:

3.6.2.1 Case Study

The chosen case studies were the base of this research. They were used for conducting a spatial analysis using analytical tools (Space Syntax) to attempt to understand the spatial relations of EDs. Also, they were used as the base of further qualitative research techniques: Interviews and field observations. Thus, two EDs were selected in Jordan to be used as case studies for this research.

1) The selected cases

To allow comparison and to retain the possibility to make a generalised conclusion, it was necessary to vary the cases as possible while selecting cases that enable sufficient data to be collected in a

reasonable precision manner. The selected cases were similar in term of the healthcare taking place regarding patient flow and intensity, while different in their spatial configuration.

Emergency departments in the two selected hospitals were chosen for comparison. The two EDs were preferred to provide two different settings that contrast in their size, age, and design. KAUH is a big teaching hospital designed at the end of the 1990s by international architectural design firms. On the other hand, the IH is a big private teaching hospital that was established in 1982. However, the IH has a big new ED established in 2009 by a local architectural firm.

The selected cases are operated by two different authorities and follow two different healthcare systems. While KAUH is operated by a public university as a teaching hospital, the IH hospital is a private one. The two selected cases serve two different significant populations in Jordan in different cities; the IH is in the capital Amman, while KAUH is in the north of the country, which serves Irbid and Ar-Ramtha cities. Moreover, the selected cases were chosen due to the availability of drawings for their original design and the possibility of producing as-built plans for the current spatial structure.

A. King Abdullah University Hospital (KAUH)

King Abdullah University Hospital (KAUH) is a teaching hospital located in Ar-Ramtha, Jordan near the southern Syrian borders. It is considered the leading healthcare facility that serves about one million inhabitants in the north of the country and to all Jordanian population in general. It was inaugurated in 2002 to holding the vision of being a distinct state-of-the-art health centre and comprehensive referral medical facility in the Middle East (King Abdullah University Hospital (KAUH): About) Figure 9.

KAUH was a joint venture project designed by the Japanese architect Kenzō Tange and the Jordanian architect Ja'afar Tuqan. Its cornerstone was laid down in 1994. The main hospital building is composed of fifteen floors high-rise building, where all hospitals beds are located. In addition to three floors low-rise buildings, where other services are located such as Accident and emergency department, outpatients' clinics, radiology department, diagnostic and others (Abdel-aziz, 2018).

Figure 9: KAUH ED department (ED location is in red) (photos were taken from Google Maps)

B. Islamic Hospital (IH)

The Islamic hospital (IH) is a private teaching hospital located in Amman, Jordan. It was opened in 1982 where it consisted of one building composed of seven floors and a service building. Afterwards, another three buildings were constructed and linked together. The new emergency department (ED) is located on the ground floor of Dr Qandil Shaker Surgical Centre. It was opened in 2009 to be one of the largest medical and surgical centres in the region. The emergency department in the IH receives more than 70,000 patient a year Figure 10.

Figure 10: The Islamic Hospital ED (ED location is in red) (photos were taken from Google Maps)

2) Ethical considerations

As part of the research ethics, the investigation started after obtaining approval from the School Research Ethics Committee (SREC) at the Welsh School of Architecture (WSA), Cardiff University. All interviews required written consent, confidential interviews, and all data to be anonymised. The work was conducted in two different case studies in Jordan, where each one was under a different authority. Therefore, three additional ethics approvals were requested and obtained from three different organisations; The Ministry of Health; King Abdullah University Hospital; and The Islamic Hospital.

3) Collecting the drawings

After obtaining the ethics approvals, the researcher was able to request and collect the original drawings for the selected case studies. The researcher then took site measurements to draft an as-built 2D floor plan for the departments, which will be used later in the research for further analysis.

4) As-built measurement

Hayward (2016) mentioned that using computer-aided software to draft the field measurements will give accurate drawings of the building rather than scale the plans from old architectural drawings. Also, having the floor plans in an electronic format, the floors' footprint can be defined and measured electronically. Thus, As-built measurements were taken to create a blueprint of the selected cases' floor plans, where the floor plans were drafted using AutoCAD software. The final drawings will be used for further analysis and to aid the data collection process.

3.6.2.2 Semi-structured interviews

In this research, interviews were adopted to collect qualitative opinions from two sets of participants to achieve objectives two and four.

- First, specialised healthcare designers and medical planners to explore their approaches to EDs spatial design.
- Second, staff working in the selected case studies to investigate the influence of the spatial structure on EDs operation.

This section covers the interview design, pilot interviews, selection of participants – sampling strategy, the sample size, ethical considerations, and undertaking the interviews.

1) Interview design

There are three types of interview design in qualitative research: structured, semi-structured, and unstructured (Fellows and Liu 2008; Wilson 2010; Naoum 2013). Structured interviews involve using predetermined structure set of closed and open-end questions towards an enquiry (Bryman and Bell 2011). However, unstructured interviews start with a broad question, which gives the flexibility of wording and questions to get deeper into the situation (Naoum 2013). Semi-structured interviews lie in the middle using both closed and open questions without following a strict structure; therefore, the

research can elaborate on specific points (Wilson 2010). Accordingly, semi-structured interviews were selected for this study. Two interview forms were designed, both with in-depth and detailed questions:

A. The first form was designed to explore healthcare designers' perception of EDs spatial design and operation by investigating three key headings:
    - Designers' views on healthcare and emergency departments' design.
    - Drivers of EDs' design approach and justifications for adopted ideas.
    - Experts' views on main design criteria (Movement, Circulation, accessibility, density, crowdedness, privacy, hierarchy, security, and social interaction).
B. The second form was designed to investigate the influence of the spatial structure on EDs usages and operation by investigating three key headings:
    - The adopted medical procedures in emergency departments.
    - The influence of the spatial structure on management and staff.
    - Staff views on design criteria extracted from the literature (Movement, Circulation, accessibility, density, crowdedness, privacy, hierarchy, security, and social interaction).

2) Pilot interviews

The interview forms were piloted with supervisors, designers, medical staff, and fellow research colleagues who gave feedback on structure and grammar. Feedback was used to improve the final version of the interview schedule.

3) Selection of participants – Sampling Strategy

Bell (2006) defines sampling as using a smaller part of the population representing the population in the study. Two types of sampling methods were identified by O'Leary (2017); random and non-random sampling. Robson (2011) explains different types of random and non-random sampling techniques (also known as probability and non-probability sampling)

Random/Probability Sampling: requires that the participant are knowledgeable to answer the questions without taking their specifics into account (Bell 2006). Examples of random sampling techniques, as explained by Robson (2011):

- Simple sampling: the required number of participants is taken randomly from the entire population, which give an equal chance for anyone to be selected, as such, in the lottery.
- Stratified sampling: the population is divided into groups, where individuals in each group have unique characteristics; then a random sampling can be applied.
- Cluster Sampling: the population is divided into clusters, where individuals in each cluster have a range of characteristics, then the cluster will be chosen randomly. This sampling technique can be used to target a population based on a geographical spread.

- Systematic sampling: the entire population is known to have a full list of the population, then the samples will be selected systematically after identifying the sample size.
- Multistage sampling: the samples are taken of existing samples, as such samples can be selected from the selected cluster samples.

Non-Random/Non-Probability Sampling: requires details to be collected about the participant specifics before they are asked to answer the questions (Fellows and Liu 2008). Examples of non-random sampling techniques, as explained by Robson (2011):

- Quota sampling – the samples represent various elements of the population to fill the quota (the required sample size) the way they occur in the population.
- Snowballing sampling – one or more samples will be identified. Then, these samples will be asked to identify others within the same population, who will also be asked to identify other individuals within the same population, and so on.
- Judgement Sampling/ purposive sampling – the samples will be selected based on their relevance to the research, where the researcher will be able to achieve a specific purpose.
- Convenience Sampling – samples will be selected continuously depending on their proximity and the researcher convenience as participants to reach the required sample size.

Thus, judgment or purposive sampling was adopted initially because it provides a base to reach relevant experts in the field. The snowballing strategy was adopted afterwards, to find more participants with similar background and experience to participate in the study. Therefore, the initial interviewed participants were asked to nominate other participants who might benefit the study.

A. The targeted designers were selected based on the following criteria:
    - All participants must be experts in healthcare design or medical planners.
    - A minimum of bachelor's degree in architecture as their highest educational qualification.
    - A Minimum of 10 years' experience in healthcare design.
    - All participants must have designed or been part of a design team for hospitals and emergency departments.
B. The targeted staff were selected based on the following criteria:
    - All participants were staff only, and all must be full-time staff working in the selected case studies.
    - Three different types of ED staff were chosen, Doctors, Nurses, and porters.
    - All participants must have a minimum of 5 years of experience in the selected case study.
    - A mix of female and male staff was selected.

4) The sample sizes

Kvale (1996) explained that the required number of participants depends on the aim of the study. However, interviews might need to be around 15 ± 10, where this number may be owing to available resources and time for the research and the law of diminishing returns (Kvale 1996). On the other hand, Kvale (1996); and Mason (2010) explained that interviews will still be needed until the researcher reaches a point of saturation, which is when further interviews will not yield new knowledge. Thus, once the saturation point was reached, it is then concluded that most of the collected views were adequately represented.

5) Ethical considerations

The obtained ethics approval used for the selected case studies was also used for conducting the interviews. Further explanation can be seen in the "Data Collection" section – "case study" - "Ethical Considerations".

6) Undertaking the Interview

Different groups of participants were interviewed:

A. Designers' interviews: Interviews were conducted in the study area – Jordan and they were all in the capital city, Amman. All interviews were held at the interviewees' offices.
B. Staff interviews: Interviews were conducted in the study area – Jordan and each group of interviews took place in selected EDs in two cities in Jordan (Amman and Irbid), in two different hospitals (The Islamic Hospital in Amman and Kind Abdullah University Hospitals in Irbid). All interviews were held in different rooms, like a private office, meeting room, rest areas, and a corridor due to staff demand. Some of the interviews were interrupted many times during the interview.

Before the interviews, participants were informed about the purpose of the study, how they were expected to take part in it, how much time the interview should take, their right not to answer any question, and their right to withdraw from the study at any time. All participants were assured that their identity would stay anonymous, and their responses would only be used for academic research and will be deleted by the end of this investigation.

All interviews started by explaining the research to the participants and explaining the consent. All participants were asked to sign the consent form before the interview begin. The interviewer (the researcher) afterword started asking the main question in the interview form followed by a follow-up and probing questions to clarify any unclear questions. All interviews where recorded and marked to show the date, the time, and the duration of each interview. Each interview lasted for about an hour to an hour and a half. All interviews were conducted in the Arabic language, where English terms were used. All interviews were transcribed and then translated into English for coding.

3.6.2.3 Field observation

Field observation was adopted in this research to collect qualitative description and evaluations of the selected case studies to investigate the influence of the spatial structure on EDs operation.

Observation is an essential and fundamental method for qualitative study (Marshall and Rossman 2006). It helps the researcher focus on different aspects, such as the context of the study, the relationships, the symbolical meaning in the cultural life, how people react with their situation, and the interpretation patterns (Wang and Groat 2013; Kumar 2014). Observation is considered a systematic data collection method for watching and listening to a specific phenomenon in the place of the study (Kumar 2014). Where the natural behaviour of people, the attitude, and the social world, in general, can be objectively recorded and observed, categorised, and measured (Haralambos and Holborn 1995; Bryman 2016)

For coding observations, the researcher must have reliable data, which is achieved by being consistent in observation; usually when it involves more than one observer or one observer in different locations studying the same behaviours. Also, to have valid data through accurately record what needs to be measured for the study (Bryman 2016).

Two types of observation can be adopted: participant observation and non-participant observation.

- Participant observation: the observer participates as a member of the observed group and observes their activities. It can be done with or without the group knowledge. The observer needs to give attention to what is happing and write notes to record the activities (Kumar 2014).
- Non-participant observation: the observer remains a passive observer in the observed group and does not participate in the group activities. The observer can observe what people in the group do and listen to what they say with getting involved (Kumar 2014).

For this study, non-participants observation was adopted in the selected EDs in Jordan. The observation included describing the EDs outdoor settings, describing the EDs indoor settings, and recording staff and users' behaviour.

Conduction observation in a research project may give some limitations, usually when people are aware that they are being observed. Kumar (2014) mentioned that problems might occur, as such, the possibility of observer bias, interruption of observation and incomplete data, and inconsistent interpretations.

1) Ethical Considerations

The obtained ethical approvals used for the selected case studies were also used for conducting the observations. Further explanation can be seen in the "Data Collection" section – "case study" - "Ethical Considerations".

2) Undertaking the observations

The observations were conducted in the study area – Jordan. Each observation took place in selected EDs in two cities in Jordan (Amman - the capital - and Irbid), in two different hospitals (The Islamic Hospital in Amman and Kind Abdullah University Hospitals in Irbid). This field observation was carried out in three stages by observing and recording the following in a text form:

- First, a detailed description of the outdoor physical setting to understand the location typology and the impact of these settings on the way the department is being used.
- Second, a detailed description of the indoor physical setting to understand the indoor typology and the impact of these settings on the way the department is being used.
- Third, a detailed description of users' and staff behaviours to understand the influence of the spatial structure on their behaviours.

Because of the aggregation of activities and behaviour grows faster as the rate of work is high, observations were performed in separate days; one day per each department, and in different time slots throughout the day:

- First, from 08:00 am to around 08:45 am, to evaluate and describe the ED building and location (Outdoor).
- Second, from 08:45 am to around 09:30 am, to evaluate and describe the EDs indoor environment.
- Third, from 10:00 am to 11:00 am, to recording users and staff behaviour.
- Third, from 06:00 pm to 07:00 pm, to recording users and staff behaviour.
- Third, from 10:00 pm to 11:00 pm, to recording users and staff behaviour.

The observation was recorded by writing field notes and a description of what is being observed. An as-built 2D floor plan for the departments - that was drafted in an early stage of the research - was used to copy the physical setting and better illustrate the observed data. Details such as, rooms functions, furniture locations, locations of the users, movement patterns, what is happening, how people are using the department, users' behaviours, crowded areas, waiting areas, were observed, and mapped. The observed data were described in detail in the filed notes and the floor plans. Reason for this, as mentioned by Kawulich (2012), that having too much data is better than not enough information, where extra data can be omitted later.

3.6.3 Data Analysis

The data analysis is the third phase of the research to achieve the research objectives, which involved three major activities: spatial analysis, interview analysis, and observation analysis. Further and detailed explanation for the analysis processes is mentioned below:

3.6.3.1 Spatial Analysis

The spatial structures of the two EDs in the two hospitals were studied thoroughly. The spatial structure from the original drawings and the as-built ones was analysed, representing before and after occupation following modification to explore their functional arrangements and changes that led to the current situation. The analysis was based on the drawing as a plan-base analysis as follows:

- First, spatial structure development was conducted to explore the spatial structure and identify spatial changes between pre- and post-occupancy settings. Manual zoning plans were created to highlight the changes in the spatial structure.
- Second, space syntax analysis was conducted afterwards to explore its outcomes as a syntactic analytical tool to analyse EDs functions spatial relationships. AGRAPH and DepthMap software were used as space syntax tools.

3.6.3.2 Interview Analysis

All interviews were transcribed into Arabic first, then translated to English before the coding process. Microsoft Office Word was used for formatting the text before importing the data to NVivo 12 software for analysis. Rose et al. (2015) explained that transcribing audio files into text can encourage verbatim quotations to support critical points in the thesis.

- *Data analysis process*

The analysis stage should include several interactive and progressive processes (Bazeley 2013). Schulz (2012) Identified several techniques associated with the interview analysis. However, there are no standard procedures to follow for analysing interviews because each research project has different circumstances that can be approached from various perspectives. Nevertheless, all different methods for analysing interview data share the use of direct quotations to support the findings.

Schulz (2012) introduces two strategies that are usually adopted. 1- Inductive approach, which is used with less structured interviews. 2- Deductive/Inductive approach, which is used with structured and semi-structured interviews, Figure 11

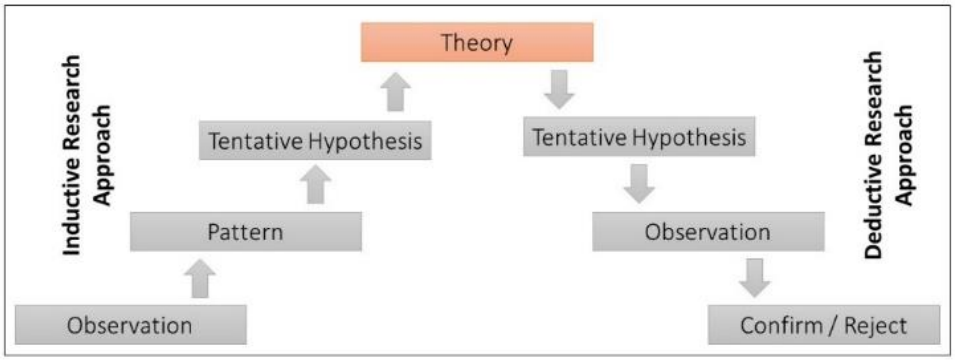


Figure 11: Inductive (bottom-up) and Deductive (top-down) interviews analysis approaches. The researcher adapted it from Schulz (2012).

A. The Inductive approach starts by making a specific observation, then to identify patterns with the observations, after that it leads to making broader generalisations and finally making tentative theories. It is called a bottom-up research approach because it lets the ideas, the concepts, and the themes emerge from the interview data.
B. The combination of Deductive/Inductive is a top-down research approach; it starts; firstly, with the theory or specific framework, then it tests the theory by making observations, and finally, the theory can be confirmed or rejected. This technique can be applied by following the steps below:
    - Stage 1: creating a set of themes or categories before starting with the analysis; these themes are usually derived from the literature and based around theoretical concepts, or they can be driven from the interviews.
    - Stage 2: divide the interviews into chunks of data like sentences and paragraphs.
    - Stage 3: start labelling the textual data with closed codes from the list of themes.
    - Stage 4: gathering all the quoted textual data under the themes.
    - Stage 5: looking for ideas within the themes to be identified as sub-themes and exploring how they relate to each other.
    - Stage 6: construct a narrative from the themes and the codes by; first, describing the themes, the codes, and the quotations from the interviews to support or reject the presented ideas. Second, discussing the interrelationships between these ideas.

For interviews analysis, Schulz (2012) believes that it is essential to find a mechanical system to manage the interview data by using coloured markers and bens or using available computer software for qualitative analysis such as NVivo, MAX QDA or ATLAS Ti.

In line with this, the research uses combinations of a deductive and inductive approach for the two interview forms (architect's interviews and medical staff interviews). Besides, the selected approach captures all the relevant information related to answer the research questions. The researcher used NVivo 12 software for analysing the interview data.

3.6.3.3 Observation Analysis

The analysis process was done to record the spatial structure's influence on operations, which was the observation's focal point. The analysis process started by critically reviewing the observed data several times to understand the data better. The observed phenomena were then synthesised to interpret the data into a comprehendible written report that explains the observed activities.

- *Presenting the data*

The data were presented as a list of points under three predefined headings.

C. First, a description of the emergency department building and location (outdoor).
D. Second, a description of the emergency department (Indoor).
E. Third, recording users and staff behaviour.

The date was also translated into a 2D as-built floor plan for the observed EDs to illustrate the data better to know the influence of the physical settings on users' behaviours.

3.6.4 Discussion and Development of Recommendations

This phase seeks to compare the findings from the research objectives to develop a better understanding of how EDs should be designed to support their operations.

3.7 Chapter Summary

The chapter gives an account of the research design and approach employed and showcased, and the employed data collection and analysis process. An explanatory mixed-method approach was adopted, combining quantitative and qualitative attributes to achieve the research objectives as they addressed different phenomena. Table 2 illustrate the research objectives and the adopted research methods. Ethical guidelines upheld during the research process were also discussed.

Table 2: Research objectives and methods

	Research Objectives	**Research Methods**
1	To explore EDs spatial design in the literature and design guidance	Literature search
2	To explore actual designers' approaches to EDs spatial design	Interviews with designers
3	To investigate EDs spatial relationships	Spatial Analysis
4	To investigate the influence of the spatial structure on EDs' operation: - How EDs are being used and functioning - Why EDs are being used the way users uses them	Field observation Interviews with EDs' staff
5	To compare the findings from the previous four objectives to develop a better understanding of how EDs should be designed to support their operations	Review and analysis

Chapter 4: Designers Interview Analysis

4.1 Introduction

This chapter presents the interviews conducted with healthcare design experts in Jordan to fulfil objective two, exploring actual designers' approaches to EDs spatial design. They were conducted to understand what is important about EDs spatial design and what drives designers' design decisions. It presents findings from the interviews with designers and the resulting themes. The chapter presents a detailed description of the coding process, data reduction, and data display elements of the interview analysis.

4.2 Interviewees' profiles

The interviews were structured to extract information from healthcare designers. These interviews recorded details and initial information about the participants, their previous experience, knowledge of healthcare design and Emergency Departments, and their design intentions and main design criteria for movement, circulation, accessibility, Density/overcrowding, privacy, hierarchy, and security. This research was conducted in line with the guidance issued by Cardiff University and gained full Ethical Approval. All interviews required written consent, all were confidential, and all data were anonymised. Details of the interviewees who took part in this investigation are discussed below.

4.2.1 Designers

Five architects were interviewed, whom they met the selection criteria and agreed to take part in this investigation. In-depth semi-structural interview type was adopted. Each meeting lasted approximately an hour and a half. The interviewees were all expert in healthcare design; two of them were specialised medical planners. The interviewees were across architectural firms' owners, chief designers, and designers who are experts in designing different types of hospitals and healthcare facilities, including EDs. The background of the participants is listed in Table 3. All interviewees had a minimum of five years of post-qualification experience, with a university degree. Some had higher educational degrees, which gives them eligibility to be part of this research.

Table 3: Designers Profiles

Participants	Gender	Category	Experience (years)	Highest qualification
Arch. RS	Male	Designer	5 – 10	BSc
Arch. AS	Male	Team leader	5 - 10	BSc
Arch. NK	Female	Chief Designer – Facility planner – Medical planner	10 – 15	BSc, MSc
Arch. HD	Male	Chief Designer	>20	BSc
Arch. DE	Male	Owner of an Architectural firm – Chief designer – Medical planner	> 20	BSc, MSc

4.3 Data Analysis

As discussed in the methodology chapter, all interviews were conducted in the Arabic language, and then were professionally transcribed and translated into English before being coded. NVivo 12

qualitative analysis software was used for analysing the interviews' transcribed data. Miles and Huberman (1994) proposed three strategies for qualitative analysis, which were adopted for this study (i.e., data reduction, data display, and conclusion or verification). Conclusions are discussed and presented in chapter nine, Discussion and Comparison.

4.3.1 Data Reduction

A careful data reduction process was conducted. Interviews generally come with some irrelevant stories, which are synonymous with qualitative studies (Miles and Huberman 1994). As such, analysis begin with data reduction, where relevant data is extracted, sorted, and organised as a large segment into relevant code (Miles and Huberman 1994). The interview transcripts data were coded at free nodes based on the research objectives and the related literature (initial level of coding). They were reduced to tree-like nodes, after that to themes, and finally, they were placed under particular overarching themes that represent the nodes. These nodes were revised as more data were coded, and a clearer picture of the dataset begin to unfold.

A combination of deductive and inductive approach was adopted for analysing the interview data. Embracing this approach benefits from using two coding techniques; first, selective coding is the selection of data related to the phenomena (Braun and Clarke 2013). This allows most related information to be coded and linked to answering the research questions. Second, complete coding aims to identify anything of interest or relevant to the research questions (Saunders et al. 2019). Using this method permitted extra data to be coded even if it did not directly address the research question but was still valuable information.

Data were coded based on the related literature and the research objectives to answer the research questions. Besides, the research captured any relevant information that might be useful in addressing the research problem. Following this approach allowed different areas to be identified for potential coding.

4.3.2 Data Display

Data display is an organised and compressed representation of information, allowing useful conclusions to be drawn (Miles and Huberman 1994). Data display contributes to the validity of the data analysis process. The studied data from the interviews with architects revealed many vital aspects related to designers' perception of EDs design. These data capture the various points of view of the interviewed designers.

4.3.3 Themes Development and Extracted Data (Designers)

Two overarching themes emerged after an extensive coding process; first ED Design; and second; ED Operation. Other themes and sub-themes arose after further coding of the interview data. For more details see Figure 12, Table 4

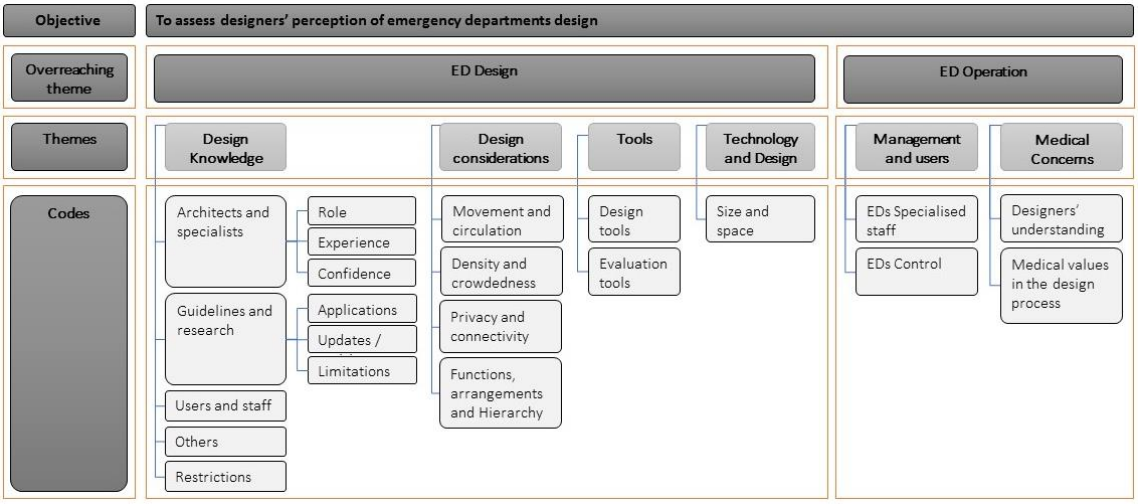


Figure 12: The emergent data from the architect's interviews analysis

Table 4: The emergent data from the architects' interview analysis.

Overarching themes	Themes	Codes	Description
ED Design	Design Knowledge	A. Architects and specialists (Role, Experience and Self-development, Confidence) B. Guidelines and research (Applications, Updates, Limitations) C. Users and staff (People) input D. Other inputs E. Design restrictions	It explores designers' sources of knowledge and information for ED design.
	Design considerations	A. Movement and circulation B. Density and **overcrowding** C. Privacy and connectivity D. Functions, arrangements, and hierarchy	It explores ED main design considerations.
	Tools	A. Design tools B. Evaluation tools	It explores the available tools and software to aid the design process or for evaluation after occupation.
	Technology and Design	A. Size and space	It explores the impact of technological development on ED design.
ED Operation	Management & users	A. EDs' specialised staff B. EDs control	It explores designers' perception of management and operations role in EDs to improve work efficiency.
	Medical Concerns	A. Designers' understanding B. Medical values in the design process	It explores designers' understanding of ED's unique environments due to their unique medical considerations.

4.3.3.1 ED Design

ED Design is the first overarching theme that emerged to assess experts' designers' perception of emergency departments design. It focuses on exploring ED design knowledge and different resources. It also focuses on the design requirements and main design criteria that affect the way EDs are designed and used. Moreover, it covers the available design and evaluation tools and how technological development influences ED design. Four major themes emerged: design knowledge, design considerations, tools, and technology and design.

I. Design Knowledge

This theme reveals the primary sources of knowledge and data that designers use for ED design. These data and knowledge are branched into different sources, and they are categorised under four codes: Architects and specialists, guidelines and research, Users and staff (people), and others.

A. Architects and specialists

The collected information from the participants reported that designing healthcare projects, such as EDs, is a shared venture scheme. It is a collaboration between architects as the designers, medical planners, medical equipment planners, medical engineers, biomedical engineers, and medical equipment factories.

> "There are three parties in the medical design process. The architect as a designer, medical planner, the medical staff, and specialists, as such, medical equipment engineers, biomedical engineers, and medical factories." (Arch DE)
>
> "The whole process when designing a hospital is a shared venture project … with the research concern in mind, the work is done by team cooperation between architects and medical architects (medical planners MP, or Medical Equipment's Planner MEP." (Arch HD)

Furthermore, the other interviewees stated that the medical planner is the expert in spatial planning and structure of healthcare facilities, including EDs.

> "Facilities planning is my primary field of experience, which means space planning or spatial structure. It is called a medical planner or healthcare facilities planner." (Arch NK)
>
> "The medical planner is responsible for this (The spatial structure, such as classification and distributions of the different functions) the most." (Arch AS)

Arch DE mentioned the significant role of a medical planner in ED design. However, he believes that medical planners with an architectural background would be more qualified than others without architectural knowledge.

Extra information was extracted from the interviews, categorised in sub-codes. These sub-codes explain designers' roles and responsibilities, their experience, and their confidence in their designs. Extra explanations are mentioned below.

1. Roles

Some participants explicitly elaborated on their role as medical planners when design EDs. It can be summarised that knowing patients' routes and the different treatment processes, as well as the different functions, are what defines medical planners.

> "We are as a medical planner and architects, we must be aware [of] the path of every patient during the treatment process, and this is our knowledge. Because if I do not know the patients' route from admission to release following the treatment process, then I am not a medical planner. We must know all these functions, how to get in and out, and if we do not, then basically, we are not medical planners. "(Arch DE)

> "We know the nature of each patient and each existed function which we are required to provide the way a function can be used from entering to exist and be treated quickly without any delay as the time is so crucial in rescuing people and the rest the doctors handle. "(Arch DE)

2. Experience and self-development

All participants mentioned that they learn and develop through experience, previous case studies, and follow any new knowledge development. All of the interviewees mentioned that their design knowledge improves with their experience.

> "The design references, the developments in the medical equipment, and the academic studies." (Arch DE)

> "By keeps on reading, due to the continuance development on the design standards by producing new versions, therefore, we keep an eye on the design references to read every new release of them. "(Arch NK)

> "New challenges come with every new project, and then we need to be critical and keep on looking for new solutions for every problem. Therefore, we keep on developing ourselves, and as a result, our experiences and knowledge keep on improving. "(Arch NK)

> "Our work is mainly built on experience by following a specific foundation out of a lesson that was learned through trial and error." (Arch RS)

Some participants mentioned the usefulness of post-occupancy evaluation to learn from previous cases.

> "Complexity sometimes cannot be predicted, where it may be discovered after occupation, then some changes can be made to improve the situation, and this is how knowledge is built up, and this is how we learn and develop." (Arch RS)

> "The design should be evaluated after occupation and use (post-occupant evaluation), and this is how we gain experience and learn." (Arch AS)

3. Confidence

All of the designers mentioned that they are making the right design decisions based on their experience.

> "We will keep on doing what we are doing; we already work based on knowledge and experience and in a good sequence." (Arch DE)

> "I am doing okay, I believe, and I will keep myself up to date with available guidelines." (Arch NK)

B. Guidelines and research

Design guidelines are one of their prime sources of information that participants use:

> "From the guidelines, plus practical experience." (Arch RS)
>
> "Building notes in the UK, such as NHS (National Health Services) - HBN (Health Buildings Notes). Where they are my primary source of information for designing healthcare buildings, and I am up to date with all of their latest releases." (Arch NK)

Arch AS said that medical planners are the foremost experts in EDs as a second source after using the design references to complete the design.

> "The medical planners do the rest because they will give you more details about some department's elements or the department's purpose." (Arch AS)

Development in medical equipment and academic studies, as well as design references, are some of the primary sources of knowledge.

> "From the design references, the developments in the medical equipment and academic studies." (Arch DE)

The list of ED design references used by the interviewees is, for example, Health Buildings Notes (HBN) in the UK, which might be the ideal one.

> "Either you can have the European reference, which is called the green book ... It was the green book in Britain during the 1980s. Also, there are American ones (AIA). There is no big difference in the functions except in some of the requirements and the spaces." (Arch DE)
>
> "There are medical brochures issued by those entities (experts in the field) who focus on healthcare design. Therefore, you need to check it from time to time to keep yourself up to date." (Arch DE)
>
> "The one I use is the HBN (Health Buildings Notes); they are released by the NHS (National Health Services) in the UK, and these guidelines do provide explanation and justification, which is way much better than the American ones. The UK guidelines could be the ideal one, and all other guidelines need to be like it, they are the top." (Arch NK)

1. Applications

One of the participants mentioned that these guidelines might have enough information to start with; however, applying this information is what makes the difference. Thus, it is the designers' responsibility to come up with creative solutions.

> "These guidelines are more than enough, the other references are the development, or the applying of the existed references during implanting different projects … This could happen by adapting the references and coming up with creative solutions." (Arch DE)
>
> "Not everyone can apply every guideline. Not everyone who can read the guidelines can follow it and apply it, which is the important part. To be creative is the best application of these design references." (Arch DE)

> "The practical application for the design references can vary between a good implementation, and an outstanding, and finally an excellent application for when using the same design references." (Arch DE)
>
> "The best application of the design references could lead to improving them but not changing them … Improve them, but the changes will be limited to minor changes." (Arch DE)

Furthermore, Arch NK adds that practical experience is vital for developing design knowledge and improving the application. In addition to medical staff inputs, which play an essential role in developing designers understanding to produce good designs.

> "The more you meet the medical staff, the more you understand. When I first started working as a medical planner, I was not confident about my knowledge because I knew little only. However, every time I meet a medical staff, especially doctors, I learn new things. Therefore, I was learning from the medical staff a lot more than the guidelines." (Arch NK)

2. Updates

All interviewees mentioned that they follow developments and updates in the design guidelines and emphasise their importance.

> "Due to the continuance development on the design standards by producing new versions, therefore, we keep an eye on them to read every new release of them." (Arch NK)

These guidelines may be developing in some areas, as such, the medical equipment area, and patients' dignity and privacy.

> "These references keep on developing, mainly in the medical equipment area." (Arch DE)
>
> Privacy has become very important, and all guidelines and even owners are asserting on it. For example: "These days they are requesting a light gypsum board partitions from the left and right to spread between patients and curtains in the front." (Arch NK)

Arch DE believes that minor updates can be made to the design guidelines, such as in spaces due to the development in the medical equipment. However, the right application of these guidelines is a critical factor to produce creative solutions.

> "The best application of the design references could lead to improving them but not changing them … Improve them, but the changes will be limited to minor changes. For example, we can consider that Neufert System has become a design reference which is a reference now based on the fundamental requirements, and it provided better solutions without any changes in the basics." (Arch DE)
>
> "There is no big difference in the functions except in some of the requirements and the spaces." (Arch DE)
>
> "Technology might affect and might be changed only by dimensions and areas." (Arch NK)

Also, Arch DE mentioned that the functional relationships between the different departments could not be changed because these relationships are the basics of the design.

"It is not that easy to change the relations because you can enhance it, but the functional relations between the departments cannot be changed." (Arch DE)

3. Limitations

Most of the participants said that the medical processes are missing in the guidelines, with no comprehensive explanations.

"Now, I do have experience in healthcare and EDs design. However, in the past, I could have made the design correctly, but I was not sure about the processes and the functions in the rooms and how the rooms have to be used and function." (Arch NK)

"What might be missing is medical processes." (Arch NK)

"Even though I have overcome this problem [Not having experience in healthcare design] after I have started to have meetings with the medical staff to understand the medical process clearly and accurately, so I can apply my design to suit that." (Arch NK)

"It is (the treatment methods) defined as follows; simple diseases, complex diseases, there is not a comprehensive specification." (Arch AS)

Arch DE adds that designers are using these guidelines differently depending on their understanding; therefore, designers' knowledge defines the design, which is gained from experience and staff inputs. Thus, this might be considered a limitation from the interviewee's point of view.

"Not everyone can apply every guideline study. Not everyone who can read the guidelines can follow it and apply it, which is the important part. To be creative is the best application of these design references." (Arch DE)

"When I first started working as a medical planner, I was not confident about my knowledge. However, every time I meet a medical staff, especially doctors, I learn new things a lot more than the guidelines." (Arch NK)

C. Users and staff (people) input

The collected information from the interviewees reported that the medical staff's inputs are precious and that it has to be considered in the design stage. Their inputs are also a vital element to improve designers' knowledge because staff are more confident and better understand the way EDs should function.

"You can take all that knowledge (to become a medical planner) from the doctors." (Arch DE)

"The more you meet the medical staff, the more you understand. When I first started working as a medical planner, I was not confident about my knowledge. However, every time I meet a medical staff, especially doctors, I learn new things. A lot more than the guidelines." (Arch NK)

"We ask for their (Medical staff) feedback about the current situation, whether it is good or not. And then we try to take their point of view on how it can be improved and what can be done or added to benefits from their experiences." (Arch RS)

Besides, Arch NK believes that the medical staff has to interfere in the design process due to the valuable inputs they bring, as mentioned before. She also believes that the final drawings have to be revised and approved by a doctor.

> "I think the medical staff, doctors, have to interfere with the design process all the time. Furthermore, the one who revises the drawings and gives his approval has to be a doctor." (Arch NK)

In addition to the staff inputs and the useful additions, they add to the design. Nurses and porters might be more helpful due to their work duties, which require them to work across the ED and deal with patients from entering to release. However, doctors might be working in a closed circle where they mainly deal with patients in a specific area.

> "Doctors are the ones whom they use the hospitals. Therefore, their inputs are precious. Doctors and nurses, by the way, not only doctors because nurses may be more familiar with the flow than the doctors." (Arch NK)

> "I believe that nurses and porters are more affected by the design and the flow because they usually company the patients from admission to release while doctors do not." (Arch NK)

D. Other inputs

Arch DE believes that previous case studies are an essential step before starting any new projects. He also adds that all case studies have the same fundamentals; however, they may differ in some other criteria, such as the size and total area, available functions, and the way services are being delivered:

> "The best reference is to look at the previous examples (previous case studies) … The previous example for each case, as I told you, for example, a hospital's emergency department with one hundred-bed is not like a hospital's emergency department that has a two-hundred bed or a specialised hospital." (Arch DE)

> "It is the same fundamental for all the case studies, but the size of areas and the functions and the way this service is delivered varies from one to another." (Arch DE)

All of the participants mentioned the role of formal regulations and governmental requirements, such as the Ministry of Health, Ministry of Public Works, The City Council, The Civil Defence, The Jordanian Engineers Association. As quoted below.

> "Regulations and formal procedures ... Ministry of Health, Ministry of Public Works, Civil Defence, Jordanian Engineers Association" (Arch DE)

> "Achieve a building within architecture principles that suit the needs of the formal design regulation such as the city council, the Engineering Association Codes, the Ministry of Health, the Ministry of Public Works, the design guideline." (Arch HD)

Some of the participants talked about the usefulness of the owner's inputs and contribution to the design process, especially when they have medical experience.

> "The owners interfere most of the time, especially when he/she has medical experience and background, which is very useful in this case." (Arch RS)

> "The owner should have an image of the hospital type and size, whether currently or for the extension of the future, this is related to the land size and his financial possibilities. We can guide the owner on what to do; most of the owners normally are either doctors or both doctors and funders." (Arch DE)

E. Design restrictions

The interviewees mentioned that complexity increases in renovation projects; therefore, more problems may accrue, limiting the design.

> "When the project is rehabilitation to improve and add more spaces and different functions, this will increase the project's complexity, such as when expanding an emergency department, which will raise the challenges on us as the design team? As a result, problems may accrue." (Arch RS)

The mentioned restrictions are but not limited to the following when it is a renovation project: structural elements, unchangeable spaces, and functions, connecting the new building or the expanded one to the hospital.

> "The structural elements such as the columns, the windows, and sometimes some of the original spaces which we could not change or modify due to various reasons." (Arch RS)

> "We could include the physical restrictions such as columns and windows, and any like structural elements may cause challenges and problems in the design stage, especially when it is a rehabilitation project." (Arch NK)

Also, owners might be seeking commercial benefits more than achieving the ideal design situation; therefore, they may compromise the design to give more prominent space to more profitable departments. Also, the hospital owners' financial situation put some restrictions on the design:

> "We always give the owner's ideal area for the emergency department, but no one follows. For example, we may see that you need no less than 800 square meters for a Hospital, so they give us 300 square meters. However, the imaging department because it might be a very profitable department it is always a huge one." (Arch NK)

> "The capacity of the emergency department depends on the hospital size, the area, and the owner's demands." (Arch DE)

> "Each project we work on has its requirements and limits, which the owner preferences and needs define them, such as the requested size and functions, the appointed land, and the available fund for the projects." (Arch RS)

> "It depends on the owner and what requests from you. We originally designed a big Emergency Department, but the owner said, "No, I do not want a big Emergency Department, I need lobby and some treatment rooms." (Arch AS)

The appointed size for the emergency department can limit the design and change the final solutions which will impact on the spatial structure and the movement routes:

> "The primary problem is having enough space because usually the owners give EDs a tiny area, and they do not give it that much attention." (Arch NK)

> "We had to make one entrance for both ambulance and non-ambulance because after we finished the design, there was no space lift to create a second entrance." (Arch AS)

Also, cultural disagreements such as gender segregation can place some restrictions on the design, because the design, in this case, needs to accommodate all the required services for the two different genders:

> "Here, we had to make the male's room a little bit far to separate them from the females and the children." (Arch AS)
>
> "I have seen in some of the executed hospitals designed by us that some changes in the design may have happened and the reason usually due to cultural disagreements such as The Separation between males and females." (Arch NK)

II. Design Considerations

This theme captures the primary consideration for designers to achieve a well-functioning ED. Some of the interviews talked about the importance of having an initial survey and feasibility study to aid the design process.

> "It is essential to have a feasibility study before start working on the design, as it will guide the whole design process." (Arch DE)
>
> "If you made the analyses (feasibility study) before you started the project and worked with the targeted categories (the people you are designing for), you will avoid many issues to come." (Arch AS)

All participants mentioned the critically of EDs in terms of time, and how fast and smooth it should be:

> "Timing is crucial here, the more smooth and rapid process of getting the patient from the emergency gate to the exact destination to get treatments, these few minutes or seconds may equal his life." (Arch DE)
>
> "Emergency departments are all about stabilising the patients as fast as possible where it treats minor injuries; mostly, this is, in my opinion." (Arch NK)

The interviewees also talked about the importance of designing for all the different users using the department. Also, users' needs should be considered carefully in the design stage.

> "Users' requirements and demands might be the essential thing to study carefully in the design stage, whether it is the staff, patients, visitors, or any other users because this will define how good the design is." (Arch RS)
>
> "Bear in mind that the central concept of healthcare and EDs design is still the same, which is to be around different users - staff patients and visitors - to alleviate their experience. Therefore, the main aim is to design for the users." (Arch NK)

This theme is also covering other key design considerations. These considerations are divided into four different criteria under the following codes: movement and circulation, density and overcrowding, privacy and connectivity, and functions, arrangements and hierarchy.

A. Movement and circulation

All of the participants mentioned two types of patients that EDs receive: walk-in and ambulance patients. Each group should have a designated entrance.

> "There will be two types of patients, on foot or by ambulance; everyone needs a different type of treatment. The challenge here is to offer a fast way to get patients to the necessarily mean, space, to treat them." (Arch DE)

> "Emergency departments should have two entrances, non-ambulance, and the ambulance. These entrances separate from the outside yet connects in the inside; therefore, it is a critical situation." (Arch AS)

> "Regarding the challenges and most important elements that we may face are entrances and exits, mainly for people movements which can be divided into two categories; the first is the Walk-in patients; whom they use the door and come on foot. Second is Ambulance patients." (Arch NK)

Also, a separate entrance for services and supplies is required for EDs.

> "Emergency Departments sure should have a special entrance for it. Therefore, the services entrance should be different." (Arch DE)

The majority of the interviewees also touched on the importance of having different movement routes for different users and materials. They have to be critically designed to avoid any intersection.

> "Not having an intersection between the required users' movements, not having any intersection in the movement routes between patients and the healthcare staff in the department. Such an intersection in the movement routes can lead to inappropriate results." (Arch DE)

> "The main thing to achieve is avoiding cross circulation to make sure there will not be any intersection between the flow of patients, staff, visitors, and even the materials (the supplies), which is what makes a good design regarding movement patterns and circulation in EDs." (Arch NK)

Also, Arch NK explicitly mentioned the critical link between the medical processes and the department's layout to achieve the best flow:

> "The flow of patients already depends on the process of the doctor (medical staff). For example: when a patient arrives, he does not go to the observation room straight away; the patient has to go through the following: First: triage room. Second: the exam treatment room. Third: his condition would be defined in this stage. Then Finally: the patient may be sent to the related section or the observation. Therefore, the layout of the emergency department forces you and the patients to go through the process of the department." (Arch NK)

Accessibility (Entrances and exits) and internal circulation are critical to consider, as mentioned by the participants.

> "The accessibility from the outside is important, and there are no obstacles. The department from inside must be clear with no intersection between people; those two are the most important point." (Arch AS)

Furthermore, it is better to have different entrances for each group of patients, as mentioned before (walk-in and ambulance patients). However, the size of the ED is mainly the factor that impacts on having two entrances. The bigger the department, the easier it will be to have two

separate entrances. Otherwise, they will share the same one, and for this, a critical analysis of the situation is required to avoid the intersection and create a smooth flow.

> "It is not compulsory or mandatory for them (the entrances of the walk-in and the ambulance patients) to be separate. Moreover, it depends on the size of the emergency department. Therefore, if it was a small emergency department, then they can share the same entrance. If there was only one entrance, then the patient's movement after the entrance should be studied critically and carefully. For example, a separate path can be designed to be used for critical patients only whom they usually arrive by ambulance. It is like a path from the entrance to a specific point in the department. Second, another specified path is for walk-in patients whom they are in a less critical situation." (Arch NK)

Designers may face some challenges when trying to make an ideal design for internal circulation and the movement routes. One of the participants emphasised the owners' demands, which may put some restrictions on the design.

> "We cannot achieve that [not having cross circulation] all the time. For example, we may say for the client that at this point, there might be a cross-section, but they (the owners) do not mind." (Arch NK)

> "It is not allowed to have cross-section paths. Therefore, we ask the client for extra space to achieve this; otherwise, this will be the situation.

B. Density and Overcrowding

Most interviewees said that a feasibility study is a crucial element to create an image and better predictions of how the situation would be after occupation. It helps in collecting information that can be used as a base point for the design.

> "It is essential to have a feasibility study before start working on the design, as it will guide the whole design process." (Arch DE)

Arch NK said that doing a feasibility study might be the only way to predict and analyse density and overcrowding in the design stage.

> "It is more about the feasibility study such as the area, how many emergency points are available, nearby hospitals, type of hospitals, the population in that area, prices ... Etc." (Arch NK)

Arch DE and Arch NK said that crowding might be a management responsibility more than a design problem, therefore, applying the adopted medical system and having proper control of the department is an effective solution for overcrowding in EDs. Meeting users' requirements is essential to improve work efficiency and reduce overcrowding.

> "It is about controlling the department. We can put strict instructions to lead the visitors were to wait for the patients and provide good services for them. Nevertheless, we cannot serve all visitors when they are more than the usual and supply the waiting area with services; it is illogical to apply. Therefore, it is all about having good control." (Arch DE)

> "I believe in such situations (Crowded and density), it depends on the hospital's management on how they operate even in EDs, it depends on how they may operate the department." (Arch NK)

Moreover, the geographical location and social norms are some of the main factors that can cause overcrowding. Therefore, it is the management role to operate and control the people.

> "We must say again that the geographic location of the hospital and the social custom plays an important role. Hospitals are not forced and cannot build vast areas to receipt all these people. We cannot design spaces for all the visitors. We realise the importance of this function, but we cannot exceed 2000 square meters to receive visitors while we have only 1000 square meters. It will cause overcrowding." (Arch DE)

> "In Jordan, we may have some cultural problems and Mismanagement sometimes because visitors are not allowed to go anywhere after triage. However, they may reach every section of the department, even operating rooms." (Arch NK)

Movement routes and internal circulation are also an essential factor to control and reduce overcrowding in EDs. All participants mentioned that the movement paths of the different users have to be separated to reduce overcrowding.

> "When the movement's routes are not clear, this will lead to congestion." (Arch AS)

> "As I mentioned before, no cross circulation in the emergency department in or out between Staff, patients, visitors, and materials." (Arch NK)

One of the interviewees suggested that having separate entrances and exits for the same ED will prevent intersections in the movement routes, which will reduce overcrowding.

> "It is better to have different entrance and exist (So that people come in from one place and go out another) for the same emergency department, so there will not be any intersection and overcrowding between the users in the same area." (Arch DE)

In addition to the previously mentioned criteria, all participants explicitly mentioned that small spaces create overcrowding.

> If I am forced to work in a small area in the design stage, it is difficult for me to find a solution for overcrowding or any other problems; they may arise due to the small space." (Arch DE)

> "it is not a planning problem, and it has to be dealt with in the feasibility study where it can reveal that a small space will not work. Therefore, we tell the owner." (Arch NK)

C. Privacy and connectivity

From the collected data, one of the interviewed medical planners emphasised the importance of privacy and that even the guidelines have started giving it more attention:

> Privacy and patient's dignity became very important. In emergency departments, the old guidelines did not give much attention to the patient's privacy. Hence, you used to enter a big space, and all patients will be distributed around, and they used to say that having curtains is enough. These days they are requesting a light gypsum board partitions from the left and right to spread between patients and curtains in the front." (Arch NK)

> Privacy is a right for all patients; it also means that not anyone can see the patients where he/she was and whatever his/her condition was (conscious and unconscious). Therefore, we must provide privacy for the patients and their families." (Arch DE)

Some participants mentioned that it is difficult sometimes to achieve privacy, such as acoustic and visual privacy. Most of the participants did mention that a single patients treatment room would be the ideal situation to secure patients' privacy.

> "In the emergency department, there is still an acoustic privacy problem, it is reduced, but it is difficult to be achieved like in private patients' rooms as they are fully isolated." (Arch NK)

However, some designers are still using curtains to separate patients' beds to provide visual privacy.

> "In a room that has two beds, the two beds are separated by a curtain. This curtain is to provide privacy for the two patients in the same room, and to provide privacy for the patient from the visitors, and to provide privacy for the patient during the treatment or the check process." (Arch DE)

Although guidelines started giving more attention to privacy in EDs as revealed from the collected data, owners sometimes try to reduce the cost by compromising other factors to save money, such as privacy:

> In the design stage, we guide the owner to apply privacy. Nevertheless, if they decided to replace gypsum boards partitions with curtains to save money, then it is their call. However, my task is to guide them to the best solution." (Arch NK)

All the participants emphasised on users' different needs in EDs to secure their privacy. For example, different movement routes to separate the circulation between the different users were among the main considerations in the design to secure privacy.

> "Guidelines and I see that achieving privacy is mainly linked to having different movement paths for each user and the material." (Arch DE)

> "Studying Privacy, Hierarchy, and Security, especially in a complex environment such as EDs is essential as it impacts all users (staff, patients, and visitors). It can be studied through the design process to design for each user. For example, we design the moving routes and spaces for the different users in the department." (Arch RS)

The requirements of the users vary among each other to secure their privacy. For example, some staff members needed to have things like office and private rooms, changing rooms, and other services such as restroom and private cafeteria.

> "Changing rooms for both genders in different locations are part of staff privacy … Their services, their restrooms, their changing rooms, spaces where they can eat are essential too; they should have their cafeteria for their privacy not to engage with the public. It is not suitable that doctors eat in front of people. the hospital is not a restaurant." (Arch DE)

Patients and visitors also require waiting areas equipped with adequate services to support their privacy and prevent them from making any disruption in the department.

> "There is also a private zone for visitors to not stay in the corridors ... They may distribute the staff and their privacy if they do not find special places for them to rest in. So, when you provide the visitors with a waiting area supplied with all services like bathrooms, and water fountains, it supports the privacy for the visitors and staff and patients as." (Arch DE)

Similarly, some participants pointed to the link between medical procedures and privacy. Implicitly it can be seen from the interviewees that hierarchy is a required factor to achieve privacy.

> Privacy may be linked to the medical procedures by identifying spaces and rooms that patients and visitors can access and be able to see. Identifying spaces and rooms that patients and visitors should not have access to or even see." (Arch RS)

Another point that was extracted from the interview data is visual connectivity. One of the participants mentioned the importance of visual connectivity, especially between medical staff and patients, and the importance of the nurse station to observe patients and control the department.

> Visual connectivity is essential between nurses and patients, and there must be a control point. At the entrances of any important spaces, there must be a nurse station to control people's flow." (Arch NK)

D. Functions, arrangements, and hierarchy

When participants were asked about the main criteria to be considered when designing EDs, they all expressed their belief that the hierarchy and the relationships between the different spaces are essential in ED design.

> "We know the nature of each patient and each existing function, which we are required to provide the way a function can be used from entering to exist and be treated easily without any delay as time is so important in rescuing people, and the rest the doctors handle." (Arch DE)

> "The hierarchy and the process of functional relationships are the basis of our knowledge as medical planners." (Arch DE)

> "I as an Architect is responsible for designing the relationships between the different spaces within a hospital or an Emergency Department as we do the grid to start the design from and draw the various links between the different spaces. Therefore, it is mainly the relationship between the different functions, which is the most important." (Arch HD)

> "The relationships between the different rooms are the essential criterion to be considered, especially rooms with related medical procedures when to move patients from one to another." (Arch AS)

Participants talked about the relationship between EDs and other related departments, which needs to be studied carefully. For example, entrances and exits relationships with imaging and operation is critical to ensure a smooth flow for users' treatment journey. Also, to serve patients and not to waste time.

> "Connecting the Emergency Department with the other departments is very important. For example, entrances and exits relation to the Imaging and the Operational Room (OR) is critical, because when patients arrive, they may need to go to the imaging section first or to be sent to the operational section straight away depending on their situation and medical condition." (Arch NK)

Participants mentioned that resuscitation and the minor operation rooms need to be near the entrance. The exam and treatment room need to be away from peoples' sight, which will secure patients' privacy and secure a smooth and fast circulation.

> "We try to place the Exam and Treatment Rooms away from people's sight, so it will be a bit hidden and cannot be reached unless you passed triage … For the resuscitation rooms and minor operation rooms, they must be close to the entrance and have closed doors, and no one can see in." (Arch NK)

The majority of the participants believe that rooms like triage, resuscitation, operation, radiology/imaging, and admission are essential, mainly in terms of their use and hierarchy and their relation to the department's entrance.

> "When I design; all the needed rooms have to be aligned and close to each other—for example, the resuscitation rooms, Minor OR … Etc. Moreover, if the patient to be moved from this room, the elevators have to be close by to move the patient to the operating rooms or imaging if they are on different floors. However, if they are on the same floor, they need to be very close." (Arch NK)

Also, arch AS emphasis on the distances between the functions in EDs. He said that it might be better to have some functions at the end of the department or even outside. For example, the location of radiology, operation rooms, and the laboratory might need to be close. However, it is okay if they were a bit far from the main entrance or even outside the ED; therefore, in this case, a fast communication system is required.

> "Due to the distance between the different rooms, some functions will be far and should be because not everyone would go there." (Arch AS)

> "The radiology room and the laboratories come after the examination room." (Arch AS)

> "Provide and ease the communication with the emergency department support service, which means that I may need the radiation department and the laboratories nearby. Or Fast communication between them for better services." (Arch DE)

The interviewed participants listed some other essential functions, such as waiting, which will prevent patients and visitors from disturbing others. Other functions are reception, accountant desk, WCs, triage, resuscitation, exam rooms, radiology, laboratory, gypsum room, operations and recovery rooms, and short-stay rooms.

> "The most important is to find them (patients) a place to rest and sit for waiting. The waiting area, the lobby, the reception, WC, the triage room, the resuscitation room, exam rooms, radiology, laboratory, and gypsum room are right here. Operations and recovery rooms, short-stay rooms that can be used when the patient needs to stay for two days or less, or he/she can be sent to the ICU. The previous are necessary functions related to the patients." (Arch AS)

Some functions might need to be close to the non-ambulance entrance, as such, reception, record, medical services office, lobby, pharmacy, accounting, and triage. Other functions need to be close to the ambulance entrance, such as stretchers park, security office, triage, and resuscitation.

"When you use the non-ambulance entrance, you will find the reception, the record, medical services, lobby, pharmacy, and accounting." (Arch AS)

"When you use the ambulance entrance, you will find the stretcher trollies, the necessary security office. The respective section of the two entrances is triage and resuscitations. The triage is indeed joint between the two entrances, but the non-ambulance visitors use it the most." (Arch AS)

III. Tools

This theme is about the available tools and software that architects know about or use in the design stage to aid the design process—furthermore, the available evaluation tools to assess the design after occupation. The collected information is categorised into two codes: design tools and evaluation tools.

A. Design tools

The interviewed architects stated that they do not use any analytical tools as a pre-occupancy evaluation other than the usual drafting software like AutoCAD, 3Ds MAX, and Revit.

"It is only applying draft software that is like AutoCAD." (Arch DE)

"The usual 3D programs such as 3D Max, Sketch-Up, Revit... etc. However, there is no specialised software for medical purposes." (Arch RS)

"We do not use any software for analysis; our work is mainly built on experience by following a specific foundation out of a lesson that was learned through trial and error." (Arch RS)

The collected data reveals the participant's perspectives on pre-occupancy analysis. It can be seen that participants only relay on the feasibility study to evaluate and predict overcrowding as a pre-design process.

"By doing a pre-design study (feasibility study), to study the location and the nearby, similar hospitals to predict the number of patients that may come to the hospital so that the hospital can be designed depending on accurate findings and facts." (Arch RS)

"It is called a feasibility study. We ask people some questions. If there is another hospital, we ask what is missing to include it in the new hospital and more about enhancing the offered services." (Arch AS)

They refer back to the design references, and previous and similar cases, in addition to their own practical experience as a means to aid the design processes. Also, they collect data from medical staff.:

"Yes, we do some evaluations. We look at some cases (Old Case Studies) to determine its advantages and disadvantages. It is more like the higher education levels here." (Arch AS)

By going back to the design references and the practical experience." (Arch DE)

"We do not study it (Movement and Circulation) in the design stage; it just comes by default when we are designing, we try to make sure there is not any cross-section. (Arch NK)

"We have never done any analysis, we have only had some meetings with some of the medical staff in the hospitals, and some of them were already working in the emergency department. These meetings were mainly to ask them about what they want from us." (Arch RS)

B. Evaluation tools

Most participants believe in the importance of post-occupancy evaluation to learn and develop their knowledge and understanding. However, none of the interviewed designers ever done any post-occupancy evaluation.

> "It could be significant because it gives the designer a better understanding of the way his design has been used to evaluate the positives and the negatives to be used or avoided in the future." (Arch RS)
>
> "It is essential to check if there are any problems to avoid in the upcoming projects." (Arch AS)
>
> I think so (to evaluate the design after occupation), but we do not do that." (Arch NK)

However, one of the participants thinks that a post-occupancy evaluation is not necessary and that it is a necessity is private:

> "It is not necessarily. Post evaluation has a personal necessity in either selling or developing and having new partners. For the evaluation stage, this is purely business more than being a geometric work. As we have said, its necessity is private." (Arch DE)

A post-occupancy evaluation could be done by observing how the building is being used, also, to collect feedback from users:

> "You need to spend a whole day there to see how it operates." (Arch NK)
>
> "We collect some feedback about the satisfaction of the community and the staff, doctors in this case. They are cooperative - It is way better than before; many problems are solved now - they said. The real and true evaluations come from the people, not yourself." (Arch AS)

Arch DE mentioned that they (as the designers) might not be obliged to conduct a post-occupancy evaluation and that it may be not necessary unless there is a necessity for it, such as the personal necessity for value evaluation for investment purposes.

> "The post-occupancy evaluation might be of use when I plan to sell the project. For example, If the owner is planning to sell or if he/she wants to develop and want to evaluate for expansion purposes and to bring partners." (Arch DE)

Also, Arch NK adds that they are not encouraged to do a post-occupancy evaluation, for example, by hospitals owners or the owner of their architectural firm. Arch because they only may receive compliments and useful feedback about their work.

> "We do not (Do a Post-Occupancy Evaluation), but we receive feedback from the owners most of the time tell us that they are satisfied, and the hospital is working fine. Another sign is that I have been working in this office for about 12 years. We still receive feedback from the same client we have and some governments we deal with asking us to do more projects for them because they are satisfied with the work and it works fine, and we are accredited design office. Usually, no one asks us to do a post-occupancy evaluation." (Arch NK)
>
> "We have never done such a thing (visiting a project after occupation). We here are employees only, and the office does not require us to do such a thing." (Arch RS)

Alternatively, they might visit a project after occupation out of curiosity with no criticality and real intentions to evaluate the project as pre occupancy evaluation.

> "It is just a regular visit; there was another project in the area, so we visited it on our way there. We always love to see our work fruits." (Arch AS)

IV. Technology and Design

This theme illustrates the impact of the development in the medical equipment' on the design of the spatial structure. The collected information shows a change in the size and space because of the development in the medical equipment sector. Therefore, one code is covering the participants' responds named Size and Space.

A. Size and space:

Most of the participants believe that healthcare design is in continuous development; therefore, they must keep following any new knowledge in the field.

> "Due to the continuance development on the design standards by producing new versions, therefore, we keep an eye on them to read every new release of them." (Arch NK)
>
> "There are medical brochures issued by those entities (experts in the field) who focus on healthcare design. Therefore, you need to check it from time to time to keep yourself up to date." (Arch DE)

Moreover, the ongoing growth in the medical planning area mainly happens due to the development in the medical equipment, which will be followed by spatial changes such as, the size and number of required spaces:

> "These references keep on developing and mainly in the medical equipment area." (Arch DE)
>
> "The development in the science will follow by a development in the medical equipment and change the needed spaces for it or example, the needed space for the X-ray rooms is not the same as in the past, because day by day the science is developing, and the equipment is getting smaller so are the needed spaces. Also, it will need less electricity and mechanic demands than before." (Arch DE)
>
> It is mainly in the sizes of the room because the medical equipment itself is developing and changing so they may become smaller or bigger, or sometimes an extra space is needed to be used as support areas such as an equipment room, control room, therefore the design may change." (Arch NK)

4.3.3.2 ED Operation

ED operation is the second overarching theme that emerged to assess experts' designers' perception of emergency departments design. It focuses on exploring the role of management and operations in EDs to improve work efficiency. Also, to explore designers understanding of the unique medical considerations in EDs. Two major themes emerged: management and users, and medical considerations.

I. *Management and users*

This theme reveals the role of EDs administration to overcome challenges that may occur during the operation of the department. These data represent the point of view of the interviewed participants. This theme is divided into two different codes: specialised staff; and control.

A. *EDs specialised staff*

Arch DE mentioned that in EDs, it is significantly vital to have fast, rapid, and smooth procedures when dealing with patients seeking and urgent medical service as quoted below:

> "Timing is crucial here, the more smooth and rapid process of getting the patient from the emergency gate to the exact destination to get treatments, these few minutes or seconds may equal his life." (Arch DE)

The collected information reveals that trained staff and specialised ED physicians are needed to deal with urgent cases and situations to achieve rapid procedures. The interviewed architects believe that a specialised staff for EDs only will overcome challenges EDs may be facing.

> "Circulation is essential, and the medical staff too, whether Doctors or nurses, all of them should be trained for such situations (Emergency and time crucial cases)." (Arch DE)

> "you need a specialised staff for the emergency department only, whom they are not the same ones who serve in the other departments in the hospital." (Arch DE)

> "The availability of an expert ED staff all day around." (Arch RS)

One of the participants also explained that additional staff and specialists need to be available and reachable in the hospital to deal with various medical in EDs. Alternatively, the hospitals can cooperate with other nearby hospitals, specialists, or healthcare services providers to answer ED urgent calls.

> "The patient can be provided with first aid. However, without proceeding with the right specialist for the case, such as an osteopath or the optometrist, for example, and so on, then you did not complete your job due to the missing link, which is considered as a challenge." (Arch DE)

> "The staff should be available and reachable, if you do not have the right specialist, you can call for someone who is using rapid communications, for example, Cardiothoracic, or an osteopath, or neurological doctor form the same hospital, or else ware, therefore, you should have prepared information that can be used at once." (Arch DE)

Moreover, it is essential to have an efficient communication mechanism in hospitals between the different departments and the different medical services providers. For example, fast communication might be needed between ED and radiology and the laboratory the most if they are far from the ED. Therefore, it is the management responsibility, as mentioned by one of the participants in this context:

> "provide and ease the communication with the emergency department support service, which means that I may need the radiation department and the laboratories nearby. Or Fast communication between them for better services." (Arch DE)

B. ED control

The interviewed architects believed that it is also the management responsibility to ensure the department running smoothly, efficiently, and in an organised way.

The majority of the interviewed architects were confident about their design approach and their knowledge regarding EDs requirements. However, problems sometimes occur as a result of faulty management to run and control the department. To emphasis, the participants believed that inefficiency in EDs flow is management responsibilities rather than a planning problem.

> "The design should be good in achieving the criteria we have mentioned like the entrances and exits, the flow to avoid intersections. The rest is on the management of the department to run the department well." (Arch DE)
>
> "I believe in such situations (Crowded and density) it depends on the hospital's management on how they operate even in EDs, it depends on how they may operate the department. However, it is not a planning problem, and it has to be dealt with in the feasibility study, where it can reveal that a small space will not work. Therefore, we tell the owner." (Arch NK)

Uncontrolled users can cause different problems in EDs and may hinder the medical process and the overall efficiency. They might create crowded areas and compromise other users' privacy; therefore, it is a management function to control users.

> "We cannot serve all visitors when they are more than the usual and supply the waiting area with services; it is illogical to apply. Therefore, it is all about having good control." (Arch DE)
>
> "Users may create problems and hinder the process and the way the department function due to different reasons, such as an uneducated user." (Arch RS)
>
> "We may have some cultural problems and Mismanagement sometimes because visitors are not allowed to go anywhere after triage. However, they may reach every section of the department, even operating rooms." (Arch NK)

Therefore, it is the administration duty to control the department by strictly applying the adopted system to manage users and ease the overall flow.

> "The administrative process must be controlled well to secure good services; there should be strictness in applying the system on everyone." (Arch DE)
>
> "It is about controlling the department. We can put strict instructions to lead the visitors where to go and wait for the patients, additionally to provide good services for them." (Arch DE)

II. Medical Concerns

This theme collects information about the significance of EDs design, which is the primary design criteria that distinguish EDs from other types of building due to its unique medical considerations. This theme is branched to two different codes: designers' understanding and medical values in the design process.

A. Designers' understanding

Most of the participants were confident about their design knowledge regarding the essential requirements of EDs. Also, the participants believed they have sufficient data about the different medical process in EDs, the relationships between the different functions, and the nature of the different patients:

> "The hierarchy and the process of the functional relationships are the basis of our knowledge as medical planners, and this talk must be compatible with the doctor's opinion." (Arch DE)
>
> "We know the nature of each patient, and each function which we are required to provide the way a function can be used from entering to exit and be patients can be treated easily without delay." (Arch DE)
>
> "We know that each emergency case has it is own space to be treated in, and these spaces are equipped with what is needed to deal with these emergencies." (Arch RS)

Triage is where patients are examined when they first arrive at the ED. It is where their medical condition is being classified:

> "We know that this stage, the patients enter, for example, and be received whether they come in an ambulance or on foot or with their parents. The first action to be taken is to classify the patients' cases in the triage room. Triage is the classification area. It could be a bed or more, a room or more." (Arch DE)

The treatment process and the required medical procedures will be decided after classifying the patient's condition in the triage area (Triage is for walk-in patients, and ambulance patients are sent directly to operation or resuscitation).

Different treatment scenarios were thought of by the interviewed architects. Arch DE mentioned that after the patient is being classified in the triage area, the patients will be examined in the examination room. After that, different decisions can be made depending on the patient's situation, for example:

1. Patients stay in the examination room, where the following can be done:
    a. A specialised doctor can be called for further examination; therefore, the patient stays in the treatment room.
    b. Further examination can be done, and vital signs/samples can be taken.
    c. Requesting an X-Ray image; therefore, the patient stays in the treatment room waiting for X-ray to be ready.
2. The patient can be admitted to the hospital.

> "Once the doctors examine the patients… the doctor has to decide the next step to be followed, such as to take the patient to the admission or call for a specialist or to be taken to his/her vital signs can be checked or ask for an x-ray for the patient. Then the doctor decides whether to classify the patient to the private emergency medicine room or the surgical emergency treatment room. Ans the surgical cases are obvious. In case the patient is wounded because of its crystal clear when a patient is wounded, he/she needs to go to the surgical emergency treatment room. However, for the internal emergency cases may take a

bit longer to be classified. Supposed to be done in less than a minute. The case then classified and sent to the intended treatment rooms to follow for the treatment process." (Arch DE)

Arch AS mentioned other points that needs to be considered, for example, walk-in patients (non-critical patients) start in the triage; therefore, the triage location is crucial. It needs to be close to the entrance of the department as well as the main related functions. After triage, patients are usually sent to one to the following:

1. The examination room (for further tests, blood samples, or request an X-Ray).
2. The minor operation rooms in the ED. Alternatively, the operation department if the cases are critical and need a major operation.
3. The resuscitation if the case was critical and needed to be resuscitated.

"You should also consider the triage location must be near the related functions and where it will send the patients later. Usually, they go to the exam room from the triage. From the resuscitation to the minor operations room directly and if the patient needed a major surgical operation after they examined him in the triage to be sent directly to the operation section. If there is no operation section in the Emergency Department, they sent him directly from the resuscitation or the triage to the operations department."

Ambulance patients (critical patients) go to resuscitation directly, where they are often unconscious. Then the patient might be transferred to the operational department if needed

"The resuscitation is used in case there was a coma, or an accident and the patient are unconscious, or anyone who slips into a coma, he/she goes immediately to the resuscitations room which is joint between the two entrances sections." (Arch AS)

The minor operations room in the ED deals with minor injuries unless the patient's situation was urgent and need an advance operation. Otherwise, the patient will be sent to the operation department, which has to be near the ED.

"Even if there is a minor operation room in the emergency department, they do not perform advanced surgeries unless they had to, and it was a very urgent situation. In the minor operation room, they mainly treat broken bones, open wounds, plaster, minor stitches." (Arch NK)

Arch NK says that walk-in patients (non-critical patient) will go through the following:

1. Triage.
2. Examination room.
3. Depending on the patient's condition, they will be sent to the related room for further treatment process if needed.

"When a patient arrives, he does not go to the observation room straight away; the patient has to go through the following: First: triage room. Second: the exam treatment room. Third: his condition would be defined in this stage. Then Finally: the patient may be sent to the related section or the observation." (Arch NK)

B. Medical values in the design process

All participants said that EDs need to accommodate two types of patients, ambulance and walk-in. Therefore, the department must be structured to ensure a smooth flow for all users.

> "There will be two types of patients, on foot or by the ambulance; everyone needs a different type of treatment. The challenge here is to offer a fast way to get the patient to the necessarily mean, space or the function to treat him." (Arch DE)

> "It is just two options: First, the walk-in patients (Non-Critical). Second the ambulance patients (Critical). The ambulance patients are critical because they are mainly on stretchers. After all, they are usually in a bad health situation." (Arch NK)

The first type of patient is ambulance patients, and they usually have a critical medical condition; therefore, they require fast procedures with the needs functions to be nearby. These conditions' criticality is due because it is usually life-threatening matters. The second type of patients is walk-in patients. They may suffer from less critical conditions than the critical one. However, they also require a smooth flow to speed up the procedures. Non-critical cases are dealt with differently than critical ones.

> "The critical case has a specific, predefined, fast, and direct route compared to the non-critical one. The non-critical case goes to triage first to be checked up for the vital signs then blood samples might be taken from the patients, then the patient might be sent to the treatment room or the observation if needed, and then the patient may be admitted or released." (Arch NK)

> "If the patient's situation is critical, the patient will be moved to the resuscitation room. Therefore, you can see that there is a connection." (Arch NK)

Besides, the participants said the design of the spatial structure needs to be able to guide the people through the medical procedures, which are defined by the doctors:

> "We try to guide them (the patients) through the procedures by design. What we do is to make sure we have a proper flow for the patients that works with the medical procedures." (Arch NK)

> "The layout of the emergency department forces you and the patients to go through the process of the department." (Arch NK)

Moreover, the interviewed architects believe that the ideal situation is achieved by avoiding cross circulation in the internal flow:

> "Achieve the ideal situation which does not have any cross-circulation throughout the whole department." (Arch NK)

> "The main challenges where the movement's paths cross." (Arch AS)

Regarding the spatial arrangements of the different functions in the ED, they are designed carefully to have all the required functions and be in the right locations, mainly the functions that need to be close to the main entrance.

> "We do mainly design the spatial structure and the circulation to ensure all the required spaces and function is there and the best location for each room and what rooms need to be close to the main entrance of the department." (Arch RS)

The most mentioned functions were the resuscitation room and the minor operation room. Both these rooms need to be close to the department's entrance as critical cases usually use them.

> "Critical cases must have very fast routs. Even when I design, all the needed rooms have to be aligned and close to each other, for example, the resuscitation rooms and the Minor." (Arch NK)
>
> "The resuscitation is used in case there was a coma or an accident, and the patient is unconscious or anyone who slips into a coma; he/she goes immediately to the resuscitations room, which is joint between the two entrances sections." (Arch AS)

The overwhelming majority of interviewed participants referred to the location of the radiology and the laboratory location. These two functions need to be nearby for fast and easy access when needed, or a fast communication if they were far.

> "In big projects, the perfect situation is to have the imaging in a specific spot near the entrance." (Arch NK)
>
> "Provide and ease the communication with the emergency department support service, which means that I may need the radiation department and the laboratories nearby. Or Fast communication between them for better services." (Arch DE)
>
> "The radiology room and the laboratories come after the examination room. Because following the sequence, triage, triage exam, he can be asked to do some tests or get an X-ray. This is applicable too, the resuscitation, and direct to the operation room." (Arch AS)

However, operation, radiology, and laboratory could be placed outside the ED, which depends on the owners' demands and the ED total floor area.

> "The operation room might not be there (in the ED); it depends on the owner's request. It could be in the operations department. The laboratory and the radiology could face the same; they could not be in the Emergency Department, so it depends on the hospital system." (Arch AS)

4.3.3.3 In Summary

At first, it was helpful to collect an overview of ED design knowledge and resources from the designers' point of view. Thus, the overarching theme 'ED Design' summarises the collected data under four themes: design knowledge, design considerations, tools, and the influence of development in technology on the design. Further detailed are mentioned below:

The theme "design knowledge" summarises the collected data regarding designers' sources of knowledge and EDs design information. The following point can be concluded.

- Designers believed that knowing patients' routes, different treatment process, and various functions in healthcare facilities, in general, is what defines a healthcare designer and medical planners.
- Their design knowledge comes mainly from design guidelines, recent research, medical staff and users, previous cases, and practical experience. However, they believe that ED design guidelines do not provide comprehensive explanations of the clinical process and their relation to the spatial structure. They collect such essential data from staff to understand ED's spatial requirements. Besides, designers believe that ED's design guidelines mainly develop in terms of the required

spaces and sizes due to the development in the medical equipment and their spatial requirements. Also, the functional relationships in the guidelines are still the same. Therefore, input from medical staff and users is essential to the design process, as providing a comprehensive explanation of **the way EDs should function**.

The theme "design considerations" summarise the collected data regarding main design criteria in general and ED in particular.

A. Designers believe that knowing the different users' needs is vital to plan a facility that supports timely, fast, and smooth procedures. For example, EDs serve two different main type of patients, ambulance patient and walk-in patients. Thus, each type should have their entrance and movement routes with no intersection between them or the material and supplies' movement routes. The importance of having dedicated paths for different users is to ensure the internal circulation and layout support the medical procedures to achieve the best flow for users. Thus, having big spaces will make it easier to have separate entrances, separate movement routes, and good functional layout, which will reduce intersections and create a smooth flow. Achieving this will impact EDs' other requirements, such as privacy, accessibility, hierarchy, and connectivity. It may also influence overall department efficiency by supporting operational demands, which includes reducing overcrowding and waiting time.
B. Interestingly, none of the interviewees uses any analytical tools to predict and evaluate overcrowding, where they only rely on a feasibility study as a pre-design procedure. However, overcrowding might be caused by various factors, which can be design related or management responsibilities. For example, for the design, meeting all users' requirements such as functions and services is critical to improving work efficiency. Also, having separate movement routes with different access points for the different users with no cross circulation is critical to achieving a smooth flow. Furthermore, the department's size is an essential factor to provide healthcare services to the predicted number of users. Nevertheless, for the management, applying the adopted medical system and proper control over departmental operation and users is a critical management role to improve the workflow and reduce overcrowding.
C. Privacy has become an essential design requirement; therefore, it can be improved by separating users' circulation routes. Also, by providing users (staff, visitors and patients) with spaces and services to secure their privacy, such as waiting areas, private areas, private offices, private rest areas, and changing rooms. Besides, privacy can be achieved through planning the hierarchy for the different functions in the layout and defining staff and other users' areas. Furthermore, management has to have proper control over the department to guide the flow and secure everyone's privacy.

D. For the ED functions design, it is vital to begin by identifying different users' requirements and functions to support work efficiency. Therefore, their hierarchy, arrangement, and relationships need to be studied carefully to support the medical process to have a timely, fast, and smooth flow. For example, entrances and exits and their relations to most related functions are critical, such as resuscitation, minor operation, triage, lobby, accountant, admission, waiting area, and adequate public services. Also, their relationships with other departments, as such, radiology, operation and laboratory are also important. The arrangement of the functions needs to service patients' needs; therefore, some functions need to be close to the entrance, while others can be further in the department, such as recovery rooms and short-stay rooms.

The theme "tool" summarises the collected data regarding available tools and software to aid the design process or evaluation after occupation.

- None of the interviewees uses any analytical tools for pre- or post-occupancy evaluation, where they sometimes conduct a feasibility study to collect information to aid the design process. The feasibility study may include initial surveys with staff, users, owners, and the community to support design decisions. Also, designers mainly use drafting software, such as AutoCAD during the design process. Furthermore, although designers do not usually conduct a post-occupancy evaluation, they understand the importance of such evaluation to learn and develop their knowledge. However, they may observe and conduct surveys with users to evaluate the way the facility work. Such an evaluation will help to identify problems that may hinder work efficiency. Nevertheless, the interviewees mentioned that they might not be obligated to conduct a post-occupancy evaluation unless there was a specific necessity for it, such as for investment purposes or asked to do one.

The theme "technology and design" summarise the collected data regarding the impact of technological development on ED design.

- Healthcare design is on continuous development; therefore, it is crucial to follow any development that may impact the spatial design. However, the interviewees believe that development in the medical equipment area may affect the design in term of the size and the needed spaces. At the same time, the spatial relationships are hard to be changed.

Second, it was helpful to collect an overview of ED operation from the designers' point of view to assess their understanding of the medical process and requirements. Thus, the overarching theme 'ED Operation' summarises the collected data under Two themes: management and users, and medical concerns. Further detailed are mentioned below.

The theme "management and users" summarise the collected data regarding designers' perception of management and operations role in EDs to improve work efficiency.

A. Designers believe that having trained staff and specialised EDs physicians will help improve the overall work efficiency. Also, to have a system to reach specialised physicians for the various medical conditions that EDs may receive when needed. Therefore, there should be an efficient internal communication instrument between the different department to reach specialists in timely manners.
B. Sometimes insufficient control and bad management may cause problems and hinder the work efficiency, which will cause overcrowding and long waiting time for patients. Thus, having a well functional spatial structure with prober control over the department will improve the overall flow.

The theme "Medical Concerns" summarise the collected data regarding designers' understanding of ED's unique environments due to their unique medical considerations.

A. Designers believe they have a good understanding of EDs functions, users' demands, and medical processes. They also have a basic understanding of the treatment journey that different patients may have to go through in EDs.
B. Designers may have a basic understanding of medical values to be implemented in the design. For example, EDs have two types of patients' arrivals (ambulance and walk-in patients); therefore, two separate entrances and separated internal circulation is required. The layout also needs to guide people and staff through the internal processes to have a fast and smooth flow. Also, where paths intersection is at the minimum and movement paths are the shortest to reduce distances and movement time. Besides, designers do recognise critical functions in EDs, as such, resuscitation and minor operation and their relation to the entrances. Also, Radiology and laboratory need to be near the ED with easy access when needed. Radiology, laboratory, and operation can be placed outside of the department when communication instruments exist.

4.4 Conclusion

Designers acknowledge that ED has unique spatial design requirements due to its unique medical considerations and operational demands. It focuses on providing timely, fast, and smooth healthcare services to a variety of an unpredicted number of patients with various, unforeseen, and urgent medical conditions on 24/7 basis. Therefore, the design of EDs has a significant influence on the quality of the delivered healthcare services to support the overall operation.

To attain good quality healthcare services and facilitate operational demands in EDs, the design has to engage different users (staff, patient, and visitors) to alleviate their experience by supporting their treatment journey and facilitating the provision of timely, fast and smooth healthcare services. Therefore, it is essential to know every patient's path and each existing function during the different

treatment processes. To clarify, designers argue that the design of the spatial structure and the functional arrangement, which impact the internal circulation and flow, are among the main considerations that may influence ED operation. Therefore, the spatial structure needs to provide the best support for the facility's various activities by having an efficient arrangement for the available spaces. Therefore, knowing EDs' functions and patients' routes is essential to designing an optimised functional layout for patients from entering to discharge without any delays.

EDs design guidelines might mainly be developing in the required spaces and their sizes to accommodate the development in the medical equipment area. Because medical equipment changes continuously, often with new space requirements, sometimes-extra spaces are needed for support; therefore, the design requirements change. However, they believe that the provided clinical relationships in the guidelines cannot be changed. Therefore, although ED design guidelines do not provide a detailed explanation for the spatial relationships of the various ED functions, they do provide sufficient information to start the design process. For this reason, ED design guidelines are implemented differently by different designers, with various degrees of success. Some result in a good implementation while others produce an outstanding implementation based on the same design references. Thus, to understand the clinical processes and the spatial requirements that are missing in the guidelines, designers rely only on meetings with medical staff to know the path of every patient and each existing function during the different treatment processes. To emphasis, staff and users are probably more knowledgeable than designers about ED operation due to their everyday experience with the design following their everyday duties. Therefore, their inputs can help steer the design decisions to support ED operating and unique practices. However, although, staff requirements and knowledge may differ depending on many factors, such as the hospital system, the type and size of ED, available functions, and the adapted protocol, their inputs still valuable and might be even required.

The interviewed designers do not use any analytical tools to aid the design process as a pre-occupancy evaluation procedure to understand the spatial relationships. They only rely on drafting software, such as AutoCAD and performing feasibility studies. Moreover, although designers acknowledge the importance of post-occupancy evaluation to identify problems that may hinder work efficiency and learn and develop their design knowledge, they do not usually evaluate. However, if they were to conduct a post-occupancy, they may observe and conduct surveys with users to evaluate how the facility works without the use of any analytical tools.

4.5 Chapter summary

This chapter presents the analysis and findings derived from the interviews conducted with healthcare designers, producing their perspectives about EDs spatial design. The next chapter will present a contrasting account from analysing the spatial configurations of selected EDs to further investigate their spatial relationships by looking at the plans' geometric properties using analytical tools.

Moreover, other chapters will present a different account from investigating the influence of the spatial structure on EDs' operation by observing current operation and interviewing staff in the selected EDs to investigate their design preferences and justify the observed usages.

Chapter 5: Spatial Analysis

5.1 Introduction

One measure of the efficiency of buildings can be derived from an analysis of their spatial configurations. This chapter presents a detailed spatial analysis of the two selected EDs to fulfil objective three, investigating EDs spatial relationships. Thus, the pre- and post-occupancy configurations of the selected EDs were analysed by applying two different techniques. First, spatial structure development, which is to explore the original design and the development in the spatial structure. Second, space syntax analysis to explore the spatial relationships between the various functions in EDs.

5.2 Pre and Post Occupancy Spatial Analysis

The original drawings and the as-built ones were used for analysing the spatial structure of the selected EDs. The selected EDs were analysed before and after modification following occupation to explore their functional arrangements and changes led to the current situation.

The analysis started by exploring the initial design from the original drawings, representing the pre-occupancy configurations and the as-built drawings, representing the post-occupancy configuration after the settings had been modified. The former was carried out to explore and assess the initial spatial organisation, the functional arrangements, and relational aspects of the spaces. The latter was conducted to identify changes and development in the spatial structure and evaluate current functions, their relational aspects, and their operational patterns. In this chapter, two analyses were made:

- First, spatial structure development: to explore pre- and post-occupancy configurations, where it becomes possible to study and highlight the evolution of the spatial structure. This is important to compare the obtained result with the data obtained from the interviews and observation of staff working in the same facility. Thus, to find whether the spatial structure changes to serve users' needs, or if users were forced to adapt to new changes.
- Second, Space Syntax analysis: to analyse the spatial structure of the pre- and post-occupancy configuration using AGRAPH and DepthMap software. To compare the obtained results for the two settings, and to explore whether the analysis reveals and predicts the influence of the spatial changes on the departments' operations.

5.2.1 Spatial Structure Development

In this stage, the analysis is divided into three stages:

- First: listing the different functions available in the selected cases from the original drawings, to better understand the original design.
- Second: Identifying the changed functions and the overall development in the spatial structure by comparing the original design with the current spatial configurations.

- Third: after identifying the changes in the spatial structure and the original functions; a current as-built plan is created to be used for further analysis.

5.2.1.1 Spatial development of KAUH ED

A. The original design

This section describes the original spatial structure and functional arrangements, which was before occupation. From Figure 13, the following points can be listed:

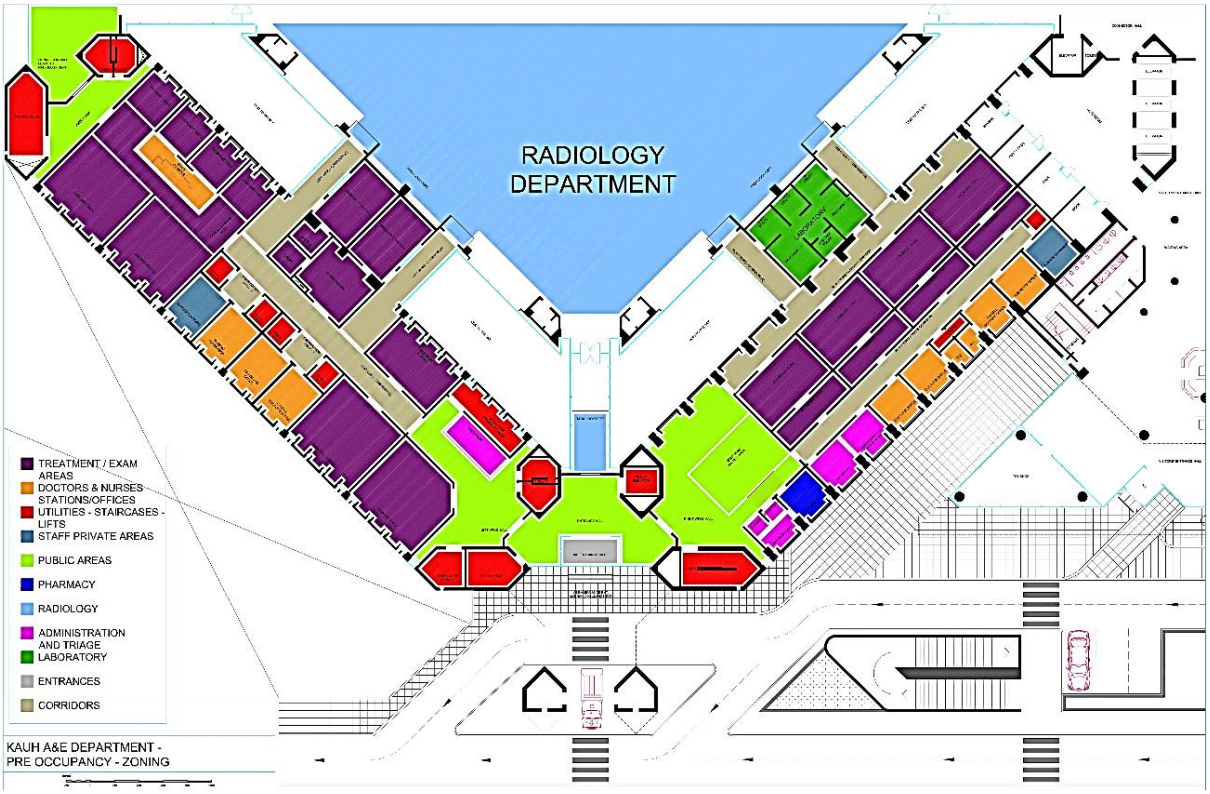


Figure 13: KAUH ED - Pre-Occupancy – Zoning

1. The department had one shared entrance for ambulance and non-ambulance patients, which is connected to an entrance hall that is connected to five different functions:
    - The right-wing section.
    - Public elevator.
    - The radiology department entrance.
    - The left-wing section.
    - Police office.
2. The department's right section had a public area (Right-wing hall) connected with a waiting area, a cashier, a reception, a pharmacy, and two corridors; one for patients and the other is for staff. Patients' corridor is connected with the laboratory and the radiology department, while the staff corridors lead to staff offices and private areas. Both corridors are connected through four cubicles in the middle, which provide private access to the cubicles for both patients and staff.

3. The left section had a public area (Left-wing hall) that is connected to a reception with a crash cart storage behind it, a resuscitation room, toilets, stretcher storage, and a corridor. The corridor in the left-wing section is connected with the following:
    - A surgical cubicle.
    - A treatment cubicle.
    - A plaster room.
    - Two small transition areas, where they lead to staff offices, utilities, and nurses changing room.
    - Two corridors are leading to the radiology department, also, to two operating theatres.
    - Overnight bed area at the far end of the corridor has a counter for staff in the middle. The overnight bed area leads to an anteroom that has toilets.

B. The spatial changes

This section describes and illustrates the development of the spatial structure and functional arrangements. From Figure 14, the following points can be listed:

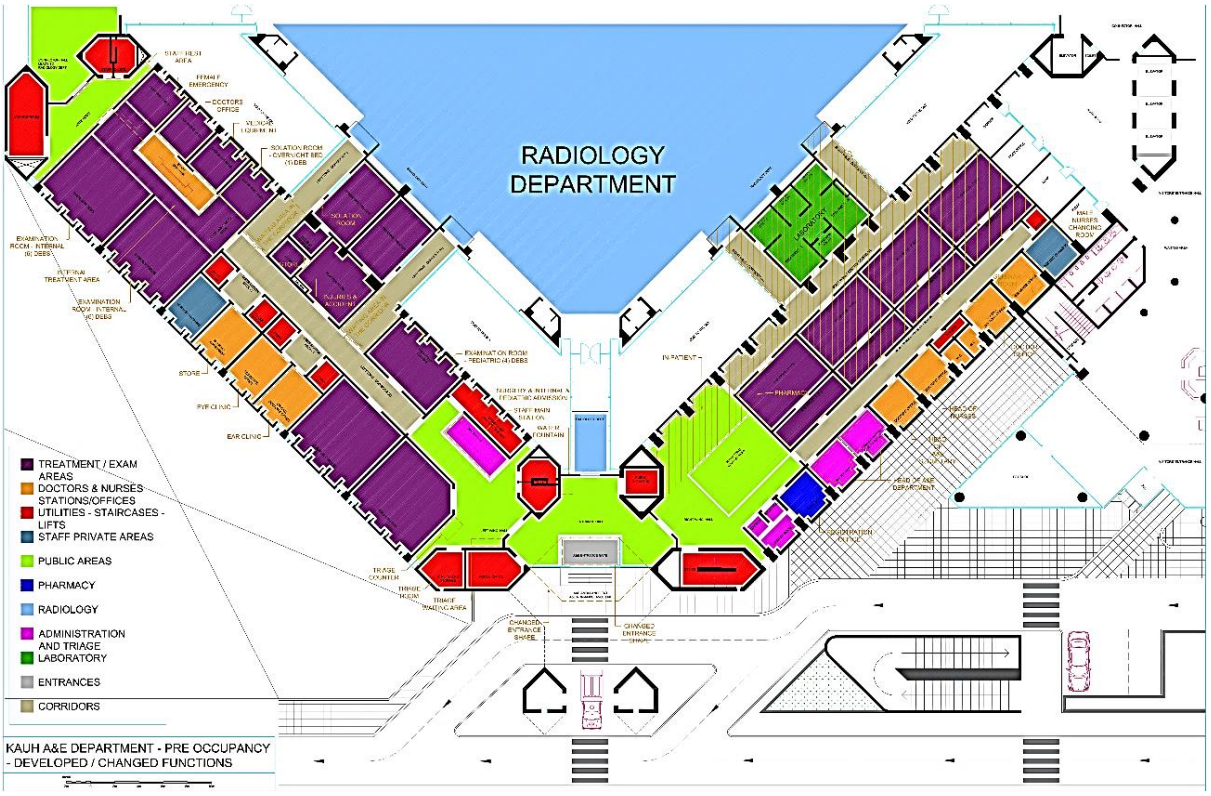


Figure 14: KAUH ED - Pre-Occupancy - Changed / Developed Function

1. Part of the ED in KAUH was used to suite the small number of patients when it was first opened. After that, it developed to accommodate the increased number of patients.
2. The entrance transition area, which is shared between the left-wing section (has ED exam areas), the right-wing section (has ED logistics services, staff offices, and inpatients section),

the radiology department, and the inpatients' department (through the left) has changed to a six-edged polygon shape.

- A water fountain was added in the entrance hall.

3. Changes to the right-wing section are as follows:
    - The pharmacy becomes a registration office for ED's patients.
    - The first treatment cubicle becomes the ED pharmacy.
    - Part of the public area, the patient corridor, the three other cubicles, the laboratory, and the two corridors leading to the radiology department have become part of the inpatient department.
    - A seminar room replaced one of the doctors' offices.
    - Define the nurses' changing room to be for male nurses.
4. The left-wing section, on the other hand, was not used fully from the beginning. Because of the small number of patients coming to the ED when it was first opened. However, current changes are as follows:
    - A counter for triage was placed before the resuscitation room, next to the stretchers' storage room.
    - Three attached chairs were placed in front of the triage counter for patients.
    - The stretchers' storage was converted to a triage exam room.
    - The reception has become a staff central station and data entry.
    - The first treatment's cubicle has become a pediatric treatment room.
    - Seats were placed at the beginning of the two corridors leading to the radiology department and the operating theatres, which created two small waiting areas.
    - The plaster room was converted to injuries and accident room.
    - One of the operation theatres was converted to an isolation room.
    - Three staff offices were converted to ear clinic, eye clinic, and storage.
    - Define the nurses' changing room to be for female nurses.
    - The overnight bed area has become an internal exam area. The four beds' spaces on the right side of the room have become an isolation room, medical equipment room, doctors' office, and a female emergency room.
    - The anteroom was converted to a staff rest area. However, it has to stay open all the time due to being an emergency exit

C. The current design

This section illustrates the current spatial structure and functional arrangements. From Figure 15, the following points can be listed:

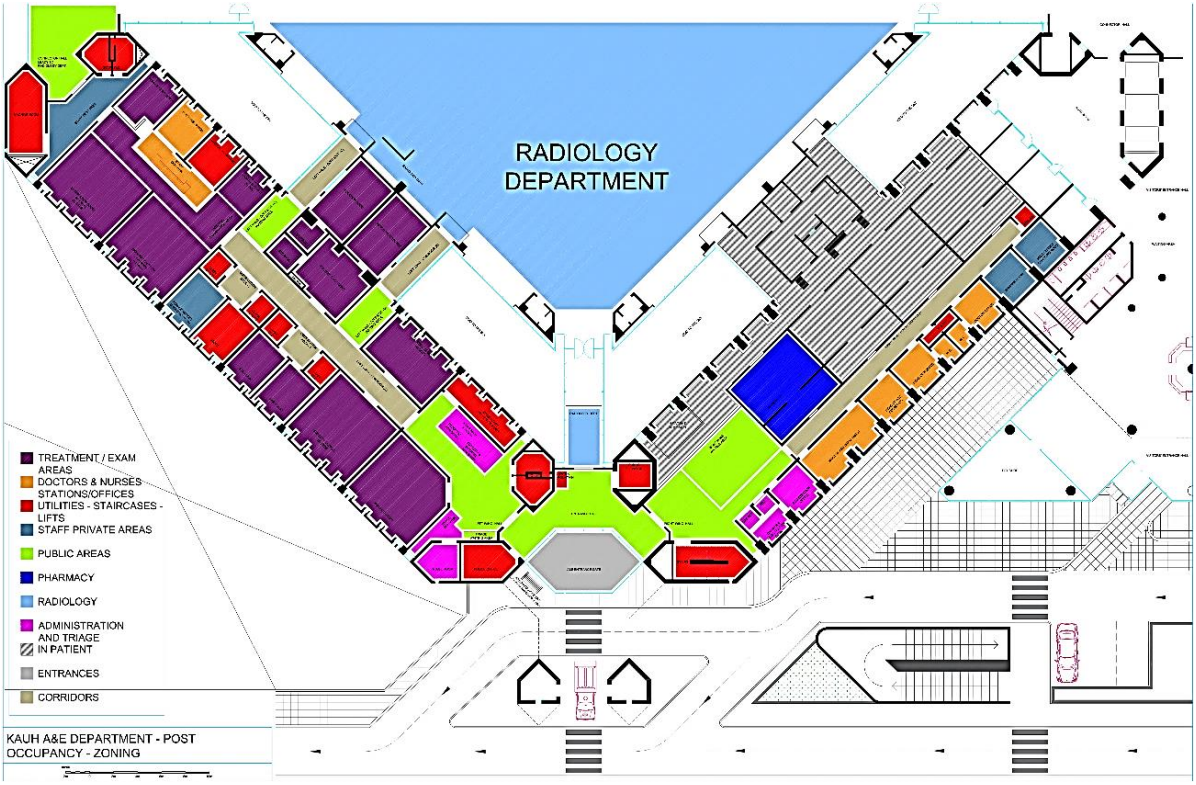
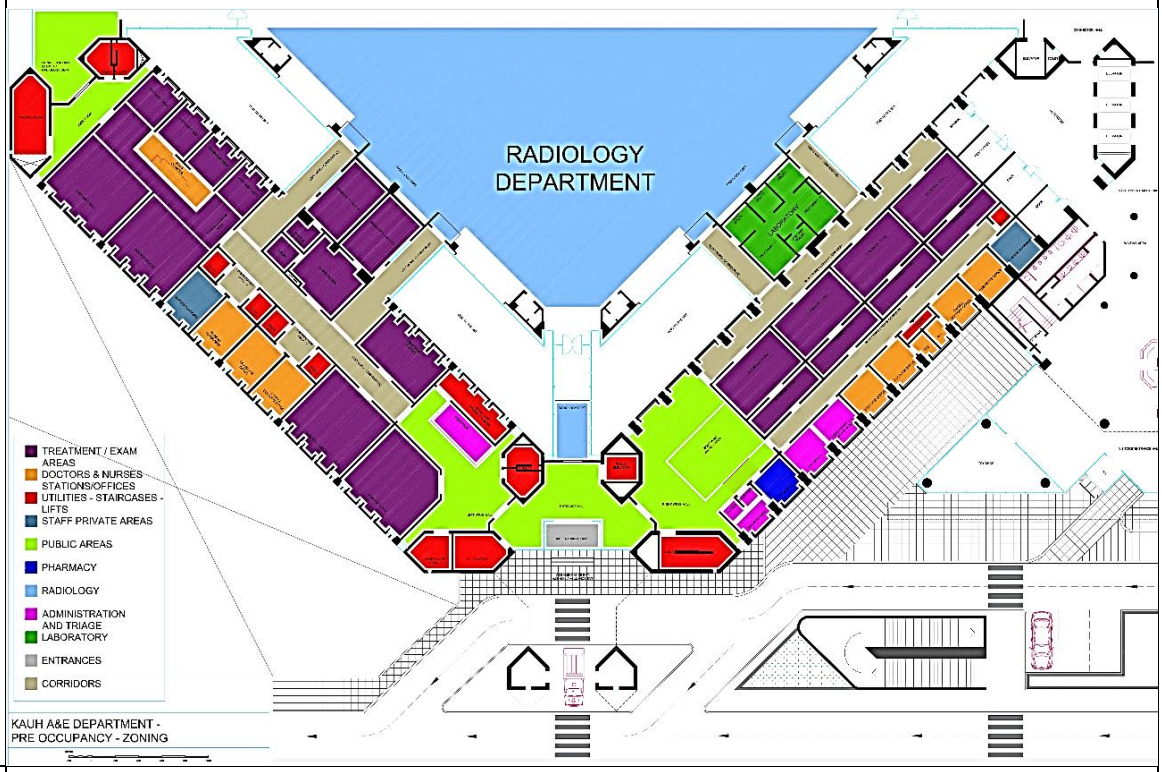
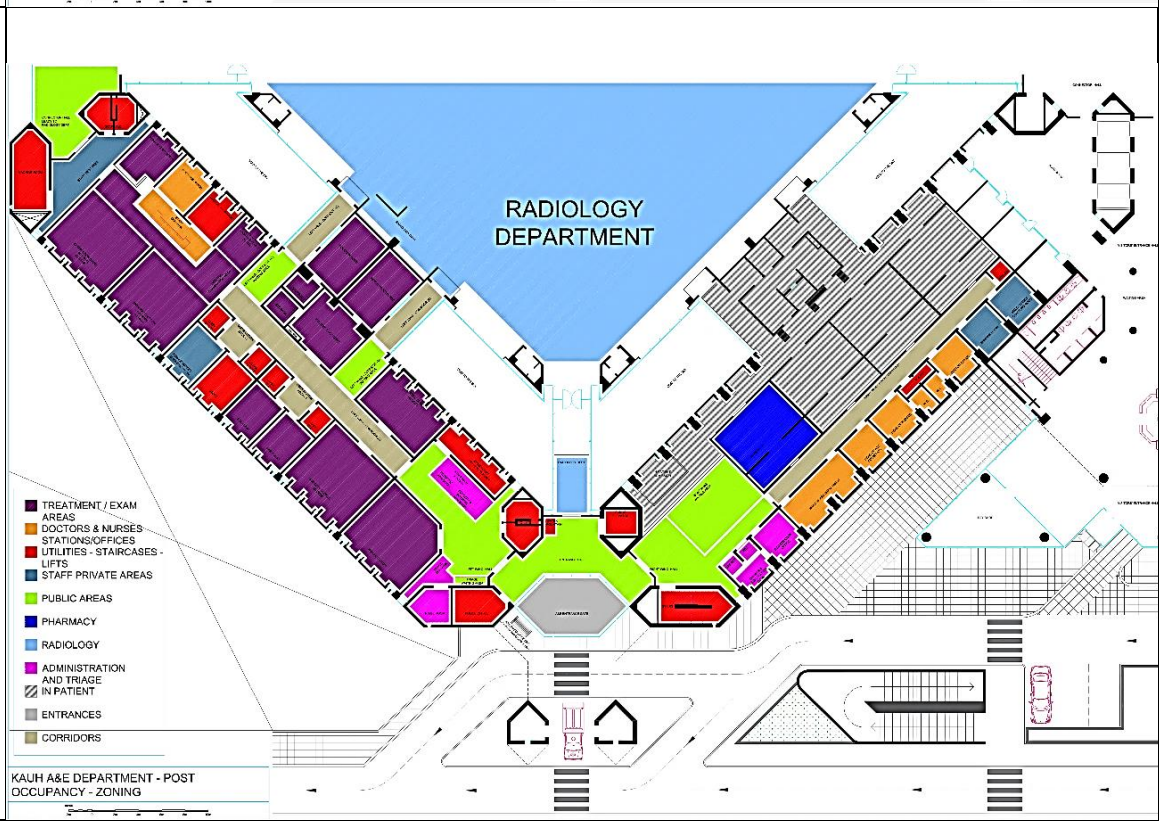


Figure 15: KAUH ED - Post-Occupancy – Zoning (modification following occupation)

1. The department developed several times and expanded gradually to adapt to the increasing number of patients.
2. Only one part of the original design is currently used as the EDs (the left-wing section), which has all the exam areas. The right-wing section is shared between the ED and the inpatients' department. The EDs have the pharmacy, the waiting area, the cashier, the registration, doctors' offices, a seminar room, staff toilets, and a kitchenette.
3. The new shape of the entrance transition area (six-edged polygon) made it less convenient for users to reach the EDs main entrance (left-wing entrance). For example, users become forced to take four turns to reach the EDs entrance (left-wing), increasing the walking distance between the main outdoor entrance and the ED entrance.
4. A water fountain was added in the entrance hall because there was no cafeteria on-site, and the hospital being in a rural area.

Table 5 provides a comparison of the spatial configurations in KAUH ED between the original design (Pre-Occupancy) and the current modification following occupation (Post-Occupancy)

Table 5: KAUH ED - Pre-Occupancy VS Post-Occupancy Zoning (modification following occupation)

Pre-Occupancy – Zoning	
Post-Occupancy – Zoning (modification following occupation)	

5.2.1.2 *Spatial development of the IH ED*

A. The original design

This section describes the original spatial structure and functional arrangements, which was before occupation. From Figure 16, the following points can be listed:

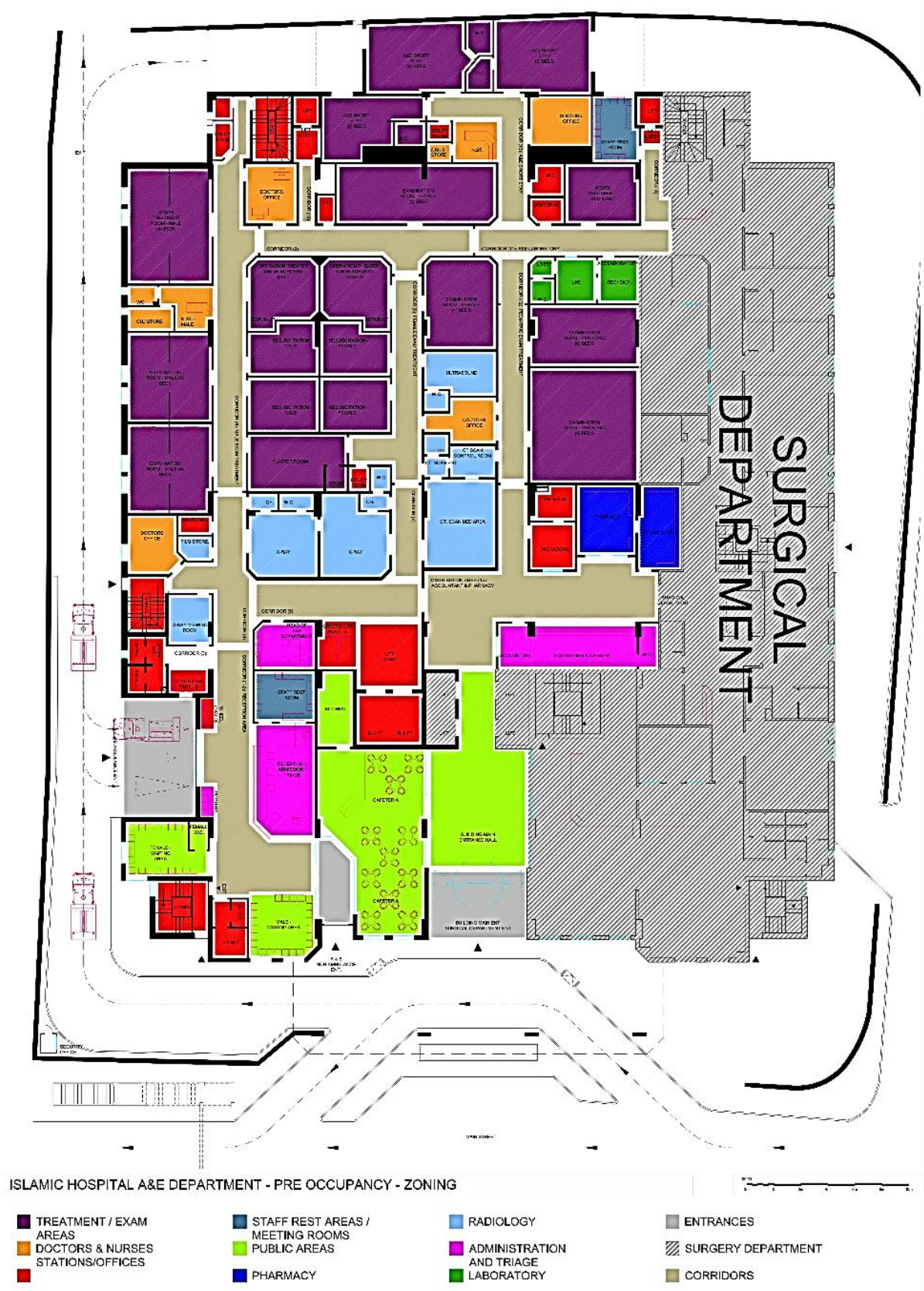


Figure 16: IH ED - Pre-Occupancy – Zoning

1. The ED department shares the ground floor with the surgical department, occupying more than half of the total floor area.
2. Entrances: the ED had two separate entrances for the ambulance and non-ambulance patients. Both entrances were directly connected with the main reception counter. The reception counter works as a reception, admission, and triage.
3. Next to the ambulance entrance was a designated area for porters and wheel chares—also, an entrance to access a stretchers park store area.
4. The ED had access to a shared cafeteria between the ED and the surgical department. For the ED, it can be accessed through the non-ambulance entrance.
5. The ED had two separate waiting areas for male and female users.
6. The ED had the following functions:
    - Male patients' exam area includes three four-bed exam rooms, two resuscitation rooms, a plaster room, an operation theatre, a doctors' office, and a nurse station.
    - Female exam area includes two exam rooms, two resuscitation rooms, an operation theatre, a doctors' office, and an ultrasound room.
    - Pediatric exam area includes two exam rooms and a shared doctors' office with the female section.
    - Short-stay area includes three observation rooms, a doctors' office, and a nurse station.
    - The radiology section includes two X-Ray rooms, a CT-Scan room, an Ultrasound room, a doctors' office, a viewing room, and a film store.
    - Pharmacy, accountant, and cashier area. This area is connected with the ED, the surgical department, and the building main entrance hall.
    - A laboratory for ED users only.
    - Two staff restrooms; the first is next to the main reception counter, and the other is located at the far end of the department.

B. The spatial changes

This section describes and illustrates the development of the spatial structure and functional arrangements. From Figure 17, the following points can be listed:

1. The ED still shares the building with the surgical department. However, the ED floor area was reduced due to removing the public area that had the pharmacy, the accountant, and the cashier from the ED, where they become part of the surgical department. However, an accountant office and a pharmacy were created for the ED.
2. Entrances: the non-ambulance entrance is closed, and the department can be accessed from the ambulance entrance (which is the same as before) or the main building entrance.

- Part of the main counter was converted to for the accountant office.
- The female waiting area was converted to triage exam room, and the female waiting area was removed.

Figure 17: IH ED - Pre-Occupancy - Changed / Developed Functions

3. The small wheelchairs area next to the ambulance entrance is now used as a waiting area, and the porters waiting area become for a stretcher.
4. The other changed areas are as follows:
    - Changes in the male exam area:
        - The plaster room was converted to a seminar room that is currently used as a staff rest area. Fracture cases are treated in minor surgery.
        - The first exam room was divided to be an eye clinic and dentistry.
        - The number of beds in the treatment rooms was increased by two to become six beds in each room.
        - Surgical doctors are using the doctors' office.
    - Changes in the female exam area:
        - One of the resuscitation room was converted to a female restroom.
        - The ultrasound room was converted to internal doctors' office.
    - The pediatric section has become the delivery section with two exam rooms and a doctors' office. The doctors' office is shared with the female section.
    - The short-stay section was converted to the pediatric section. However, one of the exam rooms was converted to male doctors' changing room.
    - Radiology: One of the X-Ray rooms was converted to an ultrasound room instead of the one in the female section. Second, the stretchers park area (A) was converted to be a room for radiologists.
    - Cafeteria: There is no cafeteria in the current design. Half of the cafeteria area has become the ED pharmacy, and the other half has become a public and waiting area.
    - The old pharmacy, accountant and cashier area have become part of the surgical department. The pharmacy was converted to an accountant, cashier, and registration office.
    - No changes to the laboratory.
    - The first staff restroom was converted to the head of the nurse's office, while the other one has become storage.

C. The current design

This section illustrates the current spatial structure and functional arrangements. From Figure 18, the following points can be listed:

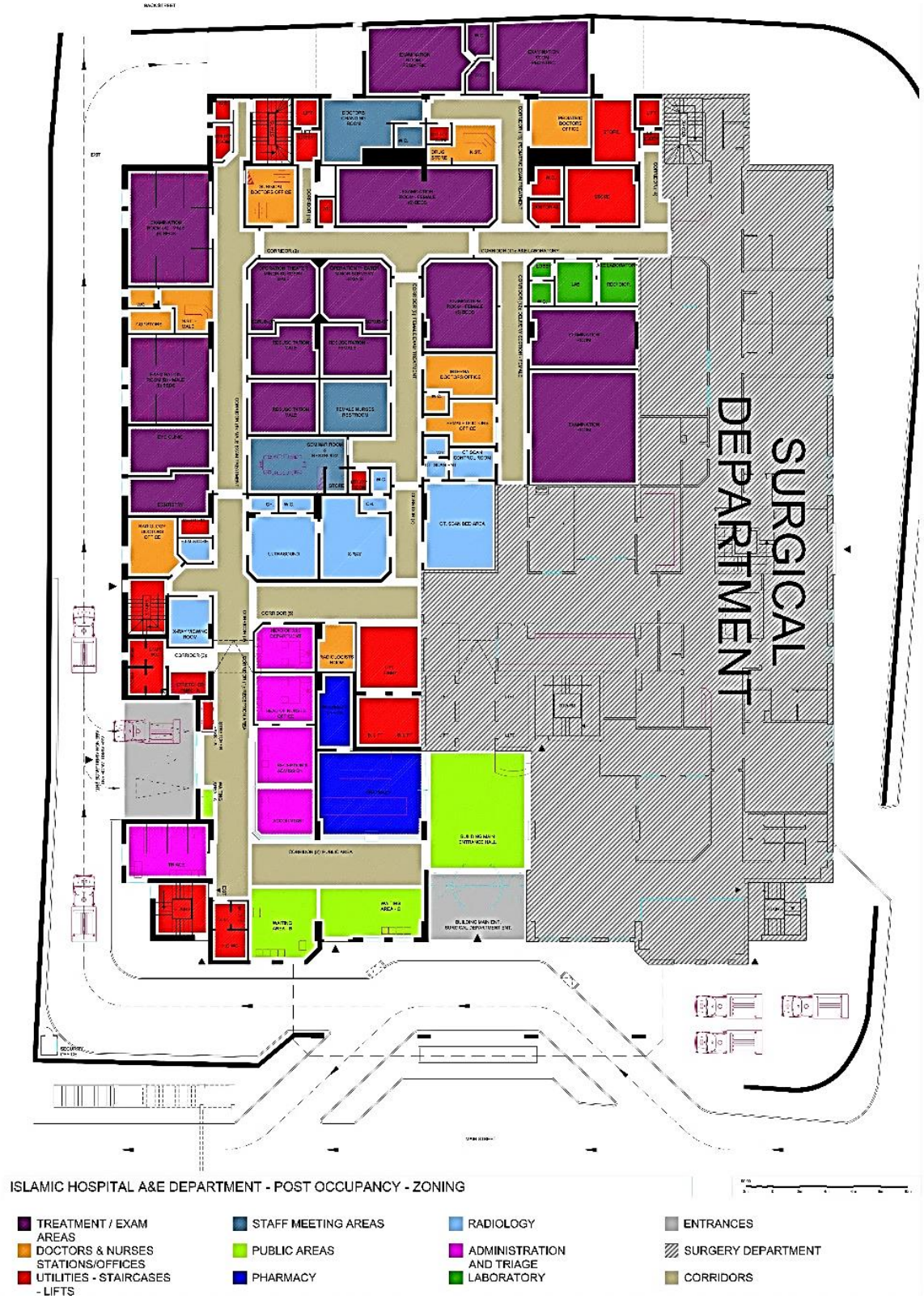


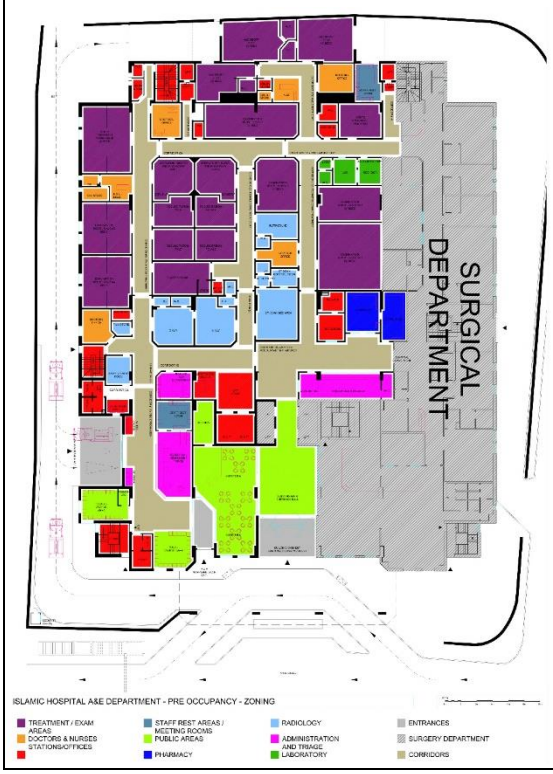
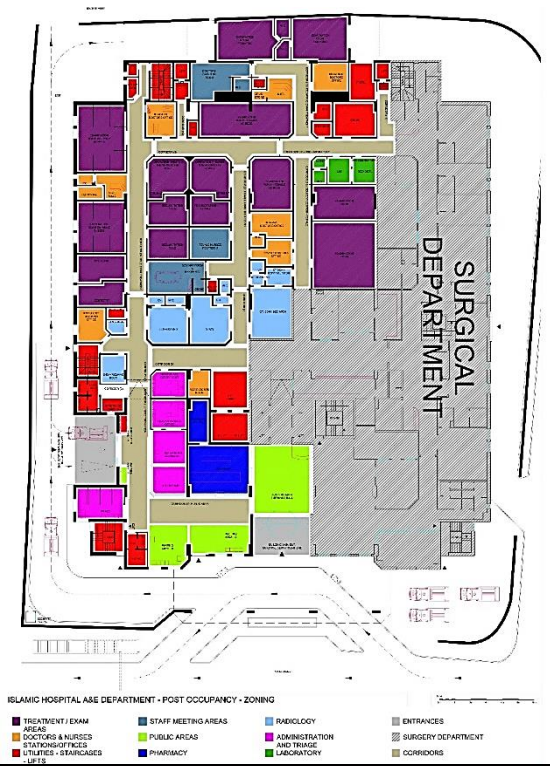
Figure 18: IH ED - Post-Occupancy – Zoning (modification following occupation)

1. The staff restroom located at the far end of the ED and one of the short-stay rooms were converted to storage rooms.

2. The pediatric section was converted to the delivery section. The short-stay section then became the pediatric section. Thus, there is no short-stay section in the department.
3. Staff restrooms were converted to head of nurses' office and storage.
    - The plaster room was converted to seminar and restroom for male staff.
    - A resuscitation room in the female section was converted to female nurses' restroom.
    - One of the exam room in the current pediatric section was converted to male doctors' changing room.
4. No cafeteria or adequate services are available.
5. The non-ambulance entrance is closed. Therefore, the ambulance entrance is used by walk-in patients.
6. The female waiting room was converted to a triage room.
7. The eye clinic and dentistry were newly established (but not yet working), where they replaced the first male exam room.
8. The pharmacy and the accountant were moved closer to the ambulance area. The accountant shares the counter with the reception and admission in a closed glass room.

Table 6 provides a comparison of the spatial configurations in KAUH ED between the original design (Pre-Occupancy) and the current modification following occupation (Post-Occupancy)

Table 6: IH ED - Pre-Occupancy VS Post-Occupancy Zoning (modification following occupation)

Pre-Occupancy – Zoning	Post-Occupancy – Zoning
	

5.2.1.3 *In summary*

Significant changes occurred in the spatial structure and the distribution of the functions in both EDs between the original design and the current one. Therefore, further analysis using Space Syntax will be conducted to assess the spatial changes on spatial relations between the different (and modified) functions.

5.2.2 Space Syntax Analysis

In this stage, Space Syntax was adopted as an analytical approach to explore the spatial relationships between the various functions in EDs. Not to mention, Space Syntax investigates and evaluate the syntactic relations for the spatial structure.

Three types of tests; Justified Graphs, Convex Maps, and Visibility Graphs associated with two tools; AGRAPH and DepthMap, were used to carry out the spatial analysis and calculate syntactic measures represent the selected EDs.

5.2.2.1 *Justified Graph*

The justified graph is the first test to understand the spatial relations of the selected EDs. It produces node and connection graphs by evaluating the entire layout, displaying the hierarchy of spaces and the total depth of each space. Justified graphs are restructured by having a specific space at the bottom of the graph called "the root space". For example, in justified graphs, spaces that are one syntactic step away from the bottom (root space) are placed on the first level; spaces that are two syntactic steps away from the bottom are placed on the second level, and so on. Thus, they produce a visual image of the overall depth of a layout calculated from one of its points (Klarqvist 1993). The different types of spatial layout that can represent syntactic connections between spaces are:

- A tree-like Justified graph: most of its nodes (levels) far from the bottom node. Therefore, the system is described as deep.
- A bush-like Justified graph: most of its nodes (levels) near the bottom node. Therefore, the system is described as shallow.
- A ring-like Justified graph: the provision of interconnected rings of movement in a layout offers choices of movement routes reducing the depth of space.

AGRAPH software was adopted to create justified graphs and calculate syntactic measurements for the selected EDs before and after modification following occupation. However, the use of AGRAPH software for extracting syntactic values involves drawing the 'node-and-connection' Justified graph manually. Thus, faults can occur during this process.

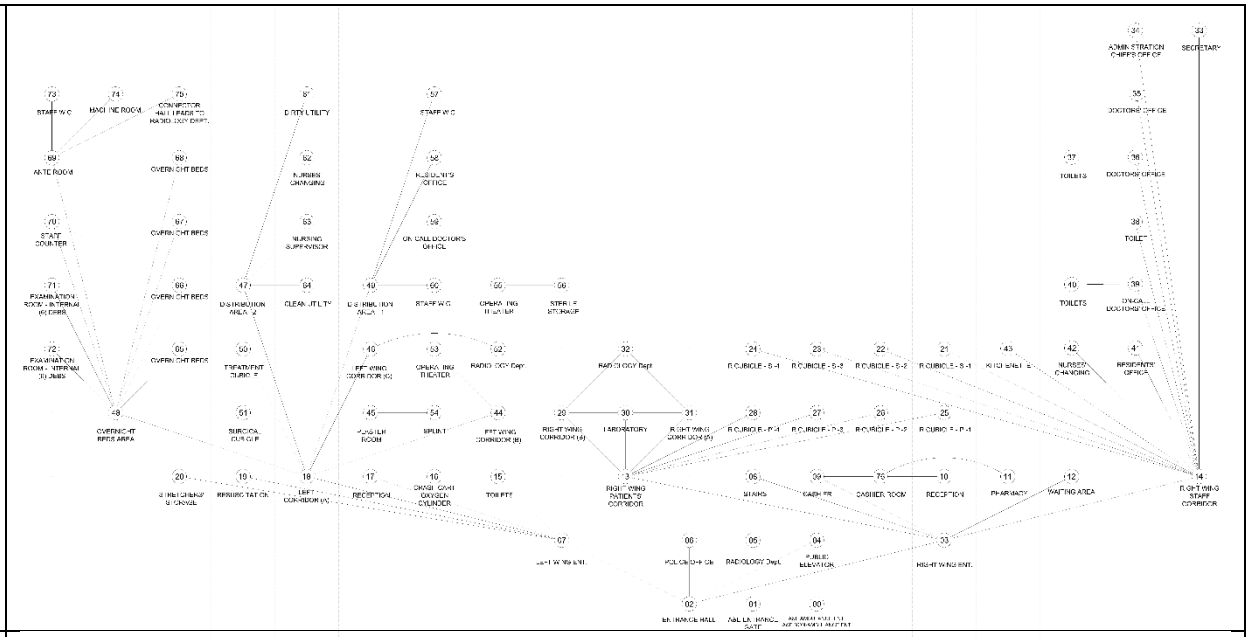
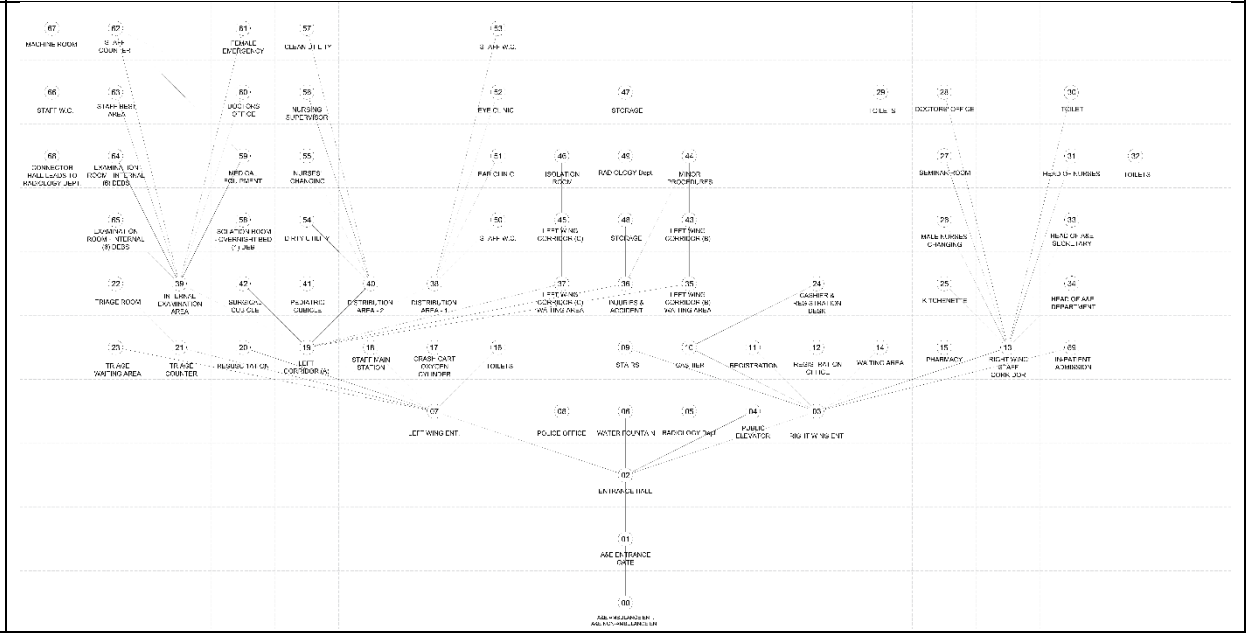
The following are the justified graphs and their mathematical results for the selected EDs. The red colour indicates the highest value in all graphs, and the blue colour represents the lowest values. The following syntactic measures will be calculated to represent the selected cases:

- Integration Values (i): measures the average depth of space to all other spaces, where the higher the values, the more spaces are integrated.
- Control Values (CV): measures the degree to which space controls access to its immediate neighbours, where the highest value indicates a greater control.

A. KAUH ED Justified Graphs

Table 7 illustrates a comparison of manual justified graphs of the various functions in KAUH ED before and after modification following occupation. Figure 19 and Figure 20 provides an enlarged view of the justified graphs in Table 7. Due to the changes in the spatial structure, the measured values will change accordingly to represent the new settings. Control and integration measures are calculated below:

Table 7: Manual justified graphs for KAUH ED functions before and after modification

KAUH ED (Pre-Occupancy)	
KAUH ED (Post-Occupancy)	

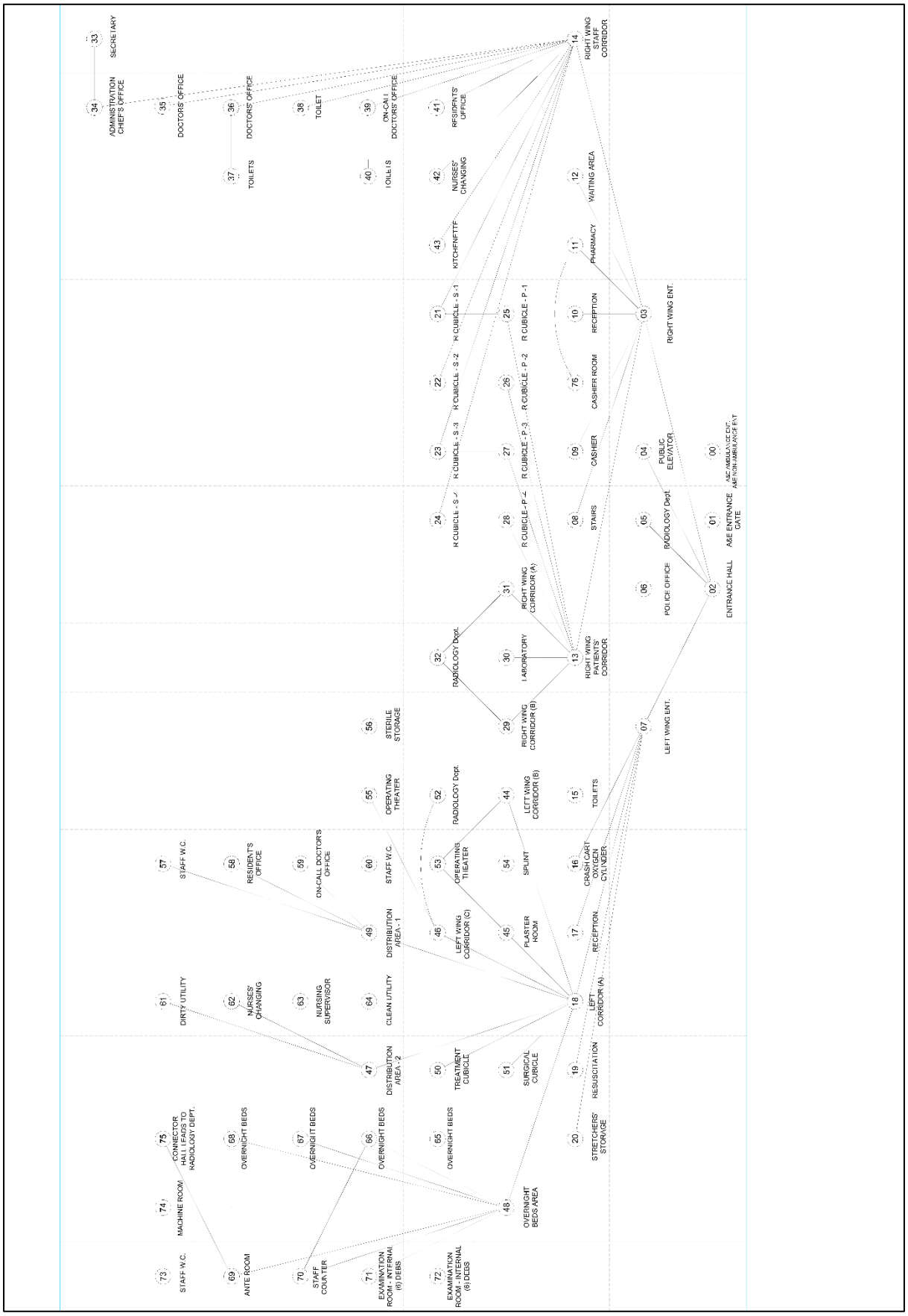


Figure 19: manual justified graphs of the various functions in KAUH ED before modification following occupation (Pre-Occupancy)

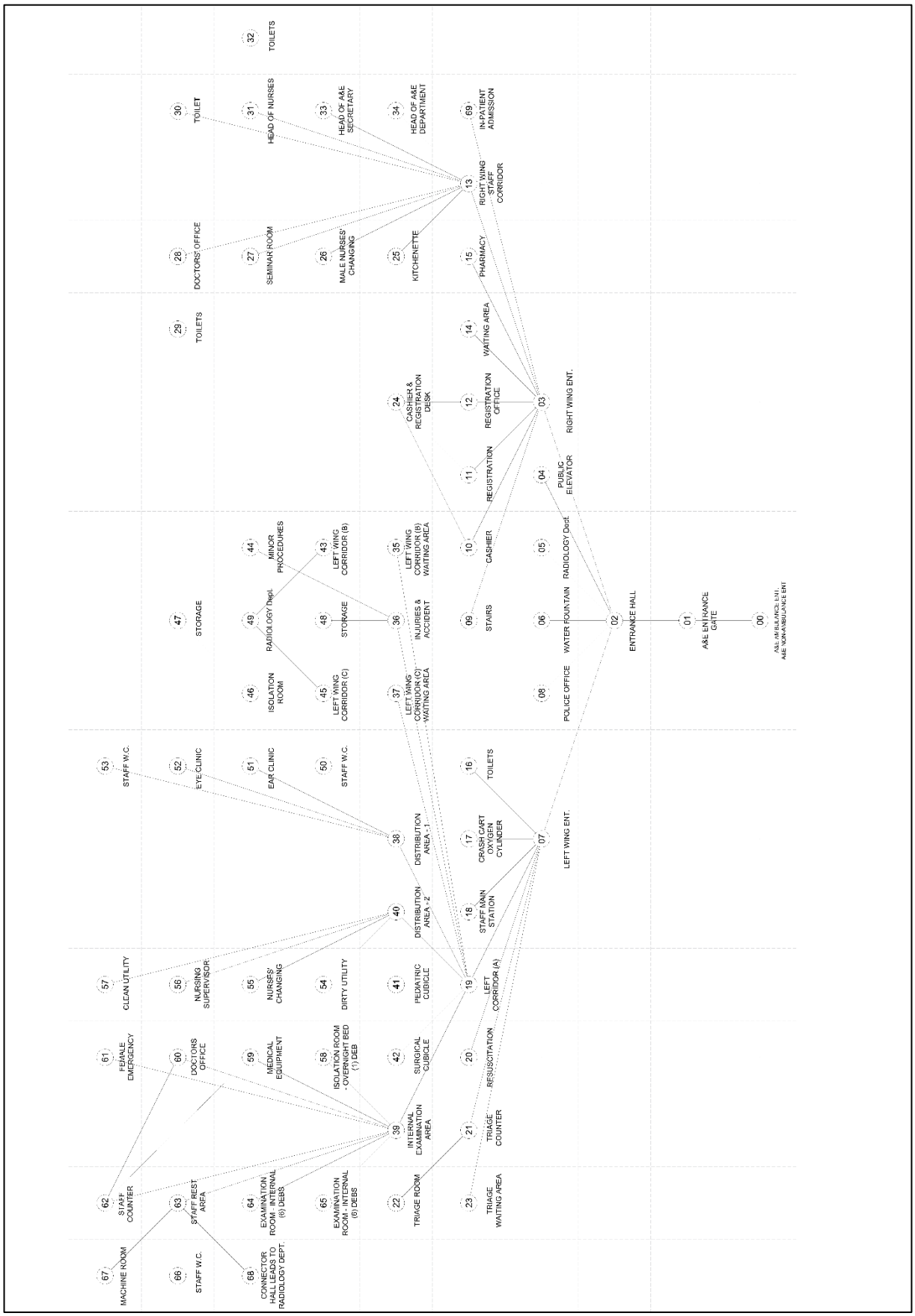
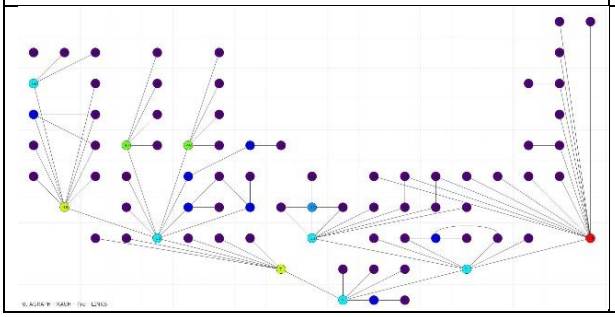
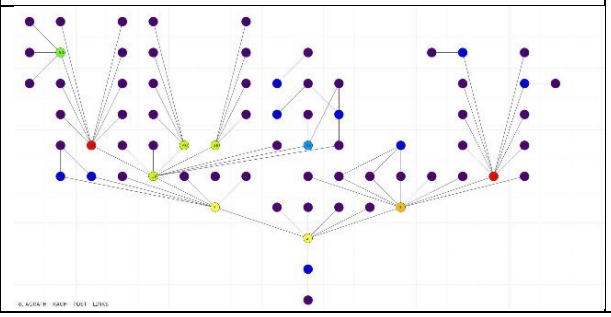
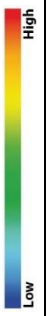


Figure 20: manual justified graphs of the various functions in KAUH ED after modification following occupation (Post-Occupancy)

1. Control Value (CV) - KAUH

Table 8 represents CVs of the various functions in KAUH ED before and after modification following occupation. CV is the value which each node receives when connected. Table 5 (on page 99) provides zoning plans of the spatial configurations in KAUH ED for before and after modification following occupation to help visualise the mentioned description below.

Table 8: Control Value (CV) – KAUH ED before and after modification.

KAUH ED Pre-Occupancy - Control Value	KAUH ED Post-Occupancy - Control Value	
		

In the pre-occupancy, the minimum CV is 0.07, while the maximum is 10.12, which is the staff corridor in the right-wing section. The main entrance hall has a 3.76 CV, leading to the right-wing and the left-wing sections.

- **First, the right-wing entrance** has a 3.86 CV, which leads to the following:
  - Waiting area, the reception, the cashier, the pharmacy, a corridor for staff private areas which has the highest CV of 10.12, a corridor for patients, which has a 3.37 CV, and the ED laboratory. Patients and staff corridors are connected in the middle through treatment cubicles.
- **Second, the left-wing entrance** has a 5.27 CV, which leads to the following:
  - reception desk, resuscitation room, and the main corridor.
  - The main corridor, which has a 3.65 CV leads to the following:
    - The surgical and treatment cubicles with a CVs of 0.11, plaster room with 1.61 CV, overnight bed areas with 5.69 CV, two other corridors with 1.11 CVs. These two corridors lead to the operation theatres and the radiology department.
    - To two other distribution areas with 4.11 CVs that lead to staff areas.

On the other hand, the post-occupancy setting has a minimum CV of 0.11, while the maximum is 7.36, which is the internal exam area in the left-wing section. The main entrance hall has a 4.73 CV, leading to the right-wing and the left-wing sections.

- **First, the right-wing entrance** has a CV of 5.75, which leads to the following:
  - To the main waiting area, the reception/registration, the cashier, the pharmacy, a corridor for staff private areas, which has 7.11 CV. However, the patient corridor, the treatment

cubicles, and the ED laboratory in the left-wing section are not part of the ED in the current settings.

- **Second, the left-wing entrance** has a CV of 4.92, which leads to the following:
  - To the reception desk, that is currently used as the main staff station, resuscitation room, triage desk, triage room, and the main corridor.
  - To the main corridor, which has a 3.96 CV, leads to the following:
    - Two treatment cubicles – Pediatric & surgery where both have 0.11 CV, injuries & accident room with 1.61 CV, internal exam area with 7.36 CV, two waiting areas in the corridors leading to the radiology department with 0.44 CV, and two other distribution areas with 4.11 CV.
  - The two corridors lead to the radiology department have 1.5 CV. One of these two corridors leads to an isolation room, while the other leads to a minor procedure room and both lead to the radiology department.
  - The two other distribution areas have a 4.11 CV; one leads to staff private areas, while the other leads to an eye and ear clinics.
  - The internal exam area, which used to be an overnight beds area has the highest control value of 7.36. It is an open plan area that contains two exam areas, one isolation area, one medical equipment area, an open office for staff, a counter for staff, and a female emergency room. It is also connected to the staff rest area that used to be an anteroom served with toilets.

Table 9 compares CVs for the main transition area in the ED in KAUH between the two settings.

Table 9: CV for the main transition area in KAUH ED before and after modification.

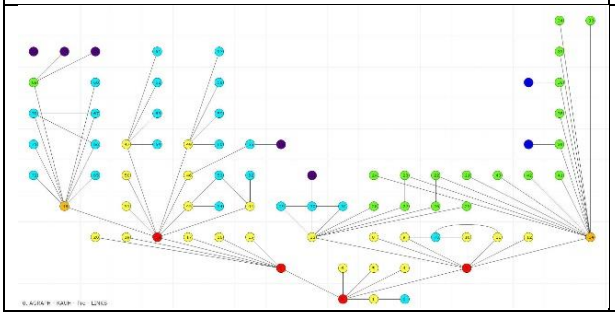
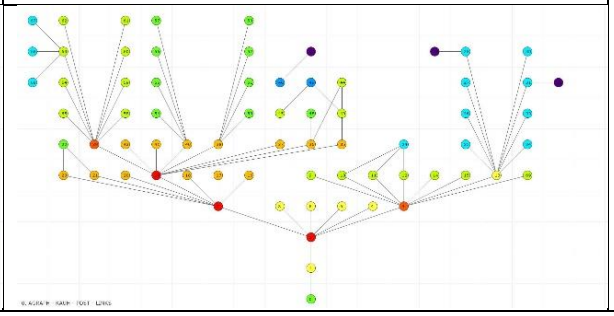
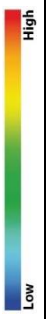
Node No.	Pre-Occupancy Evaluation	CV	Node No.	Post-Occupancy Evaluation	CV
	(Max CV= 10.12) (Min CV= 0.07)			**(Max CV= 7.36) (Min CV= 0.11)**	
2	ENTRANCE HALL	3.76	**2**	ENTRANCE HALL	4.73
3	RIGHT-WING ENTRANCE	3.86	**3**	RIGHT-WING ENTRANCE	5.75
7	LEFT-WING ENTRANCE	5.27	**7**	LEFT-WING ENTRANCE	4.92
13	RIGHT-WING PATIENTS' CORRIDOR	3.37			
14	RIGHT-WING STAFF CORRIDOR	10.12	**14**	RIGHT-WING STAFF CORRIDOR	7.11
18	LEFT CORRIDOR (A)	3.65	**19**	LEFT CORRIDOR (A)	3.96
44	LEFT-WING CORRIDOR (B)	1.11	**35**	LEFT-WING CORRIDOR (B) WAITING	0.44
46	LEFT-WING CORRIDOR (C)	1.11	**37**	LEFT-WING CORRIDOR (C) WAITING	0.44
48	OVERNIGHT BEDS AREA	5.69	**39**	INTERNAL EXAMINATION AREA	7.36

2. Integration Value (i) - KAUH

Table 10 represents the integration value of the various functions in KAUH ED before and after modification following occupation. Integration (i) is a normalised measure to the shortest path from one point to all other points in a building. Table 5 (on page 99) provides zoning plans of the spatial

configurations in KAUH ED for before and after modification following occupation to help visualise the mentioned description below.

Table 10: Integration Value – KAUH ED before and after modification

KAUH ED Pre-Occupancy – Integration Value	KAUH ED Post-Occupancy - Integration Value	
		

In the pre-occupancy, the minimum Integration Value is 7.42, while the maximum is 18.26, which is the left-wing entrance. The main entrance hall has an 18.15 integration value, leading to the right-wing and the left-wing sections.

- **First, the right-wing entrance** has a 16.76 integration value, which leads to the following:
    - To the main waiting area, the reception, the cashier, the pharmacy, a corridor for staff that has 13.50 integration value, a corridor for patients, that has 12.66 integration value, and the ED laboratory. Patients and staff corridors are connected in the middle through treatment cubicles.
- **Second, the left-wing entrance** has the highest integration value of 18.26, which leads to the following:
    - To the reception desk, resuscitation room, and the main corridor.
    - The main corridor, which has an integration value of 17.06 leads to the following:
        - The surgical and treatment cubicles with integration values of 11.77, plaster room with 11.97 Integration value, overnight bed areas with 12.95 Integration value, and two other corridors with 12.07 and 11.97 integration values. These two corridors lead to the operation theatres and the radiology department.
        - Two distribution areas with 12.17 Integration values that lead to staff areas.

On the other hand, the post-occupancy setting has a minimum integration value of 6.17, while the maximum is 18.47, which is the main corridor in the left-wing section. The main entrance hall has 16.40 integration value, leading to the right-wing and the left-wing sections.

- **First, the right-wing entrance** has a 13.56 integration value, which leads to the following:
    - To the main waiting area, the reception/registration, the cashier, the pharmacy, a corridor for staff, which has 10.61 integration value. However, the patient corridor, the treatment

cubicles, and the ED laboratory in the left-wing section are not part of the ED in the current settings.

- **Second, the left-wing entrance** has the highest Integration value of 18.47, which leads to the following:
  - To the reception desk, that is used as the main nurses' station, resuscitation room, triage desk, triage room, and the main corridor.
  - The main corridor with the highest integration value of 18.47 leads to the following:
    - To two treatment cubicles – Pediatric & surgery, where both have 12.03 Integration values, injuries & accident room with 12.41 integration value, internal exam area with 13.56 integration value, two waiting areas in the corridors leading to the radiology department with 12.34 integration vale for the first and 12.54 for the second, and two other distribution areas with 12.54 integration vales.
  - To the two corridors-leading to the radiology-which have 9.53 integration values. One of these two corridors leads to an isolation room, while the other leads to a minor procedure room. Both corridors lead to the radiology department.
  - The two other distribution areas have 12.54 integration values; one leads to staff private areas, while the other leads to an eye and ear clinics.
  - The internal exam area, which used to be an overnight beds area has an integration value of 13.56. It is an open plan area that contains two exam areas, one isolation area, one medical equipment area, an office for staff, a counter for staff, and a female emergency room. It is also connected to the staff rest area that used to be an anteroom served with toilets.

All other corridors in the layout have hight integration values, mainly because corridors act as transition areas and links many different functions together. Table 11 provides a comparison of integration vales for the main transition area in the ED in KAUH between the two settings

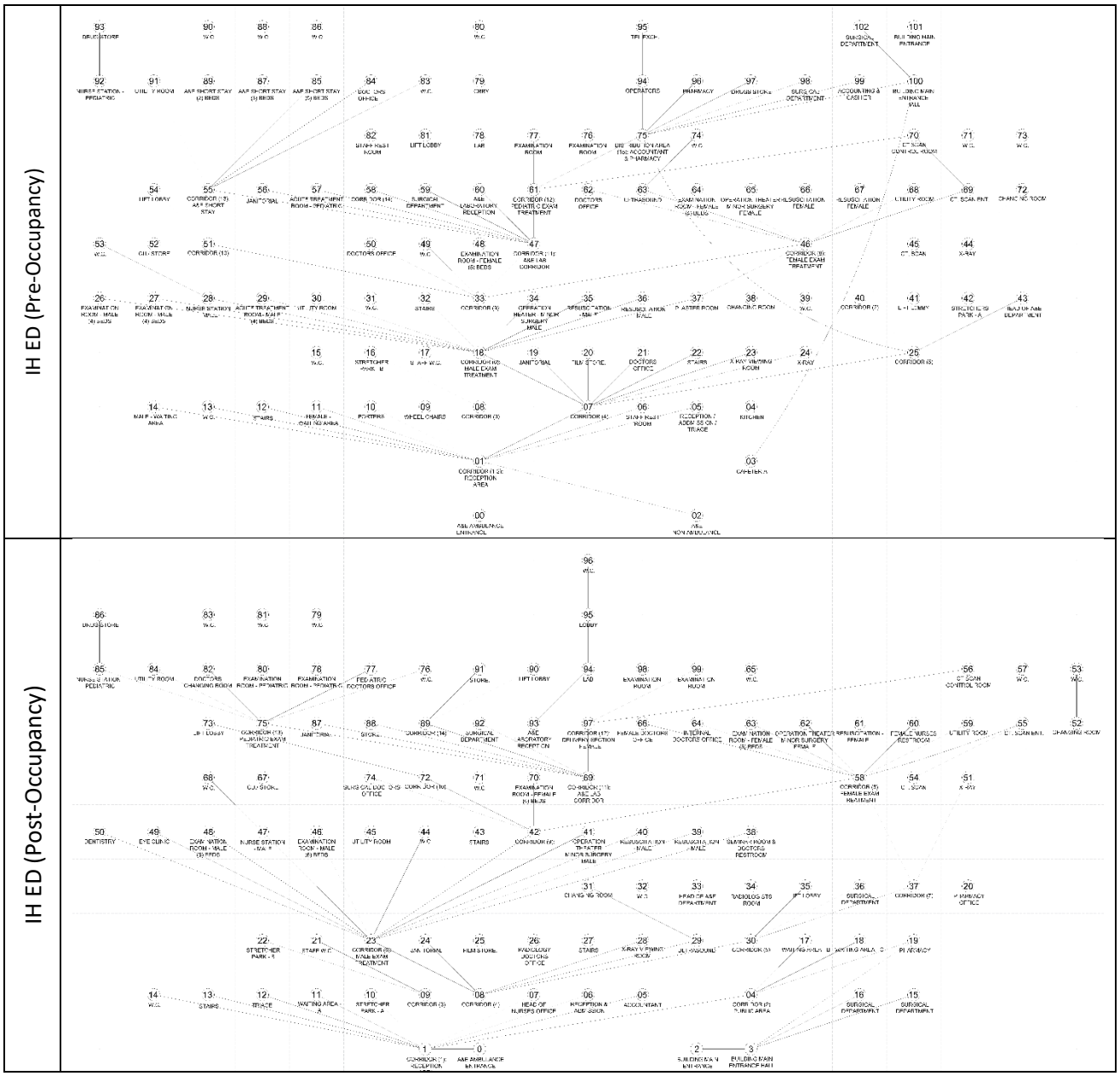
Table 11: Integration Values (i) for the main transition area in KAUH ED before and after modification.

Node No.	Pre-Occupancy Evaluation	i	Node No.	Post-Occupancy Evaluation	i
(Max i = 18.26) (Min i = 7.42)			(Max i = 18.47) (Min i = 6.17)		
2	ENTRANCE HALL	18.15	**2**	ENTRANCE HALL	16.40
3	RIGHT-WING ENTRANCE	16.76	**3**	RIGHT-WING ENTRANCE	13.56
7	LEFT-WING ENTRANCE	18.26	**7**	LEFT-WING ENTRANCE	18.47
13	RIGHT-WING PATIENTS' CORRIDOR	12.66			
14	RIGHT-WING STAFF CORRIDOR	13.50	**14**	RIGHT-WING STAFF CORRIDOR	10.61
18	LEFT CORRIDOR (A)	17.06	**19**	LEFT CORRIDOR (A)	18.47
44	LEFT WING CORRIDOR (B)	11.97	**35**	LEFT WING CORRIDOR (B) WAITING	12.34
46	LEFT WING CORRIDOR (C)	12.07	**37**	LEFT WING CORRIDOR (C) WAITING	12.54
48	OVERNIGHT BEDS AREA	12.95	**39**	INTERNAL EXAMINATION AREA	13.56

B. IH ED Justified Graphs

Table 12 illustrates manual justified graphs of the IH ED's various functions before and after modification following occupation. Figure 21 and Figure 22 provides an enlarged view of the justified graphs in Table 12. Due to the changes in the spatial structure, the measured values will change accordingly to represent the new settings. Control and integration measures are calculated below:

Table 12: Manual justified graphs for the IH ED functions before and after modification



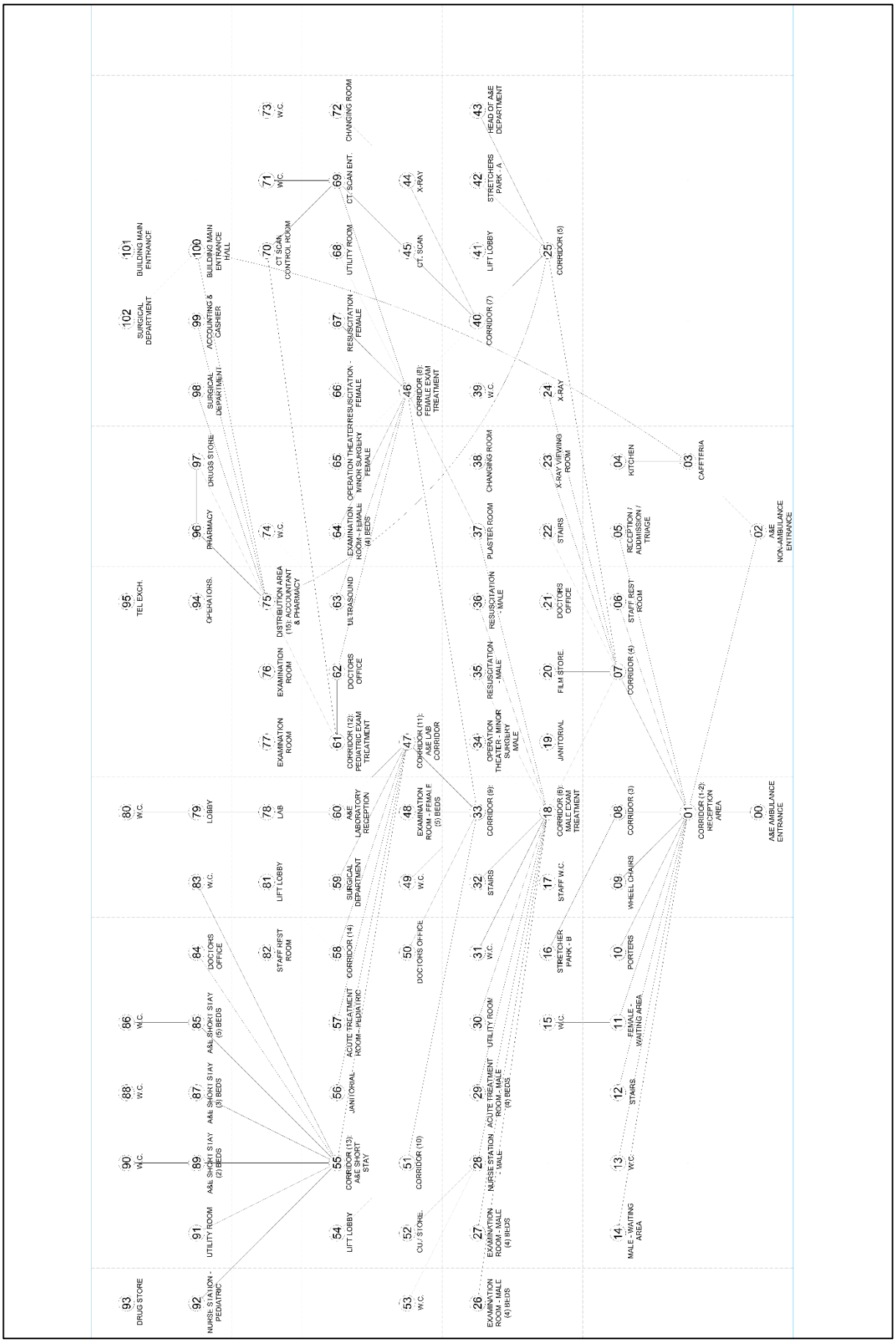


Figure 21: manual justified graphs of the various functions in the IH ED before modification following occupation (Pre-Occupancy)

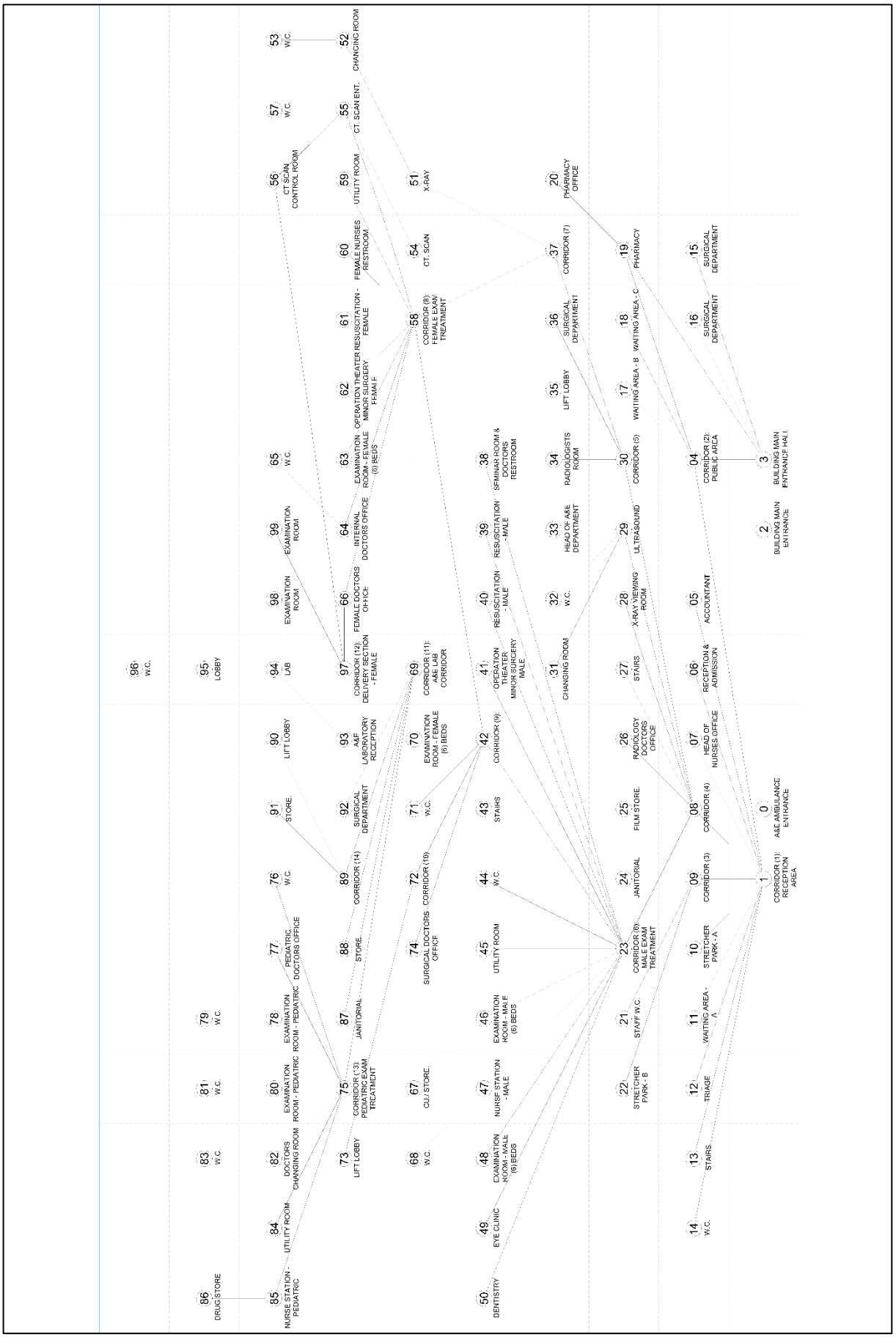
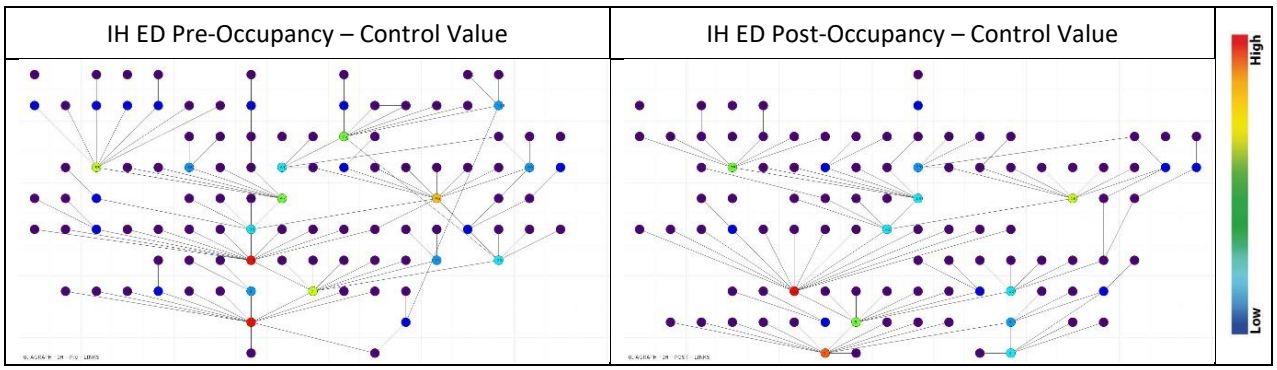


Figure 22: manual justified graphs of the various functions in the IH ED after modification following occupation (Post-Occupancy)

1. *Control Value (CV) - IH*

Table 13 represents CVs of the various functions in KAUH ED before and after modification following occupation. CV is the value which each node receives when connected. Table 6 (on page 105) provides zoning plans of the spatial configurations in the IH ED for before and after modification following occupation to help visualise the mentioned description below.

Table 13: Control Value – IH ED before and after modification



In the pre-occupancy, the minimum CV is 0.07, while the maximum is 10.08, which corridor (6) in the male exam area. The ambulance entrance has a CV of 0.08, and the non-ambulance entrance control value is 0.41. Both entrances are directly connected to the reception area that has a CV of 9.44.

On the other hand, the post-occupancy setting also has a minimum CV of 0.07, while the maximum has increased to become 11.58, which is still the main corridor in the male exam area. The ambulance entrance has the same CV of 0.08, while the non-ambulance entrance is now permanently closed. The main building entrance hall has a 3.53 CV, which is almost similar to the pre-occupancy. The reception area has a 9.64 CV, and the public corridor area has a 2.61 CV. Table 14 compares CVs for the main transition area in the ED in the IH between the two settings.

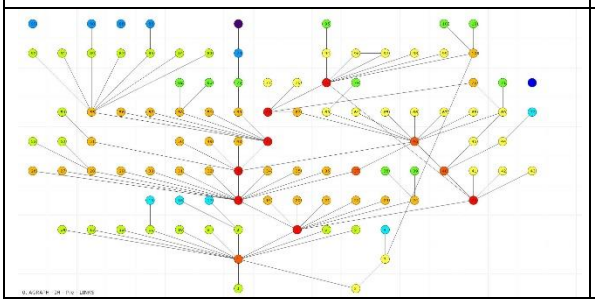
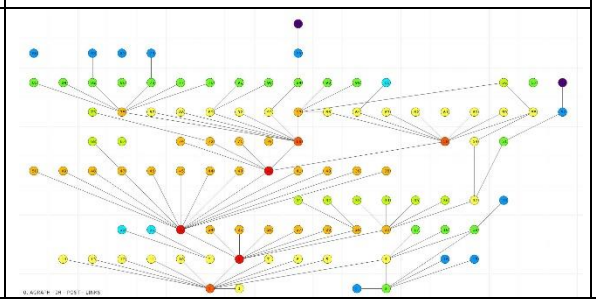
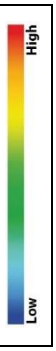
Table 14: CVs for the main transition area in IH ED before and after modification.

Node No.	Pre-Occupancy Evaluation	CV	Node No.	Post-Occupancy Evaluation	CV
	(Max CV = 10.08) (Min CV = 0.07)			**(Max CV = 11.58) (Min CV = 0.07)**	
0	ED AMBULANCE ENTRANCE	0.08	**0**	ED AMBULANCE ENTRANCE	0.08
1	CORRIDOR (1-2): RECEPTION AREA	9.44	**1**	CORRIDOR (1): RECEPTION AREA	9.64
			4	CORRIDOR (2): PUBLIC AREA	2.61
2	ED NON-AMBULANCE ENTRANCE	0.41			
7	CORRIDOR (4): leads to male exam and radiology	5.66	**8**	CORRIDOR (4): leads to male exam and radiology	5.65
18	CORRIDOR (6): MALE EXAM TREAT	10.08	**23**	CORRIDOR (6): MALE EXAM TREAT	11.58
46	CORRIDOR (8): FEMALE EXAM TREAT	7.14	**58**	CORRIDOR (8): FEMALE EXAM TREAT	6.39
47	CORRIDOR (11): ED LAB CORRIDOR	4.26	**69**	CORRIDOR (11): ED LAB CORRIDOR	4.30
61	CORRIDOR (12): PEDIATRIC EXAM TREATMENT	3.25	**97**	CORRIDOR (12): DELIVERY SECTION - FEMALE	3.12
55	CORRIDOR (13): ED SHORT STAY	5.12	**75**	CORRIDOR (13): PEDIATRIC EXAM	5.12
100	BUILDING MAIN ENTRANCE HALL	2.45	**3**	BUILDING MAIN ENTRANCE HALL	3.53

2. Integration Value (i) - IH

Table 15 represents the IH ED's various functions' integration value before and after modification following occupation. Integration (i) is a normalised measure to the shortest path from one point to all other points in a building. Table 6 (on page 105) provides zoning plans of the spatial configurations in the IH ED for before and after modification following occupation to help visualise the mentioned description below.

Table 15: Integration Value – IH ED before and after modification

KAUH ED Pre-Occupancy – Integration Value	KAUH ED Post-Occupancy – Integration Value	
		

In the pre-occupancy, the minimum integration value is 8.28, while the maximum is 24.52, which is corridor 9, that comes between the male and female exam areas. The ambulance entrance has an integration value of 13.17, and the non-ambulance entrance integration value is 13.95. Both entrances are directly connected with the reception area that has an integration value of 17.76. Also, the main corridor in the male exam area has a high integration value of 23.95.

On the other hand, the post-occupancy setting has a minimum Integration Value of 7.54, while the maximum is 23.89m, corridor 6 in the male exam area. The ambulance entrance has almost the same integration value of 13.93 compared to the pre-occupancy setting, while the non-ambulance entrance is permanently closed. The main building entrance hall has an integration value of 10.80, which is less than in the pre-occupancy settings. The reception area has an integration value of 17.51, and the public area has an integration value of 13.51.

All other corridors in the layout have hight integration values, mainly because corridors act as transition areas and links many different functions together. Table 16 provides a comparison of integration vales for the main transition area in the ED in the IH between the two settings

Table 16: Integration Values (i) for the main transition area in IH ED before and after modification.

Node No.	Pre-Occupancy Evaluation	i	Node No.	Post-Occupancy Evaluation	i
(Max i = 24.52) (Min i = 8.28)			(Max i = 23.89) (Min i = 7.54)		
0	AMBULANCE ENTRANCE	13.17	**0**	AMBULANCE ENTRANCE	12.93
1	CORRIDOR (1-2): RECEPTION AREA	17.76	**1**	CORRIDOR (1): RECEPTION AREA	17.51
			4	CORRIDOR (2): PUBLIC AREA	13.51
2	ED NON-AMBULANCE ENTRANCE	13.95			
7	CORRIDOR (4): leads to male exam and radiology	22.99	**8**	CORRIDOR (4): leads to male exam and radiology	21.95
18	CORRIDOR (6): MALE EXAM TREATMENT	23.95	**23**	CORRIDOR (6): MALE EXAM TREATMENT	23.89
46	CORRIDOR (8): FEMALE EXAM TREATMENT	20.27	**58**	CORRIDOR (8): FEMALE EXAM TREATMENT	17.57
33	CORRIDOR (9):	24.52	**42**	CORRIDOR (9):	22.77
47	CORRIDOR (11): ED LAB CORRIDOR	22.39	**69**	CORRIDOR (11): ED LAB CORRIDOR	18.80
61	CORRIDOR (12): PEDIATRIC EXAM TREATMENT	20.85	**97**	CORRIDOR (12): DELIVERY SECTION - FEMALE	14.88
55	CORRIDOR (13): ED SHORT STAY	16.66	**75**	CORRIDOR (13): PEDIATRIC EXAM TREATMENT	14.52
75	DISTRIBUTION AREA (15): ACCOUNTANT & PHARMACY	20.77			
100	BUILDING MAIN ENTRANCE HALL	15.84	**3**	BUILDING MAIN ENTRANCE HALL	10.80

C. In summary

Justifications for the differences in control and integration values between the pre- and post-occupancy settings in both EDs are due to changes in the spatial structure. As explained in the spatial development section, these changes in the spatial structure may significantly influence how the departments are being used. However, the differences in the measured values are minor and not significant, except for where there are major spatial changes. For example, in the IH ED, the control values of corridor 8, which is in the female exam area, and the values for the building main entrance have changed. These differences are due to removing the (DISTRIBUTION AREA (15): ACCOUNTANT & PHARMACY). Hence, this connection was lost, which influenced the changes in the measured values. In contrast, corridor (6) in the male exam area still has the highest values in the two settings, where there were no spatial changes near this corridor.

Similarly, in KAUH ED, significant differences were measured in control and integration values in the right-wing section between pre- and post-occupancy settings. These differences are due to removing the patients' corridor, the laboratory, and the treatment cubicles. Hence, the other spaces can become less or more, integrated, or controlled. In contrast, there are minor differences in control and integration values in the left-wing spaces between the pre- and post-occupancy settings due to changes in the spatial structure. Different values were measured in the left-wing entrance due to adding a triage counter and a triage waiting area. Also, the values for the corridors B and C in the left-wing section changed due to adding two waiting areas at their beginnings. The overnight bed area

recorded different measurements because it was converted into an internal exam area, which now has many different functions.

To conclude, justified graphs calculate the basic Space Syntax variables and analyse 'node-and-connection. It produces calculations that depend on the permeability of the spaces, where no weight is given to the functions and the exact use of these spaces. Thus, no matter how the layout has changed, the functional relationships and the way spaces work together are still missing.

5.2.2.2 *Convex Analysis*

The convex analysis is the second test to understand the spatial relations of the selected EDs. It calculates syntactic measures for the selected EDs to represent the architectural spaces. Also, it is used to validate the generated justified graphs. Convex maps represent adjacency relationships by reducing the spatial complexity of a layout to the fewest and fattest convex spaces. Therefore, in each convex space, all pairs of points are inter-visible. Thus, spatial adjacency is the fundamental relationship that characterises how structures might be configured in a spatial layout. Any two spaces are considered adjacent when it is possible to access one space directly from another without passing through intervening spaces (Hillier and Hanson 1984; Space Syntax – Online Training Platform).

DepthmapX 0.50 software was used to generate convex maps for the selected EDs before and after modification following occupation. The red colour indicates the highest value in all graphs, and the blue colour represents the lowest values. The following syntactic measures will be calculated to represent the selected cases:

- Connectivity (NCn): measures the number of spaces directly connected to one particular space in the entire layout, where the higher the values, the more spaces are connected.
- Integration (i): measures the average depth of space to all other spaces, where the higher the values, the more spaces are integrated.

A. KAUH and The IH Convex Connectivity Analysis

Table 17 illustrates convex connectivity maps of the various functions in KAUH and the IH EDs before and after modification following occupation. Due to the changes in the spatial structure, the measured values will change accordingly.

Table 17: Convex connectivity analysis for KAUH and IH ED before and after modification.

	KAUH ED Pre-Occupancy	KAUH ED Post-Occupancy	IH ED Pre-Occupancy	IH ED Post-Occupancy
convex connectivity maps				
				

- KAUH: in the pre-occupancy settings, the highly connected space is the staff corridor in the right-wing section, connected to 14 spaces. While in the current settings, different spaces share the same highest connective value, such as staff corridor in the right-wing section, the right-wing entrance area, and the main corridor in the left-wing section (Corridor A), where each one is connected to 9 spaces. So, the highly connected space in the pre-occupancy setting is connected to 14 spaces, while in the current settings it is connected to only 9 spaces.
- The IH: in the pre-occupancy settings, the highly connected spaces are the main corridor in the male exam area, which is connected to 13 spaces, and the corridor in the reception area, which is connected to 12 spaces. On the other hand, in current settings, the main corridor in the male exam area still has the highest connectivity value due to being connected to 14 spaces.
- In both EDs, all corridors have high connectivity values, while most departments' spaces have lower connectivity values. The low connectivity values start from 1, which means that space directly connects with only one space represented in blue colour.

B. KAUH and The IH Convex Integration Analysis

Table 18 illustrates convex integration maps of the various functions in KAUH and the IH EDs before and after modification following occupation. Due to the changes in the spatial structure, the measured values will change accordingly.

Table 18: Convex integration analysis for KAUH and IH ED before and after modification.

	KAUH ED Pre-Occupancy	KAUH ED Post-Occupancy	IH ED Pre-Occupancy	IH ED Post-Occupancy
convex integration maps				
				

Table 19 and Table 20 show that the calculated integrations values from graphs analysis in both cases using AGRAPH software are almost identical to the convex ones using DepthMap software. Thus, the integration values for the analysed cases are valid, and the results are accurate.

Table 19: AGRAPH and DepthMap Integration Values (i) for the main transition area in KAUH ED before and after modification.

Node No.	Pre-Occupancy Evaluation	AGRAPH	DepthMap	Node No.	Post-Occupancy Evaluation	AGRAPH	DepthMap
2	ENTRANCE HALL	18.15	1.807	**2**	ENTRANCE HALL	16.40	1.725
3	RIGHT-WING ENTRANCE	16.76	1.670	**3**	RIGHT-WING ENTRANCE	13.56	1.431
7	LEFT-WING ENTRANCE	18.26	1.818	**7**	LEFT-WING ENTRANCE	18.47	1.938
14	RIGHT-WING STAFF CORRIDOR	13.50	1.349	**14**	RIGHT-WING STAFF CORRIDOR	10.61	1.124
18	LEFT CORRIDOR (A)	17.06	1.700	**19**	LEFT CORRIDOR (A)	18.47	1.938
44	LEFT-WING CORRIDOR (B)	11.97	1.197	**35**	LEFT-WING CORRIDOR (B) WAITING	12.34	1.305
46	LEFT-WING CORRIDOR (C)	12.07	1.207	**37**	LEFT-WING CORRIDOR (C) WAITING	12.54	1.326
48	OVERNIGHT BEDS AREA	12.95	1.294	**39**	INTERNAL EXAMINATION AREA	13.56	1.431

Table 20: AGRAPH and DepthMap Integration Values (i) for the main transition area in IH ED before and after modification.

Node No.	Pre-Occupancy Evaluation	AGRAPH	DepthMap	Node No.	Post-Occupancy Evaluation	AGRAPH	DepthMap
0	AMBULANCE ENTRANCE	13.17	1.075	**0**	AMBULANCE ENTRANCE	12.93	1.077
1	CORRIDOR (1-2): RECEPTION AREA	17.76	1.448	**1**	CORRIDOR (1): RECEPTION AREA	17.51	1.458
				4	CORRIDOR (2): PUBLIC AREA	13.51	1.114
7	CORRIDOR (4): leads to male exam and radiology	22.99	1.889	**8**	CORRIDOR (4): leads to male exam and radiology	21.95	1.846
18	CORRIDOR (6): MALE EXAM TREATMENT	23.95	1.991	**23**	CORRIDOR (6): MALE EXAM TREATMENT	23.89	2.041
46	CORRIDOR (8): FEMALE EXAM TREATMENT	20.27	1.650	**58**	CORRIDOR (8): FEMALE EXAM TREATMENT	17.57	1.589
33	CORRIDOR (9):	24.52	2.041	**42**	CORRIDOR (9):	22.77	2.041
47	CORRIDOR (11): ED LAB CORRIDOR	22.39	1.829	**69**	CORRIDOR (11): ED LAB CORRIDOR	18.80	1.657
61	CORRIDOR (12): PEDIATRIC EXAM TREATMENT	20.85	1.617	**97**	CORRIDOR (12): DELIVERY SECTION - FEMALE	14.88	1.227
55	CORRIDOR (13): ED SHORT-STAY	16.66	1.365	**75**	CORRIDOR (13): PEDIATRIC EXAM TREATMENT	14.52	1.267
100	BUILDING MAIN ENTRANCE HALL	15.84	1.267	**3**	BUILDING MAIN ENTRANCE HALL	10.80	0.885

C. In summary

Convex analysis using DepthMap software was adopted to understand EDs spatial relationships as a second test to calculate syntactic measures for the selected EDs. Also, to validate the calculated measures using AGRAPH software. Based on this, the obtained result from the convex analysis confirms with the ones using AGRAPH software to generate the justified graphs, where the differences in the calculated values are due to changes in the spatial structure. These differences in the measured values are minor and not significant, except for where there are major spatial changes. However, the changes in the spatial structure may have a significant influence on the way the departments are being used.

To conclude, the convex analysis represents adjacency relationships between the spaces in the layout by reducing the spatial complexity to the fewest and fattest convex spaces. It calculates basic Space Syntax variables depending on the spaces' permeability, where no weight is given to the functions and the exact use of these spaces. Thus, no matter how the layout has changed, the functional relationships and the way spaces work together are still missing.

5.2.2.3 *Visibility Graph Analysis (VGA)*

'Visibility Graph Analysis (VGA)' is the third test to understand the spatial relations of the selected EDs. It represents the visual access to the entire layout at a time. It is constructed by analysing the reflection

of light to calculate the movement patterns of users. To explain, it is used to explore the spatial structure of the entire environment, and to explore the differences in behaviours. Thus, it provides modelling and a prediction of how spaces are being used and perceived by its users (Amini Behbahani et al. 2017). Like other space syntax techniques, VGA produce graphs to present the built environment.

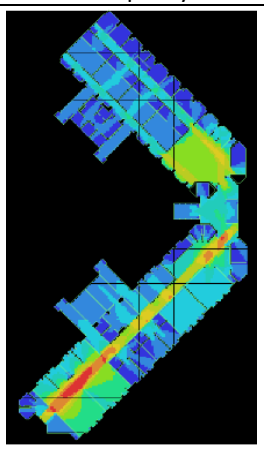
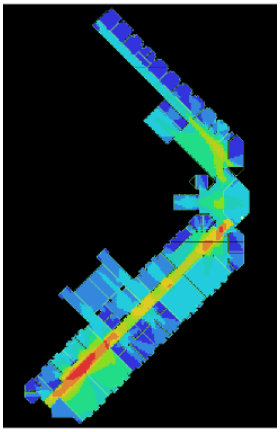
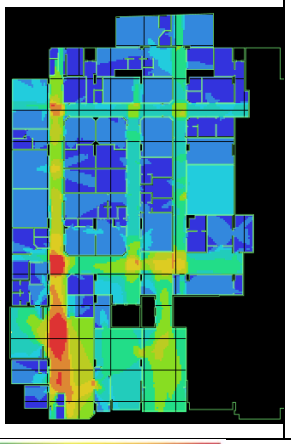
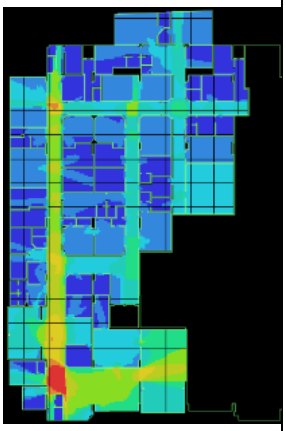
DepthmapX 0.50 software was used to generate visibility graphs for the selected EDs before and after modification following occupation. The red colour indicates the highest value in all graphs, and the blue colour represents the lowest values. The following syntactic measures will be calculated to represent the selected cases:

- Connectivity analysis: measures the number of spaces that are visually connected to other spaces, where the higher the values, the more spaces are connected.
- Visual integration: measures the depth of space to all other spaces in the system, where the higher the values, the more spaces are integrated. Integration analysis can reveal the core space in the layout. In a highly integrated space, users usually can see much of the spatial structure and can be seen.

A. KAUH and The IH VGA Connectivity

Table 21 illustrates VGA connectivity maps for the spatial structure in KAUH and the IH EDs before and after modification following occupation. Due to the changes in the spatial structure, the measured values will change accordingly.

Table 21: VGA Connectivity for KAUH and IH ED before and after modification.

	KAUH ED Pre-Occupancy	KAUH ED Post-Occupancy	IH ED Pre-Occupancy	IH ED Post-Occupancy
VGA - Connectivity				
	Low — High			

- In KAUH, it can be seen from the table above, that connectivity values between the pre- and post-occupancy settings are almost the same. The triage and staff main counter area has high connectivity values in the pre- and post-occupancy. Also, the overnight beds' area, which is now

the internal exam area, has high connectivity measures. Not to mention, the entire main corridor has a relatively high connectivity value. However, some differences can be identified in the following areas:

- The main entrance area has a slightly different connectivity measure due to the changes in the entrance shape.
- The right-wing section entrance has a slightly different connectivity measure due to the decreased number of spaces connected to the left-wing entrance area. Thus, the connectivity values have decreased.

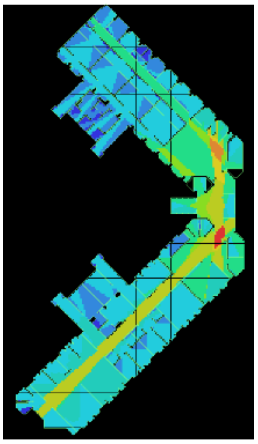
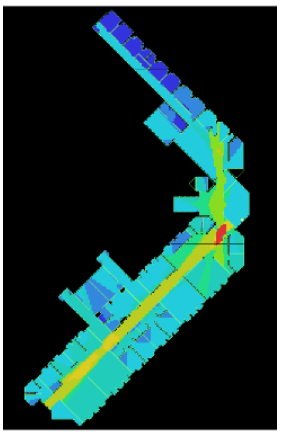
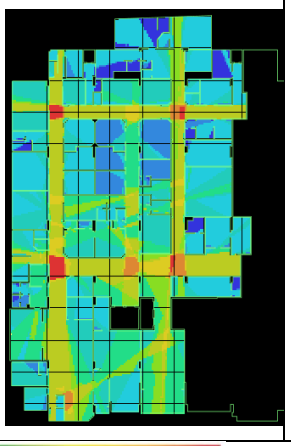
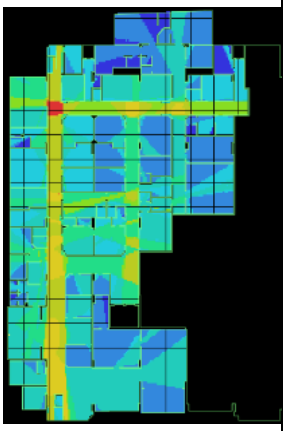
- In the IH, it can be seen from the table above, that connectivity values between the pre- and post-occupancy settings have decreased in some areas, while it remained the same in others. For example:
  - The reception area by the ambulance entrance had a high connectivity value in the pre-occupancy settings. In the current settings, the public area near the toiles has more connectivity than the reception area. This difference is due to the open reception area in the pre-occupancy, while now it is a closed area. Also, in the current design, the public area near the toilets is more of open space.
  - Corridor 4, the corridor between the main male exam area and the reception area, used to have more connectivity values than current settings. This change is owing to closing corridor 15; therefore, this connection has been lost, and more boundaries were created. Thus, connectivity values have decreased. Not to mention, the spatial changes in the reception areas.
  - Corridor 12 (which is used to be the pediatric treatment area, is now the women delivery area) used to have higher connectivity value. This change is owing to closing corridor 15; therefore, this connection has been lost, and more boundaries were created. Thus, fewer spaces are connected to corridor 12, which mean lower connectivity values.

The connectivity results using VGA analysis matches the results obtained from the convex connectivity analysis. Thus, the obtained results are valid and representable for the investigated cases.

B. KAUH and The IH VGA Visual Integration

Table 22 illustrates VGA visual integration maps for the spatial structure in KAUH and the IH EDs before and after modification following occupation. Due to the changes in the spatial structure, the measured values will change accordingly.

Table 22: VGA Visual Integration for KAUH and IH ED before and after modification.

	KAUH ED Pre-Occupancy	KAUH ED Post-Occupancy	IH ED Pre-Occupancy	IH ED Post-Occupancy
VGA - Visual Integration				
				

- In KAUH, it can be seen from the table above, that visual integration values between the pre- and post-occupancy settings are almost the same. The triage and the left-wing entrance have high connectivity values in the pre- and post-occupancy. The overnight beds' area, which is now the internal exam area has a slightly high visual integration measure. Not to mention, the entire main corridor has a relatively high visual integration value. However, some differences can be identified in the following areas:
  - The right-wing section entrance has a slightly different visual integration measure due to the decreased number of spaces connected to the left-wing entrance area. Thus, visual integration values have decreased.
- While in the IH, it can be seen from the table above, that visual integration values between the pre- and post-occupancy settings have decreased in some areas, while it remained the same in others. However, in the pre-occupancy settings, the department used to be more integrated than in the current settings. Moreover, this is owing to the significant spatial alterations in the layout. For example:
  - The closer of corridor 15 (which is the distribution area used to have the ED pharmacy and accountant and other functions) has caused the differences in the visual integration values for the entire layout. For example, the integration values of the following areas have decreased by the closer of the corridor 15.
    - Corridor 8 (the female exam area)
    - corridor 11 (the ED lab corridor)
    - corridor 12 (used to be the pediatric exam area, and currently it is the women delivery area)
    - Corridor 13 (used to be ED short stay are, and currently it is the pediatric exam area)

- Corridor 5 (used to be directly connected to corridor 15 (the lifts area) and corridor 8 (female exam area)).

The visual integration results using VGA analysis matches the results obtained from the convex integration analysis. Thus, the obtained results are valid and representable for the investigated cases.

C. In summary

VGA using DepthMap software was adopted to understand EDs spatial relationships as a third test to calculate syntactic measures for the selected EDs. Also, to validate the calculated measures in the justified graphs and convex maps. Based on this, VGA results confirm with the ones in the justified graphs and convex maps, where the differences in the values are due to changes in the spatial structure. These differences in the measured values are minor and not significant, except for where there are major spatial changes. However, the changes in the spatial structure may have a significant influence on the way the departments are being used.

To conclude, VGA analyses the visual access for the entire layout, where it is based on analysing the light reflections to calculate people's movement patterns. It generates maps to predict the way spaces are being used and experienced by its users. However, no weight is given to the functions and the exact use of these spaces. Thus, no matter how the layout has changed, the functional relationships and the way spaces work together are still missing.

5.3 Conclusion

Space syntax analysis was used in this study as a syntactic analytical tool to investigate ED spatial relationships. The intention is to determine if this type of analysis, based purely on plans, offers a useful indication of likely actual performance of ED, which could inform future designs.

The spatial analysis started by identifying the development in the spatial structure, which revealed that significant changes occurred in the spatial structure and the distribution of the functions in the selected EDs between the original designs and the current ones. Therefore, syntactic values were measured afterwards using space syntax tools, AGRAPH and DepthMap, for the various functions in the selected cases before and after modification following occupation, which revealed minor and not significant differences in the calculations, except for where there were major spatial changes. However, the changes in the spatial structure were major; therefore, these changes may significantly influence the way the selected EDs are operating, which may not be predicted from the syntactic measures.

EDs have a work routine that follows a controlled movement tracks due to its complexity and the way it functions. To emphasis, each ED adapts to a different triage and medical procedures systems. Each system has its way of dealing with medical cases in terms of their treatment routine, priority, and the flexibility of spatial adaptation when dealing with various medical conditions. As a result, EDs function

in controlled ways, where spaces are linked together depending on their operation rather than their permeability. Besides, EDs may sometimes work in an unpredicted way to urgent suite critical demands the department may have to face. Therefore, the obtained syntactic values, such as control, integration, and connectivity, do not provide data regarding spaces functional relationships to support the workflow due to their complex operational requirements. To emphasise what is missing in space syntax theory, it does not give weight to the changes in the functions of the analysed space and how they work together in controlled environments like EDs. Thus, alterations in the spatial structure may significantly influence how the department is being used, while these changes might be hard to predict using syntactic measures.

On the other hand, these values can provide valuable data to aid the design process in assigning suitable functions for each space or distributing spaces in the layout depending on their properties and physical connection, designing spatial adjacencies to reduce layout complexity. To emphasise, obtaining these values can aid the design of EDs' spatial structure and functional distribution by providing valuable data regarding various design parameters that need to be considered in the design stage, such as the hierarchy of spaces, accessibility, and privacy. For example, knowing these values for each space in the system can help healthcare designers to identify public spaces, semi-public spaces, semi-private spaces, and private spaces. Also, to identify, for example, the connected and easy access spaces, segregated spaces, and spaces with greater control over other spaces. Thus, these values can be used to assign suitable functions for each space. For instance, public spaces should have high integration values with less privacy and easy access from outside. While on the other hand, more private spaces in the department should have low integration values and higher privacy levels and restrict access for unauthorised users. Thus, more qualitative analysis techniques were used afterwards to formulate a better understanding of ED's spatial situation and ways to predict and improve the functional relationships.

5.4 Chapter summary

The chapter gives an account of the spatial analysis conducted for KAUH and the IH EDs to understand their spatial relations. The spatial configurations of the two EDs were explored before and after modification following occupation. Two analytical approaches were used—first, spatial structure development. Second, space syntax analysis. A comparison between the obtained results is included. The next two chapters will present a contrasting account from investigation the influence of the spatial structure on EDs operation in the same selected EDs by: first; observing the actual usages; second; interviewing staff to explore their design preferences and to understand the observed usages.

Chapter 6: Observation Analysis

6.1 Introduction

This chapter presents findings from the field observation carried out in both KAUH and the IH EDs to fulfil the first part of objective four, investigating the influence of the spatial structure on EDs operation. They were carried out to understand how EDs are being used and function by observing users' behaviours and activities.

A detailed description of the observation notes is presented. The unit's rhythm allowed each observation study to be completed in one day between 8:30 AM and roughly 11:00 PM. Because of the aggregation of activities and behaviour grows faster as the rate of work is high. This field observation was carried out in three stages by observing and recording the following in a text form:

- First, a detailed description of the outdoor physical setting to understand the location typology and the impact of these settings on the way the department is being used. This phase was conducted early in the morning between 08:00 AM and 08:45 AM
- Second, a detailed description of the indoor physical setting to understand the indoor typology and the impact of these settings on the way the department is being used. This phase was conducted between 08:45 AM and 09:30 AM.
- Third, a detailed description of users' and staff behaviours to understand the influence of the spatial structure on their behaviours. This phase was conducted in three different times afterwards: from 10:00 AM to 11:00 AM, from 06:00 PM to 07:00 PM, and from 10:00 PM to 11:00 PM.

6.2 Observational notes for King Abdullah University Hospital ED (KAUH)

This field observation was conducted in KAUH ED to evaluate the influence of the spatial structure on users' usages. Figure 23 is the zoning plan for the current state; Figure 24 illustrates the observed points. There are three observational phases:

6.2.1 Phase 1: Building and location (Outdoor)

A detailed description of the physical settings in KAUH ED was recorded. The researcher placed himself outside the building and walked around the perimeter. This phase was recorded on Thursday 03-05-2018 between 08:00 AM and 08:45 AM. The observational notes are shown in Figure 24.

1. Building:
    - The ED is attached to the main hospital building and being on the right side of the building.
    - The emergency department has a dedicated drive-through street which is part of the hospital's street network.
2. Accessibility:
    - The department has one private street entrance for both ambulance and walk-in patients. This entrance leads to a transition space, then to the entrance hall. The entrance hall leads to the

right-wing section entrance (has the registration office, the accountant, the ED pharmacy, the ED inpatient admission, a waiting area, and staff private areas/offices.), the radiology, and the left-wing section (has all ED exam cubicles).

- The department can be reached from inside the hospital complex.

3. Outside Wayfinding:
    - The ambulance entrance can be reached easily.

6.2.2 Phase 2: Indoor environment

A detailed description of the indoor situation of KAUH ED was recorded. The research placed himself in various indoor locations in the public area. This phase was recorded on Thursday 03-05-2018 between 08:45 AM and 09:30 AM. The observational notes are shown in Figure 24.

1. Indoor entrance:
    - The department entrance (the left-wing section entrance) is for the ambulance and non-ambulance patients. However, it is far from the street entrance, difficult to find, and requires more turns to be reached. Also, it is difficult for ambulance cases which are coming on stretchers to manoeuvre easily.
2. Waiting areas:

    There are three areas where people can wait in the ED.

    - First, the main waiting area in the right-wing section. The following points were observed:
        - It is in the right-wing section by the logistic services and far from the exam areas.
        - It has no services such as toilets, food machine, and drinks machine. Not to mention, there is no near cafeteria—only a water fountain in the entrance hall. Thus, people use the toilets in the ED (in the left-wing section).
        - There is no communication system between staff and patients. A nurse will come in person to call the patient to the department, which is a long walking distance.
        - It is considered outside the department.
        - People tend to walk a lot between the waiting area and the ED. Therefore, they sometimes wait near the department gate, such as by the main counter, in the corridors, and the other two waiting areas in the left-wing section.
    - Second, two waiting areas in the middle of the ED in the left-wing section. They are located at the beginning of the two corridors leading to the radiology department.
        - People almost block the corridors, making it hard for the staff to move when taking a patient to radiology on beds or wheelchairs. Staff start asking people to clear the way. Thus, they are hindering staff mobility.
        - People in the first corridor have clear visual access to the Eye and Ear clinics and staff toilets. Simultaneously, People in the second corridors have clear visual access to the

internal exam area and female nurses changing room. Thus, they are compromise staff and patients' privacy.

- Three, one small waiting area in the left-wing section by the entrance is used by patients waiting to be triaged.

Not having proper waiting areas is causing difficulties that impact of the function if the department, which creates crowdedness and reduces efficiency:

- Patients and their companions wait in the corridors.
- Staff sometimes start looking for the patients in the whole department by calling their names because they might be anywhere.

3. Triage:
   - It is located just after the left-wing entrance in front of the admission counter. It includes a triage counter to take patients history, triage room for assessment, and a small waiting area.
   - People wait around the main admission counter (central staff station) for triage, which causes crowdedness.
4. Registration and accountant:
   - Registration and accountant are in the right-wing section, which is far from the ED. Also, they are considered outside the department.
5. ED boundaries:
   - Exam areas are only in the left-wing section. Therefore, the street entrance, entrance hall, and the functions in the right-wing entrance are considered outside the ED.
6. Internal circulation and users' flow:
   - Users must walk between the right and the left wings multiple times to fulfil the formal requirements, increase process time, reduce satisfaction, and create confusion, not to mention the long walking distances users must take.
   - Patients and caregivers have a programmed flow that is the department's used protocol, and this protocol follows the current spatial structure.
   - There is no control over the flow and accessibility; non-staff (patients, visitors, etc.) can go freely in the department with no constrains.
7. Internal spatial structure:
   - The department was designed to be used differently. It used to consist of both the right and the left wings. However, currently, the left-wing is used as the emergency department and has all the exam cubicles. On the other hand, the right-wing has the pharmacy, the registration office, the accountant, the private staff areas, and ED inpatient admission. Also, it has the main waiting area for the emergency department.
   - It can be described as a corridor base department, where all functions are on both sides of the corridor. As a result, users can have visual access to the entire corridor (from the left-wing

door to the staff rest area). Also, users can see all the rooms on both sides of the corridor when moving into the department.

8. Radiology department:
    - It is behind the ED, and it can reach from the main entrance or the two corridors in the left-wing section.
    - The two corridors in the left-wing section are the main movement path between the ED and the radiology department. However, the waiting areas by the beginning of the two corridors hinder the efficiency of movement.
9. The ED pharmacy:
    - The pharmacy is in the right-wing section, where is the registration, the accountant counter, the ED In-patient admission, and staff offices.
    - People tend to go to the pharmacy as the last destination before they leave.
10. Internal accessibility:
    - The emergency department has no closed gate (controlled gates). People are moving freely everywhere.
    - There is no control over the flow and accessibility; non-staff (patients, visitors, etc.) can go freely in the department with no constrains.
11. The ED laboratory:
    - The department does not have a laboratory. The porter usually takes ED samples to the central laboratory in the main building by going through the radiology department. As a result, time is wasted while sending the samples and getting the results; also, a long walking journey for staff.
12. Staff main stations:

    The staff has two stations in the ED:

    1. Staff central station that is located after the entrance of the left-wing section.
        - It is a staff gathering point for patients' admission and data entry.
        - It is part of patients' journey before admission. Patients have to handle their registration file by the counter before they are admitted in the ED.
        - The whole area gets very crowded as a core point in the department between admission, triage, and treatment cubicles. It is at the beginning of the main corridor that links the entire department.
    2. Staff counter in the internal exam area.

6.2.3 Phase 3: Users and staff behaviour

A detailed description of users and staff behaviours in KAUH ED were recorded. The research placed himself in a various indoor location in the public area. This phase was recorded on Thursday 03-05-

2018 in three different times; from 10:00 AM to 11:00 AM, from 06:00 PM to 07:00 PM, and from 10:00 PM to 11:00 PM. The observational notes are shown in Figure 24.

1. Users' Gathering areas:
    - People are usually walking around throughout the entire department and can be almost everywhere. However, they gather in various areas in and out of the department doing various activities (standing, sitting, talking, talking on phones, eating, smoking etc.). For example:
        - Outside the building and near and around the street entrance.
        - In the entrance hall (the central area between the right and the left sections). Mainly people are moving in this area rather than standing still.
        - People are moving in and around the main waiting area in the right-wing section.
        - People gather by the receptions and triage area. Staff and medical students are mainly placed behind and next to the main staff counter working, waiting, or talking. At the same time, patients are gathering in front of the counter, around the triage area. Not to mention, all users move very frequently in front of the counter while entering and leaving the department.
        - People may wait by the staff counter in the internal exam area.
        - People may wait in the corridors in the left-wing section.
    - It was also observed that people tend to wait near what is relevant to them. For example:
        - People wait by the triage area, main staff counter, and the entrance hall when they are waiting to be triaged or admitted to the ED.
        - People wait in and around the right-wing section waiting area, and the entrance hall when they are waiting for one of the following:
            - Be admitted to the ED Inpatients section.
            - To collect a prescription from the pharmacy, or
            - For the registration and accountant purposes
        - People wait in the corridors in the left-wing section when they are through an examination process, being a companion with a patient, or eye and ear clinics patients.
2. Other behaviours of users:
    - Patients are usually combined with one to three people and sometimes more than this.
    - Family members and visitors walk freely in the department with no restrictions and can enter almost any room.
    - Family members and visitors interact with staff in the corridors.
    - Family members and visitors sometimes stop staff walking in the corridors to seek medical advice or ask about their patients.
    - After 07:00 PM to about midnight, the department becomes very busy and crowded.

- Owing to the current spatial structure of having the ED related functions on both sides, users must move between the two sections for administration and logistics purposes; therefore, crowding occurs.
- It was observed that users were unsure where to go after entering from the street entrance as they started looking around and asking for directions (first-time users). It can be concluded that the ED entrance is vague and hard to be reached.

Figure 23: Zoning plan for the ED in KAUH – Post-occupancy

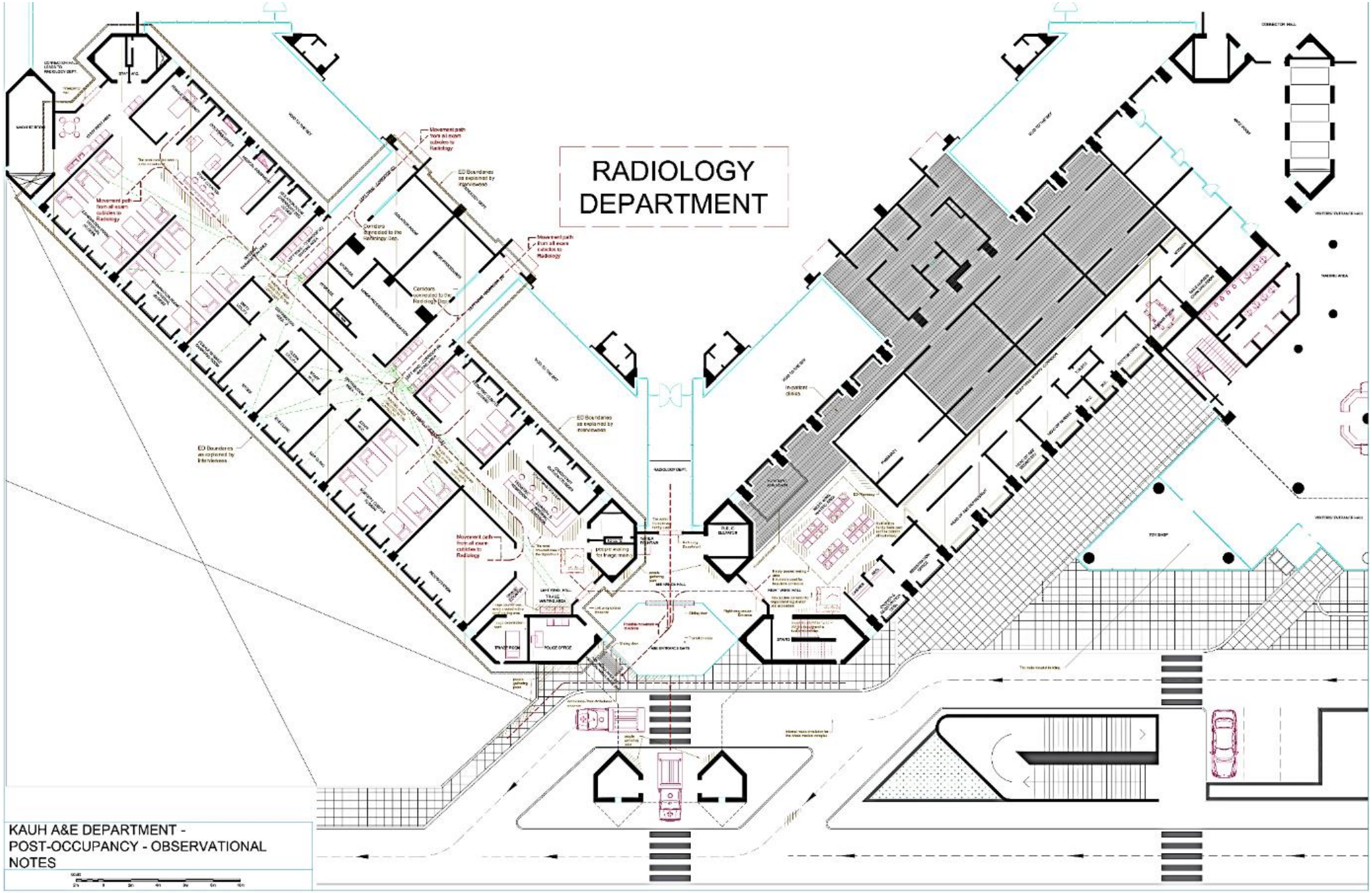


Figure 24: Observational notes for the ED in KAUH – Post-occupancy.

6.3 Observational notes for the Islamic Hospital ED (IH)

This field observation was conducted in the IH ED to evaluate the influence of the spatial structure on users' usages. Figure 25 is the zoning plan for the current state; Figure 26 illustrate the observed points. There are three observational phases:

6.3.1 Phase 1: Building and location (Outdoor)

A detailed description of the physical settings in the IH ED was recorded. The researcher placed himself outside the building and walked around the perimeter. This phase was recorded on Tuesday 01-05-2018 between 08:00 AM and 08:45 AM. The observational notes are shown in Figure 26.

4. Building:
    - The ED is in a separate building from the main hospital building.
    - The building is about 200m after a traffic light on the main street.
    - The ED shares the same building with the surgical department.
    - The EDs occupies about half the total area of the ground floor.
    - The building location is causing crowdedness in the street due to having the entrance on the main street directly, which is a very busy one. The street is a primary road that leads to Amman's city downtown.
5. Accessibility:
    - The emergency department can be accessed from three entrances:
        A. The ambulance entrance (designed for cars only).
            - It is located on the left side of the building.
            - It shares the same one-way route that leads to the following in the same order:
                - Surgical department (Main entrance).
                - Walk-in entrance (permanently closed).
                - Ambulance entrance.
                - Underground car parking.
                - Back street of the building, which leads to the main hospital building.
            - It is used by walk-in patient too, and people access this entrance by coming from:
                - The main street in front of the building.
                - The back street behind the building (where main hospital building is located)
            - No dedicated path for the walk-in patient to reach ambulance entrance (patients are walking on the street which is designed for vehicles)
            - Users sometimes use this entrance to pass through (to go to the surgical department or to use the toilets)
        B. The surgical department entrance (building main entrance).

- Users can go through the building main entrance to the ED, which is for the operation department. This entrance is accessed from the main street.
- The main street is busy, and a traffic light is just before the building, making it hard to change lane to enter the building.
- Some people use this entrance to go to the main hospital building through the emergency department as a short cut.

C. A small walk-in entrance that is now permanently closed.

- There is no sign to guide people to the ED (only on sine on the inside wall just before the ambulance entrance). The entrance is not clear from the outside.
- The emergency department's entrances and exits are not clear; therefore, people come and ask for directions many times. (ask for directions for the different functions outside the emergency department and about the surgical department).
- The ambulance entrance is not visible to users, and it is located on the left side of the building.
- The building's main entrance does not indicate that it can be used to reach the ED.

6.3.2 Phase 2: Indoor environment

A detailed description of the indoor situation of the IH ED was recorded. The research placed himself in a various indoor location in the public area. This phase was recorded on Tuesday 01-05-2018 between 08:45 AM and 09:30 AM. The observational notes are shown in Figure 26.

1. Indoor entrance:
   - The department's indoor gate is further into the department and neither close to the ambulance entrance nor to the registration counter and waiting areas.
   - It is a double door that is always open with no restrictions (anyone can enter that gate)
2. Waiting areas:

   Waiting areas in the department can be described as:

   - A small waiting area is in front of the registration counter and next to the department's ambulance entrance. It has three attached chairs for people to wait.
   - Two relatively big size areas in front of the accountant and the pharmacy located in the far-right end of the building.
     - They are considered outside the department and far.
     - They do not have enough seats for people. the number of available seats can service around 12 people (3 attached seats for four users each)
     - They contain the following:
       - ATM, fresh orange juice machine, and attached seats.
     - Between the two waiting areas is the closed walk-in patients.

3. Triage:
    - It is located next to the ambulance entrance. It has four beds with curtains in between, five attached chairs in front of the beds, and a small desk for staff.
    - The triage room is divided male and female (two beds for males and two for females).
4. Registration and accountant:
    - Registration and accountant are in front of the ambulance entrance, far from the ED indoor gate and the exam areas. Thus, they are considered outside the department.
5. ED boundaries:
    - The ED starts with the department indoor gate. Therefore, not all available functions are considered inside the Emergency Department, as such, registration, accountant, triage, waiting areas, pharmacy, and radiology section.
    - The emergency department has no closed boundaries (controlled gates); it feels like it is an open-plan design and people are moving freely everywhere.
6. Internal circulation and users' flow:
    - Users have to walk between the exam areas and the public area multiple times to fulfil the formal requirements, increase process time, reduce satisfaction, and create confusion, not to mention the long walking distances users have to take.
    - Patients and caregivers have a programmed flow that is the department's used protocol, and this protocol follows the current spatial structure.
7. Internal spatial structure:
    - The ED in the IH is relatively big, and it can be described as a corridors-based department, where a liner design is used. The department has five different sections: male exam area, female exam area, pediatric exam area, delivery section, and a radiology section. The functions and their spatial relation can be seen in Figure 25
8. Radiology section:
    - The department has X-ray, CT-Scan, and ultrasound rooms, and they all are placed at the beginning of the department after the reception and before the examination/treatment areas. In addition to radiology-related spaces, such as radiologist office, viewing room, film store, and doctors' office.
9. The ED pharmacy:
    - It is in L shape, and it can be accessed from both sides of the L shape. It serves the operation department and the ED.
    - A window has been open recently in front of the waiting area to service the emergency department.
    - People tend to go to the pharmacy as the last destination before they leave.

10. Internal accessibility:
    - The emergency department has no closed gate (controlled gates). People are moving freely everywhere.
    - There is no control over the flow and accessibility; non-staff (patients, visitors, etc.) can go freely in the department with no constrains.
11. The ED laboratory:
    - The department has a laboratory for the ED use only. It is located at the far end of the department, which is distantly far.
12. Staff main stations:

    The staff has different station distributed in various locations in the ED.

    1. Staff central station is in front of the ED entrance.
        - It is a staff gathering point for patients' admission and data entry.
        - It is part of the patients' journey. Patients have to register first when they come to the ED. Also, they have to revisit the admission counter every time they may need a new procedure.
    2. Two other small nurse stations are in the male and pediatric exam areas.

6.3.3 Phase 3: Users and staff behaviour

A detailed description of users and staff behaviours in The IH ED were recorded. The research placed himself in a various indoor location in the public area. This phase was recorded on Tuesday 01-05-2018 in three different times; from 10:00 AM to 11:00 AM, from 06:00 PM to 07:00 PM, and from 10:00 PM to 11:00 PM. The observational notes are shown in Figure 26.

1. Users' Gathering areas:
    - People are usually walking around throughout the entire department and can be almost everywhere. However, they are gathering in the following areas the most:
        - Outside the building and by the ambulance entrance (talking, smoking eating, on the phone, standing, crying).
        - People may gather by the main counters (a mix of patients, family members, visitors, and staff).
            - Staff is behind the counter, and other staff are coming and leaving.
            - Patients are waiting to be served or if they may have other inquiries.
            - Visitors and family members when they have any inquiries.
        - People may wait in the waiting areas (in front of the main counter and the pharmacy).
        - They also wait inside the department and in the corridors.
2. Other behaviours of users:
    - Patients are usually combined with one to three people and sometimes more.

- Family members and visitors walk freely in the department with no restrictions and can almost enter any room except for the female areas.
- Family members and visitors interact with staff in the corridors.
- Family members and visitors sometimes stop staff walking in the corridors to seek medical advice or ask about their patients.
- After 06:00 PM to about midnight, the department becomes very busy and crowded.
- Frequent revisits to the reception and admission counter by patients, family members and visitors for various inquiries.
- People sometimes argue with the accountant due to financial issues, causing a delay for other patients.
- People use the department access points and public areas as a passthrough between the back street of the building (out-patients, main hospital building etc.) and the main street.

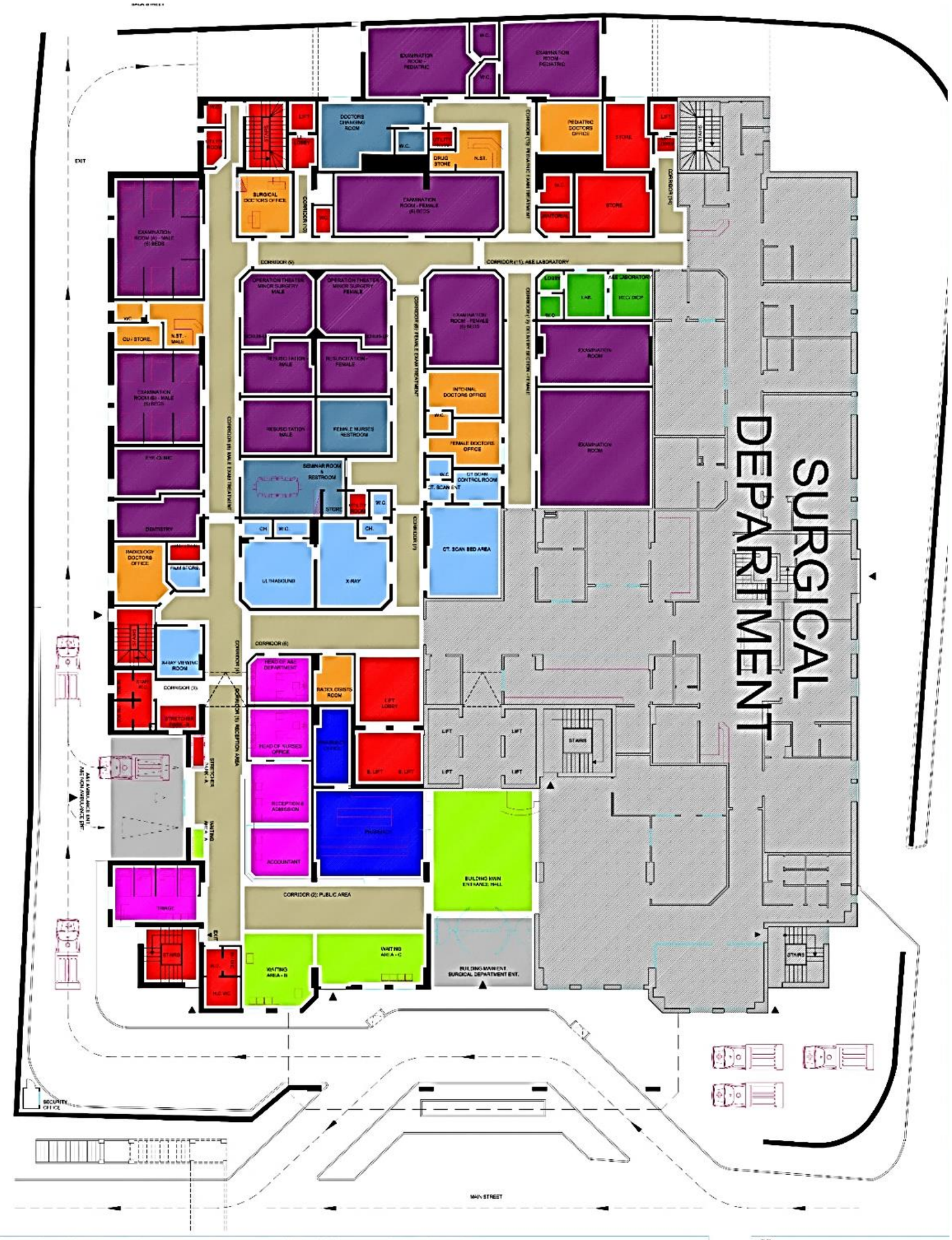


Figure 25: Zoning plan for the ED in the IH – Post-occupancy

Figure 26: Observational notes for the ED in the IH – Post-occupancy.

6.4 In summary

The following points can be elicited from the conducted field observation in the ED in both KAUH and the IH. The collected data focused on evaluating the influence of the spatial structure on EDs usages and how different people are using the department.

A. Accessibility

In KAUH, the department has one shared street entrance for ambulance and non-ambulance patients. This entrance leads to a transition space, then to the entrance hall. The entrance hall leads to the right-wing section entrance (has EDs services and inpatients admission), the radiology, and the left-wing section (has all ED exam cubicles). Thus, it was observed that this confuses users coming to the ED from the street entrance, where it requires them many terns to reach the ED. The ED entrance cannot be seen from the outside due to the turns which block visual connectivity. Besides, it was recorded that different groups of people share the street entrance (ambulance entrance/walk-in entrance) and the entrance hall. For example, ED (in the left-wing), ED services (in the right-wing), the inpatient (in the right-wing), the radiology entrance, and a lift in the entrance hall that leads to the upper floors, all are sharing the same entrance area. As a result, it is crowded most of the time, by all these groups of people.

On the other hand, in the IH, the department has one shared entrance for ambulance and non-ambulance patients, located on the left side of the building. However, it was observed that non-ED users also use this entrance. For example, since the ED is in a separate building located between the main hospital building and the main street, some people use the ED as a walk through between the two. Also, since the ED shares the building with the operation department, some people come through the ED entrance to reach the operational department. Besides, some people come to the ED to use the toilets and the pharmacy in the public area. Therefore, these behaviours are causing crowdedness and confusion, while a good number of users are only passing through. Another point to add is that the ED inner entrance location is further in the department and far from the ambulance entrance, which might be useful in terms of privacy and hierarchy. However, it is still a long distance to walk to reach the exam and treatment areas, including resuscitation and minor operation rooms.

B. ED's logistic services

In KAUH, the ED area is divided between two sections: first, the left-wing section, which is the ED and has all the examination cubicles, including triage; and second, the right-wing section, which has ED's services (registration, accountant, pharmacy, staff offices, and waiting area). Thus, the locations of the services are far away and not connected to the ED. However, ED users move between the two sections multiple times to fulfil the formal department requirements. For example, ED users come or are directed to triage first for initial assessment; then they are asked to finish the registration requirements, then they are asked to handle their file in the admission counter in the left-wing; finally,

they are usually directed to the waiting area in the right-wing to wait for their turn. After they are admitted, they might be required to visit the registration and accountant for additional medical requirements, such as blood test, radiology image, or medicine. They have to pass the entrance hall shared between many different groups of people every time. Thus, overcrowding occurs, processing times increase, waiting time increases, and less user satisfaction is recorded.

On the other hand, the IH ED might be having the same situation. Since the department is relatively big, ED's services are in front of the ambulance entrance, including triage, next to the entrance. Moreover, as stated before, the ambulance entrance is far from the ED inner entrance and the exam cubicles. However, ED's users have to visit the registration and accountant multiple times to fulfil the formal department requirements. For example, EDs users come first to the registration, then the accountant to pay a deposit; then they will be asked to go to the triage assessment room. They are then usually directed to the waiting area to wait for their turn. After they are admitted, they might be required to visit the registration and accountant for additional medical requirements, such as blood test, radiology image, or medicine. Thus, crowding occurs, processes time increases, waiting time increases, and less satisfaction can be recorded among users.

C. ED's waiting areas and triage

In KAUH, the main waiting area is in the right-wing section in front of registration, accountant, and pharmacy which, as mentioned, is far and not connected to the ED. At the same time, triage and exam cubicles are in the left-wing section, in front of the admission counter. Thus, it was observed that users do not tend to wait in the waiting area. They mainly gather by the ED entrance, near the admission and triage counter, and in the ED main corridor. Also, they gather in the entrance hall, near the ED entrance, and outside by the ambulance entrance. As a result, it was recorded that staff sometimes start looking for the patients and calling their names in the ED, near the ED entrance, in the entrance hall, and the main waiting area. Add to this the long walking distances that staff, patients, and visitors have to take to move between the waiting area and the exam cubicles. Such behaviours hinder the department workflow, reduce efficiency, and increase crowding in the department and out. This might be owing to the waiting area being far with a lack of connectivity and adequate services.

On the other hand, the IH ED might also have the same situation. The main waiting area is in the far-right end of the building, opposite pharmacy, and accountant, far and not connected to the ED. Triage, reception and accountant are located near the ambulance entrance. At the same time, all exam cubicles are after the inner gate of the department. Thus, it was also observed that users do not tend to wait in the waiting area. They mainly gather near the ambulance entrance, by the registration counter, further in the department near the radiology rooms, near the ED inner gate, and in the ED main corridors. As a result, as in KAUH, it was recorded that staff sometimes start looking for the patients and calling their names in the ED. Add to this the long walking distances that staff, patients

and visitors have to take to move between the waiting area and the exam cubicles. Such behaviours hinder the department workflow, reduce efficiency, and increase crowding in the department and out. This might be owing to the waiting area being far with a lack of connectivity and adequate services.

6.5 Conclusion

It was observed in the selected EDs that the arrangement of the functions and their spatial relationships is hindering the department workflow. To emphasis, spaces that are functionally connected following the clinical and formal requirements of the various patients' treatment journeys have poor adjacencies and complex spatial relationships that are hindering the workflow. For example, it requires more walking for all user moving between the functions to attain the formal requirements of the internal procedures, which in turn are causing a delay in the processes times and are physically tiring. They are causing other problems too, such as confusion among patients and visitors following the flow of their treatment journey, increase in the procedures and waiting times, overcrowding in certain areas, long waiting time for patients waiting to be seen, and a reduction in satisfaction among all users especially patients and staff.

Also, the arrangement of the functions and their spatial relationships are causing non-staff users not to use certain functions and behave in ways that may better suit their needs. For instance, patients and visitors do not tend to stay in the waiting areas because they are far from and not connected to the ED. Therefore, they come closer to the ED's inner gates and the examination areas when possible. Also, non-staff users' behaviours are causing an extra burden on the ED. For example, users' lack of awareness regarding emergency medicine, where people may come to the ED for reasons that are not urgent. Also, the number of people coming with the patient, which may reach ten people or more. Besides, due to not having access restrictions on the entrances in both cases and these areas being connected to other non-ED functions, non-ED users pass by these areas to reach other areas in the hospital. Therefore, such behaviours are causing more load on the ED that could have been avoided.

6.6 Chapter Summary

The chapter presents the analysis and findings derived from the field observation carried in both KAUH and the IH EDs to understand the influence of the spatial structure on EDs operation and how they are used. The next chapter will present a contrasting account from the interviews conducted with staff in KAUH and the IH EDs to further understand the influence of the spatial structure on EDs operation and investigate the observed usages.

Chapter 7: Staff Interview Analysis

7.1 Introduction

This chapter presents the interviews conducted with staff in both KAUH and the IH EDs to fulfil objective four, evaluating the influence of the spatial structure on EDs operation. Also, to understand why EDs are being used the way users use them. It builds on the results from the observational studies described in the previous chapter and presents findings from the interviews with healthcare staff and the resulting themes. The chapter also describes the coding process, data reduction, and data display elements of the interview analysis.

7.2 Interviewees' profiles

The interviews were structured to extract information from staff working in the selected EDs for this research. These interviews recorded details and initial information about the participants, previous experience, knowledge about the medical process in Emergency Departments, and their opinion about the design concerning main design criteria, as such, spatial structure, circulation, movement, accessibility, density/overcrowding, privacy, hierarchy, and security.

This research was conducted in line with the guidance issued by Cardiff University and gained full Ethical Approval. All interviews required written consent, all were confidential, and all data were anonymised. Details of the interviewees who took part in this investigation are discussed below.

7.2.1 Medical Staff

Ten medical staff were interviewed, whom they met the selection criteria and agreed to take part in this investigation. In-depth semi-structural interview type was adopted. Each interview lasted approximately an hour to an hour and a half. The participants were two emergency doctors with one of them to be an ER specialist, three emergency nurses with two of them to be the head nurse in their department, one staff nurse, and one porter with no academic degree. More details about the selection criteria are mentioned in Chapter Three, Research Design and Methodology.

The background of the participants is listed in Table 23. All interviewees had a minimum of five years of post-qualification experience, with a university degree.

Table 23: Medical Staff Participants Profiles

Participants	Hospital	Gender	Category	Experience (years)
Doctor AB	King Abdullah University Hospital	Male	ER Doctor - ER Specialist	5 – 10
Nurse IM		Female	Head Nurse	15 - 20
Porter FA		Male	Porter	5 – 10
Doctor MU	The Islamic Hospital	Male	ER Doctor - ER Specialist	5 – 10
Nurse MO		Male	Head Nurse	>20
Nurse JU		Male	Staff Nurse – porter	10 – 15
Engineer MA		Male	Head of Maintenance	15 - 20

7.3 Data Analysis

As discussed in the methodology chapter, all interviews were conducted in the Arabic language, and then were professionally transcribed and translated into English before being coded. NVivo 12 qualitative analysis software was used for analysing the interviews' transcribed data. Miles and Huberman (1994) proposed three strategies for qualitative analysis, which were adopted for this study (i.e., data reduction, data display, and conclusion or verification). Conclusions are discussed and presented in Chapter Eight: Discussion and Comparison.

7.3.1 Data Reduction

A careful data reduction process was conducted. Interviews generally come with some irrelevant stories common with qualitative studies (Miles and Huberman 1994). The analysis begin with data reduction, where relevant data is extracted, sorted, and organised as a large segment into relevant codes (Miles and Huberman 1994). Based on the research objectives and the related literature, the interview transcripts data were coded at free nodes (initial level of coding). They were reduced to tree nodes, after that to themes, and finally, they were placed under particular overarching themes that represent the nodes. These nodes were revised as more data were coded, and a clearer picture of the dataset begin to unfold.

A combination of deductive and inductive approach was adopted for analysing the interview data. This approach benefits from using two coding techniques; first, selective coding is the selection of data related to the phenomena (Braun and Clarke 2013). This allows most related information to be coded and linked to answering the research questions. Second, complete coding aims to identify anything of interest or relevant to the research questions (Saunders et al. 2019). Using this method permitted extra data to be coded even if it did not directly address the research question but was still valuable information.

Data were coded based on the related literature and the research objectives to answer the research questions. Besides, the research captured any relevant information that might be useful in addressing the research problem. Following this approach allowed different areas to be identified for potential coding.

7.3.2 Data Display

Data display is an organised and compressed representation of information, allowing useful conclusions to be drawn (Miles and Huberman 1994). Data display contributes to the validity of the data analysis process. The studied data from the interviews with ED staff in both cases revealed many vital aspects related to the influence of the spatial structure on EDs usages and operation. These data capture the various points of view of the interviewed participants.

7.3.3 Themes Development and Extracted Data (KAUH)

Two overarching themes emerged after an extensive coding process; first ED Design Influence; and second; ED Operational Influence. Other themes and sub-themes arose after further coding of the interview data. For more details see Figure 27, Table 24

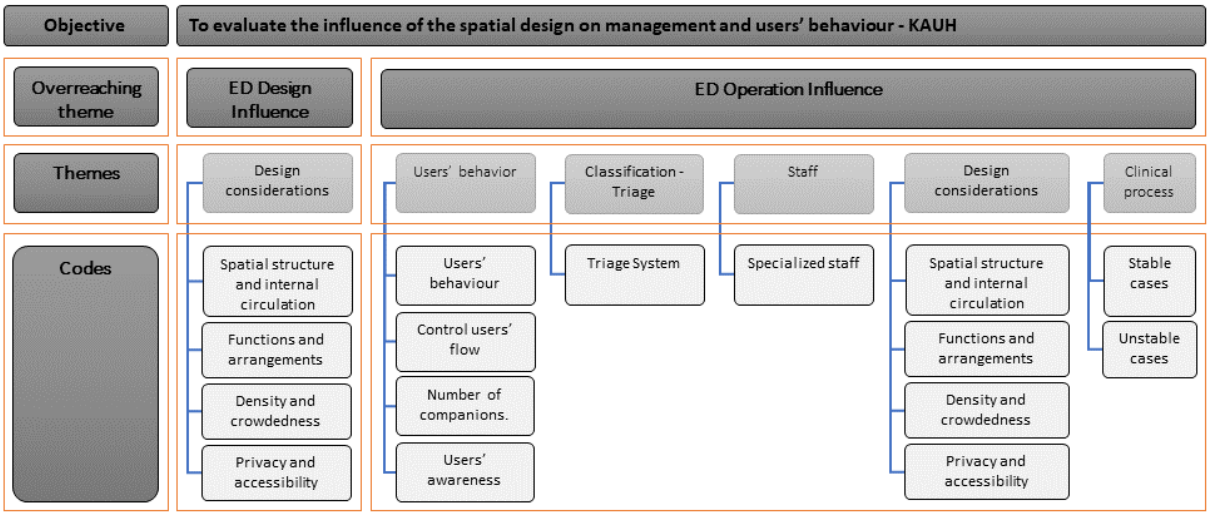


Figure 27: The emergent data from the Staff interview analysis (KAUH ED).

Table 24: The emergent data from the Staff interview analysis (KAUH ED).

Overarching themes	Themes	Codes and Subcodes	Description
ED Design Influence	Design considerations	A. Spatial structure and internal circulation. B. Functions and arrangements. C. Density and overcrowding. D. Privacy and accessibility.	It illustrates staff opinion regarding key design elements and considerations for EDs.
ED Operation Influence	Users' Behaviour	A. Waiting behaviour. B. Control users' flow. C. The number of companions. A. Users' awareness.	It illustrates staff opinion regarding how users behave in the ED where such behaviour may cause problems that impact overcrowding and waiting time.
	Classification	A. Triage system	It illustrates staff thoughts regarding patients' classifications in the ED.
	Staff	A. Specialised staff	It illustrates staff opinion regarding staff responsibility and their impact on the workflow's efficiency in the ED.
	Design considerations	A. Spatial structure and internal circulation. B. Functions and arrangements. C. Density and overcrowding. D. Privacy and accessibility.	It illustrates staff opinion regarding staff and management took procedures to overcome the difficulties in the previously mentioned design considerations

	Clinical process	A. Stable cases B. Unstable cases	

7.3.3.1 ED Design Influence

ED Design Influence is the first overarching theme that emerged to evaluate the influence of the spatial design on management and users' behaviour. It focuses on exploring the design from the staff point of view. It also focused on the design requirements and main design criteria that affect how the department is being used. One major theme emerged: design considerations.

I. Design Considerations

These considerations are categorised under four codes: spatial structure and internal circulation, functions and arrangements, density and overcrowding, privacy, and accessibility.

A. Spatial structure and internal circulation

This code illustrates participants point of view for a better spatial structure. This code is divided into subcodes as will be mentioned below.

1. Spatial development

The spatial structure in KAUH ED has dramatically changed since the first occupation. The main reason for this development was the small numbers of patients when the ED operated for the first time. Therefore, only one part of the original design is used as the ED.

"The emergency department's original design used to be divided into two sections. The right-wing is the medical section, and the lift wing is the trauma section, and both parts together are the emergency department. However, and because it was a huge department in comparison to the number of patients, the hospital's management has decided to use only the left-wing section as the whole emergency department." (Head Nurse IM)

2. Spatial satisfaction

The interviewed participants expressed their dissatisfaction with the current spatial structure. They all believe that it is not being used the way it was designed.

"The spatial structure we have is not good enough. It could be better." (Doctor AB)

"Since we are not using the original design and we are using only a part of it as a whole, therefore, it is not correctly working because it is not the right situation." (Head Nurse IM)

However, one of the participants mentioned that having the current spatial design is an advantage in term of having a compact department where everything is close. Also, walking distances are not long.

"The advantage is that we have a small and nearly compact department, so everything is within reach. Especially having the X-Ray in the department next to ours. Therefore, we do not walk a lot." (Head Nurse IM).

Although the current design is good in terms of having most of the needed functions near, it is bad in terms of size. The ED being tight for space is causing issues with the internal circulation.

"A problem we have is that the department is a bit tight, which is a problem regarding the internal movement routes." (Head Nurse IM).

Also, the current situation has caused some difficulties in term of the EDs functions and their distribution.

"I believe the reason we have all these problems because this current situation is not the original design, and this is not the original intentions of the designer, and we are using it in an entirely different way. Maybe, therefore, it is not working correctly with us." (Head Nurse IM).

For example, the current spatial arrangement is not convenient for formal internal procedures. Patients have to move multiple times between the ED and the registration and accountant office. Therefore, the current functional arrangement is making movement difficult because people have to walk long distances.

"In the hospital policy, when the patient needs any examination or scans, or whatever might be needed, it has to be entered in the system, and the patients need to go to pay for it … therefore, the patient or companion will have to go to the accounting more than five times which can make confusion in the emergency department and to the accountant or the patient." (Doctor AB)

3. Central Design

All the interviewed participants mentioned that having a central spatial design where all the need functions are close to each other is ideal in EDs. For example:

"I believe that since it is an emergency department, all the treatment cubicles should be open to the staff counter. For example, it can be seen in the plans that the paediatric and the surgical are closed rooms. The Internal medicine room is far from them, so there is no visual connection between them." (Head Nurse IM).

Triage should be near the entrance and be easily seen. Also, ED functions that users require such as the registration, the accountant, and the pharmacy should be around the triage area.

"There should be a triage area in the middle space, and all that triage need to be around, such as E.R pharmacy, E.R accounting, E.R entrance and the waiting lounge. Such an arrangement is how I see it should be to work better." (Doctor AB)

Having a central spatial design will improve visual connectivity which will enhance the patient's observation.

"It is better to have visual connectivity with the main staff counter even the resuscitation room. For example, the internal treatment area has a dedicated staff station, and it overlooks all of the beds." (Head Nurse IM).

"Sometimes, especially in EDs, patients may have some complication while they are in the department; therefore, it is better to have an open plan area." (Head Nurse IM).

The Head Nurse IM explained that it would be challenging to observe patients effectively when it is not an open plan design, requiring more staff members.

"This might be difficult to have a nurse counter in each medical room, because, then we need to increase the number of staff and full equipment, so it is better to be opened to the counter as much as I know." (Head Nurse IM).

"Usually, we have three nurses working with ten patients. Therefore, it is difficult to have control over all of them unless they all can be seen." (Head Nurse IM).

As a result, staff prefer examination rooms where they have all the patients around, such as in the internal exam room (it has a central staff counter that is overlocking all bed areas)

"The internal medicine works fine because it is an open space. However, the surgery section is not good because it is a closed room." (Head Nurse IM).

4. Accessibility

The interviewed participants mentioned that patients sometimes get lost and cannot easily find their way due to the current spatial structure and lack of signs.

"We get many questions in the surgical ED such as, where I can find the entrance. Where can I find the accounting? Where I can find the pharmacy and so on, even the pharmacy is in the other sector." (Doctor AB)

Furthermore, the department entrance cannot be seen from outside. It is also hard to reach due to the many turns that need to be taken to get to the department.

"Even cars and ambulances cannot be seen from the inside because triage is hidden from the main entrance." (Doctor AB)

B. Functions and arrangements

This code illustrates participants point of view regarding the spatial arrangement of the different functions in KAUH ED. For example:

1. Triage: participant mentioned that triage needs to be the closest function to the entrance of the department.

   "The triage comes first, and then the resuscitation room and the Internal medicine room comes after that." (Doctor AB).

   However, in the current design, triage location is far away and hidden from the entrance. Also, for users to reach the triage counter, they need to take multiple turns.

   "The triage area cannot even be seen from the main entrance area because the triage is hidden from the main entrance." (Head Nurse IM).

2. Registration, accountant, and ED pharmacy: Patients have to come to the registration and accountant counter multiple times, starting from before admission. However, they are in the right-wing section, which is far from the ED.

   "They are far. For example, in the hospital policy, when the patient needs any examination or scans, or whatever might be needed, it must be entered in the system. Then, patients need to go to pay for it; therefore, the patient or companion will have to go to the accounting more than five times which can make confusion." (Doctor AB).

3. Laboratory: not having a dedicated laboratory for the ED is causing difficulties for staff. Because all samples have to be taken physically to the central laboratory in the main hospital building, not to mention, the hospital laboratory is far from the ED, where it serves the whole hospital with no priority to ED samples.

   "We do not (have a laboratory for the ED), and it is a bit far in the main building of the hospitals." (Head Nurse IM).

   "It is a long-distance to walk, and it takes time to go to the laboratory." (Porter FD).

   There is a need to have a separate laboratory for the ED only, which will help reduce patients staying time.

   "In my opinion, if they need to help us in solving this problem, it is to create a separate lab for the Emergency Department." (Doctor AB).

"If all the functions we need are in the department, it will be much easier for us to work and move around. For example, if the laboratory is in the department, it would have been much better." (Porter FD).

4. Staff private areas: ED staff may have more work pressure than other hospital workers; therefore, it is essential to have a restroom for them.

"We cannot go outside; we have to stay placed in the department. Although we may have restrooms and cafeterias in other sections of the hospital, we as emergency department staff cannot leave the department." (Head Nurse IM).

Staff are not satisfied with the current rest area in the ED. It is an emergency exit that was converted to be a rest area for staff.

"There are no resting-rooms; you can find what looks like that. Nevertheless, it is just two bathrooms, a small kitchen and a sofa." (Doctor AB).

"There is no formal restroom for the staff in the department whatsoever, which is very inconvenience most of the time. Therefore, we have created a restroom for the medical staff at one of the emergencies exits by adding a small table and a sofa. However, it is not the restroom, and it is tiny." (Head Nurse IM).

Also, it has privacy issues because everyone can enter.

"This room supposed to be for the Emergency Department, nurses and the doctors. However, even the security can enter it, or the made and from other portals, anyone can have access to this space." (Doctor AB).

"There is no private bathroom for staff which is essential to have in emergency departments." (Head Nurse IM).

Doctors and nurses have problems with their current changing rooms in the ED. For example, doctors' changing rooms are located on the seventh floor in the main hospital building. Also, female nurses' changing room is in the middle of the department with no toilets, showers, or a private entrance.

"The E.R nurses have changing rooms for both genders. However, for us, we as doctors have to go up to the seventh floor where are our changing rooms and sleeping rooms." (Doctor AB).

"Female nurses changing room should be divided into sections from the inside, and it should have a bathroom and a shower. Because having a private bathroom and a shower is essential

in emergency departments because of the different patients' cases we handle." (Head Nurse IM).

5. Waiting areas: waiting areas are a significant problem in the department. The department has about three areas for users to wait:
   a. The entrance hall in the right-wing section has been recently adopted to be a waiting area by putting some chairs and a screen.

"Renew the emergency department and the lounge; there were no chairs in the waiting area. The management has put chairs and a new screen." (Porter FD).

However, this waiting area is considered outside the department, and far from the examination areas, therefore, it is not usefully in use.

"The waiting lounge should be on the same side too, so it would be easy for the patient to enter alone without company or only one." (Doctor AB)

"It is the one on the right-wing as it can be seen on the plan, but people do not often use it. It could be a bit far." (Head Nurse IM).

"We do have a waiting area in the right-wing, and it has seats, TV and everything they may need, but no one is using it." (Head Nurse IM).

   b. Two small areas at the beginning of the two corridors in the left-wing section have become waiting areas by adding some chairs for people waiting in the department.

"There is no waiting area! Therefore, we had to use the corridors as waiting areas, but it is not helping as it is causing overcrowding." (Head Nurse IM).

These two waiting areas are causing overcrowding and hinder movement.
"There are some rest chairs in the corridor on both sides, which could make it worse." (Doctor AB)

"We are currently using the corridors as waiting areas, so it gets very crowded, and this hinders our movement and work." (Head Nurse IM).

6. The Eye and Ear clinics: These two clinics are placed in the middle of the ED, causing overcrowding. Also, they hinder the overall movement in the department because of the patients waiting for these clinics. All participant believes that they should be moved out of the ED.

"The waiting area in the first corridor is always full of patients of the eye's and ear's clinics in the Emergency Department. Patients come here usually because appointments with the

official eye and ear clinics in the hospital may be very far away and hard to catch an appointment in a short time." (Doctor AB)

"Therefore, when people see the overcrowding in front of these clinics (the "ear and the eye clinics) they think that the whole emergency department is crowded especially The Internal and the surgical emergency medicine rooms while it is not." (Porter FD).

7. Radiology: having the radiology department near the ED department is an advantage which helps save time.

   "The radiology department is next to us, where all our corridors lead to the x-ray department." (Head Nurse IM).

8. Internal and surgical cubicles: both rooms are separated from each other. The surgical room is located near the department's entrance in front of the pediatric room, while the internal medicine room is located at the end. However, Doctor AB said that they should have been but together because sometimes patients may need both:

   "The surgery and the internal exam used to be together. Now, the internal has been moved to it the current location." (Head Nurse IM).

   "The surgical medicine room should be as important as the Internal medicine room or a bit less; it needs to be near the Internal medicine room and not far from each other." (Doctor AB)

   The current spatial arrangement of the ED department is made to serve the needs of each function. For example, having an internal medicine room at the end of the department is because it needs a bigger space.

   "In the current situation, we have the surgical medicine room closer to the entrance than the internal medicine room because of the available space. Because of the internal exam room needs more space." (Doctor AB).

   The internal medicine room is the most used in the department, comes before that the surgical room. Therefore, it should be located near the entrance.

   "The internal medicine room is the most used one, and it should be equipped the most with enough monitors and similar equipment. The surgical room has high turnover, but the patient does not spend much time there and does not need heavy monitoring like patients in Internal medicine." (Doctor AB)

   "The triage comes first, and then the resuscitation room and the Internal medicine room comes after that." (Doctor AB)

9. Resuscitation: it is essential because of its purpose of saving lives rather than its workload. Therefore, it needs to be the closest to the entrance.

   "The resuscitation room is essential, not because we use it a lot, but it is the most important section /room when it is needed to save lives." (Doctor AB)

   "The nearest room should be near the entrance is the resuscitation room." (Doctor AB)

10. Short stay: patients sometimes need to stay in the department for a short time to be observed. However, patients will keep occupying beds in the examination room for observation if there is no short stay room.

    "We need a full-prepared room with equipment and staff for the Emergency Department, this is for the admitted cases, but there are no beds for them or patients under monitoring from 12 to 24 hours, we can call it E.R admission for such general treatments." (Doctor AB)

    "Because we have cases that need to be monitored only and for 24 hours (Short Stay Rooms), therefore, such patients do not need to occupy one of the hospitals' beds because someone else may need it." (Doctor AB)

C. Density and Overcrowding

The collected data are categorised under two sub-codes: Current situation and main reasons. Further explanation is provided below:

1. Current situation: The department gets busy in the mornings between 11 am to about 4 pm. Also, in the evenings between 7 pm to about 2 am, which is the most.

   "The department gets crowded almost daily in the morning shift between 11, and 12 am until 4 pm. Also, in the night shift, from 7 pm to 12 am, or 2 am, the department can be very crowded these times." (Doctor AB)

   Dr AB and Porter FA said that the most crowded room is the Internal medicine room.

   "The Internal medicine room for sure is where usually overcrowding happens." (Doctor AB)

   Head Nurse IM and porter FA also explained that overcrowding could be almost everywhere in the department, but mainly in the corridors.

   "All the department, especially the corridors, you can see it from the entrance to the internal section, lots of people, mainly after 10:00 am." (Head Nurse IM).

   "The main corridor from the entrance next to the triage up to the overnight section and the corridors leading to the X-Ray department becomes very crowded starting from 10:00 am." (Head Nurse IM).

"people stand in the corridors mainly to wait. Thus, you face difficulty if you want to drag a bed or even move sometimes." (Porter FA).

2. Main reasons: The interviewed participants elaborated on possible causes for overcrowding:
   a. The spatial distribution of the department's functions: Dr AB said that overcrowding happens for many reasons, such as the location of the laboratory, the registration, the accountant, and the whole arrangement of the functions.

"Other reasons for overcrowding besides the social culture, the lab availability, and procedures intransigence is the lab location and the utility distribution. The spatial arrangement or different functions is causing overcrowding." (Doctor AB)

   b. Cultural understanding and people awareness: People may come to the ED for any reason they think might be critical.

"Reason for overcrowding: First, the society and culture issues, they come to the emergency department for any reason (some time ridiculous reasons)." (Doctor AB)

   c. A big challenge is the number of people coming with each patient as sometimes it may reach 5 to 10 people.

"Sometimes, you find more than ten people came with one patient, which can make unnecessary noise. This could affect the patient and the other patients and make it hard for doctors and nurses to do their jobs." (Doctor AB)

"Sometimes, the number of people exceeded the maximum ability of the room. Thus, we call hospital security, and we try to calm down people and show them the way out to leave the department." (Head Nurse IM).

"People who are standing are more than those who are sitting. Because the patients come with him 4 or 5 people, you may find more than five people with each patient that may reach 20 people." (Porter FA).

   d. The waiting areas in the corridors in the left-wing section led to the radiology department, causing overcrowding and hindering users' movement. Also, people are using these waiting areas freely with no restrictions.

"There are some rest chairs in the corridor on both sides, which could make it worse." (Doctor AB)

"There is no waiting area! Therefore, we had to use the corridors as waiting areas, but it is not helping as it is causing overcrowding." (Head Nurse IM).

"For example, at the Internal emergency medicine room, the patients sit in the corridor leading to the x-ray department where you can find a small waiting area." (Porter FA).

e. The Eye and Ear clinics: these two clinics replaced doctors' offices; therefore, they did not use to be part of the design. They are in the middle of the department and almost do not follow the emergency system. To emphasis, they are like out-patients' clinics in the ED department which is causing functional confusion.

"The waiting area in the first corridor is always full of patients of the eye's and ear's clinics in the Emergency Department. Patients come here usually because appointments with the official eye and ear clinics in the hospital may be very far away and hard to catch an appointment in a short time." (Doctor AB)

"We have here in the department the eye and the ear clinics. therefore, it gets very crowded in this area (the area in front of the eye and the ear clinics)." (Porter FA).

f. ED laboratory: not having an ED laboratory or at least a closed one is causing a delay in the process, which causes overcrowding. Because time is wasted in the transformation process, the ED samples might need priority over other departments' samples.

"The nurse takes the blood sample from the patient and give it to the porter to deliver it to the lab that serves the whole hospital. The labs will deliver the results late because they do not usually run the blood test for the ED, and they treat it like a sample from any other department in the hospital, which is wrong. So, the tests will take roughly an hour and a half, and this is a major cause for overcrowding." (Doctor AB)

"The doctors have their required samples, and the reason for the overcrowding is the delay in the results. I do not know if this delay is because of the laboratory workers or the devices they are using." (Porter FA).

g. The intransigence in the internal procedures: patients have to follow formal internal procedures before and during the examination process. Thus, such formal procedures cause difficulties, overcrowding, and increase the waiting time.

"The procedures complexity. For example, when it is a blood test, we take a blood sample and enter it in the system, and the companion registers it and get a receipt for it. Then, the nurse takes the sample from the patient and give it to the porter to deliver it to the lab that serves the whole hospital." (Doctor AB)

h. Patients admitted in the hospital usually keep on occupying a bed in the ED until a bed in the hospital becomes available.

> "The hospital's beds are always full. Therefore, I have five or six patients, have finished their examinations, and are admitted to the hospital. However, there are no available beds for them, so they stay here in the emergency department waiting for a bed to become available." (Doctor AB)

i. Finally, because people can move freely in the department with no restrictions.

D. Privacy and accessibility

Head nurse IM said that staff lacks privacy in the ED Due to lacking the essential functions like private toilet, rest area, and private workspaces in the department.

> "Currently, the staff do not have privacy; they do not have private bathrooms; they do not have a restroom. I am talking here about the whole staff, including doctors, nurses, and anyone who works in the department." (Head Nurse IM)

Also, he adds that patients' privacy is not ideal; for example, curtains are used to separate patients' beds. And for acoustic privacy, staff only try to lower their voices.

> "Acoustic privacy to hear sensitive information is crucial for us. we only try to lower our voices." (Head Nurse IM)

Dr AB mentioned that having the patients' companions in the exam room compromises all users' privacy mainly when the companions are more than the acceptable number.

> Privacy is the main problem here; it is a disaster. When there are more than ten companions with the same patient, of course, this will leave the bed curtains open and bother the other patients next in bed in both side and will kill their privacy." (Doctor AB)

Besides, users can have access to almost everywhere in the department, which is a significant challenge in all aspects.

> "Patients can go wherever they want and have access to any room, including the staff's private areas." (Doctor AB)

Finally, having the waiting areas in the middle of the department is compromising all users' privacy.

7.3.3.2 *ED Operation Influence*

ED operation Influence is the second overarching theme that emerged to evaluate the influence of the spatial design on management and users' behaviour. It focuses on exploring ED operation from the staff point of view. It also focused on the way the department is being used. Four major themes emerged: users' behaviour, classification, staff, and design considerations.

I. Users' behaviour

This theme reveals data regarding users' behaviours that may hinder the operation of the department. The collected data are categorised under four codes, as discussed below:

A. Waiting behaviour: people do not like to wait, and they usually gather in the corridors and the exam rooms. This behaviour might be owing to the lack of control in the department by the management.

> "If we did not check the patient within 5 to 10 minutes, he would start complaining and make troubles." (Doctor AB)
>
> "The main problem we have is having people in the corridors. they should not be here in the first place, but this is difficult to control." (Head Nurse IM)
>
> "When the department is crowded, people keep waiting in the corridors which increase overcrowding, and they keep wandering in and out the departments. even if they went out of the department, they go for a short time, and then they come back." (Head Nurse IM)
>
> "People sometimes do not follow orders and department regulations." (Head Nurse IM)

Besides, the current arrangement of the waiting areas in the department is inconvenient. For example, the main waiting area is far from the department, and having the two waiting areas in the corridors in the middle of the department is inconvenient.

> "For example, at the Internal emergency medicine room, the patients sit in the corridor leading to the x-ray department where you can find a small waiting area. There are chairs in it, but the people who are standing are more than those who are sitting." (Porter FA)

B. Control users' flow: users can move freely in the department with almost no constraints. Therefore, they wait in the corridors and inside the doctors' offices.

> "Patients' companions can go everywhere in the emergency department without permission... with no limitation or control. They even enter the resuscitation room." (Doctor AB)
>
> "They can have access to anywhere in the department; it is like an open department, unfortunately." (Head Nurse IM)

C. The number of companions: many people usually accompany the patient, which is a problem because they will be with the patient in the treatment area, in the corridors, and sometimes they interfere with the staff work. However, this problem is due to a lack of control.

"Sometimes, you find more than ten people came with one patient, which can make unnecessary noise. This could affect the patient and the other patients and make it hard for doctors and nurses to do their jobs." (Doctor AB)

"The department gets crowded mainly because of the companions with the patients. The patients are laying down on his bed, doing nothing." (Head Nurse IM)

"You may find more than five people with each patient that may reach 20 people." (Porter FA)

D. Users' awareness: increase users' awareness in term of the emergency department services and the way it works. Also, regarding the number of people that should come with the patient. Increasing users' awareness will impact of the reduction of overcrowding and improve the overall functions of the department.

"People should know it is wrong for a group to come with the patient." (Doctor AB)

Reason for overcrowding: First, society and culture issues. People come to the emergency department for any reason (some time ridicules reasons). The second is that most patients' companions can reach 10 to 15 persons." (Doctor AB)

Increase patients' awareness and having sufficient control over the department will reduce overcrowding.

"To improve the design of the ED regarding density and overcrowding, the department needs More control and education for patients and visitors." (Head Nurse IM)

II. Classification

This theme reveals data from the interviewed staff regarding patients' classifications.

A. Triage system: the adapted triage system in KAUH is the Canadian system

"We do have triage policy, and we follow the Canadian triage system and depending on the triage system and the patients' symptoms, we divide patients." (Head Nurse IM)

However, the triage system is not fully competent in the department.

"The priority system is not applicable here. The priority here depends on the chief complaint and the patient vital signs, but this is not activated here. All the patients come through the reception, and then they enter the department freely looking for a doctor, and the doctor decides if it is a chief complaint." (Doctor AB)

Also, the prioritising in the triage system is not effective.

"This system (Prioritizing) is not available here because if we did not check the patient within 5 to 10 minutes, he would start complaining and make troubles." (Doctor AB)

III. Staff

This theme reveals data regarding staff responsibility and their impact on the efficiency of the workflow in the ED:

A. Specialised staff: having an emergency specialist is better for EDs because they will be more experienced and cover all ED cases. Because sometimes patients may be delayed finding the right specialist from the hospital.

"The doctor here, an E.R or general surgery doctor and do not have the authority to dispose of the patients if the patient needed a consult without referring back to the shift specialist or the resident doctor here in the Internal or the surgical medicine rooms." (Doctor AB)

"To admit a patient in the hospital; the patient needs to be evaluated by a specialist. Moreover, the specialists have to come from their department, which consumes lots of time." (Doctor AB)

"There must be a senior doctor all the time in the Internal emergency medicine rooms. Furthermore, there must be a surgent in the surgical emergency medicine rooms and a specialist pediatric in the pediatric emergency medicine room." (Porter FA)

Having medical students who are not yet experienced in ED practices sometimes causes delays.

"They are in their training year. So, they are still fresh in their experience and not skilled enough to act fast and efficiently. They call another profession doctor due to their inexperience, and this may delay the work somehow." (Porter FA)

IV. Design Consideration

This theme reveals data regarding staff and management taken procedures to overcome difficulties in the design mentioned in the overarching theme "DE Design Influence" under the code "Design Consideration." The collected data are categorised under four codes:

A. Spatial structure and internal circulation

From the theme "ED design influence", all participants stated that they are having difficulties with the current spatial structure in KAUH ED due to the initial design being developed and expanded without proper planning. To explain, the spatial structure has changed gradually by using part of the department at a time and expand when needed.

"I have been working in this hospital since it was first open and when it was opened, we only used three rooms, only the resuscitation, the paediatric and the surgical. Moreover, we used

to use them for everything and all the cases and illness because they were more than enough for our patients. Also, we used to have all the current section we have now in these three rooms only, and it was very chaotic. Then we started to expand as the number of patients were increasing to the inner part of the left-wing until we finally reach the current situation that we have now." (Head Nurse IM).

"It was a gradual expansion which we expanded every time we felt the number of patients has increased." (Head Nurse IM).

Therefore, it was not an efficient spatial adaptation which caused more problems as mentioned in the ED Design theme.

B. Functions and arrangements

From the theme "ED design influence", the interviewed participants mentioned some of the problems they have regarding the different functions in the ED. Thus, the management worked toward some solutions to overcome these difficulties.

1. The department was designed to have a dedicated laboratory for the ED only. However, it was closed because the number of users was low, and it did not need one at that time. Therefore, the department was using the laboratory in the main hospital building.

   "There is a laboratory in the right section. However, as I have just mentioned because the number of patients was tiny, the management decided to use only one part (the left-wing)." (Head Nurse IM)

   One of the participants said that hiring more staff (porters) would ease the processing time for getting the samples to the laboratory in the main building.

   "Emergency department should have two porters or more because at the morning shift, I am the only one who is working and there is huge pressure on me. Because while I am on my way to transport some supplies, they may call me and ask me to leave anything I am working on and come back to take a medical sample to the laboratory which is in the main building." (Porter FD).

   All participants agreed that a solution is to establish a laboratory for the ED only, which will speed up the processes and reduce overcrowding and waiting times.

   "In my opinion, if they need to help us in solving this problem, it is to create a separate lab for the Emergency Department." (Doctor AB).

2. Because there was no waiting area in the department, the management created the current waiting areas in the ED:

- First: the management created the two waiting areas in the two corridors in the department's left-wing section that leads to the radiology department.

"We had to solve a problem, which is not having a waiting area and people come to the department anyway, and they needed an area for waiting. Therefore, we have placed these chairs." (Head Nurse IM)

"There is no waiting area! Therefore, we had to use the corridors as waiting areas, but it is not helping as it is causing overcrowding." (Head Nurse IM)

However, the location of these waiting areas is inconvenient and causing problems. For example, they are causing overcrowding, hindering all users' movement, and compromising all users' privacy.

"The waiting areas in the corridors leading to the X-Ray are misused. These corridors should have been used only for the radiology department." (Head Nurse IM)

"We are currently using the corridors as waiting areas, so it gets very crowded, and this hinders our movement and work." (Head Nurse IM).

- Second: the management adopted the entrance hall in the right-wing section (opposite the ED pharmacy, registration, and accountant) to become a waiting area as a solution.

"Renew the emergency department and the lounge; there were no chairs in the waiting area. They have put chairs and a new screen." (Porter FA).

However, it is far from the department and not connected to the department; therefore, it is not much in use.

"We do have a waiting area in the right-wing, and it has seats, TV and everything they may need, but no one is using it." (Head Nurse IM).

3. There was no dedicated area for triage, and it was designed to be in the main entrance area. However, in the current design, triage was placed after the door of the right-wing section. Also, the location of the triage counter is hidden from the entrance and cannot be seen easily.

"The triage area is tiny, and this is not how it was designed. The triage area used to be placed in the main entrance area. Now it is a bit hidden and cannot be seen from outside. Also, the inside cannot see the outside. So, we cannot know if a car passed by or not." (Head Nurse IM)

Also, there was no triage counter; it was only a room for triage examination. However, the department needed a counter to take the patients' medical history before they are triaged.

The counter is the first stage users come across in the ED to give their history and initial assessment.

"We did not use to have a counter outside the triage, so we have established this counter to take the necessary information then in the room next to the desk is the triage examination room." (Head Nurse IM)

4. In the new spatial arrangement, Eye and Ear clinics were added to the emergency department. Both clinics are in the middle of the current ED and replace two doctors' offices.

   "The Ear clinic and the Eye clinic in the current emergency department used to be used as a doctor's offices." (Head Nurse IM)

   However, these clinics are causing overcrowding, and they are contradicting with the department work. Therefore, all staff believes they should be placed outside the department.

   "The waiting area in the first corridor is always full of patients of the eye's and ear's clinics in the Emergency Department." (Doctor AB)

   "It should be far from the Emergency Department and moved to the normal clinics." (Doctor AB)

5. There was no rest area for staff. Therefore, an emergency exit was adopted to become a rest area for staff. However, staff are not content with this rest area for some reasons. First, it is still an emergency exit and cannot be closed. Second, it does not have enough services for its purpose. Third. It has no privacy where almost all users can use it and walk through it.

   There is no formal restroom for the staff in the department whatsoever, which is very inconvenience most of the time. Therefore, we have created a restroom for the medical staff at one of the emergencies exits by adding a small table and a sofa. However, it is not the restroom, and it is tiny." (Head Nurse IM).

6. Since only part of the department was in use due to the small number of users; the surgical and the internal exam cubicles used to be together in the same space. However, currently, they are separated into different exam cubicles.

   "The surgery and the internal users to be together, now the internal has been moved to its current location." (Head Nurse IM).

   Doctor AB said that surgical and internal medicine rooms should be but together because sometimes patients may need both which reflect on having all the functions around each other.

> "I think it is wrong to separate between Internal medicine and surgical emergency medicine because some cases need both at the same time. It would be better to have both medical emergencies, the surgical and the Internal in one area." (Doctor AB)

Therefore, it would be better if the internal and surgical exam cubicles are in the same area.

C. Density and Overcrowding

From the theme "ED design influence", all participants stated that the ED is affected by overcrowding and long waiting times. Thus, all participants elaborated on reasons for overcrowding from their point of views.

The participants mentioned some solutions that might reduce overcrowding, for example:

Dr AB suggested that having a general practitioner and a family doctor in the ED to deal with cold cases. Such a procedure will reduce the pressure on the ED.

> "We need a cold cases clinic, that may have both a GP and a Family medicine doctors. If the patient caught the flu or cough, this is not an ED case, so he should go there. a GP or a family doctor should treat such cases." (Doctor AB)

Also, holding some beds in the hospital to be used for cases coming from the ED. Therefore, admitted cases will not have to wait in the ED before they can be taken to the hospital.

> "Some of the hospital beds should be for the Emergency Department only and not used by the elective admission." (Doctor AB)

Besides, having rooms in the ED for patients waiting to be admitted to the hospital, or patients that need short observation:

> "We need a full-prepared room with equipment and staff for the Emergency Department, this is for the admitted cases, but there are no beds for them or patients under monitoring from 12 to 24 hours." (Doctor AB)

D. Privacy and accessibility

From the theme "ED design influence", all participants stated that the ED has privacy problems. Also, they elaborated on some reasons they think is affecting privacy. However, the only solution that was taken to improve privacy and the flow was creating the waiting area in the right-wing section. However, this room is far with no connections with the department, which is not much in use.

> "The waiting lounge should be on the same side too, so it would be easy for the patient to enter alone without company or only one." (Doctor AB)

"It is the one on the right-wing as it can be seen on the plan, but people do not often use it. It could be a bit far." (Head Nurse IM).

"We do have a waiting area in the right-wing, and it has seats, TV and everything they may need, but no one is using it." (Head Nurse IM).

V. Clinical process

This theme summarises the clinical process and the common treatment journey of common cases the ED in KAUH may receive for patients, nurses, and doctors. As described by the participants, these cases are categorized as stable and unstable, depending on the department formal procedures. During the interviews, these clinical processes were re-described to record accurate information. Also, the interviewees were showed a 2d plan of the department to illustrate their movement better, Figure 28

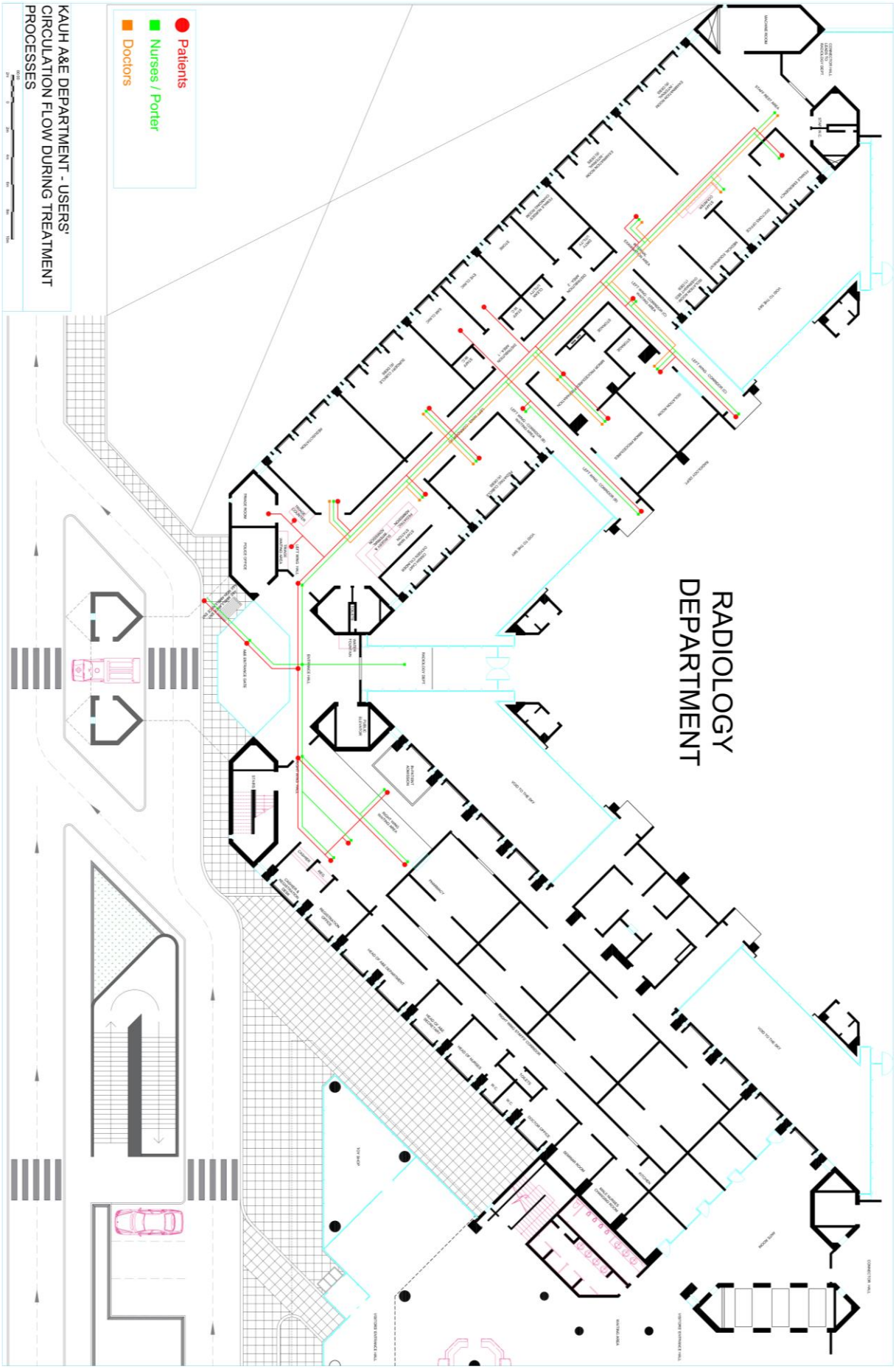


Figure 28: KAUH ED – patients', nurses', and doctors' movement paths to fulfil the clinical process

A. Stable cases:

This section describes patients' routine space activities (male, female, and children) during the treatment procedure of cases categorised as stable. It also records the role of nurses and doctors dealing with such, or similar cases. These cases include internal and surgical cases, for example:

- Internal medicine cases can be, for instance, thoracic, neuro medicine, cardiac, nephron. Furthermore, they could be, cold cases, such as flue, chest infection, coughing, shortening of breath, and headache.
- Surgical cases can be, for instance, orthopaedics, urology, neurosurgeon, and fractures.

Table 25 outlines a detailed description of patients', nurses', and doctors' movement journeys in steps order following the medical requirements to treat patients with cases categorised as stable in KAUH ED. Figure 29 provides a visual illustration of the described movement journeys in steps order to highlight the spatial relationships of the functions.

Table 25: Stable cases movement routes with detailed explanation *in KAUH ED.*

Medical Condition	**Stable cases**				
Male Patient		**Male Nurse**		**Male Doctor**	
1	Patients enter from the ED street entrance.	1	If the patient did not come to the treatment room alone, a nurse would call the patient from the following: • Admission counter area • Waiting area (In the right-wing) • Triage waiting area. • The two waiting areas in the corridors (In the left-wing)	1	The doctor usually placed by the main admission counter or the staff counter in the internal treatment area.
2	Patients come to the triage counter for an initial assessment. • Patients may have to wait in the small waiting area in from of the triage counter.	2	Patients will be taken to the Intended treatment area: • Internal treatment room. • Surgical treatment room. • Pediatric treatment room. The patient may need one or all the following: ▪ Medicine. ▪ Laboratory tests. ▪ Radiology. ▪ Minor operation.	2	The doctor will come to the room (where the patient is) to examine the patient and do some or all the following: ▪ Given advice and released. ▪ Medicine. ▪ Laboratory tests. ▪ Radiology.
3	Patients go to the registration and accountant in the right-wing section to open a medical file. • Patients will be given their medical file and directed back to triage for vital assessment	3	The nurse will call the doctor to examine the patient. Alternatively, the doctor might be in the room already.	3	After examining the patient, the doctor would be back to one of the main staff stations and wait for the results (lab and imaging results) unless he was called to see other patients.
4	After triage, the patient will be direct to the admission counter. • Patients have to handle their medical file to the staff.	4	The nurse will be back to the room (where the patient is) to be with the doctor and take the doctor commands.	4	After seeing the results (lab and radiology), the doctor will go back to see the patient and do the following: • Complete the treatment. • Keep the patient for observation. • Admit the patient. • Release the patient.

5	In the admission counter, patients will be directed to the Intended treatment area: • Internal treatment room. • Surgical Treatment room. • Pediatric treatment room. Or patients might be asked to wait in the waiting area for their turn.	5	If the patient needs medicine, the nurse will go to the nurse station to prepare the medicine.	5	The doctor would be back to the staff main stations unless he/she were called to see other patients.
6	In the treatment room, patients may go through the following: ▪ Given advice and released. ▪ Medicine. ▪ Laboratory tests. ▪ Radiology.	6	The nurse will go back to the room to do the following: • Give the patient the medicine. • Take samples from the patient. • Arrange with the radiology if needed		
7	The patient will be taken to the radiology department if needed.	7	If patients need laboratory tests; samples will be taken from the patient, and a porter will take the samples to the hospital laboratory.		
8	After radiology, the patient will be taken back to where he/she was.	8	The patient will be taken to the radiology department if needed.		
9	The patient can face the following: • sent to the inpatient floor. • Kept for observation. • Released However, patients can stay in the ED for a bed to become available.	**9**	After radiology, the patient will be taken back to where he/she was.		
10	Released patients will go back to the admission counter.	10	After performing the previous procedures and treat the patient, the nurse will do one of the following: • Take the patient to the operational department if needed. • Take the patient to the inpatient section if needed. However, the patients can stay in the ED for a bed to become available. • Or the patient will be released.		
11	Then patients will be directed to the accountant in the right-wing section for financial requirements.				
12	Patients may need to go to the pharmacy in the right-wing section to collect their medicine.				
13	Patients have to pass through the following areas to reach the exit: 1. The right-wing entrance. 2. The main entrance hall. 3. The entrance gate (The transition area) 4. Finally, the Ambulance/Non-Ambulance entrance/exit				

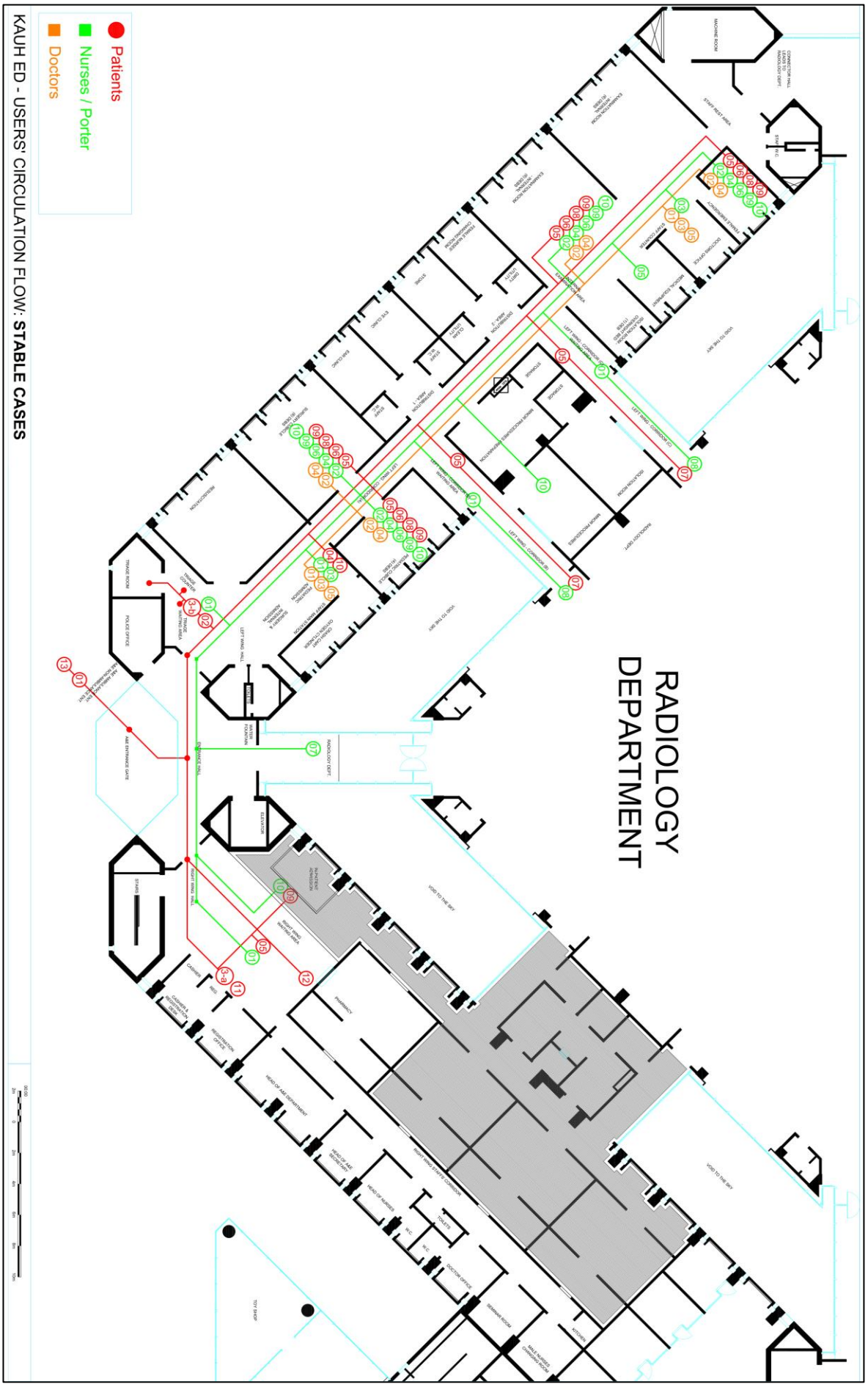


***Figure 29: KAUH ED* - Stable cases movement routes and their spatial relationships**

B. Unstable cases:

This section describes the routine space activities patterns of patients (male, female, and children) during the treatment procedure categorised as unstable. It also records the role of nurses and doctors dealing with such, or similar cases. These cases can be, for example:

- All ambulance cases, trauma cases in general, falling down cases, car accident, cutting wounds, broken bones, and anything caused by a falling-down.

Table 26 outlines a detailed description of patients', nurses', and doctors' movement journeys in steps order following the medical requirements to treat patients with cases categorised as unstable in KAUH ED. Figure 30 provides a visual illustration of the described movement journeys in steps' order to highlight the spatial relationships of the functions.

Table 26: Unstable cases movement routes with detailed explanation *in KAUH ED.*

Medical Condition	**Unstable cases**				
Male Patient		**Male Nurse**		**Male Doctor**	
1	Patients enter from the entrance. • Patients usually come with some company. • Patients can be conscious or not. • Patients usually come in an ambulance or internal transfer.	1	A nurse usually receives the patient from the entrance	1	The doctor usually placed by the main admission counter or the staff counter in the internal treatment area. Alternatively, they might be called in advance (or a bell will ring in the department) and wait for the patient in the resuscitation room. • The doctor/s sometimes come and meet the patient by the ambulatory entrance.
2	Patients will be taken directly to one of the following: • The resuscitation. • The minor operation. All the necessary procedures will be conducted in the room. Therefore, the patient may need the following: ▪ Necessary procedures ▪ Medicine. ▪ Laboratory tests. ▪ Radiology. ▪ Minor operation. • The patient's companion enters the room with the patient and waits for the doctor requests to do the needed paperwork at once. • If the patient is alone, a member of the staff will do the paperwork	2	The nurse will take the Patients directly to one of the following: • The resuscitation. • The minor operation. The patient may need the following: • Necessary procedures. • Laboratory tests. • Radiology. • Medicine. • Minor operation.	2	The doctor will come to the room (where the patient is) to examine the patient and do some or all the following: ▪ Necessary procedures. ▪ Medicine. ▪ Laboratory tests. ▪ Radiology. ▪ Minor operation
3	The patient will be taken to the radiology department if needed.	3	The nurse will call the doctor to examine the patient. Alternatively, the doctor might be in the room already.	3	Once the patient case is stabilised, the doctor would be back to his/her office and wait for the results (lab and imaging results) unless he was called to see other patients
4	After radiology, the patient will be taken back to where he/she was.	4	The nurse will be back to the room (where the patient is) to be with the doctor and take the doctor commands.	4	After seeing the results (lab and radiology), the doctor will go back to see the patient and do the following: • Complete the treatment. • Keep the patient for observation.

					• Admit the patient. • Release the patient.
5	After patients are treated, they can face the following: • Sent to the inpatient floor. • Kept for observation. • Released. However, patients can stay in the ED for a bed to become available.	5	If the patient needs medicine, the nurse will go to the nurse station to prepare the medicine. However, usually, the resuscitation room has everything that might be needed.	5	The doctor would be back to the staff main stations unless he/she were called to see other patients.
6	Released patients will go back to the admission counter.	6	The nurse will go back to the room to do the following: • Give the patient the medicine. • Take samples from the patient (the porter will take the samples to the lab) • Arrange with radiology if needed		
7	Then patients will be directed to the accountant in the right-wing section for a financial requirement.	7	The patient will be taken to the radiology department if needed.		
8	Patients may need to go to the pharmacy in the right-wing section to collect their medicine.	8	After radiology, the patient will be taken back to where he/she was.		
9	Patients have to pass through the following areas to reach the exit: 5. The right-wing entrance. 6. The main entrance hall. 7. The entrance gate (The transition area) 8. Finally, the Ambulance/Non-Ambulance entrance/exit	9	After performing the previous procedures and treat the patient, the nurse will do one of the following: • Transfer the admitted patient to the inpatient department. However, patients can stay in the ED for a bed to become available. • A nurse will transfer the patient to the exam room for observation. • Or the patient will be released.		

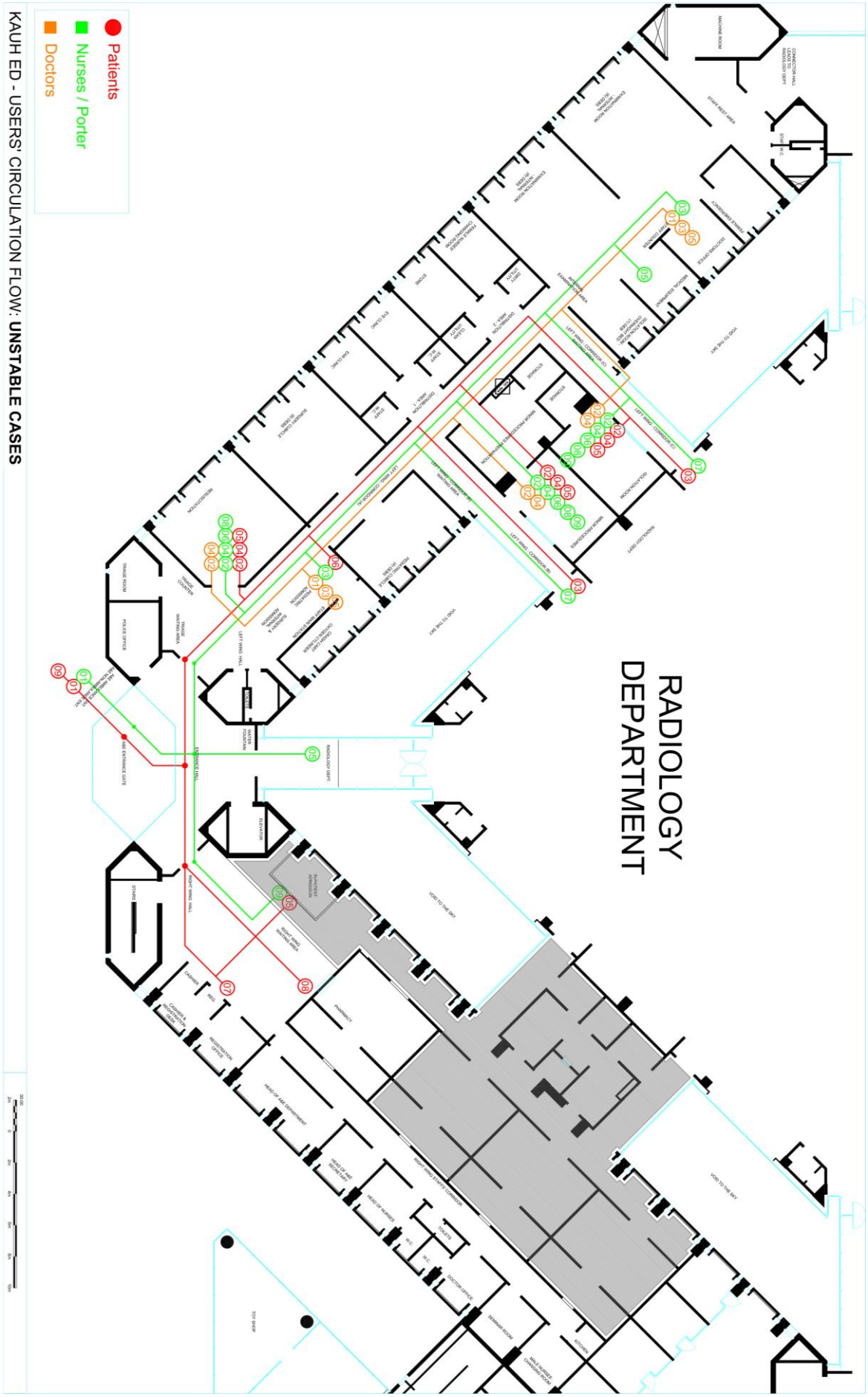


***Figure 30: KAUH ED* - Unstable cases movement routes and their spatial relationships**

7.3.3.3 *In summary*

The following points can be elicited from the conducted interviews with Staff in KAUH. The collected data focused on assessing the influence of the spatial design on ED usages and operation.

At first, it was helpful to collect an overview of the design influence on users' behaviour. Thus, the overarching theme 'ED Design influence' summarises the collected data under the theme design considerations. Further detailed are mentioned below:

The theme "design considerations" summarise the collected data regarding EDs main design considerations, which influence the department usages. The following point can be concluded.

A. KAUH ED used to be relatively big; however, only part of the department was in use, and then it expanded in phases to reach the current settings. The department's spatial development was influenced by the number of users, where every expansion happened to increase department capacity. Although the current design is tight, compact, and most of the available functions are near each other, which reduces walking distances, staff showed dissatisfaction with the current design. This is due to not having all the needed functions in the ED, the current functional distribution, and because it is usually crowded. For example, the laboratory, waiting areas, registration, and accountant location is inconvenient because it does not support the internal procedures, which cause users to move long distances and be scattered in the department. The ED cannot be seen from outside; the entrance is also hidden and requires many turns to be reached. Thus, staff preferred to have all the needed functions close to each other. For example, a central design where all the needed functions are around would improve patients' observation, reduce walking distances, improve workflow, and impact crowding and waiting time. As a result, the EDs spatial structure needs to have a proper arrangement for the needed different functions to serve the department's intended functionality.
B. For EDs' functions, staff elaborated on the spatial distribution of some of the department's functions. For example:
    - Triage: triage needs to be the closest function to the entrance; however, in KAUH ED, it is hidden from the entrance and cannot be easily reached.
    - Registration, accountant, and ED pharmacy: although patients are required to visit registration and accountant multiple times, they are located in the right-wing section, far from the ED. Thus, this is causing patients to walk more.
    - Laboratory: the department uses the lab in the main hospital building, which is far and causes delays in the sending and processing the samples.
    - Staff private areas: Staff do not have proper private areas in the department. Such rooms need to be private for staff use only and be far from the public and connected to the ED.

These rooms should include all the needed services and utilities such as showers, toilets, and lockers.

- Waiting areas: the main waiting area is considered outside the department, created recently in the right-wing area. However, the right-wing waiting area is far and not connected; therefore, people do not often stay in it or even use it. Furthermore, two other waiting areas are in the left-wing corridors, which are in the middle of the department. These two waiting areas are causing overcrowding and hindering movement. They were created because users used to wait while standing; therefore, the management placed some chairs for people.
- Eye and Ear clinics: new eye and ear clinics replaced two doctors' offices in the ED. However, they do not follow the triage system and contradict with the department workflow. They are causing crowding and hindering flow due to the number of people waiting outside the clinics.
- Radiology: having the radiology department near the ED is advantageous because it saves time and effort for staff and patients.
- The internal and surgical medicine rooms: internal and surgical patients used to share the same exam areas, which was convenient due to the integration between the two cases. However, the internal exam area was moved to a bigger space at the end of the department. It was owing to be receiving the highest number of cases compared to other ED cases. However, these rooms should be located near the entrance and each other.
- The resuscitation room is one of the most crucial rooms in the department due to its significant role in saving lives. Therefore, it needs to be the nearest to the department entrance.
- A room for short stay cases: having a short-stay room in the department is an advantage to reduce the pressure on the department's beds because some cases need to be observed for a short time before they are released or admitted to the hospital.

As a result, a proper arrangement for the needed different functions in EDs will reduce spatial complexity and improve work efficiency. As a result, crowding and waiting time will be reduced.

C. Overcrowding in KAUH ED is a significant problem, where it can be seen almost everywhere in the department (the left-wing section). For example, the main corridor in the left-wing section, the internal exam room, and the corridors leading to the radiology. Therefore, hinder the workflow, where it becomes hard to move and move patients. Participants elaborated on possible causes for overcrowding. For example:

- The current spatial distribution, such as the registration, the accountant, the laboratory, and the location of the waiting areas is hindering the department work, which is causing overcrowding and waiting time. For example, the waiting area in the right-wing section is

far, and people do not tend to use it, while the waiting areas in the left-wing section corridors are hindering the department work and cause overcrowding. Also, the location of the registration and accountant is causing people to walk more.

- User' awareness, some people may come to EDs for any reason; therefore, users need to know the meaning of emergency medicine and what might be considered an emergency.
- A significant challenge is the number of people coming with the patient, disturbing the department and cause delays and crowding.
- The location of the laboratory is far, which cost more time for the overall process. Also, it is tiring for the staff.
- The intransigence in the internal procedures that users' needs to follow is also causing overcrowding and confusion.
- Not having a short-stay room (observation rooms) is putting more load on the department. For example, short-stay rooms are used for patients waiting to be admitted or whom they may need to be observed for some time. Having these rooms will free an occupied ED bed and reduce the load on the department.
- Control over users, because currently, they can move freely in the department with no access restrictions, which is not right for EDs to function efficiently.

As a result, a proper arrangement for the needed different functions in EDs will improve the overall work process, which will reduce overcrowding and waiting time. The management rule is to ease the formal internal procedures, control patients and visitors flow and apply access restrictions on non-staff users.

D. Staff were not satisfied with privacy in KAUH ED; for example, staff lack proper staff private areas, compromising their privacy. The department has only one restroom for staff that was recently created in an emergency exit. Also, there are no changing rooms for male doctors, and the female changing room lacks proper services. Staff also elaborated on possible factors that may affect patients' privacy. For example:

- Using curtains to separate patients' beds is not ideal for patients' privacy.
- Having too many peoples with patients will compromise all users' privacy.
- Uncontrolled users' flow and free access to the exam areas and the department compromise all users' privacy.
- Having waiting areas in the middle of the department compromises privacy because they can see most of the department from inside.

As a result, a proper spatial structure of the department's needed functions with proper control over users' flow and accessibility will reflect on many factors. For example, it will improve privacy, the overall flow, reduce overcrowding, decrease waiting time and the department function in general.

Second, it was helpful to collect an overview of the operation influence on users' usages and taken actions to overcome design problems. Thus, the overarching theme 'ED Operation influence' summaries the collected data under four codes: users' behaviour, classification, staff, and design considerations. Further detailed are mentioned below:

The theme "users' behaviour" summarises the collected data about the way users behave, where such behaviours may cause problems that impact waiting times and overcrowding by hindering the department's operational activities. The following point can be concluded.

A. Participants explained some behaviour users might show in KAUH ED. For example, patients and visitors do not like to wait, and they usually gather in the corridors. Moreover, this might be owing to the lack of control over users. Also, functions location, as such, the waiting areas in the corridors in the left-wing section are inconvenient. They are also moving freely in the department with no access restrictions; as such, they may wait in the corridors and the treatment areas. Not to mention, the number of people coming with the patients, which is causing crowding, disrupting staff work, and make unnecessary noise. The reason for such behaviours might be owing to the following:
    - The location of the current waiting areas is inconvenient.
    - There are no access restrictions and sufficient control over users' flow from the management side.
    - Public awareness needs to be increased by educating users about emergency medicine and the allowed number of companions, reflecting on the department's overall function, such as waiting time and overcrowding.

    As a result, a proper spatial structure of public areas in the department is significantly essential to reduce overcrowding and waiting time. The management can also apply firm procedures to control users' flow better and look for means to increase users' awareness about emergency medicine.

The theme "Classification" summarises the collected data regarding patients' classifications in the IH ED. The following point can be concluded.

A. The adopted triage system in the IH ED is the Canadian triage system, which is used to prioritize patients on their medical conditions. However, the triage system is not fully competent in the department; thus, the priority system is not applied. Also, there should be an experienced staff member in triage to adequately diagnose patients' condition and send them to the right place. As a result, a defect in the triage system will cause problems and hinder the department work. As a result, triage should be placed in the public areas with the administration counter, where patients

can be triaged on arrival after registration and wait for their turn. Not to mention, management role to effectively operate a triage.

The theme "staff" summarises the collected data regarding staff responsibility and their impact on the workflow's efficiency in the IH ED. The following point can be concluded.

A. Having specialised staff in the department will ease the work processes and improve the workflow's overall efficiency and reduce the needed different specialists. Thus, ED specialists can cover all different cases that come to the department.

The theme "design considerations" summarise staff and management taken procedures to overcome difficulties in the design that were mentioned in the overarching theme "DE Design Influence" under the code "Design Consideration." The following point can be concluded.

A. Only part of the original spatial structure was used owing to the small number of users. Thus, the department expanded in phases to suit the increased number of users; therefore, every expansion happened to increase its capacity. However, functional relationships might have been neglected by focusing on providing spaces rather than considering spatial relations. As a result, the new spatial structure should consider how it would function to reduce the current problem; however, it mainly had a department that fits the number of users.
B. To overcome difficulties in functional distribution, some solutions were adopted. For example:
    - Since the laboratory is far in the main building, management hired a porter to transfer samples to the lab.
    - The department was lacking waiting area; therefore, management created the following waiting areas:
        - Two waiting areas by the beginning of the two corridors in the left-wing section were created for people waiting in the corridors. However, it is causing overcrowding and hindering users' movement.
        - The entrance hall in the right-wing section was recently adopted to become a waiting area. However, people do not tend to stay in it because it is far and not connected to the department.
    - Triage was placed at the beginning of the ED (left-wing section) in the stretchers' storage room. However, it is far from the entrance and cannot be easily seen.
        - Triage counter was created in the left-wing entrance hall to take patients history.
    - Two doctors' offices in the middle of the current ED were converted to eye and ear clinics. However, they are causing more congestion in the department. Therefore, it might be better to have them outside the department.

- An emergency exit was adopted to become a rest area for staff. However, it lacks privacy because it is still an emergency exit with no access restrictions for other users. Also, it is small and inconvenient.
- The department separated the surgical and the internal exam room in the last spatial development where they used to be in the same room. The reason for this change is that they needed a bigger room for the internal exam room. The current internal room is the biggest in the department. However, these rooms should be but together because sometimes patients may need both.

As a result, a proper arrangement for the needed different functions in EDs will improve the work process, which will reflect on overcrowding and waiting time.

C. Overcrowding is a significant problem in the ED; therefore, participants proposed some solutions that might reduce the ED's workload to reduce crowding and waiting time. For example:
   - Having a general practitioner or family doctors will reduce the pressure on the ED.
   - Reserving some beds in the hospital for admitted patients will reduce patients waiting time before admission. As a result, reduce occupations time for EDs' beds.
   - Also, having a short stay room will reduce the load on the ED. Because patients sometimes need to stay in the department only for observation.

   As a result, overcrowding is still a significant problem in the department. However, there was no real solution to reduce crowding other than the mentioned proposed solutions. Nevertheless, a proper arrangement for the needed different functions in EDs will improve the work process, which will reflect on overcrowding and waiting time.

D. Privacy is a significant problem in the ED, which is owing to the problems mentioned previously. However, to improve privacy and users flow in the department, the management created the waiting area in the right-wing section to reduce the number of people waiting inside the department and better control the flow. However, the room's location is far and disconnected; therefore, people do not wait in it.

   As a result, privacy is still a significant problem in the department. The only solution was to create the waiting areas in the right-wing entrance hall to improve privacy, crowding, flow and better organise and control users. However, it did not seem to be an effective solution, as mentioned before. Therefore, a proper arrangement for the needed different functions in EDs will improve the work process, which will reflect on privacy.

7.3.4 Themes Development and Extracted Data (IH)

Two overarching themes emerged after an extensive coding process; first ED Design Influence; and second; ED Operational Influence. Other themes and sub-themes arose after further coding of the interview data. For more details see Figure 31, Table 27

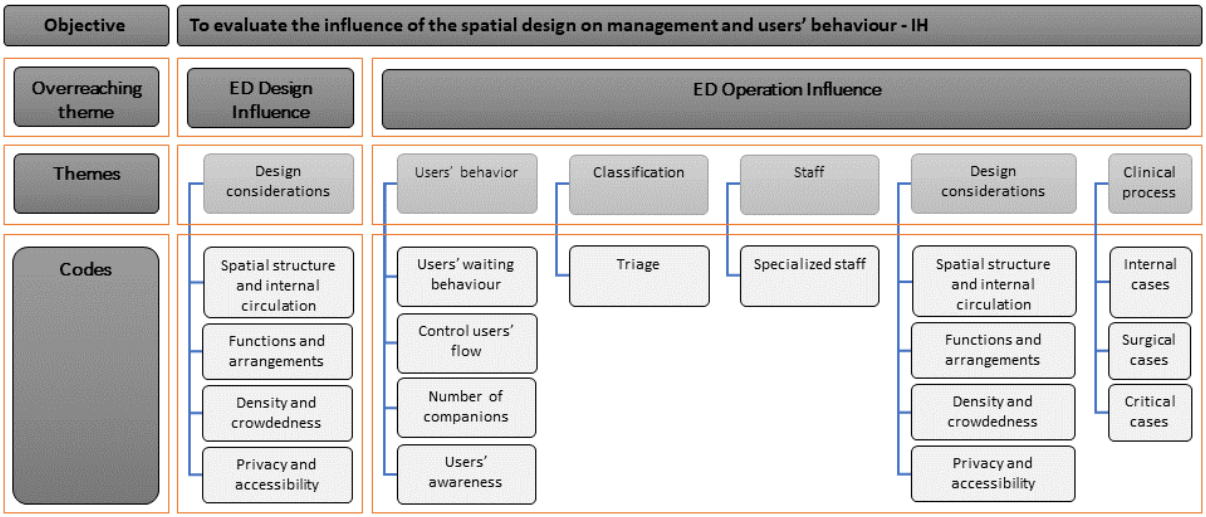


Figure 31: The emergent data from the Staff interview analysis (The IH ED).

Table 27: The emergent data from the Staff interview analysis (The IH ED).

Overarching themes	Themes	Codes and Subcodes	Description
ED Design Influence	Design considerations	E. Spatial structure and internal circulation. F. Functions and arrangements. G. Density and Overcrowding. H. Privacy and accessibility.	It illustrates staff opinion regarding key design elements and considerations for EDs.
ED Operation Influence	Users' Behaviour	B. Users' waiting behaviour. C. Control users' flow. D. The number of companions. E. Users' awareness.	It illustrates staff opinion regarding how users behave in the ED where such behaviour may cause problems that impact overcrowding and waiting time.
	Classification	A. Triage	It illustrates staff thoughts regarding patients' classifications in the ED.
	Staff	A. Specialised staff	It illustrates staff opinion regarding staff responsibility and their impact on the workflow's efficiency in the ED.
	Design considerations	A. Spatial structure and internal circulation. B. Functions and arrangements. C. Density and Overcrowding. D. Privacy and accessibility.	It illustrates staff opinion regarding staff and management took procedures to overcome the difficulties in the previously mentioned design considerations
	Clinical process	A. Internal cases B. Surgical cases C. Critical cases	

7.3.4.1 ED Design Influence

ED Design Influence is the first overarching theme that emerged to evaluate the influence of the spatial design on management and users' behaviour. It focuses on exploring the design from the staff point of view. It also focused on the design requirements and main design criteria that affect how the department is being used. One major theme emerged: design considerations.

I. Design Considerations

This theme reveals data from the interviewed staff in the IH regarding EDs design considerations. These considerations are categorised under four codes: spatial structure and internal circulation, functions and arrangements, density and overcrowding, privacy, and accessibility.

A. Spatial structure and internal circulation

This code illustrates participants' point of view regarding the spatial structure and the internal circulation in the IH; it also reveals their ideas to have a better spatial structure. This code is divided into subcodes as will be mentioned below.

1. Spatial satisfaction

All the participants expressed their dissatisfaction with the current spatial design they have in the Islamic Hospital. One of them believes that the spatial structure is not ideal to be used for EDs.

"The arrangement and the spatial structure we have is awful. This building was not designed in the first place to have an emergency department. Therefore, it should have built a different way." (Dr MU)

"The negative thing is having this wide and big spaces which consider as a burden and increase the load on both staff and patient." (Head Nurse MO)

Others mentioned that having such a big ED has positive and negative aspects. Having a big ED helps to obtain all the needed functions to have a self-contained treatment facility.

"The positive thing is that we have CT-Scan and the X-Ray rooms in the emergency department. As well as a laboratory." (Head Nurse MO)

"Many committees, like the Saudi committee and the quality control committee, visited our hospital and praised the emergency system and said it is like a big hospital." (Nurse JO)

Besides, big ED, such as in the Islamic Hospital, may increase staff workload by increasing the walking distances. Because patients and staff move quite often between the different functions:

"The negative thing is that having this wide and big spaces are considered a burden, which increases the load on both staff and patient. Moreover, it is considered as a time consuming and an effort wakening the staff. The need for walking long distances makes the process harder." (Head Nurse MO)

"For Example: Particularly with children (the Pediatric section), you are forced to walk from the Pediatric section to the radiological section to make one X-ray, which is like you are going back to the triage." (Dr MU)

Also, the long-distance, the spatial distribution of the functions does waste time. Therefore, it is better to have the most used ED functions and services near the patient to save time and effort for all users.

"The most important thing is to have all services for patients close to them; this is a significant point because this will save us time and accelerating the process with the least effort to be taken." (Head Nurse MO)

"It is a waste of time. It takes time and effort to finish the whole process. because of the distance and second because of the closed spaces and room." (Dr MU)

"Even if they could not reduce the walking distances; the different areas should not be far, they should be near us." (Nurse JO)

The participants stated that gender segregation is like having another department in the emergency department because males and females have their treatment areas separated.

"This hospital is divided according to gender (men and women), which is the current spatial structure." (Dr MU)

"Another disadvantage is the separation between men and women, making the distance longer and requiring bigger spaces. Therefore, it is like a department in a department which is causing the big area we have." (Head Nurse MO)

2. Central Design

All the interviewed participants believed that having a central design, where all the different functions are close, is the ideal spatial Structure for the ED:

"The correct arrangement for an emergency department is to have a central space in the middle, and the centre is the doctor's counter. Besides, all the needed medical systems and all the patients are around that central area." (Dr MU)

"There is what is called a circular system/flow. Such having all necessary services around you. The pharmacy is near me, and the laboratory, accountant, and patients' rooms and the

centre will be the nursing station. Therefore, I can see all patients and follow up with their case, and this is the international emergency design/system, which is the right one. However, it cannot be applied here because we have a big area. We have no less than six treatment rooms and four critical rooms. Therefore, there will be no space for the rest of the required services." (Head Nurse MO)

B. Functions and arrangements

This code illustrates participants point of view regarding the spatial arrangement of the different functions in the IH ED. For example:

1. The most used room in the ED: treatment rooms, minor procedure room, and the resuscitation are the most used rooms. Therefore, these functions are the core of the department.

   "We have three categories—first, the treatment room, which includes surgical and internal medicine. Second, the minor room for surgical cases. Third, The resuscitation room for heart attacks." (Head Nurse MO)

2. Waiting areas**:** the waiting areas are considered outside the department with not enough services. Thus, people wait in the department's corridors, disturbing staff and patients' movement and causing crowding.

   "There is no adjacent waiting area, as can you see. When I ask the visitors to go to the waiting area, they will set next to the pharmacy." (Nurse JO)

   "All over the world, there is what is called a waiting area. However, we do not have one, and we have been asking for one." (Head Nurse MO)

   "Patients can wait outside in the corridors even if they are standing. Furthermore, sometimes they come to our offices in the offices." (Dr MU)

3. Administration counter, accountant, triage, and the pharmacy: they are located outside the department, and in a very distant area from the treatment areas. The pharmacy is the furthest, which causes difficulties for all ED users.

   "The main counter and the pharmacy should be close to the department and near each other." (Nurse JO)

   "We have suggested that the pharmacy and the accountant room to be in the emergency department. The triage room to be in the place of the X-Ray room, to be in the department." (Head Nurse MO)

4. Resuscitation rooms: both male and female resuscitation rooms are almost in the middle of the ED and far from the ambulance entrance.

"The resuscitation in the middle of the department. It has to be near the main door because each second matters to save lives." (Head Nurse MO)

5. ED laboratory: is near the pediatric section, and far from the male and female treatment areas. However, according to staff, the lab's location is inconvenient because it depends on human effort to transfer samples and collect results, which consume time and effort. Not to mention, the laboratory is in continuous use.

   "However, the big size makes the patient tired. Taking the samples to the lab and going back again to get the results does consume time and tire staff." (Head Nurse MO)

   "Patient needs to use the laboratory more than the radiology section." (Nurse JO)

   "Replace the radiology section with the laboratory (to be closer), and the radiology not to be the farthest but to be the last option." (Nurse JO)

   Dr MU says that the lab's location is only affecting staff and that patients will not be affected. However, he believes that having a specific system such as a vacuum system to transfer the samples will solve the lab's problem being far.

   "Regarding the laboratory, it may not be a problem because patients do not have to deal with it, we as the medical staff do transferee samples to the laboratory, not the patients." (Dr MU)

   "It may be considered far for the staff also. However, if you have the vacuum system to transfer the samples, then it is OK. And this is how it should be in all hospitals. It can be installed under the ceiling, and it is easy to be built." (Dr MU)

6. Radiology: it consists of an X-ray room, CT-Scan room, and ultrasound. In addition to the related rooms like the viewing room, the doctors' office, and an office for the technicians. The radiology section is almost placed at the beginning of the department, near the middle. However, the interviewed participants said that it is advantageous to have a radiology section in the department. However, they believe it needs to be further in the department or outside, but near the ED. Because of the high demand for radiology, which causes waiting time to happen.

   "The radiology section is good to have it in the emergency department or at least near the department. But not in this way." (Dr MU)

   "Here in the emergency department, there is no private or certain route that you can take to the radiology section directly. You should walk in a circle passing almost the whole department." (Nurse JO)

"I think if the X-ray rooms were at the end of the department, it would be better. I mean not the farthest but replace the radiology section with the laboratory, and the radiology is not the farthest but to be the last option. Like to be instead of the pediatric section." (Nurse JO)

"There is high pressure on the radiology section. Patients will stay waiting until they get the results, and it needs some time. So sometimes such procedures create overcrowding." (Nurse JO)

7. The pediatric treatment area is the furthest section in the department; therefore, participants emphasised that it is far. Thus, the process will take more time and effort.

   "The pediatric treatment area is the worst section of the department." (Dr MU)

   "The disadvantage is that the patient needs to walk from here (triage area) to the pediatric section, which is a long distance. For example, if the patient has to go from the X-ray section to the pediatric section. It is like from the begging of the department to the end of the department. And it is very far." (Head Nurse MO)

   The head nurse MO argued that having the pediatric this far is excellent in terms of the noise children make that may disturb other patients.

   "Having the pediatric section far away might be a positive thing because usually, they are disturbing (Screaming, crying …etc.). So, this might be considered as privacy for the other male and female patients in the department." (Head Nurse MO)

8. Male nurse station: it is located between the two male treatment rooms. The interviewees commented that having the nurse station in this way will affect patients' observation. This opinion goes back to the participant's thought of a central spatial structure as an ideal arrangement for EDs.

   "I have told you that the nurse station is outside the treatment rooms. I am not going to call it a nurse station; it is a medicine station. If you check out the other treatment rooms, they do not have a nurse station; it is only a room that has the counter." (Dr MU)

   "It is essential for the patient to see the nurse station. However, we do not have that." (Head Nurse MO)

9. Staff private areas: there is only one changing room for doctors in the pediatric department. Thus, one of the interviewees stated that the location of the room being far and in the pediatric section is inconvenient because; first, staff cannot hear the emergency bell in the room, second, it does not have a private movement route.

   "I cannot hear the emergency bell when I am in the changing room." (Dr MU)

"When we are leaving, everyone will be asking us where we are going." (Dr MU)

Furthermore, there is only one room for meetings that were converted from being a plaster room. This room is placed at the beginning of the department, just before the resuscitation room. All the interviewed stated that such a room is essential to have for training and formal meetings. Also, this room is used as staff rest and break area:

"This room is for resting and training, and it is essential to have." (Head Nurse MO)

"The meeting room is used for the breaks, the meetings, lectures, and seminars." (Head Nurse MO)

10. Dental and eye clinics: they were created recently, where they replaced a big treatment area in the male section. They are located at the beginning of the department, in front of the meeting room.

"The demand for dental as well as ophthalmology is low, and it is almost scarce." (Nurse JO)

Both clinics operate differently, as the eye clinic operates after 5:00 pm (after outpatient clinics are closed), while the dental clinics run 24/7.

"The eye clinic starts after 5:00 pm (after the outpatient clinics are closed). The dental is 24 hours in the emergency." (Nurse JO)

11. Entrances: the department can be accessed from the ambulance entrance and the mina building entrance. However, some users are using these entrances as a walkthrough between the hospitals and the main street.

"The emergency system must be a closed system in a closed unit." (Dr MU)

"There should be privacy for the emergency department; here we have all people coming through the emergency department entrance, which is wrong." (Head Nurse MO)

C. Density and Overcrowding

The collected data is categorised under two sub-codes: Current situation and main reasons. Further explanation is mentioned below:

1. Current situation: in the IH ED, it gets busy in the night shift between 07:00 pm and 10:00 pm.

"Here in the Islamic hospital, we do not suffer crowding in the emergency department, but other hospitals suffer high pressure that may reach 50 to 60 people in the waiting area." (Dr MU)

"From 7 to 10 pm, we get much work. Crowding everywhere in the department." (Nurse JO)

2. Main reasons: The interviewed participants elaborated on possible causes for overcrowding. For example:

a. The spatial distribution of the department's functions: having a big department is excellent in terms of patients' distribution. Because patients will be distributed in the department, which will reduce overcrowding. However, it is terrible in terms of the size, which is causing delays and trying staff.

"Having a big department may have some positive aspects such as patients are separated, so It does not become crowded." (Head Nurse MO)

"Having a big department could be considered a disadvantage because it increases the time of the process and delaying the treatment of the patient." (Head Nurse MO)

"The distribution is one of the reasons for overcrowding; if it was better than this, you may face fewer problems and treat more cases because it takes time. Because it is a big department." (Nurse JO)

b. Cultural understanding and people awareness: People may come to the ED for any reason they think might be critical.

"Unfortunately, some patients come to the hospitals because it is a private one for relief and vacate or when they feel they are tired and do not want to go to work. Alternatively, sometimes they feel they might get sick, so they come to the Emergency Department." (Dr MU)

c. A big challenge is the number of people coming with each patient as sometimes it may reach 5 to 10 people.

"For an instant, in a fall case or a car accident, you find a large number of visitors came with the patient." (Nurse JO)

d. Not having access restrictions over users' flow is one of the main reasons for crowding in the department.

"They can wait outside (in the corridors) even if they are standing. Moreover, sometimes they come to our offices in the offices." (Dr MU)

"Visitors can go wherever they want, and It is a problem." (Nurse JO)

Thus, having a closed and controlled ED will reduce overcrowding and waiting time.

"By having a closed area and having a triage system in the emergency department." (Dr MU)

"If people follow the instructions of having one bed and one accompany, they will reduce the overcrowding." (Dr MU)

e. The intransigence in the internal procedures: patients have to follow formal internal procedures before and during the examination process. Thus, such formal procedures cause difficulties, overcrowding, and increase the waiting time.

"It became more comfortable than before for patients; for example, we send the patient to the counter just one time and another time in the final check when the patient is to leave." (Nurse JO)

D. Privacy and accessibility

The interviewed participants stated that privacy is essential to have for all users in the ED.

"Applying the privacy system helps to secure the patient and improve the relationship between the doctor and the patient." (Dr MU)

However, the collected data shows that staff were not satisfied with their privacy in the department. For example, their privacy is compromised because all different users can access almost everywhere in the department.

"Patients' sometimes came directly to see the doctor, because no one was by the main counter, so they just allow themselves in." (Dr MU)

"Patients and their companion can go wherever in the department and have access to almost all the rooms. And it is wrongdoing. However, it is not activated here in the department." (Head Nurse MO).

"Visitors can go wherever they want, and It is a problem." (Nurse JO)

Also, patients' privacy is compromised because of the lack of control over the department.

"We do not have privacy for any patient here; anyone can more the curtain and see the patient. For example, sometimes, when I am checking a patient -worse when it is a female- anyone may come asking for anything, and people believe it is OK to do so." (Head Nurse MO).

7.3.4.2 ED Operation Influence

ED operation Influence is the second overarching theme that emerged to evaluate the influence of the spatial design on management and users' behaviour. It focuses on exploring ED operation from the staff point of view. It also focused on the way the department is being used. Four major themes emerged: users' behaviour, classification, staff, and design considerations.

I. Users' behaviour

This theme reveals data regarding users' behaviours that may hinder the operation of the department. The collected data are categorised under four codes, as discussed below:

A. Waiting behaviour: People do not like to wait after triage assessment owing to being in a private hospital.

> "Patients usually do not accept to wait due to them being in a private hospital if they are required to wait; they would have gone to a public hospital." (Head Nurse MO)

B. Control users' flow: users can move freely in the department with almost no constraints. Therefore, they wait in the corridors and inside the doctors' offices.

> "They can wait outside (in the corridors) even if they are standing. Moreover, sometimes they come to our offices in the offices." (Dr MU)

> "Visitors can go wherever they want, and It is a problem." (Nurse JO)

C. The number of companions: many people usually do company the patient, which is a problem because they will with the patient in the treatment area, in the corridors, and sometimes interfere in the staff work. However, this problem is due to the lack of control by the management.

> "For an instant, in a fall case or a car accident, you find a large number of visitors came with the patient." (Nurse JO)

> "The patient's companions usually come to the doctor asking about the patient case, which is wrong … and sometimes they are three to four people or more." (Head Nurse MO)

Dr MU explained that following a good system with sufficient control over the department may complement the design's defects.

> "Even if the design is not proper, but it is essential to have a system and policies to follow … protocols." (Dr MU)

> "you can upgrade the design by following a good system." (Dr MU)

For example, having a gate for the department and reasonable control will fix this problem:

> "Adding a gate and only allowing patients and one person to come with the patient is essential and more comfortable for us to deal with the case." (Dr MU)

D. Users' awareness: Dr MU believes that it is essential to increase people awareness about the emergency department and medical conditions:

"Unfortunately, some patients come to the hospitals because it is a private one for relief and vacate or when they feel they are tired and do not want to go to work. Alternatively, sometimes they feel they might get sick, so they come to the Emergency Department." (Dr MU)

"We need people to understand what an emergency is and what are the medical conditions and how they can be different." (Dr MU)

II. Classification

This theme reveals data from the interviewed staff regarding patients' classifications.

A. Triage system: The adopted triage system in the ED department is the Canadian style. This system has five categories. These are resuscitation, emergent, urgent, less urgent, and referral.

"We have the Canadian style Categorisation, which includes five categories, starting from the severe cases that need action immediately to the less- dangerous cases that should be transferred to clinics (referral cases)." (Head Nurse MO)

However, the triage system is not fully competent in the department, and there should be more strict procedures to control triage and patients' flow.

"If we have an efficient triage system, patients would not have entered the department and caused us problems, and they would be waiting in the waiting area." (Dr MU)

Also, triage should have more experienced staff:

"Sometimes, the receptionist in the triage system sends the patients randomly to the specialist or sends them to the specialist before registering their data to see what the doctor may say to the patient." (Dr MU)

"The missing is that we need a doctor (Physician) in triage." (Dr MU)

III. Staff

This theme reveals data regarding staff responsibility and their impact on the efficiency of the workflow in the ED:

A. Specialised staff: having an emergency specialist is better for EDs because they will be more experienced and cover all ED cases. Because sometimes patients may be delayed finding the right specialist from the hospital

"In Emergency departments, there should be ER specialist with good experience or background in the emergency room, not fresh graduated nurses or doctors with no experience." (Dr MU)

> "This will make it easy for the patient because the patient will find the right specialist they need, and the waiting time will be decreased because the doctor is available for the patient." (Head Nurse MO)

Because otherwise, more staff will be required:

> "But the only disadvantage (of having a big department) is that you need an extra member staff. For example, the pediatric section staff will not help in the internal part; the staff in the women section cannot help." (Head Nurse MO)

> "Each section requires its staff, and this is the disadvantage of having many specialities." (Head Nurse MO)

IV. Design Considerations

This theme reveals data regarding staff and management taken procedures to overcome difficulties in the design mentioned in the overarching theme "DE Design Influence" under the code "Design Consideration." The collected data are categorised under four codes:

A. Spatial Structure and internal circulation

From the "ED design influence" theme, all participants stated that having the current spatial Structure in the IH ED is casing more burden on staff. Because of the long walking distances between the functions, which are trying and requires more time. Thus, the management worked toward some solutions to improve the current situation, for example:

Increase staff members; therefore, management sometimes hired a porter to help the medical staff overcome long walking distances. Also, they request staff from other departments in the hospital when needed.

> "Sometimes, the hospital provides a porter for us to overcome the problem of long distances." A Messenger, transferring the samples to the lab and take the patients to the X-Ray. only for stable cases to help us." (Nurse JO)

> "We call specialists staff from different departments. Most of the department in the hospital has no less than five to six medical staff members, so it will be fine to fetch one of them." (Nurse JO)

Also, some of the interviewees emphasised their effort to keep the work running.

> "it was a personal effort; we try hard to ease the different process and facilitate the procedures by our ourselves. For an instant, I used to go by myself to the laboratory, the X-ray. I used to take the patients to the X-ray section by myself when it is busy." (Dr MU)

The triage officer helps us in some procedures, and we can call him/her to ask for something from the reception counter or the accountant, so we do not come." (Nurse JO)

B. Functions and arrangements

From the "ED design influence" theme, all participants stated that some of the different functions are far from each other. Furthermore, having the current functional distribution is tiring and take more time for all users (Staff, patients, and visitors). Thus, the management worked toward some solutions to ease the internal processes for some of the functions:

1. The administration counter, accountant, triage, and the pharmacy are far and considered outside the department. Thus, management has opened a new window in the pharmacy wall next to the accountant counter to make it easy for ED users to reach the pharmacy.

   "They have opened a new window next to the accountant counter, so when you finish with the accountant, the pharmacy window will be next to you. You do not need to go around that long-distance as before to reach the pharmacy." (Nurse JO)

2. The intransigence in the internal procedures: patients have to follow formal internal procedures before and during the examination process. Thus, the management tried to ease the processes for patients:

   "It became more comfortable than before for patients; for example, we send the patient to the counter just one time and another time in the final check when the patient is to leave." (Nurse JO)

3. ED laboratory is at the far end of the department; near the pediatric section. One of the solutions was to hire more staff, such as a porter. Furthermore, the management changed the location of the laboratory window to make it closer:

   "Hiring the porter made things more comfortable; the laboratory has changed the window position and made it closer." (Nurse JO)

   Also, some staff members were requesting their tests using the phone instead of going in person to ease the processes.

   "Sometimes, when we need a test from the lab, we make a call." (Nurse JO)

   "It is better to bring a sheet and fill it, as documentation. However, we save time this way by using the phone." (Nurse JO)

4. Also, the plaster room was converted to be a meeting room. The reason for this is that staff needed a big room for meetings and brakes. Moreover, the plaster room was not much in use, where cases can be treated in the minor surgery room.

"That is why we gave up this large size room because we know well its benefit as part of the facilities that staff need." (Head Nurse MO)

"They thought that they needed a meeting room, and the plaster does not require a specific room, and it can be done in the minor procedure room." (Nurse JO)

C. Density and Overcrowding

From the "ED design influence" theme, all participants stated that density and overcrowding might not be a significant issue; however, overcrowding happens mainly in the rush hour between 07:00 pm and 10:00 pm. Thus, the elaborated-on reasons for overcrowding from their point of views.

The participants mentioned some behaviours when it gets crowded, for example:

1. When the treatment rooms are busy, patients will be treatment anywhere available in the department, such as the minor procedure room or the resuscitation room.

   "If the treatment rooms are fully occupied, we may have to take the patients to minor surgery room or the critical room (resuscitation), which is wrong." (Dr MU)

   "Due to crowding, I sometimes had to examine patient in unsuitable places such as on a sofa because all rooms are occupied. Not to mention, patients waiting in sofas and our offices. All patients are waiting for their turn to come." (Dr MU)

2. When the department reaches the maximum capacity, they stop admitting patients, which cases waiting time for others.

   "There is something called the rush hour. For example, we can deal with 40 cases; and once we have the 40 cases in the department, we have then to stop for a while. Therefore, waiting occurs." (Head Nurse MO).

Also, they emphasised on some taken procedures to improve workflow, for example:

1. Management had some alteration to the spatial structure to reduce movement distances, such as a new window was installed next to the accountant to make the pharmacy closer to users. Also, Changing the location of the laboratory window to make it closer to users.
2. Management started hiring more staff, as such porters, to overcome having a big department. Some participants said that increasing staff members would ease their work. Having a big department will put more load on staff, which will impact the overall treatment process.

   "The problem of not having enough staff members which requires calling members from other departments." (Head Nurse MO)

"To solve the crowding problem; First, increase the number of staff. Second, having the porter solves part of the problem." (Nurse JO)

3. Making formal internal procedures easier for users to reduce their walking distances. One of the participants suggested that the formal procedures, sometimes, case delays and dissatisfaction for patients. Therefore, it is better to ease patients process to reduce their movement times.

   "Patients do not go to a lot of different sections. When I send the patient to stamp for an image, then stamp the laboratory test. this will take much time, and the patient will get confused." (Nurse JO)

   "It became more comfortable than before for patients; for example, we send the patient to the counter just one time and another time in the final check when the patient is to leave." (Nurse JO)

4. Staff started to take personal efforts; for example, they started to improvise and take more responsibilities to accelerate the work rhythm.

5. Nurse JO also referred to the use of new medical equipment in reducing process time. He said that some of the essential measures used to take a long time. However, know it is as easy as a posh of a button.

   "In the past, we had to measure the blood pressure in a long process, but now, it is about one click to measure the whole vital signs, and this has saved us lots of time." (Nurse JO)

D. Privacy and accessibility

From the "ED design influence" theme, all participants stated that having privacy is essential for all users. However, the staff were not satisfied with the privacy they have in the department. Thus, they proposed some solutions to improve privacy, for example:

1. Patients' privacy can be Improve by creating small private treatment spaces for patients. For example, creating single rooms or building solid partitions rather than curtains. These small areas are a solution for acoustic privacy too.

   "We still have a privacy problem because the curtain is not enough." (Head Nurse MO).

   "Privacy can be improved by Separating patients' beds, having enough beds for all patients in small rooms." (Dr MU)

"A separation walls. So, each patient will have a closed area, so it is only a gypsum board walls and a curtain so each patient will have his/her closed area with it is own curtain." (Dr MU)

2. Privacy can be Improve by having specific private routes for some of the essential functions to separate the movement of the different users.

"Patients in the emergency department do not move except to the X-ray or the admission for admission purposes." (Nurse JO)

"Here in the emergency department, there is no private or certain route that you can take to the radiology section directly … you should walk in a circle passing almost the whole department. the same thing happens when you come back from the radiology section." (Nurse JO)

V. *Clinical process*

This theme summarises the clinical process and the common treatment journey of common cases the ED in the IH may receive for male patients, nurses, and doctors. As described by the participants, these cases are categorized as internal, surgical, and critical cases, depending on the department formal procedures. During the interviews, these clinical processes were re-described to record accurate information. The interviewees also showed a 2d plan of the department to illustrate their movement better, Figure 32. Due to ethical and cultural constraints, the workflow practices were recorded in the male examination areas with male patients and doctors.

Figure 32: IH ED – patients', nurses', and doctors; movement paths to fulfil the clinical process.

A. Internal (medical) cases

This section describes male patients' routine space activities during the treatment procedure of cases categorised as internal cases. It also records the role of male nurses and doctors dealing with such, or similar cases. These cases can be, for example:

- Patients with flu, headache, abdominal pain or similar cases share the same treatment pattern.

Table 28 outlines a detailed description of patients', nurses', and doctors' movement journeys in steps order following the medical requirements to treat male patients with cases categorised as internal in the IH ED. Figure 33 provides a visual illustration of the described movement journeys in steps' order to highlight the spatial relationships of the functions.

Table 28: **Internal cases movement routes with detailed explanation *in the IH ED.***

Medical Condition	**Internal cases**				
Male Patient		**Male Nurse**		**Male Doctor**	
1	Patients enter from the main entrance of the building or the ambulance entrance.	1	If the patient did not come to the treatment room alone, a nurse would call the patient from the waiting area or triage.	1	Doctors are usually placed in their offices: • Surgical doctor's office. • Internal doctor's office. Alternatively, they might be in the exam rooms.
2	Patients come to the reception and admission counter first.	2	The patient will be taken or send to the examination room (A) or (B) depending on beds availability. • Room A is preferred by staff due to the bigger size. • The patient may need the following: ▪ Given advice and released. ▪ Medicine. ▪ Laboratory tests. ▪ Radiology.	2	The doctor will come to the room (where the patient is) to examine the patient and do some or all the following: • Given advice and released. • Medicine. • Laboratory tests. • Radiology.
3	The patient goes to the accountant to pay a deposit.	3	The nurse will call the doctor to examine the patient. Alternatively, the doctor might be in the room already.	3	After examining the patient, the doctor would be back to his/her office and wait for the results (lab and imaging results) unless he was called to see other patients.
4	The patient will be directed to the triage room for an initial assessment. • Or wait in the waiting area (there are three areas patients can wait in, as shown in the plan).	4	The nurse will be back to the room (where the patient is) to be with the doctor and take the doctor commands.	4	After seeing the results (lab and radiology), the doctor will go back to see the patient and do the following: • Complete the treatment. • Keep the patient for observation. • Admit the patient. • Release the patient.
5	After triage, the patient can go through one of the following: • Wait in the waiting area (there are three areas patients can wait in, as shown in the plan). • Be sent directly to the examination room.	5	If the patient needs medicine, the nurse will go to the nurse station to prepare the medicine.	5	The doctor will be back to his office, or he may be called to see another patient.
6	The patient will be taken or send to the examination room (A) or (B) depending on available beds.	6	The nurse will go back to the room to do the following: • Give the patient the medicine.		

	• Room A is preferred by staff due to the bigger size. • The patient may need the following: ▪ Given advice and released. ▪ Medicine (painkiller). ▪ Laboratory tests. ▪ Radiology.		• Take samples from the patient. • Arrange with the radiology if needed	
7	The patient will be taken to the radiology department if needed.	7	For laboratory tests, the nurse will send the samples to the laboratory	
8	After radiology, the patient will be taken back to where he/she was.	8	The nurse will be back to the room (where the patient is)	
9	After patients are treated, they can face the following: • Sent to the inpatient floor. • Kept for observation. • Released. However, patients can stay in the ED for a bed to become available.	9	The patient will be taken to the intended room in the radiology section if needed.	
10	Released patients will go back to the reception and admission counter.	10	After radiology, the patient will be taken back to where he/she was.	
11	Then patients will be directed to the accountant for financial requirement	11	The nurse will go back to the laboratory to get the results.	
12	The patient may need to go to the pharmacy to collect his medicine.	12	The nurse will deliver the lab results to the doctors whether he is in the office (surgical or internal doctor's office) or the examination room.	
13	The patient can exit from the ambulance entrance or the main building entrance.	* Radiology results will be delivered by a different nurse or the radiology doctor. * sometimes the doctor himself comes to collect the images in person to save waiting time.		
		13	After performing the previous procedures and treat the patient, the nurse will do one of the following: • Transfer the admitted patient to the inpatient department. However, patients can stay in the ED for a bed to become available. • Keep the patient in the exam room for observation. • Or the patient will be released.	

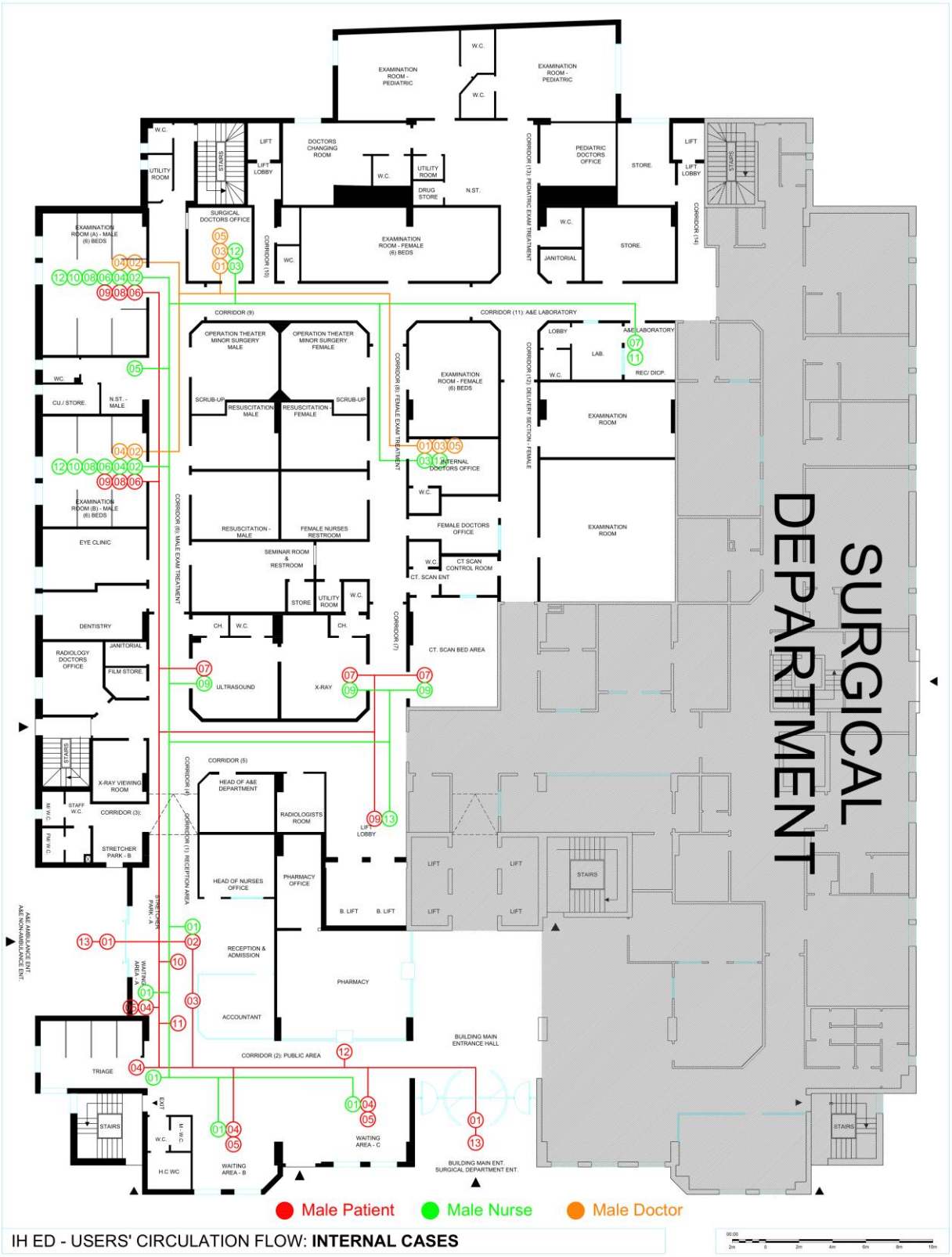


Figure 33: IH ED - Internal cases movement routes and their spatial relationships

B. Surgical cases

This section describes the routine space activities patterns of male patients during the treatment procedure of cases categorised as surgical cases. It also records the role of male nurses and doctors dealing with such, or similar cases. These cases can be, for example:

- Patients who are wounded or have a fracture or similar cases that share the same treatment pattern.

Table 29 outlines a detailed description of patients', nurses', and doctors' movement journeys in steps order following the medical requirements to treat male patients with cases categorised as surgical in the IH ED. Figure 34 provides a visual illustration of the described movement journeys in steps' order to highlight the spatial relationships of the functions.

Table 29: **Surgical cases movement routes with detailed explanation *in the IH ED.***

Medical Condition	**Surgical cases**				
Male Patient		**Male Nurse**		**Male Doctor**	
1	Patients enter from the main entrance of the building or the A&E ambulance entrance.	1	If the patient did not come to the minor operation room alone, a nurse would call the patient from the waiting area.	1	Doctors are usually placed in their offices (Surgical doctor's office). Alternatively, they might be waiting for the patient in the minor operation room.
2	Patients come to the reception and admission counter first.	2	The patient will be taken or send to the minor operation room. The patient may need the following: • Medicine (painkiller). • Laboratory tests. • Radiology. • Or minor operation in the operation room (Plaster)	2	The doctor will come to the minor operation room to examine the patient and do some of the following: • Medicine (painkiller). • Laboratory tests. • Radiology. • Or minor operation in the operation room (Plaster)
3	The patient goes to the accountant to pay a deposit.	3	The nurse will call the doctor to examine the patient. Alternatively, the doctor might be in the room already.	3	After examining the patient, the doctor would be back to his/her office and wait for the results (lab and imaging results) unless he was called to see other patients.
4	The patient will be directed to the triage room for an initial assessment. • Or wait in the waiting area (there are three areas patients can wait in, as shown in the plan).	4	The nurse will be back to the room (where the patient is) to be with the doctor and take the doctor commands.	4	After seeing the results (lab and radiology), the doctor will go back to see the patient and do the following: • Complete the treatment. • Keep the patient for observation. • Admit the patient. • Release the patient.
5	After triage, the patient can go through one of the following: • Wait in the waiting area (there are three areas the patient can wait in, as shown in the plan). • Be sent directly to the exam room or the minor operation room.	5	If the patient needs medicine, the nurse will go to the nurse station to prepare the medicine.	5	The doctor will be back to his office, or he may be called to see another patient.
6	The patient will be taken or send to the minor operation room. The patient may need the following: • Medicine (painkiller). • Laboratory tests.	6	The nurse will go back to the room to do the following: • Give the patient the medicine. • Take samples from the patient. • Arrange with the radiology if needed		

	• Radiology. • Or minor operation in the operation room (Plaster)			
7	The patient will be taken to the radiology department if needed.	7	For laboratory tests, the nurse will send the samples to the laboratory	
8	After radiology, the patient will be taken back to where he/she was.	8	The nurse will be back to the room (where the patient is)	
9	After patients are treated, they can face the following: • Sent to the inpatient floor. • Kept for observation. • Released. However, patients can stay in the ED for a bed to become available.	9	The patient will be taken to the intended room in the radiology section if needed.	
10	Released patients will go back to the reception and admission counter.	10	After radiology, the patient will be taken back to where he/she was.	
11	Then patients will be directed to the accountant for financial requirement	11	The nurse will go back to the laboratory to get the results.	
12	The patient may need to go to the pharmacy to collect his medicine.	12	The nurse will deliver the lab results to the doctors whether he is in the office (surgical or internal doctor's office) or the minor room.	
13	The patient can exit from the ambulance entrance or the main building entrance.	* Radiology results will be delivered by a different nurse or the radiology doctor. * Sometimes the doctor himself comes to collect the images in person to save waiting time.		
		13	After performing the previous procedures and treat the patient, the nurse will do one of the following: • Transfer the admitted patient to the inpatient department. However, patients can stay in the ED for a bed to become available. • Keep the patient in the exam room for observation. • Transfer the patient to exam the room for observation if he/she was in the operation room. • Or the patient will be released.	

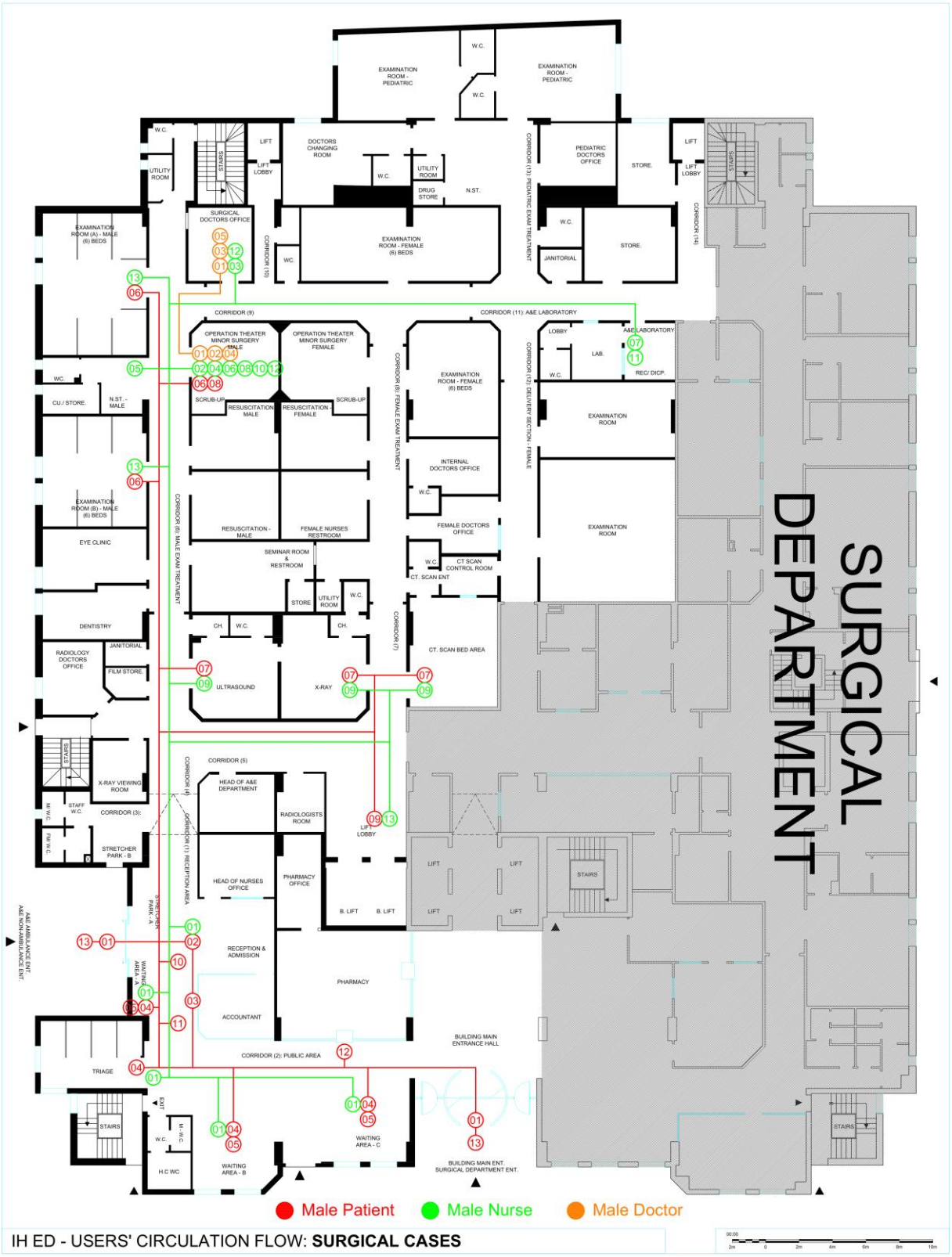


Figure 34: IH ED - Surgical cases movement routes and their spatial relationships.

C. Critical cases

This section describes the routine space activities patterns of male patients during the treatment procedure of cases categorised as critical cases. It also records the role of male nurses and doctors dealing with such, or similar cases. These cases can be, for example:

- Patients who are having life-threatening conditions

Table 30 outlines a detailed description of patients', nurses', and doctors' movement journeys in steps order following the medical requirements to treat male patients with cases categorised as critical in the IH ED. Figure 35 provides a visual illustration of the described movement journeys in steps' order to highlight the spatial relationships of the functions.

Table 30: **Critical cases movement routes with detailed explanation *in the IH ED.***

Medical Condition	**Critical cases**				
Male Patient		**Male Nurse**		**Male Doctor**	
1	Patients usually enter from the ambulance entrance. • Patients usually come with some company. • Patients can be conscious or not. • Patients usually come in an ambulance or internal transfer.	1	A nurse usually receives the patient from the ambulance entrance.	1	Doctors are usually placed in their offices: • Surgical doctor's office. • Internal doctor's office. Alternatively, they might be called in advance (or a bell will ring in the department) and wait for the patient in the resuscitation room. • The doctor/s sometimes come and meet the patient by the ambulatory entrance.
2	Patients will be sent to the minor operation or resuscitation room, where they may need the following: ▪ Necessary procedures. ▪ Medicine. ▪ Laboratory tests. ▪ Radiology ▪ Minor operation. ▪ The patient's companion enters the room with the patient and waits for the doctor requests to do the needed paperwork at once. ▪ If the patient is alone, a member of the staff will do the paperwork	2	The nurse will take the patient to the resuscitation room or minor operation (the empty one). The patient may need the following: ▪ Necessary procedures. ▪ Laboratory tests. ▪ Radiology. ▪ Medicine. ▪ Minor operation.	2	The doctor will come to the resuscitation room or minor operation (where the patient is) to examine the patient and do some or all the following: ▪ Necessary procedures. ▪ Medicine. ▪ Laboratory tests. ▪ Radiology. ▪ Minor operation
Four scenarios can happen for the patient in the resuscitation: 1. Admitted to the hospital: If the patient case is critical and needs an advanced operation. 2. Taken to the minor operation: If the patient case is critical and needs an operation. 3. Stay in the resuscitation room: If the patient case is critical and needs immediate operation; the operation will be performed in the resuscitation room. 4. Stay in the resuscitation room: If the patient can be treated in the resuscitation room. 5. Transfer the patient to the examination room.					
3	The patient will be taken to the radiology department if needed.	3	The nurse will call the doctor to examine the patient. Alternatively, the doctor might be in the room already.	3	Once the patient case is stabilised, the doctor would be back to his/her office and wait for the results (lab and imaging results) unless he was called to see other patients
4	After radiology, the patient will be taken back to where he/she was.	4	The nurse will be back to the room (where the patient is) to be with the doctor and take the doctor commands.	4	After seeing the results (lab and radiology), the doctor will go back to see the patient and do the following: • Complete the treatment.

					• Keep the patient for observation. • Admit the patient. • Release the patient.
5	After patients are treated, they can face the following: • Sent to the inpatient floor. • Kept for observation. • Released. However, patients can stay in the ED for a bed to become available.	5	If the patient needs medicine, the nurse will go to the nurse station to prepare the medicine. However, usually, the resuscitation room has everything that might be needed.	5	The doctor will be back to his office, or he may be called to see another patient.
6	Released patients will go back to the reception and admission counter.	6	The nurse will go back to the room to do the following: • Give the patient the medicine. • Take samples from the patient. • Arrange with radiology if needed		
7	Then patients will be directed to the accountant for financial requirement	7	For laboratory tests, the nurse will send the samples to the laboratory		
8	Patients may need to go to the pharmacy to collect their medicine.	8	The nurse will be back to the room (where the patient is)		
9	The patient can exit from the ambulance entrance or the main building entrance.	9	The patient will be taken to the intended room in the radiology section if needed.		
		10	After radiology, the patient will be taken back to where he/she was.		
		11	The nurse will go back to the laboratory to get the sample results.		
		12	The nurse will deliver the lab results to the doctors whether he is in the office (surgical or internal doctor's office) or the resuscitation room.		
		* Radiology results will be delivered by a different nurse or the radiology doctor. * sometimes the doctors his self comes to collect the images in person to save waiting time.			
		13	After performing the previous procedures and treat the patient, the nurse will do one of the following: • Transfer the admitted patient to the inpatient department. However, patients can stay in the ED for a bed to become available. • A nurse will transfer the patient to the exam room for observation. • Or the patient will be released.		

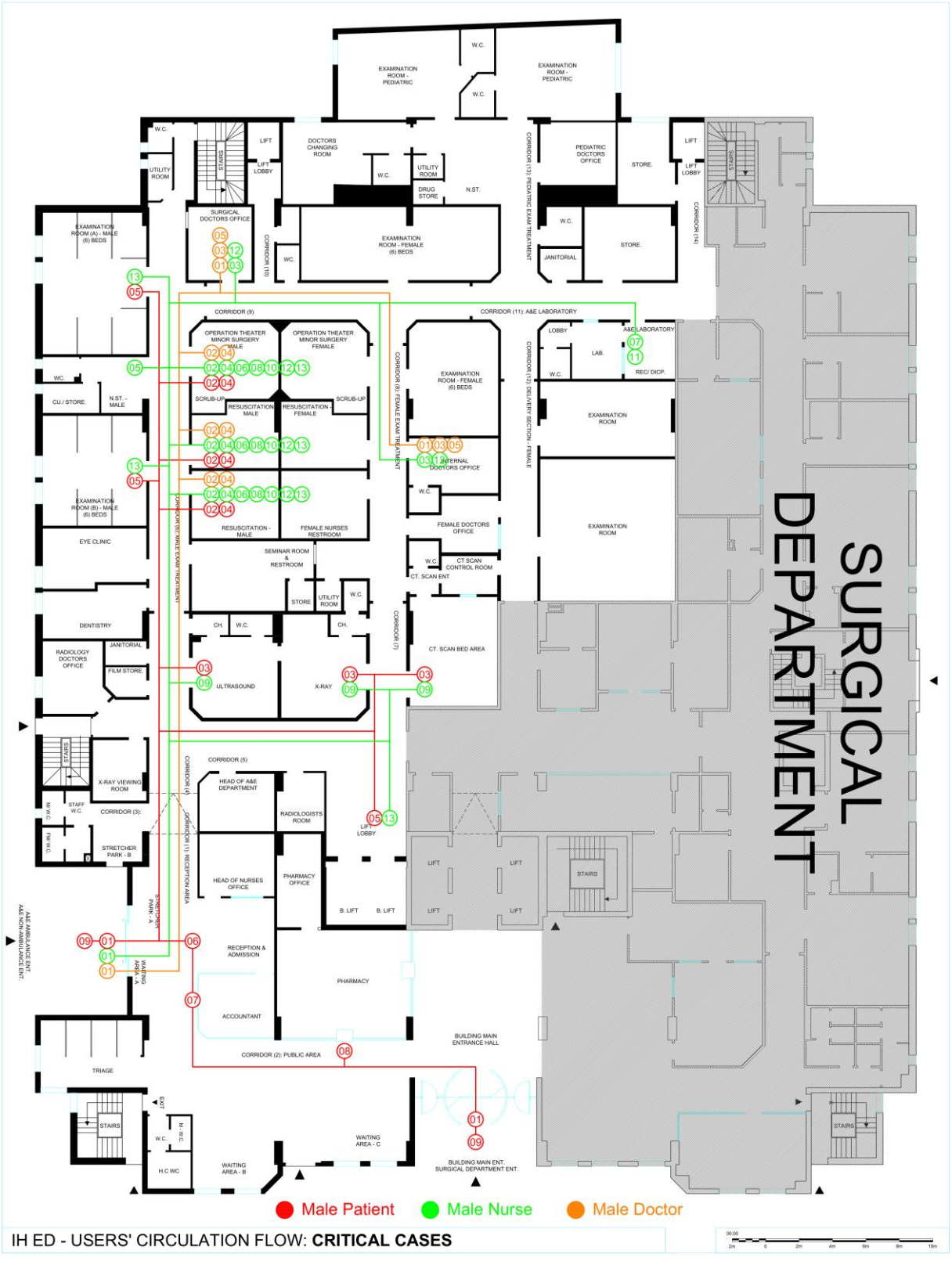


Figure 35: IH ED - Critical cases movement routes and their spatial relationships.

7.3.4.3 In summary

The following points can be elicited from the conducted interviews with Staff in the IH. The collected data focused on assessing the influence of the spatial design on ED usages and operation.

At first, it was helpful to collect an overview of the design influence on users' usages. Thus, the overarching theme 'ED Design influence' summaries the collected data under the theme design considerations. Further detailed are mentioned below:

The theme "design considerations" summarise the collected data regarding EDs main design considerations, which influence the department usages. The following point can be concluded.

A. Although the IH ED's spatial structure is relatively big and has most of the needed functions for EDs, Staff showed their dissatisfaction with the current design. Having such a big department can contain many functions, such as the radiology section, laboratory, male exam area, female exam area, pediatric exam area, and delivery section. Not to mention, resuscitation and minor operation rooms and other administrative areas and public services are also in the ED, which creates a self-contained department. However, it is causing difficulties in term of the long walking distances staff has to take, which cause delays, tiring staff and extends processes time. Thus, staff preferred to have all the needed functions close to each other. For example, a central design where all the needed functions are around would improve patients' observation, reduce walking distances, improve workflow, and impact crowding and waiting time. As a result, the EDs spatial structure needs to have a proper arrangement for the needed different functions to serve the department's intended functionality.
B. Since the IH ED contains many functions mentioned in the previous point, staff elaborated on the spatial distribution of some of the functions. For example:
    - Waiting area, administration counter, accountant, ED pharmacy, and triage, need to be in the same area with close distances to treatment cubicles.
    - Resuscitation and minor operation rooms need to be close to the entrance.
    - The laboratory is one of the most used functions; therefore, it is preferable to have one for ED only in the department or outside. If it was outside the ED, then there should be a system to transfer samples, such as a vacuum system and an effective communication instrument.
    - Radiology services are usually on high demand; therefore, it is preferred to be near the ED rather than in the department. Having radiology in the department can cause delays, waiting time, and crowding because results usually take time to be ready. Not to mention, having the radiology section in the ED may complicate the overall functional distribution.
    - The pediatric treatment areas need to be separated from the male treatment areas. However, it should not be very far owing to the shared functions. Having it far will increase staff walking distances, which will increase the workload.

- Patients' observation is vital in EDs; therefore, the staff mentioned that nurse station need to overlock treatment cubicles.
- EDs should have private areas for staff, such as restrooms, meeting rooms, private offices, and changing rooms. Staff private areas should be separated from public areas with private movement routes, while connected to the ED.
- Eye and ear clinics can be part of the ED. Nevertheless, they do not need to be included in the same spatial Structure, where they can be outside with direct access.
- EDs should be closed with private access points for the ED only.

As a result, a proper arrangement for the needed different functions in EDs will reduce spatial complexity and improve work efficiency. As a result, crowding and waiting time will be reduced.

C. Overcrowding and density might not be a significant problem in the IH ED, but waiting time is still a challenge. However, participants elaborated on possible causes for overcrowding. For example:
   - Participants believe that the current spatial structure and functions distribution is inconvenient, which cause delays, tiring, and lengthy processes time. Thus, it may lead to crowding and long waiting time.
   - User' awareness, some people may come to EDs for any reason; therefore, users need to know the meaning of emergency medicine and what might be considered an emergency.
   - A significant challenge is the number of people coming with the patient, disturbing the department and cause delays and crowding.
   - Management needs to apply access restriction, and control users flow because users have free access to almost everywhere in the department, which is a challenge.
   - Another reason for increasing waiting time and crowding is the intransigence in the internal procedures. Thus, users and staff movement increase to fulfil these administrative requirements.

   As a result, having this big department with the current functional distribution is one reason for reducing work efficiency. Therefore, a proper arrangement for the needed different functions in EDs will improve the overall work process, which will reduce overcrowding and waiting time. The management rule is to ease the formal internal procedures, control patients and visitors flow and apply access restrictions on non-staff users.

D. Privacy is essential to have, which is the right of all users in the department. However, staff were not satisfied with privacy in the IH ED, for example, a lack of assessing patients and visitors' privacy restrictions compromises staff privacy. Patients and visitors can go almost everywhere in the department. Also, there are not private movement routes for staff away from the public. As a result, a proper spatial structure of the department's needed functions with proper control over users' flow and accessibility will reflect on many factors. For example, it will improve privacy, the overall flow, reduce overcrowding, decrease waiting time and the department function in general.

Second, it was helpful to collect an overview of the operation influence on users' usages and taken actions to overcome design problems. Thus, the overarching theme 'ED Operation influence' summaries the collected data under four codes: users' behaviour, classification, staff, and design considerations. Further detailed are mentioned below:

The theme "users' behaviour" summarises the collected data regarding the way users are behaving. Such behaviours may cause problems that impact waiting time and overcrowding by hindering the department's operational activities. The following point can be concluded.

A. Participants explained some behaviour users might show in the IH ED. For example, patients and visitors do not like to wait after being triaged, where they may require to be seen immediately. They are also moving freely in the department with no access restrictions; as such, they may wait in the corridors and the treatment areas. Not to mention, the number of people coming with the patients, which is causing crowding, disrupting staff work, and make unnecessary noise. Such behaviours might be due to not having a separate public a staff treatment area, where patients and visitors may be forced to stay in one place and denied access to the treatment areas. As a result, such behaviours can hinder staff work and extend the treatment process, which will impact crowding and waiting time.

   As a result, a proper spatial structure of public areas in the department is significantly essential to reduce overcrowding and waiting time. The management can also apply firm procedures to control users' flow better and look for means to increase users' awareness about emergency medicine.

The theme "Classification" summarises the collected data regarding patients' classifications in the IH ED. The following point can be concluded.

A. The adopted triage system in the IH ED is the Canadian triage system, which is used to prioritize patients on their medical conditions. However, the triage system is not fully competent in the department; thus, the priority system is not applied. Also, there should be an experienced staff member in triage to adequately diagnose patients' conditions and send them to the right place. As a result, a defect in the triage system will cause problems and hinder the department work. As a result, triage should be placed in the public areas with the administration counter, where patients can be triaged on arrival after registration and wait for their turn. Not to mention, management role to effectively operate a triage.

The theme "staff" summarises the collected data regarding staff responsibility and their impact on the workflow's efficiency in the IH ED. The following point can be concluded.

A. It was revealed that having ED specialist physicians will ease the work processes and improve the workflow's overall efficiency due to their ability to cover most ED cases. Also, having specialised ED staff will reduce the needed different staff members.

The theme "design considerations" summarise staff and management taken procedures to overcome difficulties in the design that were mentioned in the overarching theme "DE Design Influence" under the code "Design Consideration." The following point can be concluded.

A. To overcome difficulties in the spatial structure and the internal circulation, the large spatial structure; the management hired a porter to help staff with the internal process. Also, the staff mentioned their efforts to accelerate the work rhythm by doing things by themselves. As a result, a proper arrangement for the needed different functions in EDs will reduce workload and the needed time. Thus, some changes have happened as will be mentioned in the next point.
B. To improve the functional distribution in the ED, some changes have happened. For example, a new window was installed next to the accountant to make the pharmacy closer to ED users and reduce their movement. Also, changing the location of the laboratory window to make it easier to access the laboratory and reduce delays. Furthermore, there was no room for staff formal meeting and seminars; therefore, plaster room was converted to become a meeting room and a rest area for staff. Also, management made the formal internal procedures easier for users to reduce their walking distances and accelerate the workflow. Moreover, the staff started to improvise to save themselves time and effort by doing thing personally. As a result, a proper arrangement for the needed different functions in EDs will improve the work process, which will reflect on overcrowding and waiting time.
C. When the department gets crowded, staff become forced to treat patients in an inappropriate location and anywhere available, such as corridors. When the department gets fully occupied, the department stops admitting patients, which increases waiting time and crowding. Furthermore, participants emphasised on some taken procedures to improve workflow, as mentioned previously in this theme. For example, the spatial alteration mentioned in the previous points by Creating new windows for the pharmacy and the laboratory is a solution to make them closer. Also, hiring more staff, as such, porters to help staff with the internal process. Making the formal procedures easier for users to reduce their walking distances, accelerate the workflow and increase patients' satisfaction—Staff personal effort to accelerate the work rhythm. Finally, using new medical equipment to accelerate diagnoses and examination procedures and reduce process time.
D. Privacy is a significant problem in the ED due to the department's mentioned problems. Not to mention, no actions were taken to improve privacy; however, participants proposed some solutions. For example: Having single rooms for patients, or using wall partitions rather than

curtains, which will improve acoustic privacy too. Moreover, Separate movement routes as possible between staff and patients. Management is also responsible for applying a strict system to control the department, including access restriction, which will improve privacy. As a result, private staff areas with private access routes will enhance staff privacy. Second, having single rooms or wall partitions instead of curtains will improve patients' privacy. A proper arrangement for the needed different functions in EDs will improve the work process, which will reflect on privacy.

7.4 Conclusion

Staff in KAUH ED mentioned that the advantage of having a compact ED is the fact that all the needed functions are near each other, which reduces walking distances between the functions. However, having a tight space might be inconvenient in terms of the internal workflow and functional spatial relationships, where complexity increases. To clarify, cross circulations become unavoidable. Also, not all of the needed functions can be placed in the ED, where some services will be placed outside the ED and faraway. On the other hand, staff in the IH ED mentioned that the advantage of having a big ED is the fact that all the necessary functions are included in the department. For instance, it reduces the need to transfer patients outside the ED or the need for other services from different departments. Therefore, it allows the creation of self-contained EDs. However, although having a large space is good in having all the needed functions in the ED, the functions might be scattered in the ED and far away from each other, resulting in a complex layout. Therefore, staff in both EDs were not satisfied in either approach because the current spatial structures are not working in harmony with the complex operational systems, which is hindering the workflow. To emphasise, although the selected ED differ in size, where one is big and the second is relatively compact, staff in both EDs were not satisfied with the spatial structure they have, which is because of the poor distribution of the functions and their spatial relationships. In other words, spaces in both EDs that are functionally connected following the clinical and formal requirements of the various patients' treatment journeys have poor adjacencies and complex spatial relationships to navigate following the operational requirements. Therefore, although including the required functions in the ED is an advantage, they need to be part of the operational circulation to support the workflow.

Staff and management in both cases worked toward some solutions to overcome difficulties regarding the spatial distributions and functions availability. Also, to reduce users' movement and accelerate the processes times. For example, the management tried to ease the formal requirements, which require patients and staff to revisit the registration and accountant desk multiple times during the same treatment journey for financial and administrative purposes. Therefore, they sought to reduce their movement distances by reducing the number of times patients need to move between the different functions to fulfil their formal requirements. Also, they increased staff members by hiring porters to

alleviate pressure on staff for the time consuming and tyring processes and to accelerate the required procedures. Besides, the staff started to improvise and take more responsibilities to accelerate the work rhythm. Staff also elaborated on operational changes to improve the flow and reduce overcrowding and waiting times. For example, there is a need for applying more firm control over users in the selected cases by having access restrictions and more control over their flow. Also, control over the unexpected number of users' coming with the patients is required, which is a significant challenge in the case studies. Also, increase users' awareness of the nature of emergency medicine to avoid any unwanted load. Besides, to accelerate the clinical processes by having specialised staff and physicians to deal with EDs' urgent and various cases.

It can be stated that the spatial relationships between ED diverse functions need to provide the best support for the various activities through an adequate arrangement for the available spaces, which are a significant factor that impacts on the efficiency of the workflow more than the size of the ED as explained in the obtained data above. Therefore, the operational requirements need to be considered early in the design stage to support the delivered healthcare services in EDs. Therefore, EDs functions and their functional spatial relationships need to support EDs complex operational requirements to create a smooth workflow for all users, which might differ in different contexts. Therefore, this can also be elicited from the interviewed staff solution, that a central design (open plan), where they can have all the needed function (exam areas) around and near each other, also, having the main staff station in a central area that is overlooking patients' areas might be the ideal spatial scenario. Therefore, this will reduce the required walking distances, improve patients' observation, reduce the number of required staff and equipment, save time, and accelerate the processes with the least effort to be taken, which will improve the overall workflow.

7.5 Chapter summary

The chapter presents the analysis and findings derived from the interviews conducted with staff in KAUH and the IH EDs, where it produces their perspectives about the influence of the spatial structure on ED operation. The next chapter will discuss and compare the research finding from the preceding chapters to identify the most critical influences on ED design and operation. It will discuss and compare the obtained data from the reviewed literature and design guidelines, designers' interviews, the spatial analysis, the field observation, and the interviews conducted with staff in the selected EDs.

Chapter 8: Discussion and Comparison

8.1 Introduction

This chapter discusses and compares the research findings from the preceding chapters to identify the most critical influences on ED design and operation. It suggests how these influences could be adopted to improve ED design and operation by reducing overcrowding and waiting time.

From the findings of previous chapters, several points can be listed that reflect the intersection of the various methods, which will be categorised under three themes; key elements of ED spatial design; ED spatial structure and clinical process; and designing better ED. These themes are explained below:

8.2 Key elements of ED spatial design

A. The importance of design in EDs

Designers and the reviewed literature and guidelines share the same understanding about the ED work envelope: to receive and provide healthcare services to various patients with various, unforeseen, and urgent medical conditions on 24/7 bases. The design of EDs, therefore, has a significant influence on the quality of the delivered healthcare services to support the overall operation (Codinhoto et al. 2008; Tzortzopoulos et al. 2008; UK Department of Health 2013; Wanigarathna 2014). The next section will briefly summaries the main design goals for EDs.

B. ED main design criteria

To attain good quality healthcare services and to facilitate operational demands in EDs, the design needs to accommodate their various activities by creating efficient environments that support their unique operational demands. Therefore, Huddy and McKay (1996); and the Australasian College for Emergency Medicine (2014), mentioned that EDs design should be practical and supportive for the way patients with different medical conditions are treated. They also mentioned that the design should reflect on the needs of health professionals to manage and provide care for their patients to improve functionality. The design of EDs should be flexible and adaptable due to future changes in emergency care models, which may require changes and relocation of the clinical treatment spaces. Similarly, the interviewed designers stated that the central concept of an ED's design is to engage different users (staff, patient, and visitors) to alleviate their experience by supporting their treatment journey and providing them with timely, fast and smooth healthcare services. The next section will briefly summarise one of the main design considerations that significantly influence the quality of the delivered healthcare services.

C. ED layout and spatial relationships

One of the main design considerations is the layout and their spatial relationships within EDs (Kolb et al. 2008; Tzortzopoulos et al. 2008; Simon and Canacari 2012; Chan et al. 2014; Tawfik et al. 2014; Hayward 2016a; Abdelsamad et al. 2018), which impact on the efficiency of operation, patients' flow, and overall users' experience. Also, insufficient layout with bad spatial relationships is one of the main causes of overcrowding and long waiting times in EDs. Bearing in mind that complex clinical

requirements govern ED workflows and overall circulation. The interviewed designers agree with Lorenz et al. (2015); and Hayward (2016) that to create efficient layouts in the planning stage, it is essential to understand the functional layout and to identify the location of the various required spaces for all users to match the formal organisational structure. Moreover, designers added that it is also essential to know the path of every patient and each existing function during the different treatment processes. To clarify, designers argue that knowing EDs' functions and patients' routes is essential to designing an optimised functional layout for patients from entering to discharge without any delays. Therefore, it can be concluded – similar to Van Der Voordt and Van Wegen (2007) argument – that the spatial structure, needs to provide the best support for the various activities in the facility by having an efficient arrangement for the available spaces, which is explained further in the next sections. The next section summarises ED functions and their functional spatial relationships from the guidelines and designers' perception.

D. ED functions and clinical process

Knowing ED functions is an essential step to aid the design of their layouts and spatial structure. The thesis reviewed international design resources and guidance (Adler 1999; American Institute of Architects (AIA) 2006; UK Department of Health 2013; Australasian College for Emergency Medicine 2014; International Health Facility Guidelines (iHFG) 2017; Tarawneh 2018; Australasian Health Facility Guidelines 2019) to understand ED infrastructure and functions better. The literature provides a similar list of functions to be included in EDs with only minor differences between them. For example, entrances and waiting areas, triage and registration, treatment and exam areas including resuscitation, acute, fast-track, other specialist zones and rooms, support areas, services, and staff areas are among the repeatedly similarly listed functions in the reviewed literature. However, some of the reviewed resources mentioned other functions, such as laboratory, radiology, pharmacy, observation units, operation, and orthopaedic and fracture clinics in EDs. They mentioned that these functions could be included in the EDs or outside, depending on various factors. For example, the total area and available spaces, the locations of the ED, and the assigned budget. However, it is critical to have these functions as part of the circulation to support the workflow and operation. For example, in the studied cases, the location of the laboratory, the radiology, the inpatients, and operation departments do not support the operational requirements in EDs, which is hindering the workflow and is increasing the processes required time. Also, both cases do not have observation units (rooms for short observation when patients are required to stay in the ED for further examination or waiting for admission); therefore, patients keep on occupying their beds in the ED and cause delays in accepting other patients.

Functional spatial relationships are another vital aspect that affects flow and operation. Therefore, ED design guidelines provide the fundamental information that needs to be accommodated in the spatial structure. They also provide basic and limited explanations of the clinical processes and their spatial

relationships to help achieve the main goal of such critical healthcare facilities. However, the UK design guidelines provide more detailed and clear illustration diagrams of different clinical pathways that patients follow in EDs, as explained in the literature review chapter. Nevertheless, these limits in the proposed design guidance in the guidelines to explain the spatial functional relationships are feasible due to the broader populations they are targeting, which create rooms for flexible adaptations. These flexibilities in the design guidelines allowed them to be implemented differently by different designers and in different contexts. These flexibilities also allowed the design to adapt to the various factors that may influence the final product, such as the type of the ED, the available space, the available fund, the required functions, the clinical requirements, the cultural norms, and the context determinants. These flexibilities, also, allowed for future spatial and technical development, especially in the medical equipment area and clinical, operational requirements, which will provide the possibility to adapt to any required changes. Therefore, EDs spatial design needs to be flexible and adaptable due to future changes in emergency care models, which may require changes and relocation of the clinical treatment spaces. The next section summarises staff inputs to explain the functional spatial relationships in EDs lacking in the guidelines.

E. Staff inputs to explain the functional spatial relationships in EDs

Designers mentioned that ED design guidelines are developing in the required spaces and their sizes to accommodate the development in the medical equipment area. Because medical equipment changes continuously, often with new space requirements, such that sometimes-extra spaces are needed for support; therefore, the design requirements change. However, they believe that the provided clinical relationships in the guidelines cannot be changed. Therefore, designers believe that although ED design guidelines do not provide a detailed explanation for the spatial relationships of the various ED functions, they do provide sufficient information to start the design process. For this reason, ED design guidelines are implemented differently by different designers, with varying degrees of success. Some result in a good implementation while others produce an outstanding implementation based on the same design references. Thus, designers rely only on meetings with medical staff to understand the clinical processes and the spatial requirements missing in the guidelines, which is to know the path of every patient and each existing function during the different treatment processes. However, lack of users' involvement (mainly staff) is identified among the reviewed studies, where some of them such as Tawfik et al. (2014) and Abdelsamad et al. (2018), mainly relied on medical planners and expert healthcare designers to understand the clinical requirements and operations. The next section summarises some scholars attempts to improve ED workflow.

8.2.1 Spatial adjacencies and complexity

Adjacency is to distribute the spaces depending on the department's frequent interaction needs, its working spatial relations, and prioritising proximity such as close and closer. On the other hand, the

spatial structure complexity can be defined as the number of spaces a person has to pass through to move between two spaces. Alternatively, the number of turns a person has to take to navigate from a space to another space. Therefore, the reviewed guidance and the literature mentioned that spaces in EDs need to support their operational flow to improve operational productivity and minimise traffic travel distances by incorporating an effective spatial distribution (Neuman 2011; Australasian Health Facility Guidelines 2019; Harrell 2020), which will also result in decreasing departmental fragmentation and costs (Frampton and Guastello 2010).

Similarly, the interviewed designers claimed that they design the spatial structure of ED to suit users' needs and the operational requirements to create a good functional layout with smooth and efficient circulation. Therefore, to support EDs' complex operational requirements and workflow, designers need to have enough data with a critical adaptation of the data to create good spatial adjacencies and reduce spatial complexity. Thus, they mentioned that it is critically important to understand the hierarchy and the process functional relationships, which is done by knowing the different paths and related functions for the different treatment processes that different patients have to take. Therefore, they align the rooms and distribute them depending on their needs, which is the main staff inputs in the design.

The interviewed designers do not use any analytical tools to aid the design process as a pre-occupancy evaluation procedure to understand the spatial relationships. They only rely on drafting software, such as AutoCAD and performing feasibility studies. Moreover, although designers acknowledge the importance of post-occupancy evaluation to identify problems that may hinder work efficiency and to learn and develop their design knowledge, they do not usually conduct such evaluation. However, if they were to conduct a post-occupancy, they may observe and conduct surveys with users to evaluate how the facility works without the use of any analytical tools. Space syntax analysis was used in this study as a syntactic analytical tool to investigate ED spatial relationships.

A. Spatial analysis for the syntactic relationships

The spatial analysis started by identifying the development in the spatial structure, which revealed that significant changes occurred in the spatial structure and the distribution of the functions in the selected EDs between the original designs and the current ones. Therefore, syntactic values were measured afterwards using space syntax tools, AGRAPH and DepthMap, which might be the only available computerise method to analyse the spatial relationships in built environments. Therefore, analysing the various functions in the selected cases before and after modification following occupation revealed minor and not significant differences in the calculations, except for where there were major spatial changes. However, the changes in the spatial structure were major; therefore, these changes may significantly influence the way the selected EDs are operating, which may not be predicted from the syntactic measures. This agrees with Tawfik et al. (2014) in their research to

improve the physical design of an ED in Malta to reduce overcrowding during disaster situations by computerised relationship layout planning (CORELAP) algorithm. They conclude that using the numeric values of the assigned relationships by CORELAP does not adequately represent the relationships between the spaces. Hence, it may not be appropriate in many layout scenarios because it does not adequately represent that one relationship is much more important than the others. Therefore, they argue that the assignment of suitable user values is needed to create a layout that achieves the closeness rating as relevant as possible.

On the other hand, the obtained syntactic values, such as control, integration, and connectivity do not provide data regarding spaces functional relationships to support the workflow in the selected EDs, which is due to their complex operational requirements, where spaces are linked together depending on their operation rather than their permeability. On the other hand, these values can provide valuable data to aid the design process in assigning suitable functions for each space or distributing spaces in the layout depending on their properties and physical connection, which to design for close spatial adjacencies to reduce layout complexity.

8.2.2 EDs functional spatial relationships

Designers mentioned that ED design guidelines provide enough data to start the design process. Therefore, there is a similarity between designers' perceptions and what is mentioned in the literature and the guidelines regarding EDs clinical functions and their spatial relationships. However, designers stated that the functional relationships and operation are missing in the design guidance; therefore, they collected these data from staff to design the spatial structure. Moreover, another considerable challenge is having enough space, which might be the main physical constraint they face to achieve the ideal spatial adjacencies and functional distribution in EDs.

Moreover, after comparing the collected data from designers and the literature regarding the location of ED main clinical functions with the current designs of the selected cases, certain discrepancies were identified. For example, the following are from the data obtained from designers, literature, and the design guidance for the main clinical functions in EDs compared with the result from the spatial analysis and staff preferences:

1. **Entrances:** EDs should have 24/7 private separated entrances for walk-in and ambulance patients with no cross circulation, and that is not shared with any other departments. The ambulance entrance should also offer a fast, direct, and private route to the related functions due to the criticality of patients' conditions, such as resuscitation and minor operation. Besides, a parking slot for ambulances near the ambulance entrance is also required. Table 31 summarises the current spatial settings in both EDs in KAUH and the IH compared with staff comments.

Table 31: Current spatial analysis of both EDs in KAUH and the IH compared with staff comments (Entrances)

Current spatial analysis of both EDs in KAUH and the IH	Staff comments
- Both cases have one street entrance for walk-in and ambulance patients. - Both cases have their indoor gate of the ED far from the public functions and the street entrance. - In KAUH EDs, the street entrance is shared with other departments; therefore, many turns need to be taken after the entrance to reach the ED inner gate. - In the IH ED, the entrance is only for the ED; however, it is used as a walk-through to reach the operational department and the main street.	The entrance should be clear and easily accessible and seen from outside to reduce confusion among users. Also, it should be visible from the inside to see coming patients.

2. **Public services:** designers and the guidelines have a similar perception on the location of the reception to be near the entrance and overlooking the waiting area and triage room, also, they need to lead directly to the assessment and treatment area. Besides, the waiting area should have adequate public services, such as toilets, stretchers, and wheelchair parks. Designers also mentioned other functions in the Jordanian context that need to around the reception and the waiting area, such as accountant, medical records, and a security office. Table 32 summarises the current spatial settings in both EDs in KAUH and the IH compared with staff comments.

Table 32: Current spatial analysis of both EDs in KAUH and the IH compared with staff comments (Public services)

Current spatial analysis of both EDs in KAUH and the IH	Staff comments
In both cases, the public services' location lacks spatial connectivity, which increases the flow complexity. For example: In KAUH ED, the functions are as follow: - Triage: is far away and hidden from the entrance, which also requires multiple turns to be reached. - The main waiting area is far (placed in a different section) and not connected to the ED. - Registration, accountant, and the pharmacy are overlooking the main waiting area, far and not connected to the ED. - The two waiting areas in the corridor leading to the radiology dept are hindering the workflow. In the IH ED, the functions are as follow: - Triage is very far from the exam areas.	KAUH Staff: - Triage: should be near the entrance and easily seen. All the support services (registration, accountant, admission, waiting lounge, and the pharmacy) should around triage to support patients flow following the formal requirements. - The main waiting area is causing people no to use it, where they start coming to the ED and near the exam areas because it is far. - Because people start coming in the ED, the management created the two waiting areas in the corridor leading to the radiology dept, hindering the flow and causing overcrowding.

- The waiting area is far from the registration and accountant, which is also far from the exam areas. - Registration and accountant are in front of the main entrance	The IH Staff: - The location of these services does not support the operational requirements, which as causing more walking load on all users.

3. **Resuscitation and minor operation:** they must be close to the ED entrance (ambulance entrance) with direct and restricted access points, and high privacy levels away from the waiting area. The resuscitation area should also be close to the assessment and treatment rooms with direct access for rapid patient transfer. Besides, there should be separate movement routes for walk-in and ambulance patients with no cross-circulation. Table 33 summarises the current spatial settings in both EDs in KAUH and the IH compared with staff comments.

Table 33: Current spatial analysis of both EDs in KAUH and the IH compared with staff comments (Resuscitation and minor operation)

Current spatial analysis of both EDs in KAUH and the IH	**Staff comments**
In KAUH ED, resuscitation and minor operation are as follow: - The resuscitation is the first clinical function in the ED after triage. However, it has a complex relationship with the street entrance. - The minor operation is in the middle of the ED, in the corridors leading to the radiology dept, which is far and complex to reach. Besides, there are two waiting areas in these corridors. In the IH ED, the resuscitation and minor operation are as follow: - They are located in the middle of the ED, which requires users to walk more and navigate through many other spaces, such as all public areas and radiology to be reached. Therefore, they are far and complex to reach.	- The resuscitation room needs to be the nearest to the ED entrance for being a life-saving function more than it is workload.

4. **The exam and treatment areas**: or the rapid assessment and treatment facilities as named in the UK guidance, are for patients' assessment and treatment. These rooms can be used for the ambulance and walk-in patients with minor injuries and illnesses, and others with major injuries and illnesses. Moreover, some of these rooms can be used for patients with ear, nose, throat, ophthalmic, dental problems, pediatric, alcoholic, and drug patients. Besides, some of these rooms can be used as a plaster room and a minor operation theatre. These areas also need to have accessible toilets, dirty and clean utilities, and stores for clinical equipment. Moreover, these facilities can be in an open space area surrounded by different cubicles, where all cubicles should lead to a central working area equipped with a supplies station.

   Furthermore, designers mentioned that these rooms need to be located away from people sight with restrict access and cannot be reached unless patients pass triage. Therefore, they should be

placed after triage and near the entrance for easy assessment on arrival. Table 34 summarises the current spatial settings in both EDs in KAUH and the IH compared with staff comments.

Table 34: Current spatial analysis of both EDs in KAUH and the IH compared with staff comments (The exam and treatment areas)

Current spatial analysis of both EDs in KAUH and the IH	Staff comments
In both EDs, exam and treatment areas are scattered in the ED and far away from the public areas, triage, and the entrance. For example: - In KAUH ED, there are three separate exam areas for internal, surgical and pediatric cases. - In KAUH, the Eye and Ear clinics are located in the middle of the ED. - In the IH ED, the exam areas are divided between male, female and pediatric rooms, where each type of patients have their exam rooms. For example, there are two exam areas for male patients and two for female patients. Moreover, the pediatric section is located at the end of the ED, far and not connected to the rest of the department. Therefore, the spatial complexity increases	- All the exam and treatment areas need to be grouped in one big space (multidisciplinary rooms) overlooking the staff station. Also, they should be closer to the entrance of the ED due to their frequent use. - In KAUH, the Eye and Ear clinics do not follow the ED priority system (Triage); therefore, they hinder the workflow and causing overcrowding.

5. **The ED relationships with other hospital departments, such as the radiology, the operation and laboratory,** are essential due to the ED critical work environment. Designers added that this is because patients sometimes need these support services earlier in their treatment journey depending on their condition, which what the interviewed staff also mentioned. Therefore, they can be placed in the ED and arranged to serve patients' unpredicted needs concerning their relationships with the other functions. On the other hand, they can be placed outside the ED with fast and smooth access to reduce any delays in movement, therefore, in this case, a fast communication system is required between the ED and these functions. Thus, having these functions as part of the ED internal circulation to support the clinical process's requirements may influence the ED workflow and operation. Table 35 summarises the current spatial settings in both EDs in KAUH and the IH compared with staff comments.

Table 35: Current spatial analysis of both EDs in KAUH and the IH compared with staff comments (the radiology, the operation and laboratory)

Current spatial analysis of both EDs in KAUH and the IH	Staff comments
In KAUH ED, operation, radiology, and laboratory are as follow: - The operational dept is located far from the ED with many turns to be taken and spaces to be passed to be reached.	**The laboratory is one of the main used functions in EDs, thus:** - Due to not having a laboratory for the ED in KAUH, the staff mentioned the need to

- Radiology dept is very close with direct access to the ED. However, two waiting areas were created in the corridors leading to the radiology dept, which hindered the flow. - There is no dedicated laboratory for the ED; therefore, samples are being physically sent to the hospital central laboratory, which is extra walking load, tiring, and increasing the processes time. **In the IH ED, operation, radiology, and laboratory are as follow:** - The operational dept is on the floors above the ED with direct and easy access. - The ED has its radiology section, including X-Ray, CT-Scan, ultrasound and the needed support functions. However, all rooms are located between the public areas and the exam areas, hindering the flow. - The ED has its laboratory, which is an advantage; however, it is located at the far end of the ED. Also, samples are being physically transferred, which is tiring and increases the processes time.	have a dedicated laboratory for the ED, which will reduce walking distances and fasted the processing time. - Staff in the IH ED mentioned the need to have a system to transport the samples and receive the results without physically sending the samples, which will reduce walking distances and fast the processing time. The radiology dept: - Staff in KAUH liked having the radiology dept near, to save time and effort. - Staff in the IH mentioned that the location of the radiology section in the ED is increasing the spatial complexity. It is also hindering the workflow; therefore, it needs to be by the end of the ED.

6. **Short observation rooms**: or clinical decision units (CDU) named in the UK guidance, are used after the assessment and treatment phase, where patients might be kept in the department for further assessment and treatment before they are transferred or discharged. However, an observation area might be hard to preserve due to the high demand for beds in EDs. Table 36 summarises the current spatial settings in both EDs in KAUH and the IH compared with staff comments.

Table 36: Current spatial analysis of both EDs in KAUH and the IH compared with staff comments (Short observation rooms)

Current spatial analysis of both EDs in KAUH and the IH	Staff comments
Both cases do not have observation rooms.	These rooms are essential to reduce the pressure on ED's beds, which will reduce overcrowding and waiting times. Because not having a short stay room will result in patients keeping on occupying beds in the ED that are needed for other patients.

A. Design and management influence on ED's operations

Designers claim that when they have a good size space, they will place all the required functions in their designated locations to support users' needs, including public services. Also, they will create efficient and clear movement routes with no cross circulations. This should help users to flow through the ED functions smoothly. Therefore, achieving this will generate a good design that serves its purpose. However, the design has limits to provide services to a specific number of users, where exceeding these limits will cause overcrowding and long waiting times. Therefore, it becomes the management responsibility to have good operational control over the ED rather than a design deficiency. For example, the social norms in the Jordanian context, such as the number of people who may come with the patients, are among the main reasons for overcrowding. Therefore, having people that exceed the ED holding capacity without proper control will cause overcrowding. Moreover, designers believe that it is also the management responsibility to have specialised ED physicians to reduce any delays due to the lack of experienced staff. Also, having all the needed staff and specialists to answer ED urgent calls, even if they were placed outside the ED, as long as fast communication instruments exist.

On the other hand, the staff mentioned that the spatial structure of their ED does not support their operational requirements. To emphasise, although the selected ED differ in size, where one is big and the second is relatively compact, staff in both EDs were not satisfied with the spatial structure they have. This is because of the poor distribution of the functions and their spatial relationships, as mentioned earlier. In other words, the current spatial structure in the two EDs has inefficient space adjacencies and more complex spatial relationships to navigate following the operational requirements. Therefore, the current spatial structures do not work in harmony with the complex operational systems, hindering the workflow. For example:

Staff in KAUH ED mentioned that the advantage of having a compact ED is the fact that all the needed functions are near each other, which reduces walking distances between the functions. However, having a tight space might be inconvenient in terms of the internal workflow and functional spatial relationships, where complexity increases. To clarify, cross circulations become unavoidable. Also, not all of the needed functions can be placed in the ED, where some services will be placed outside the ED and faraway. On the other hand, staff in the IH ED mentioned that the advantage of having a big ED is the fact that all the necessary functions are included in the department. For instance, it reduces the need to transfer patients outside the ED or the need for other services from different departments. Therefore, it allows the creation of self-contained EDs. However, although having a large space is good in term of having all the needed functions in the ED, the functions might be scattered in the ED and far away from each other, resulting in a complex layout.

To emphasise, the location and the spatial relationships of the entrances and access points, the logistic services (registration, administration, and accountant), triage, the waiting areas, and the exam areas in the selected cases, do not support their operational requirements. To clarify, patients must move between these functions' multiple times as part of the circulation of their treatment journey; therefore, they are forces to take many turns and pass other spaces to fulfil the formal operational requirements. Moreover, the location of the mentioned function and other clinical functions, such as the exam areas, the laboratory, the radiology, minor operation, resuscitation, and the inpatients' dept have complex spatial relationships. To clarify, the staff has to navigate between these functions as part of the clinical requirements depending on the patients' condition and the needs of their treatment journey. For instance, the location of the laboratory in KAUH not being in the ED, where staff have to navigate through the entire ED to get to the laboratory, which is located in the main hospital building, to send the samples. Patients are sometimes required to revisit the registration, accountant, and the waiting areas before and after they are admitted for formal or financial demands following their treatment requirements. Therefore, the reception area in the IH and the entrance hall in KAUH, become overcrowded due to the number of users moving in and through these areas.

The arrangement of the functions and their spatial relationships are causing non-staff users not to use certain functions and behave in ways that may better suit their needs. For instance, patients and visitors do not tend to stay in the waiting areas because they are far from and not connected to the ED. Therefore, they come closer to the ED's inner gates and the examination areas when possible. Also, non-staff users' behaviours are causing an extra burden on the ED. For example, users' lack of awareness regarding emergency medicine, where people may come to the ED for reasons that are not urgent. Also, the number of people coming with the patient, which may reach ten people or more. Besides, due to not having access restrictions on the entrances in both cases and these areas being connected to other non-ED functions, non-ED users pass by these areas to reach other areas in the hospital. Therefore, such behaviours are causing more load on the ED that could have been avoided.

To conclude, staff dissatisfaction in either approach is because spaces in their EDs that are functionally connected following the clinical and formal requirements of the various patients' treatment journeys have poor adjacencies and complex spatial relationships. Although including the required functions in the ED is an advantage, they need to be part of the operational circulation to support the workflow. Therefore, the current spatial structure and the distribution of the functions in both EDs is hindering the departmental workflow. For example, it requires more walking for all user moving between the functions to attain the formal requirements of the internal procedures, which in turn are causing a delay in the processes times and are physically tiring. They are causing other problems too, such as confusion among patients and visitors following the flow of their treatment journey, increase in the

procedures and waiting times, overcrowding in certain areas, long waiting time for patients waiting to be seen, and a reduction in satisfaction among all users especially patients and staff.

B. Staff proposed solutions

Staff in both cases mentioned that a central design (open plan), where they can have all the needed function (exam areas) around and near each other, also, having the main staff station in a central area that is overlooking patients' areas might be the ideal spatial scenario. Therefore, this will reduce the required walking distances, improve patients' observation, reduce the number of required staff and equipment, save time, and accelerate the processes with the least effort to be taken. This solution is already what the design guidelines are proposing, as mentioned earlier. For example, it was mentioned in the guidance that exam rooms could be used by ambulance and walk-in patients with minor injuries and illnesses and other patients with major injuries and illnesses. Therefore, these facilities can be in an open space area surrounded by different cubicles, where all cubicles should lead to a central working area equipped with a supplies station. These cubicles can also hold various functions that suit patients' various medical conditions, such as for patients with ear, nose, throat, ophthalmic, dental problems, pediatric cases, and alcoholic and drug patients. Some of these rooms can be used as a plaster room and a minor operation theatre. Staff and the design guidance agreed on the importance of having ED support services, such as laboratory, radiology, operation, and inpatient dept part of the ED circulation with fast, easy and clear access points.

Staff also elaborated on operational changes to improve the flow and reduce overcrowding and waiting times. For example, there is a need for applying more firm control over users in the selected cases by having access restrictions and more control over their flow. Also, control over the unexpected number of users' coming with the patients is required, which is a significant challenge in the context of the case studies. Also, increase users' awareness of the nature of emergency medicine to avoid any unwanted load. Besides, to accelerate the clinical processes by having specialised staff and physicians to deal with EDs' urgent and various cases.

Staff and management worked toward some solutions to reduce users' movement and accelerate the processes times. For example, the management tried to ease the formal requirements, which require patients and staff to revisit the registration and accountant desk multiple times during the same treatment journey for financial and administrative purposes. Therefore, they sought to reduce the number of times patients need to move between the different functions to fulfil their formal requirements. Also, they hired porters to alleviate pressure on staff for the time consuming and tyring processes and to accelerate the required procedures.

To conclude, the researcher agrees with Van Der Voordt and Van Wegen (2007) argument that the spatial structure of the different functions in a building needs to provide the best support for the

various activities through an adequate arrangement for the available spaces. Therefore, it can be stated that the spatial relationships between ED diverse functions are a significant factor that impacts on the efficiency of the workflow more than the size of the ED, which is evident from the obtained data above. Thus, inefficient spatial structure and poor relationships between the organisational demands and arrangement of functions in healthcare facilities can cause various challenges, as mentioned earlier. Hence, Huddy and McKay (1996); UK Department of Health (2013); and Australasian College for Emergency Medicine (2014) stated that the operational requirements need to be considered early in the design stage to support the delivered healthcare services in EDs. Therefore, EDs functions and their functional spatial relationships need to support EDs complex operational requirements to create a smooth workflow for all users, which might differ in different contexts. This research argues that the clinical process should govern spatial relationships. Therefore, following these clinical processes will help identify weaknesses that need to be improved.

8.3 ED spatial structure and clinical process

EDs have unique operational workflows and clinical requirements. EDs provide urgent healthcare services to a variety of patients with a variety of unpredicted medical conditions. These medical conditions require different treatment procedures that use different functions and follow different clinical pathways from arrival until the patient is admitted, referred, or discharged. Therefore, Patients and staff following the different treatment journeys in EDs must stop and move between key locations depending on the process in hand. As a result, the spatial structure needs to help the user to navigate through the ED following their treatment journey and clinical requirements.

To better understand the clinical procedures and their spatial performance, the actual movement routines of various users (doctors, nurses, and patients) following the exam and treatment procedures were tracked, recorded and described (see chapter seven: staff interview analysis), which are the most common medical conditions in the selected cases.

8.3.1 The clinical process in the selected cases.

After analysing the workflow of the most common medical conditions that both KAUH ED and the IH ED receive**, the classifications of patients' medical conditions are slightly different in the selected EDs**, which is governed by the hospital polices. Therefore, the available clinical functions are slightly different, to suit the medical classifications in each ED. For example:

in KAUH ED, the most common medical conditions described by staff are classified as stable and unstable cases. These cases are described as follow:

1. Stable cases: these cases do not require immediate medical intervention; therefore, patients will follow the normal procedures and be treated in the internal, surgical, or pediatric rooms depending on the patients and their medical conditions.

- Internal medicine cases can be, for instance, thoracic, neuro medicine, cardiac, nephron. They could also be cold cases, such as flue, chest infection, coughing, shortening of breath, and headache.
- Surgical cases can be, for instance, orthopaedics, urology, neurosurgeon, and fractures.
- Pediatric cases cover all children's medical conditions.

2. Unstable cases: these cases will require immediate medical intervention; therefore, patients will be taken directly to the minor operation room or the resuscitation room.
    - These cases can be, for instance, all ambulance cases, trauma cases in general, falling down cases, car accident, cutting wounds, broken bones, and anything that may be caused by a falling-down.
3. Also, KAUH ED receives ophthalmology and dental cases, which all have separate exam rooms in the ED. However, although these clinics are placed in the middle of the ED, they do not follow the triage system, where they have their admission system apart from the ED.

In the IH ED, the most common patients' medical conditions, as described by staff, are classified as Internal (Medical), surgical, and critical cases. These cases are described as follow:

1. Internal (Medical) cases: these cases do not require immediate medical intervention; therefore, patients will follow the normal procedures and be treated in the exam rooms.
    - These cases can be, for instance, flu, headache, abdominal pain, or any other similar cases that share the same treatment.
2. Surgical cases: these cases also do not require immediate medical intervention; therefore, patients will be following the normal procedures and be treated in the exam rooms or the minor operation room.
    - These cases can be, for instance, patients who are wounded or having a fracture or any other similar cases that share the same treatment.
3. Critical cases: these cases will require immediate medical intervention; therefore, patients will be taken directly to the resuscitation room.
    - These cases can be, for instance, Patients who are having life-threatening conditions.
4. The IH ED also receives obstetrics ology/gynaecology, paediatrics, ophthalmology, and dental cases, which all have separate exam areas in the ED.

Therefore, although the medical conditions are categorised and explained differently by staff in KAUH ED and the IH ED, they have almost the same clinical processes. For example, in KAUH ED, internal (medical) and surgical cases are categorised as stable cases. They almost require the same clinical processes; however, they are examined and treated in two separate rooms. Similarly, although internal

(medical) and surgical cases are separately explained in the IH ED, they also require almost the same clinical processes. However, what is different in the IH ED is that these two cases are examined and treated in the same exam rooms unless the patients required the minor operation room due to requiring specific equipment to deal with wounds and fractures. In contrast, in KAUH ED, wounded or fractured cases are categorised as critical cases rather than surgical cases in the IH ED, where they will also be treated in the minor operation room.

Comparatively, the same can be said about the critical cases in both EDs. For example, in KAUH, critical cases will be taken directly to the resuscitation, or the minor operation room depending on the patients' medical condition where, as mentioned, wounded, or fractured cases will be sent to the minor operation rooms, while life-threatening conditions will be taken to the resuscitation room. Similarly, in the IH ED, critical cases are taken directly to the resuscitation room, where all the needed procedures will be performed. Therefore, what is different in the IH ED is that wounded or fractured cases are categorised as surgical rather than critical as in KAUH ED.

8.3.2 Users' clinical journeys and their functional relationships

After analysing the recorded data above, it was revealed that the investigated users' categories (patients, nurses and doctors) almost follow a specific, predefined, and controlled movement journeys following the operational requirements in each ED for the investigated medical conditions. Unless urgent and unpredicted procedures may become required based on patients' complications. Therefore, their movement journeys following the medical requirements are as follow:

A. **Patients:** The selected EDs usually receive two different types of patients that use the ED differently. First, walk-in patients, who are usually come on food with no critical medical conditions. Second, ambulance patients, who are usually come by ambulance and have critical medical conditions. Therefore, their movement journeys can be divided into three phases:
    1. **Before admission:** in this stage, patients are required to follow the formal operational requirements, which include registration and triage. Therefore, patients will be navigating between the entrance, registration, accountant, admission, triage and waiting area, which all preadmission requirements. Therefore, they will go through the following:
        I. Before admission, walk-in patients will navigate through the ED as follow:
            1. The street entrance of the ED.
            2. The registration and accountant counter (in KAUH, patients will have to visit triage first for an initial assessment, then to the registration and accountant).
            3. Triage to assess patients' condition and assign priority (in KAUH, patients will have to go to the admission counter first to present their medical file then they will be directed to triage).

4. The waiting area, which patients will be waiting for admission.

II. Before admission ambulance patients do not require preadmission procedures, where they will be sent directly to the resuscitation room or minor operation.

2. **After admission:** in this stage, patients are admitted in the ED; therefore, they will be following the clinical requirements for their treatment journeys. Thus, patients will be navigating between the exam rooms, minor operation rooms, resuscitation rooms, radiology, and the inpatients' dept. Therefore, they will go through the following:

I. After admission, walk-in patients will move from the waiting area, where they will navigate through the ED as follow:

1. The intended exam room, which decided depending on the patients' medical condition. For example, non-critical cases will be sent to the internal, surgical, or minor operation rooms in KAUH, while in the IH, they will be sent to the exam or minor operation rooms.
2. Radiology if needed.
3. Back to the room where the patient was.
4. In this stage, patients will usually face four different scenarios; transferred to other exam rooms, transferred to the inpatients' dept, kept for observation, or released.

II. After admission ambulance patients are sent directly from the entrance to the resuscitation or minor operation room depending on the patient's conditions and needs; after this, they may navigate through the ED as follow:

1. Patients in this stage might be kept in the resuscitation or minor operation, or they might be transferred to the needed section in the hospital depending on the case's criticality.
2. Radiology if needed.
3. Back to the room where the patient was.
4. In this stage, patients will usually face four different scenarios; transferred to other exam rooms, transferred to the inpatients' dept, kept for observation, or released.

3. **Released patients:** in this stage, patients would have finished their treatment requirements; therefore, they will follow the discharge procedures. Thus, patients will be navigating between registration, accountant, pharmacy, and the ED exist. Therefore, they will go through the following:

I. Both released ambulance and walk-in patients may navigate through the ED as follow:

1. Back to the registration and accountant counter
2. The ED pharmacy if needed.

3. Exits from the same entrance.

As a result, walk-in patients have relatively long journey between the required functions for their treatment. Moreover, before they are admitted in the ED, they will have to self-navigate between the entrance, registration, accountant, triage, the waiting area and the exam areas. On the other hand, their movement will be controlled by the medical staff after they are admitted. They will mainly be moved between the exam areas, radiology, and the inpatients' dept depending on their medical requirements. Finally, they will have to self-navigate again once their examination and treatment finish, where they will be moving between the exam area, registration, accountant and the ED exit.

B. **Nurses:** Nurses main duties are to support patients' various treatment journeys, including their clinical requirements; therefore, they navigate through the entire ED moving between all the available functions in the ED. However, their movements are sometimes controlled by following repetitive processes to attain patients' clinical requirements. For example, nurses have to navigate between the entrance and public areas, the exam areas (exam, minor operation, and resuscitation rooms), the nurse station, the drug store, and doctors' offices. Also, they may be required to take samples and results to and from the laboratory. Besides, they may be required to transfer patients to the radiology, inpatients, and between the exam areas (more detailed explanation of nurses' movement are in chapter seven: staff interview analysis). Therefore, nurses have the lengthiest movement routes in the selected EDs to fulfil the medical procedures' requirements. They may also be spending most of their time in the corridors moving between the ED different spaces.

C. **Doctors:** Doctors main duties are to examine patients in the intended rooms (where the patients are places). Therefore, their movement journeys are not significantly affected by the clinical processes, where they may mainly navigate between their offices/stations and the exam areas. Thus, doctors might be having the shortest movement routes in the selected EDs to fulfil the requirements of the medical procedures. They may also be spending most of their time in their offices/stations and with the patients.

In conclusion, the arrangement of the functions in the selected EDs does not work in harmony with the flow of the formal and clinical process, which increase the walking load and the processes time. To emphasise, in the selected EDs, many of the functionally connected spaces following the sequence of the formal and clinical processes are spatially disconnected and far from each other.

For example, the front-of-house functions, such as the entrance, registration, accountant, triage, and waiting area, are spatially disconnected. Their arrangement and spatial relationships do not support the workflow in the ED. However, they are part of the patients' movement sequence. Also, they are disconnected and far from the exam areas. However, these functions are mainly affecting patients as

the main user of these spaces. In addition, some of the main life-saving functions, such as resuscitation rooms and minor operation theatres have a complicated spatial relationship with the main entrance of the ED. Also, ambulance patients, whom their life may depend on their fast and smooth access to these functions, share the same complex movement path with the walk-in patients.

Moreover, the EDs spatial relationship with the main support services, such as the laboratory, radiology, and inpatient and operation dept, is another critical issue. For example, although the laboratory is one of the most used services in the KAUH ED, the ED does not have a laboratory, where samples are being sent to the main hospital laboratory. Also, the radiology section in the IH ED is located in at the beginning of the ED, which is hindering the operational flow and access to the male exam areas, such as the resuscitation, minor operation, and exam room for being located between the public services and the exam areas. Besides, in the IH ED, the radiology section has complex spatial relationships with the female and pediatric section.

Functions need to be arranged to suit medical requirements and considerations, which will improve the workflow, reduce processing time, reduce staff and patients' walking distances between the functions, and increase satisfaction among all users. On the other hand, the spatial structure in the selected EDs might have over-defined boundaries by having closed and specialised rooms. Thus, in light of this research, this might be a disadvantage due to the limits it imposes on current adaptation and future changes. Therefore, the operational requirements are forced to adapt to the spatial structure. Besides, future technological development, which requires spatial changes, also, changes in the clinical processes, will become hard to implement in a rigid spatial structure. Hence, flexibility in the spatial structure design should be allowed, which will provide the possibility to adapt to any required changes, which will be explained in the next section.

8.4 Designing better ED

Although the literature and design guidelines do not provide a detailed explanation for the clinical spatial relationships of the various ED functions, they provide sufficient information to start the design process, which is what architects also believe. The guidelines provide the fundamental information that needs to be implemented in the spatial structure to help achieve the main goal of such critical healthcare facilities. Therefore, they are implemented differently by different designers, which is feasible due to the broader populations the design guidelines are targeting. They are also implemented differently due to the many factors that may influence the final product, such as the type of the ED, the available space, the available fund, the required functions, the clinical requirements, the cultural norms, and the context determinants.

Following are some of the main basic requirements that the design of EDs should accommodate according to the collected data from the interviewed designers, literature, and the design guidelines, which are critical to have to support the operational workflow.

1. EDs should have dedicated 24/7 private separated entrances for walk-in and ambulance patients with separate movement routes and no cross circulation. The entrances should not be shared with any other departments. The ambulance entrance should offer a fast, direct, and private route to the related functions due to the criticality of patients' conditions, such as resuscitation and minor operation. A parking slot for ambulances near the ambulance entrance is also required. However, in the selected cases, the entrances lack privacy and are used to access other department and functions. Also, ambulance and walk-in patients share the same entrance, where cross-circulation and overcrowding become inevitable.
2. EDs before admission functions (front-of-house), such as registration, accountant, triage, and the waiting area (lobby) should be near each other and spatially connected (overlooking the waiting area). They also should be provided with adequate public services, such as toilets, stretchers, and wheelchair parks, and should lead directly to the assessment and treatment areas. However, in the selected cases, although these functions are functionally connected following the formal requirements of the various patients' treatment journeys, they have poor spatial relationships, which increase the spatial complexity. These functions also have complex spatial relationships with the examination areas; therefore, confusion, overcrowding, and misuse occur.
3. EDs critical functions, such as the resuscitation and minor operation rooms, must be close to the ED entrance (ambulance entrance) with direct and restricted access points and high privacy levels away from the waiting area. This is to secure fast and smooth movement routes, which is due to their criticality in saving lives. They also should be close to the assessment and treatment rooms with direct access for rapid patient transfer. However, in the selected cases, these rooms are placed far away from the entrance with complex spatial relationships to be reached. They are also far and not connected to the examination areas.
4. The exam rooms can be used for the ambulance and walk-in patients with minor injuries and illnesses, and others with major ones. Some of these rooms can be used for patients with ear, nose, throat, ophthalmic, dental problems, pediatric, alcoholic, and drug patients. Others can be used as a plaster room and a minor operation theatre. These areas need to have accessible toilets, dirty and clean utilities, and stores for clinical equipment. These facilities can also be in an open space area surrounded by different cubicles, where all cubicles should lead to a central working area equipped with a supplies station. However, in the selected cases, the exam rooms are strictly functionally and spatially defined, where future changes and adaptation

become hard. They also lack visual connectivity with staff stations, which may cause medical complications among patients. Besides, in the selected cases, the exam areas and far away from the main entrance, the waiting areas, the front-of-house functions, and the public services.

5. ED spatial relationships with other main related departments, such as the radiology, the operation, and the laboratory, are critically important due to their continuous need as part of patients' treatment requirements, which significantly influence ED workflow and operation. Therefore, they can be placed in the ED and arranged to best serve patients' unpredicted needs concerning their relationships with the other functions. Or they can be placed outside the ED with fast and smooth access to reduce any delays in movement. However, in the selected cases, their locations do not work in harmony with the workflow. Thus, they are hindering the overall operational flow—for instance, the location of the laboratory in KAUH, and the radiology in the IH.

Therefore, although these functions are critically important to be included in the ED circulation, the spatial structure of the two selected EDs in Jordan lacks even these basic requirements. Thus, this research agrees with the interviewed designers that the design guidelines provide enough data to start the design process, where they all almost offer the same fundamental spatial requirements. However, the UK design guidelines provide more detailed and clear illustration diagrams of different clinical pathways patients follow in EDs. Moreover, because these guidelines target broader populations, they lack comprehensive explanations of the functional spatial relationships, which may vary in different contexts and different types of EDs. Therefore, the operational requirements, which may vary in different contexts, need to be considered early in the design stage as a main part of the design process to support the delivered healthcare services in EDs. Consequently, EDs functions and their functional spatial relationships need to support EDs complex operational requirements, such as the clinical process, to create a smooth workflow circulation for all users, which can be achieved by creating good functional adjacencies and reduced spatial complexity.

As a result, due to the rapid development in technology and population demands, healthcare facilities have to support these changes and yet more to come. Therefore, the design of healthcare facilities has to evolve too by adopting new design strategies. Codesigning is a promising approach to engage different stakeholders in all stages of the design process in comprehensive and structured ways to produce a design that can cater to its various users' various demands. Stakeholders and end-user involvement in the design process can be done using various methods, such as behavioural mapping, journeys mapping, in-depth interviews, focus groups, and observations to make full and comprehensive use of their knowledge and experiences, and design requirements. Thus, the design would improve the overall operation by enhancing the workflow, reducing processing time, reducing

staff and patients' walking distances between the functions, and increasing satisfaction among all users.

To have a better ED operation, it is also essential to acknowledge the design limits to provide services to a specific number of users, where exceeding these limits will cause problems – as mentioned before in the thesis, which will lead to overcrowding and long waiting times. It is also essential to acknowledge that it might be insufficient to change the design to suit some of the cultural norms, such as having extra/bigger waiting areas to accommodate the great number of companions that may come with the patients as in the investigated cases. In the Jordanian context, as an example, the social norms, such as the number of people that may come with the patients, are among the main reasons for overcrowding, which may exceed ten people as mentioned by the interviewed staff. Having this number or similar with each patient will cause extra burdens on the ED and hinder the workflow. However, the researcher agrees with the interviewed designers and the mentioned functional requirements in the design guidelines: to have a waiting area with all the needed services to accommodate users' basic needs. Because dedicating extra spaces for the visitor will never be a satisfactory solution, the number of visitors may never be consistent. Even so, the extra dedicated spaces will never be enough when the number increases. Also, in EDs, extra spaces might be much more needed for clinical functions, such as short observation areas, which are still hard to preserve, as mentioned in the literature. Therefore, for the moment, achieving a good design that services its purpose should be followed with good operational control to support healthcare delivery. For example, problems that may be caused by the cultural norms may become the management responsibility to handle rather than a design deficiency. It is also the management responsibility to have specialised ED physicians to reduce any delays due to the lack of experienced staff. Also, having all the needed staff and specialists to answer ED urgent calls, even if they were placed outside the ED, as long as fast communication instruments exist.

Chapter 9: Conclusion and Recommendations

9.1 Introduction

This research begins by exploring potential problems in Emergency Departments (EDs) in hospitals. Overcrowding and long waiting times were identified as major problems after reviewing the literature. This is the first study that has explored the spatial relationships of ED functions and their influence on operations and activities in EDs to the researcher's best knowledge. Therefore, this thesis aimed to provide evidence and a better understanding of ED functional spatial relationships and how the layout facilitates or hinder users' flow to reduce overcrowding and waiting times. This research is based on a detailed study of two selected EDs in Jordan using four main methods. The research questions were as follows:

- "What influence does spatial structure have on the operation of EDs?"
- "How can spatial structure improve workflow and reduce overcrowding and waiting times in EDs?"

9.2 Research objectives and adopted methods

This research sought to achieve five objectives, as shown in Table 37, to answer the research questions. To achieve these objectives, because they addressed different phenomena, different methods, and techniques for collecting and analysing the data were reviewed. A pragmatic (Mixed-Method) approach was adopted, which allows the use of both qualitative and quantitative techniques to achieve the research objectives.

Table 37: Research objectives and methods

	Research Objectives	**Research Methods**
1	To explore ED spatial design in the literature and design guidance	Literature search
2	To explore actual designers' approaches to ED spatial design	Interviews with designers
3	To investigate ED spatial relationships	Spatial analysis
4	To investigate the influence of the spatial structure on ED operation: - How EDs are being used and functioning - Why EDs are being used the way users uses them	Field observation Interviews with EDs' staff
5	To compare the findings from the previous four objectives to develop a better understanding of how EDs should be designed to support their operations	Review and analysis

9.3 Objective One (Literature Review Chapter)

This phase started by collecting necessary information about healthcare design in general and the influence of the spatial structure of EDs on their operations and activities. The review explored available design guidelines and literature to understand ED design, spatial relationships, functions, and clinical pathways. It explored previous research on issues around ED design and spaces. It also explored design evaluations in general and space syntax as a plan-based analytical tool for analysing ED's spatial

layouts. The literature review concluded that the design of ED spatial structure and their spatial relationships should support their operational activities by having close functional adjacencies of the various spaces concerning their operational relationships to reduce spatial complexity. However, the influence of the spatial structure and its functional spatial relationships on EDs operation, as far as it may be confirmed, might not be addressed adequately in ED design literature to improve spatial performance. For example, the reviewed design guidelines are limited in providing detailed explanations of the medical processes and their spatial relationships, which is feasible due to the constraints it may impose when targeting diverse populations (See more explanations in the Literature Review and Discussion Chapters).

Limitations in users' involvement were also identified among the reviewed literature. These limitations can be in the structure of the data collecting phases, such as the targeted stakeholders and the adopted data collection methods Also, the contexts considerations. For example, researchers in the reviewed literature collected data regarding the clinical and operational requirements in EDs from medical planners and expert healthcare designers rather than the medical staff. Online surveys were used to collect data from staff, which might not be enough to gather more in-depth data about ED's spatial and functional relationships. Finally, the use of plan based analytical tools, such as space syntax, to understand ED's functional spatial relationships were also lacking. Therefore, objective three sought to investigate ED spatial relationships using Space Syntax tools; DepthMap and AGRAPH. More details are mentioned in the heading 9.5 Objective Three (Spatial Analysis).

Knowing the ED's functional/operational spatial relationships can help the design process reduce unnecessary steps and optimise each clinical procedure's required time. In the Jordanian context as an example, the functional spaces within EDs can have competing needs and priorities to follow each treatment process. Therefore, individual (users) preferences must be balanced against mandatory requirements and actual functional needs. Thus, it is important to explore ED spatial relationships from different perspectives to frame a complete picture of the situation.

9.4 Objective Two (Designers Interview Analysis)

This phase sought to explore actual designers' approaches to ED spatial design. The interviewed designers mentioned that to attain good quality healthcare services and facilitate operational demands in EDs, the spatial structure design needs to provide the best support for EDs' various activities. Clinical procedures are the main activity, and so the ED needs to be designed for an efficient arrangement of the available spaces. Efficiency in this sense means that spaces need to have close functional adjacencies concerning their working relationships to reduce spatial complexity, which will reduce unnecessary steps and optimise the treatment and formal procedures times. However, they believe that the available ED design guidelines lack detailed explanations of ED functional spatial relationships

to support operational demands. Therefore, the interviewed designers emphasised the importance of engaging staff (mainly doctors) early in the design stage to know their preferences and operational requirements, and to understand the clinical processes and their functional spatial relationships that are missing in the guidelines. However, some designers believe that they have the required knowledge to design an ED, which might not be enough, in light of this research, to result in a better EDs. Also, no particular methods or ways of engaging stakeholders were identified among designers. Therefore, users' engagement in the design is limited and unstructured. Hence, there is a lack of methodological rigour in determining needs from end-users.

The interviewed designers do not use any analytical tools to aid the design process as a pre-occupancy evaluation step to understand the spatial relationships. They only rely on drafting software, such as AutoCAD and performing paper-based feasibility studies. Moreover, although designers acknowledge the importance of post-occupancy evaluation to identify problems that may hinder work efficiency and to learn and develop their design knowledge, they do not usually conduct such evaluation. However, if they were to conduct a post-occupancy evaluation, they may observe and conduct surveys with users to evaluate how the facility works without using any analytical tools, which they never do.

9.5 Objective Three (Spatial Analysis)

This phase sought to investigate ED spatial relationships using plan-based analysis tools to understand ED's functional spatial relationships to improve operation and flow. The spatial analysis started by identifying the development in the spatial structure, which revealed that significant changes occurred in the spatial structure and the distribution of the functions in the selected EDs between the original designs and the current ones. Therefore, syntactic values were measured afterwards using space syntax tools, AGRAPH and DepthMap, for the various functions in the selected cases before and after modification following occupation, to predict the way spaces are being used and perceived by its users. However, the differences in syntactic values revealed only minor and insignificant differences in the calculations, except when major spatial changes were made later. Thus, these changes may significantly influence how the selected EDs operate, which may not be predicted by the syntactic analysis. Therefore, field observations were conducted to explore these findings further.

9.6 Objective Four - A (Observation Analysis)

This phase sought to investigate the influence of the spatial structure on ED operation to know how they are being used and functioning. It was observed in the two selected cases that the arrangement of functions and their spatial relationships is hindering the department workflow. To emphasise, spaces that are functionally connected in sequence following the various patients' treatment journeys' clinical and formal requirements have poor adjacencies and complex spatial relationships. These spatial relationships are causing problems that are hindering the flow and increasing treatment times.

Also, they are causing non-staff users not to use certain functions and behave in ways that may better suit their needs. However, these findings contradict the findings from the spatial analysis using Space Syntax tools. To emphasise, the obtained syntactic relationships aimed to predict the way spaces are being used and perceived by its users. However, these relationships were calculated based on spaces' permeability where no weight is given to their functions, exact usages, and functional relationships. Therefore, alteration in the spatial structure might be hard to predict using syntactic measures, while these changes may significantly influence how the department is being used. The observations revealed that the current usages were governed by the available functions and their functional relationships that have complex spatial relationships in the current settings. This is because EDs work in controlled ways to suit their complex operational demands, such as clinical procedures. Thus, Space Syntax is limited and might be misleading for analysing EDs' spatial relationships to predict their spatial performance. Therefore, interviews with ED staff were conducted to investigate the spatial structure's influence on ED operation from users' perspectives.

9.7 Objective Four - B (Staff Interview Analysis)

This phase sought to investigate further the influence of the spatial structure on ED operation to know why EDs are being used the way users uses them. It can be elicited from the conducted interviews that few variables influence the operational activities, such as the total floor area of the ED, the density of occupation, connections between the functions, and the spatial adjacencies. For instance, an ED's size is one factor that influences its operation. For example, having a large floor area allows the inclusion of all the needed functions to create a self-contained department. However, functions might be scattered in the ED and far away from each other, resulting in a complex layout. Having a compact space allows the functions to be close to each other, reducing walking distances. However, this may increase spatial complexity and hinder the workflow due to cross circulation and having some functions outside the department. In term of functions' connections and the spatial adjacencies, the workflow in EDs is governed by clinical procedures that depend on the classifications of patients' medical conditions. Therefore, the flow varies for different users: patients, nurses, doctors, and auxiliary staff (technicians, porters, cleaners, etc.), where each set of users requires the use of different functions in different sequences following the clinical procedures and the operational demands. Thus, they require different spatial relationships to cater to their different operations, as explained in detail in the Discussion Chapter. However, the clinical functional relationships are critically important to guide the spatial structure design to cater to users' various spatial requirements. For example, both EDs sought to overcome deficiencies in the spatial structures by hiring porters and easing the formal requirements, reducing staff and patients' walking distances and the required time for the different processes. In conclusion, the distribution of the functions and their spatial relationships needs to work in harmony with the adopted clinical procedures and their functional relationships for the different users,

improving the flow and ease users' movement by reducing unnecessary steps and optimising procedures time.

9.8 Objective Five (Discussion and Comparison)

This phase discusses and compares the research findings from the preceding chapters to identify ED design and operation's most critical influences. In any spatial structure, poor spatial relationships between the organisational demands, users' requirements, and arrangement of functions can cause various challenges, as mentioned earlier in the thesis. Therefore, the spatial relationships between ED diverse functions significantly impact its users' workflow more than the ED's size, as evident before. Because spaces in EDs have critical functional relationships governed by a sequence of various clinical procedures for the different classified medical conditions. These clinical procedures vary among the different users', such as patients, nurses and doctors, which are required to examine and treat patients from entering to discharge. Consequently, users require the use of different functions in different sequences following the clinical requirements and operational demands. However, EDs functional relationships and how they should be spatially connected to cater to users' different requirements are neither clearly explained in the literature nor predicted using plan-based analysis methods as explained before to aid the design process.

Moreover, the next step to design EDs better; EDs functions and functional spatial relationships need to support EDs complex operational demands. And be able to cater to their different users due to their different functional spatial requirements. Due to ED complex operation, various users' requirements, rapid development in technology, medical innovations, and changes in population demands, healthcare facilities have to support these variables and yet more to come. Therefore, healthcare facilities' design has to evolve by adopting new design strategies to create a smooth workflow circulation for all users and facilitate operational demands by having close functional adjacencies and reduced spatial complexity. Co-designing is a promising strategy to engage different stakeholders in all stages of the design process in comprehensive and structured ways to produce a design that can cater to its various users' various demands and its unique operational demands. Stakeholders and end-user involvement in the design process can be done using various methods, such as behavioural mapping, journeys mapping, in-depth interviews, focus groups, and observations, which is to make full and comprehensive use of their knowledge and experiences, and design requirements. To have a better ED operation, it is also essential to acknowledge the design limits to provide services to a specific number of users, where exceeding these limits will cause problems – as mentioned before in the thesis, which will lead to overcrowding and long waiting times. It is also essential to acknowledge that it might be insufficient to change the design to suit some of the cultural norms, such as having extra/bigger waiting areas to accommodate the significant number of companions that may come with the patients as in the investigated EDs (detailed in the Discussion Chapter)

9.9 Contributions to the Body of Knowledge

This research started by exploring potential problems Emergency Departments (EDs) in hospitals are facing. Overcrowding and long waiting times were identified as major challenges after reviewing the literature. Accordingly, a further literature review was conducted to investigate spatial relationships and operational requirements in hospital emergency departments (EDs) in Jordan. The investigation looked at ED design guidance and previous research on ED design, functions, and operational activities and how the spatial relationships of ED functions influence ED's operational activities. The review revealed limited research in these areas and a lack of detailed design guidance about ED functional and spatial relationships. This research, therefore, investigates for the first time ED spaces and their functional and spatial relationships with the aim to explore their influence on the flow of EDs' operational activities. The research carried out fieldwork in two carefully selected case study hospitals – one public and one private – in Jordan. A mixed-methods approach was adopted to thoroughly investigate the research problem using three data collection methods: interviews, spatial analysis, and direct observations of operation of EDs.

Interviews with hospital designers confirmed that ED design guides do not provide the necessary detailed explanations of ED functions and their spatial relationships and are not enough to design the most effective ED. The findings highlighted limitations in stakeholders' engagement during design to understand the actual practices and the operational requirements. Another identified limitation is the lack of use of computer-based analytical tools to aid the design processes as pre-or post-occupancy evaluations. Accordingly, as a first step, this study explored the use of Space Syntax tools as potential design aids to analyse the two case study hospitals. This part of the research found that later changes to the original designs have resulted in different functional allocation of spaces, which has significantly influenced how the selected EDs operate, thereby invalidating any earlier syntactic analysis as was confirmed from the direct observations. Thus, it concluded that spatial analysis alone does not improve the design outcome and may create a false sense of certainty. Direct observations showed that in practice, the arrangement of the functions and their spatial relationships in the selected EDs hinder departmental workflow, which was not predicted from the spatial analysis. The observations were supplemented by interviews with various ED staff members to understand why the spaces are used the way they are. The findings revealed that current spatial configurations do not support the medical procedures for the ED patients with different medical conditions. Therefore, the current spatial allocation of functions hinders EDs' efficient workflow operation and causes overcrowding and longer waiting times. These were also found exacerbated by the cultural practice of several family members arriving at ED with the patient and being able to move around in the ED.

In conclusion, this research identified three factors affecting operational activities. First, ED activities depend on the spatial organisation of functions and their need for adjacent relations, which in turn

depend on the medical procedures that vary in different types of EDs and different contexts. Second, behavioural and management aspects both influence operational flow, such as patients arriving with many relatives, which hinder the operational flow and cause overcrowding and delays. Finally, the period between when the hospitals were designed and occupied saw an evolution in medical operational requirements supported by technological advances, which undermines the functional allocation of spaces.

This research recommends that ED functions and their operational spatial relationships need to support EDs' complex operational demands to cater to the needs of different users (patients and staff) and their different requirements. Therefore, the spatial organisation of healthcare facilities in Jordan has to evolve by adopting new design strategies, including co-designing with key hospital stakeholders to allow their engagement though all stages of the design process in comprehensive and structured ways.

This research has provided new insight and understanding of ED's functional spatial relationships in the context of Jordanian hospitals. It has also highlighted the need for a more efficient hospital spatial management of functions and their connections to the ED department. The findings of this research are also of high relevance to the design of future hospitals in Jordan, where ED departments are included by adopting new design strategies.

9.10 Recommendations

1. First, ED design guidelines, including the UK one, provide the fundamental information that needs to be accommodated in EDs spatial structure. However, they do not provide enough on their own. Therefore, the UK ED design guidelines can be adopted, such as in the Jordanian context, to be the initial stage of the design process. Because it provides the most detailed and clear illustration diagrams of different clinical pathways that patients follow in EDs.
2. Second, Adopting Co-designing as a design strategy to design better EDs can accommodate the rapid development in technology, medical innovations, and population demands. Such design strategies allow the engagement of different stakeholders and end-users in all stages of the design process to produce a design that can cater to its various users' various demands. Also, to cater to the ED's unique clinical and operational requirements. This can be done using various methods, such as behavioural mapping, journeys mapping, in-depth interviews, focus groups, and observations to make full and comprehensive use of users and stakeholders' knowledge, experiences, and design requirements.
3. Third, hospitals should carry out regular space management efficiency evaluation for ED in line of development in the medical practices, procedures and protocols, and associated technological innovations.

9.11 Research limitations and future work

This research has spanned a wide range of research areas and methods, including EDs design and operation, spatial analysis techniques, interviews, and field observations. Hence, the results of this research might have provided encouraging data regarding the investigated phenomena. However, in general, research projects have limitations, such as time, available resources, employed methods for data collection and analysis, and different variables associated with the research questions, increasing difficulties in producing comprehensive solutions for the research question(s). Nevertheless, research may provide data regarding a phenomenon to better understand the problems without further practical solutions. The following points summarise possible limitations of the current research and the corresponding recommendations for future research:

- Fieldwork and analysis are limited to two cases. It is not possible to generalise from such a small number. So, no claim is made for the samples' representativeness included in this research, such as healthcare design experts, cases studies, and staff, for generalisation to a wider population. More research is required before generalisations can be possible. However, the presented finding and recommendations in this research including the suggested solutions can be applied to other hospitals in Jordan given the specificity of each case.
- Further investigations across universal and different cultures regarding ED design and operation are interesting areas for future research. Also, adopting EDs in different contexts as cases studies.
- Further research into various aspects of EDs and healthcare facilities in the Jordanian context would have practical values. For example, social, economic, environmental, and educational factors need to be investigated to explore potential solutions for current healthcare building design problems in Jordan.
- Further research into designing for flexibility in EDs is needed to investigate ways for designing better EDs. However, ED's spatial flexibility may have critical considerations than any other type of buildings due to its unique operational requirements, such as hygiene and infection, patients and staff privacy, and noise and possible destruction.

From the finding of this research, it can be seen that designing healthcare facilities – EDs in this context – is not an easy and straightforward process due to the criticality in their unpredicted work nature, and accordingly, the complexity in their design requirements. Therefore, rigorous and comprehensive design strategies should be adopted to inform the design in its early stages to create a design that can efficiently serve its purpose, overcome common difficulties, and cater for its various users. Also, to create a design that can adapt to unforeseen challenges and forced changes, where the current pandemic is a great example. As a result, the design of such complicated facilities should be treated as a joint venture project, where all related entities need to be involved in the design process. Therefore, architects have to play this part and be the leader, the organiser, and the executor of this project to achieve the best that can be done.

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Appendix

A. Ethical Approval obtained from Cardiff University:

WELSH SCHOOL OF ARCHITECTURE
ETHICS APPROVAL FORM FOR STAFF AND PHD/MPHIL PROJECTS WS

Tick one box:	☐ STAFF ■ PHD/MPHIL
Title of project:	Exploring current spatial analysis methods, to create a better understanding of social practices in hospitals Emergency Departments.
Name of researcher(s):	Mohammad Abukeshek.
Name of principal investigator	Prof Chris Tweed.
Contact e-mail address:	Abukeshekmk@cardiff.ac.uk
Date:	11th of July 2018

Participants		YES	NO	N/A
Does the research involve participants from any of the following groups?	• Children (under 16 years of age)		▪	
	• People with learning difficulties		▪	
	• Patients (NHS approval is required)		▪	
	• People in custody		▪	
	• People engaged in illegal activities		▪	
	• Vulnerable elderly people		▪	
	• Any other vulnerable group not listed here		▪	
• When working with children: I have read the Interim Guidance for Researchers Working with Children and Young People (http://www.cardiff.ac.uk/archi/ethics_committee.php)		▪		

Consent Procedure	YES	NO	N/A
• Will you describe the research process to participants in advance, so that they are informed about what to expect?	▪		
• Will you tell participants that their participation is voluntary?	▪		
• Will you tell participants that they may withdraw from the research at any time and for any reason?	▪		
• Will you obtain valid consent from participants? (specify how consent will be obtained in Box A)[1]	▪		
• Will you give participants the option of omitting questions they do not want to answer?	▪		
• If the research is observational, will you ask participants for their consent to being observed?	▪		
• If the research involves photography or other audio-visual recording, will you ask participants for their consent to being photographed / recorded and for its use/publication?	▪		

Possible Harm to Participants	YES	NO	N/A
• Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		▪	
• Is there any realistic risk of any participants experience a detriment to their interests as a result of participation?		▪	

Data Protection		YES	NO	N/A
• Will any non-anonymous and/or personalised data be generated or stored?			▪	
• If the research involves non-anonymous and/or personalised data, will you:	• gain written consent from the participants	▪		
	• allow the participants the option of anonymity for all or part of the information they provide	▪		

Health and Safety	YES
Does the research meet the requirements of the University's Health & Safety policies? (http://www.cf.ac.uk/osheu/index.html)	▪

Research Governance	YES	NO	N/A
Does your study include the use of a drug? You need to contact Research Governance before submission (resgov@cf.ac.uk)		▪	
Does the study involve the collection or use of human tissue? You need to contact the Human Tissue Act team before submission (hta@cf.ac.uk)		▪	

[1] If any non-anonymous and/or personalised data be generated or stored, *written consent* is required.

Prevent Duty	YES	
Has due regard be given to the 'Prevent duty', in particular to prevent anyone being drawn into terrorism? https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/445916/Prevent_Duty_Guidance_For_Higher_Education_England_Wales_.pdf http://www.cardiff.ac.uk/publicinformation/policies-and-procedures/freedom-of-speech	▪	

If any of the shaded boxes have been ticked, you must explain in Box A how the ethical issues are addressed. If none of the boxes have been ticked, you must still provide the following information. The list of ethical issues on this form is not exhaustive; if you are aware of any other ethical issues you need to make the SREC aware of them.

Box A The Project (provide all the information listed below in a separate attachment)

1. Title of Project
2. Purpose of the project and its academic rationale
3. Brief description of methods and measurements
4. Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria
5. Consent and participation information arrangements - please attached consent forms if they are to be used
6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them
7. Estimated start date and duration of project

All information must be submitted along with this form to the School Research Ethics Committee for consideration

Researcher's declaration (tick as appropriate)

• I consider this project to have **negligible ethical implications** (*can only be used if none of the grey areas of the checklist have been ticked*).	▪
• I consider this project research to have **some ethical implications**.	
• I consider this project to have **significant ethical implications**	

Signature Researcher or MPhil/PhD student — **Name** Mohammad Abukeshek — **Date** 11th July 18

Signature Lead investigator or supervisor — **Name** Chris Tweed — **Date** 16.7.18

Advice from the School Research Ethics Committee

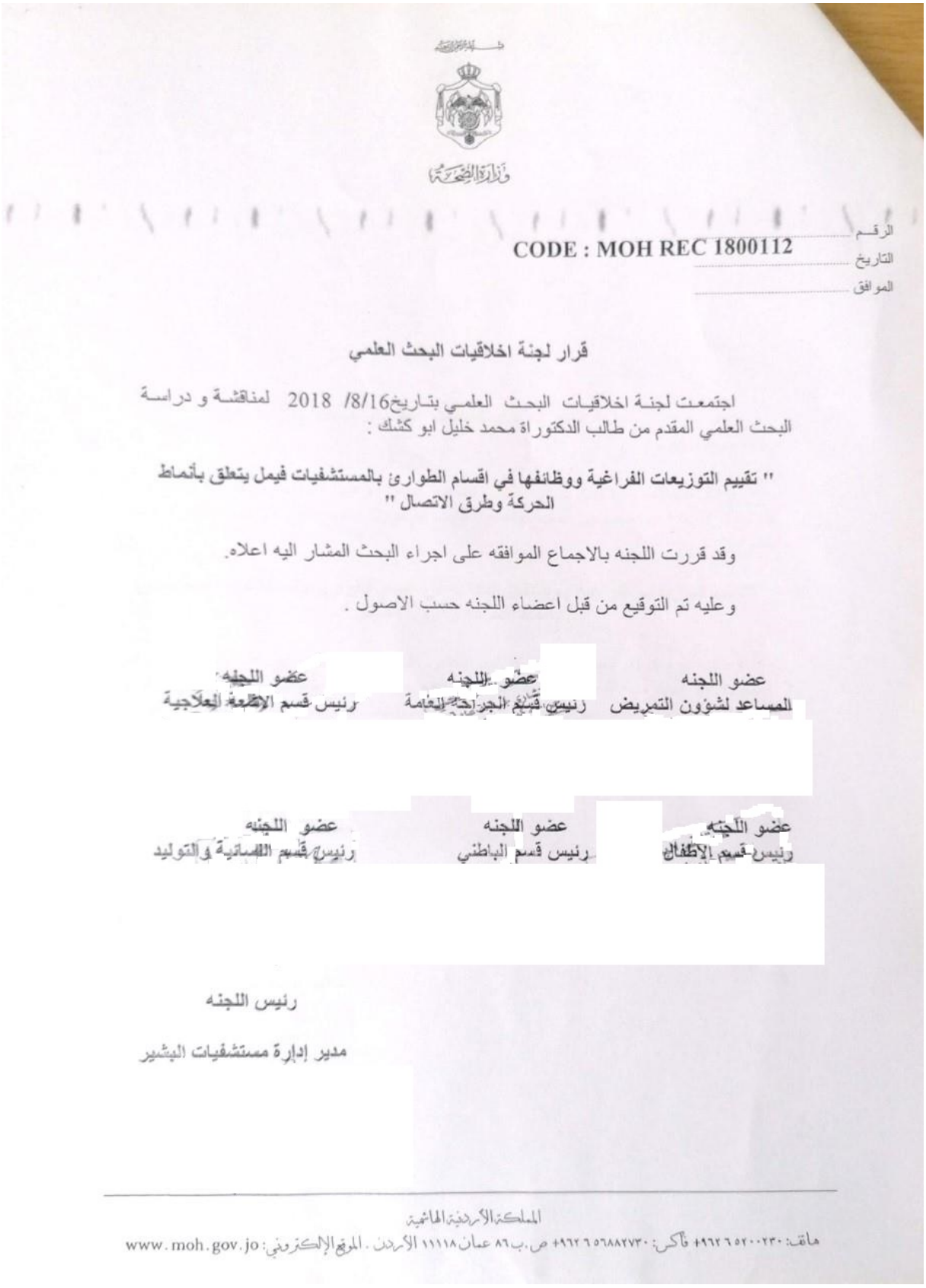
STATEMENT OF ETHICAL APPROVAL

This project had been considered using agreed Departmental procedures and is now approved

Signature — **Name** — **Date**

Chair, School Research Ethics Committee

B. Ethical Approval obtained from the Ministry of Health in Jordan:



وزارة الصحة

الرقم .....
التاريخ .....
الموافق .....

CODE : MOH REC 1800112

قرار لجنة اخلاقيات البحث العلمي

اجتمعت لجنة اخلاقيات البحث العلمي بتاريخ16/8/ 2018 لمناقشة و دراسة البحث العلمي المقدم من طالب الدكتوراة محمد خليل ابو كشك :

" تقييم التوزيعات الفراغية ووظائفها في اقسام الطوارئ بالمستشفيات فيما يتعلق بأنماط الحركة وطرق الاتصال "

وقد قررت اللجنه بالاجماع الموافقه على اجراء البحث المشار اليه اعلاه.

وعليه تم التوقيع من قبل اعضاء اللجنه حسب الاصول .

عضو اللجنه
المساعد لشؤون التمريض

عضو اللجنه
رئيس قسم الجراحة العامة

عضو اللجنه
رئيس قسم الاشعة العلاجية

عضو اللجنه
رئيس قسم الإطفال

عضو اللجنه
رئيس قسم الباطني

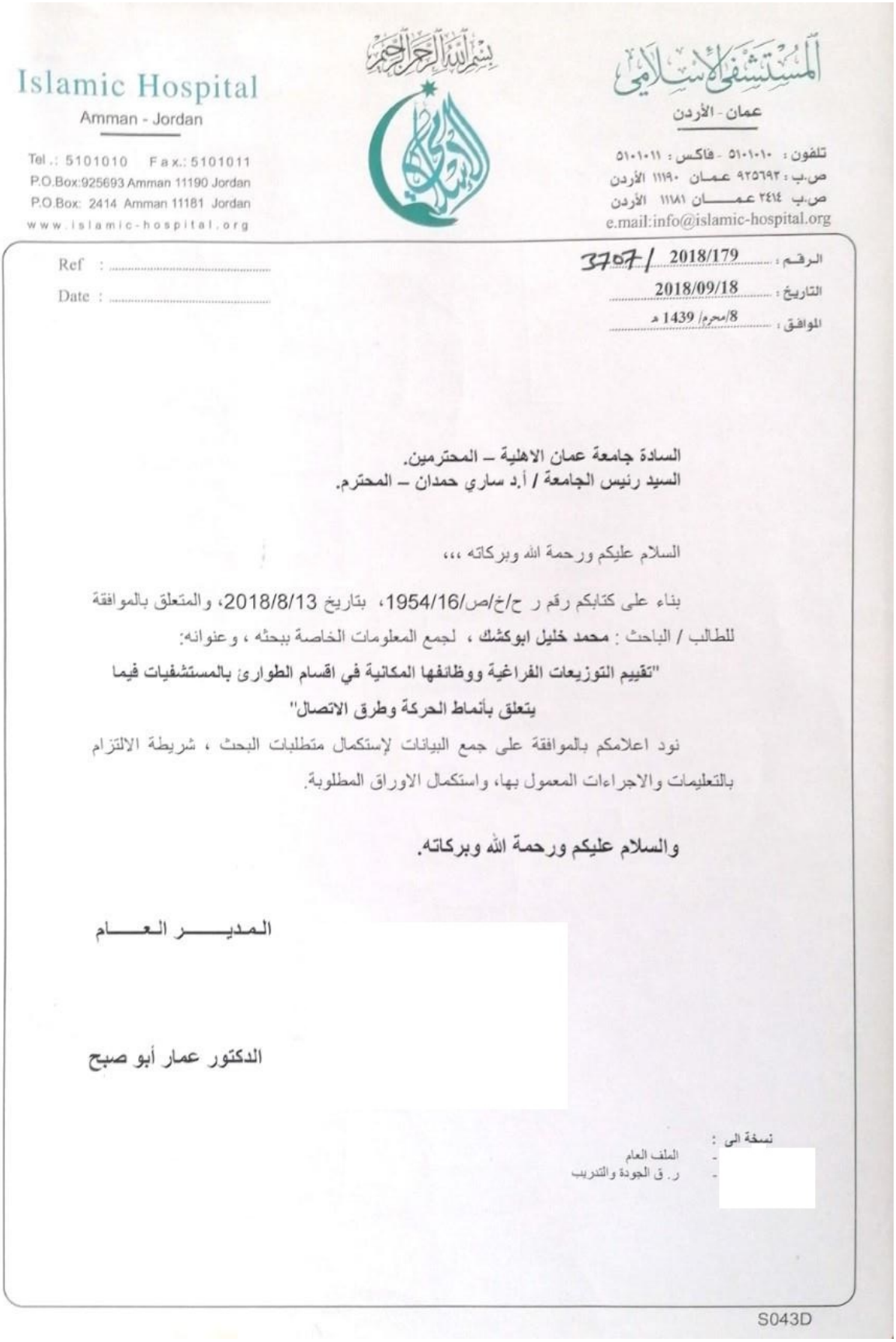
عضو اللجنه
رئيس قسم النسائية والتوليد

رئيس اللجنه

مدير إدارة مستشفيات البشير

المملكة الأردنية الهاشمية
هاتف: ٠٠٢٣٠ ٦٥٢٠ ٦٢٦+ فاكس: ٦٥٦٨٨٢٧٣٠ ٦٢٦+ ص.ب ٨٦ عمان ١١١١٨ الأردن . الموقع الإلكتروني: www.moh.gov.jo

C. Ethical Approval obtained from the Islamic Hospital (IH) (Private Hospital):



Islamic Hospital
Amman - Jordan
Tel.: 5101010 Fax.: 5101011
P.O.Box:925693 Amman 11190 Jordan
P.O.Box: 2414 Amman 11181 Jordan
www.islamic-hospital.org

بسم الله الرحمن الرحيم

المستشفى الإسلامي
عمان - الأردن
تلفون : ٥١٠١٠١٠ - فاكس : ٥١٠١٠١١
ص.ب : ٩٢٥٦٩٣ عمان ١١١٩٠ الأردن
ص.ب ٢٤١٤ عمان ١١١٨١ الأردن
e.mail:info@islamic-hospital.org

Ref :
Date :

الرقم : 3707 / 2018/179
التاريخ : 2018/09/18
الموافق : 8/محرم/ 1439 هـ

السادة جامعة عمان الاهلية – المحترمين.
السيد رئيس الجامعة / أ.د ساري حمدان – المحترم.

السلام عليكم ورحمة الله وبركاته ،،،

بناء على كتابكم رقم ر ح/خ/ص/1954/16، بتاريخ 2018/8/13، والمتعلق بالموافقة للطالب / الباحث : **محمد خليل ابوكشك** ، لجمع المعلومات الخاصة ببحثه ، وعنوانه:

"تقييم التوزيعات الفراغية ووظائفها المكانية في اقسام الطوارئ بالمستشفيات فيما يتعلق بأنماط الحركة وطرق الاتصال"

نود اعلامكم بالموافقة على جمع البيانات لإستكمال متطلبات البحث ، شريطة الالتزام بالتعليمات والاجراءات المعمول بها، واستكمال الاوراق المطلوبة.

والسلام عليكم ورحمة الله وبركاته.

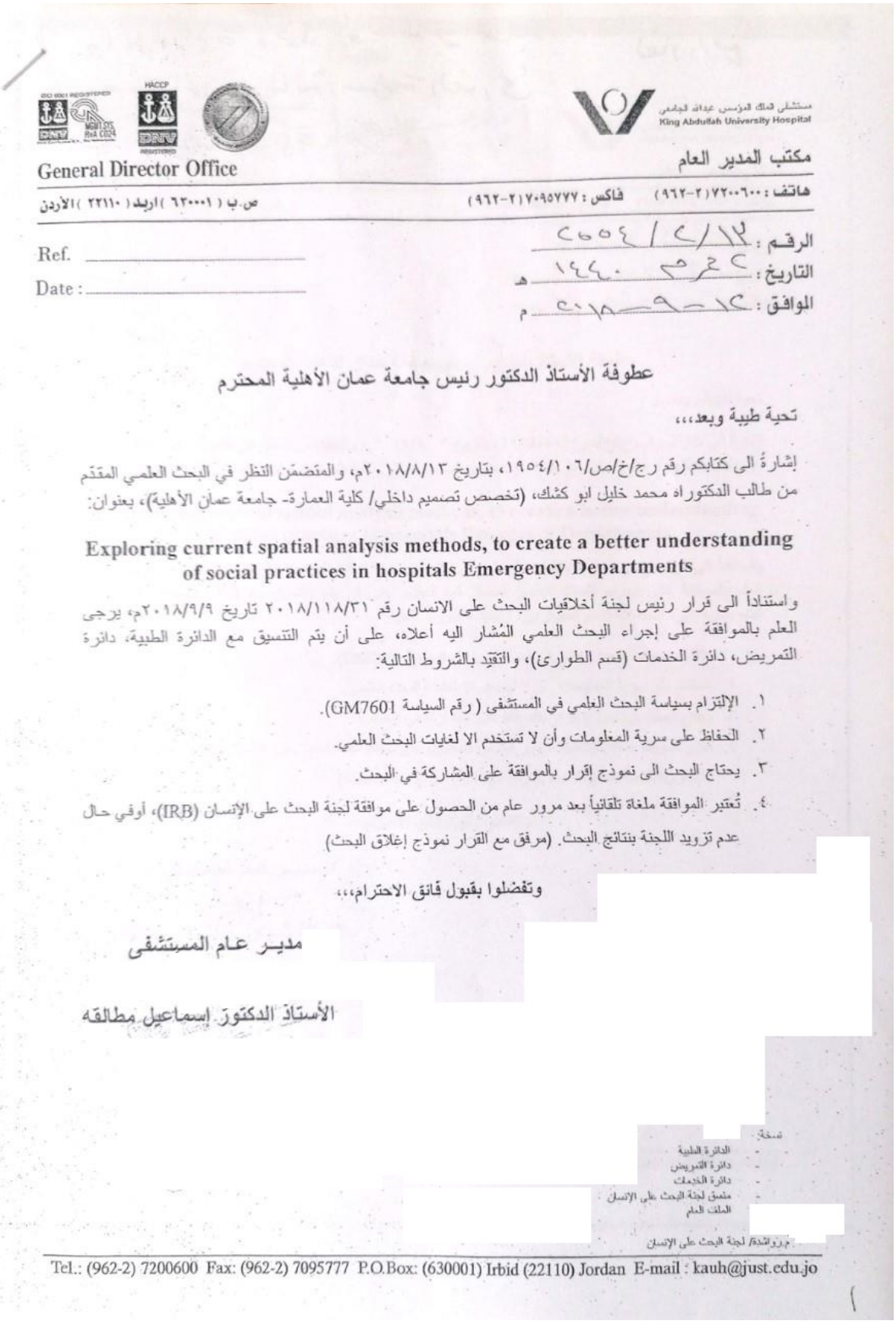
المديـــــر العـــام

الدكتور عمار أبو صبح

نسخة الى :
- الملف العام
- ر. ق الجودة والتدريب

S043D

D. Ethical Approval obtained from King Abdullah University Hospital (KAUH):



مستشفى الملك المؤسس عبدالله الجامعي
King Abdullah University Hospital

مكتب المدير العام
General Director Office

هاتف: ٧٢٠٠٦٠٠ (٢-٩٦٢) فاكس: ٧٠٩٥٧٧٧ (٢-٩٦٢) ص.ب (٦٣٠٠٠١) اربد (٢٢١١٠) الأردن

Ref.
Date:

الرقم: ٢٠٥٥٤/٢/١٧
التاريخ: ٢٥ محرم ١٤٤٠ هـ
الموافق: ١٤-٩-٢٠١٨ م

عطوفة الأستاذ الدكتور رئيس جامعة عمان الأهلية المحترم

تحية طيبة وبعد،،،

إشارةً الى كتابكم رقم ر ج/خ/ص/١٩٥٤/١٠٦، بتاريخ ٢٠١٨/٨/١٣م، والمتضمّن النظر في البحث العلمي المقدّم من طالب الدكتوراه محمد خليل ابو كشك، (تخصص تصميم داخلي/ كلية العمارة- جامعة عمان الأهلية)، بعنوان:

Exploring current spatial analysis methods, to create a better understanding of social practices in hospitals Emergency Departments

واستناداً الى قرار رئيس لجنة أخلاقيات البحث على الانسان رقم ٢٠١٨/١١٨/٣١ تاريخ ٢٠١٨/٩/٩م، يرجى العلم بالموافقة على إجراء البحث العلمي المُشار اليه أعلاه، على أن يتم التنسيق مع الدائرة الطبية، دائرة التمريض، دائرة الخدمات (قسم الطوارئ)، والتقيّد بالشروط التالية:

١. الإلتزام بسياسة البحث العلمي في المستشفى (رقم السياسة GM7601).
٢. الحفاظ على سرية المعلومات وأن لا تستخدم الا لغايات البحث العلمي.
٣. يحتاج البحث الى نموذج إقرار بالموافقة على المشاركة في البحث.
٤. تُعتبر الموافقة ملغاة تلقائياً بعد مرور عام من الحصول على موافقة لجنة البحث على الإنسان (IRB)، أوفي حال عدم تزويد اللجنة بنتائج البحث. (مرفق مع القرار نموذج إغلاق البحث)

وتفضلوا بقبول فائق الاحترام،،،

مديـر عـام المستشفى

الأستاذ الدكتور إسماعيل مطالقه

نسخة:
- الدائرة الطبية
- دائرة التمريض
- دائرة الخدمات
- منسق لجنة البحث على الإنسان
الملف العام

م.ر.و/ لجنة البحث على الإنسان

Tel.: (962-2) 7200600 Fax: (962-2) 7095777 P.O.Box: (630001) Irbid (22110) Jordan E-mail : kauh@just.edu.jo

E. Consent Form:

Consent Form - Confidential data

I understand that my participation in this project will involve completing an interview about the design of healthcare and emergency departments in terms of its spatial structure and the overall function of the layout. The interview will require about 60 minutes of my time. The researcher will transfer and explain each question in Arabic language.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time. I am free to withdraw or discuss my concerns with Professor Chris Tweed.

I understand that the information provided by me will be held confidentially, such that only the Researcher - Mohammad Abukeshek - can trace this information back to me individually. The information will be retained for up to 3 years when it will be deleted/destroyed.

I understand that I can ask for the information I provide to be deleted/destroyed at any time and, in accordance with the Data Protection Act, I can have access to the information at any time.

I, _____ **[PRINT NAME]** consent to participate in the study conducted by Mohammad Abukeshek, Welsh School of Architecture, Cardiff University with the supervision of Prof Chris Tweed.

Signed:

Date:

F. Architects Interview Form:

Interview Guide with Architects who are experienced in the design of healthcare and Emergency Departments

Welsh School of Architecture
Cardiff University
Bute Building
King Edward VII Avenue
Cardiff, CF10 3NB
Wales, UK
Tel: +44 (0)29 087 4430
Fax: +44 (0)29 2087 4623

The following is a guide that outlines the main structure of the interview with Architects who are experienced in the design of healthcare and emergency departments. It is part of a study undertaken for obtaining a PhD degree about exploring current spatial analysis, functionality and social practices in emergency departments in hospitals.

The researcher would like to ask you some questions about healthcare and emergency departments' design. Your answers are appreciated, as the information you provide will be very helpful for understanding current conditions of spatial arrangements and functional use of Emergency Departments (EDs) in hospitals.

The interview will take about 75 minutes. Please do not feel obliged to answer a question if you do not wish to. Your response will be strictly confidential and used only for this academic research.

Please do not hesitate to ask any question and feel free to add your comments. Thank you for your time and feedback.

Researcher: **Mohammad Abukeshek**

Email: Abukeshekmk@cardiff.ac.uk
Tel (UK): 0044 - 7341717837
Tel (Jordan) 00962 - 799086661

Supervisor: **Professor Chris Tweed**

Email: Tweedac@cardiff.ac.uk
Tel (UK): 0044 - 2920876207

1

Date of Interview: _____. **ID:** _____

1. General Information (approx. 05 min):

This section is designed to highlight on the participant general experience and Background.

1.1. Participant Sex:

- ☐ Male.
- ☐ Female.

1.2. Participant age range:

- ☐ Less than 24 years old.
- ☐ 25 – 34 years old.
- ☐ 35 – 44 years old.
- ☐ 45 – 54 years old.
- ☐ 55 – 64 years old.
- ☐ 65 years or older.

1.3. How long have you been working for healthcare design (total experience)**?**

1.4. What is your main speciality when designing for healthcare/hospitals?

1.4.1.Is there an Emergency Department Specialist?

1.5. Can you list some of the hospitals/healthcare projects you did?

2. Architecture Design for hospitals and Emergency Departments (approx. 15 min):

This section will focus on exploring healthcare design in general and emergency departments in particular from the participant point of view, depending on their background experience, knowledge and preferences.

2.1. What issues/challenges that needed to be considered in the design of emergency departments in particular?

2.1.1.What are the main criteria to consider when designing Emergency departments?

2.2. How Healthcare/Hospitals design specially EDs design have been developing?

2.2.1.what do you do to sustain an up to date knowledge in the field of EDs design? And …

2.2.2.Generally speaking … From where you acquire your knowledge for EDs design?

2.3. What guidelines or resources are, available/or you use for Hospitals design in general and EDs in particular?

2.3.1.Are these guidelines and resources sufficient/enough to be used?

2.3.2.What might be missing in these databases and how they can be improved?

2.3.3.In your opinion … How these resources and guidelines can be improved?

2.3.4.Is there is guidelines or any other kind of design resources for EDs only?

a. In your opinion, … How important it is to have specific guidelines only for EDs? (do we need ones?)

2

2.4. Do you use any kind of tools for hospitals design specially EDs (design analysis tools or pre-occupant evaluation tools)?

If Yes...

2.4.1.Can you list some of them with a brief description?

2.4.2.Are these tools sufficient/enough to be used?

If not,

i. why? What might be missing
ii. What do you to overcome their issues?

2.4.3.Are they different than what might be used for different type of building?

2.4.4.In your opinion … How can these tools be improved and developed?

2.5. what aspects that may influence the design of EDs?

Ex. The Medical procedures in EDs, Injuries classification/taxonomy … Etc.

2.6. Who may interfere in the design by giving an opinion or having special requests … Etc.)

Ex., the Owner, The medical staff (nurses/doctors) … Etc.

2.6.1.To what extend they may interfere?

2.6.2. How valuable is their intervention? (does hinder or help the design and the function of the design?)

2.7. Are injuries classification/taxonomy (depending in the treatment process) being thought of when design the spatial structure of EDs?

If Yes...

2.7.1.How can design be approached to accommodate different injuries' groups with different requirements, needs and treatment process?

3. Current Design Situation for the Emergency Departments (approx. 15 min):

This section will aim to discuss either a case study that the participant has designed or has been part of the design stage if possible or at least a random project he did in healthcare and ED design. To understand their initial intention and thought that may have impacted on their designs and how their approached may have developed so far.

3.1. Have you designed emergency departments before?

3.1.1.If yes:

a. Can you list some?
b. what are the main gols to achieve when designing EDs? (most important aspects to consider?)
c. What challenges you may face design EDs
d. How your design approach has changed so far?

3.2. Have you been using the same guidelines mentioned previously? Or

3.2.1.Are they the same ones mentioned previously?

If no,

3.2.2.What are the old ones? … and what was missing with them?

3.3. Have you visited a project after occupation to see how it functioned (Post-Occupancy Evaluation)?

3.3.1.If Yes: Please answer the following

a. What project / projects? (kind of hospital)
b. When did you visited the project (after how many months or years)?
c. What did you hoped/expected to see?
d. Was it functioning in a good way still as designed, or it needed some improvements?
e. What kind of improvement that might have been needed and why?
f. What could have been done better during the design stage?

3.3.2.If No: can you, please explain why?

3.4. How will you do things differently for the next time you design an ED?

4. Current Design Situation regarding Circulation, Movement, and Accessibility (approx. 10 min):

This section will try to explore Circulation, movement and Accessibility as a design criterion that will have a major impact on this research. It will focus on either a particular case study that the participant has designed or has been part of the design stage if possible or at least random project he did within healthcare and ED design.

4.1. How movement patterns and circulation can be studied especially in a complex environment such as EDs it can be studied in the design stage

a. How medical procedures are taken into consideration in the EDs design stages?
b. Should it be evaluated after occupation and use (post-occupant evaluation)?
c. How can it be evaluated (how you think that should be done)?

4.2. What makes good design regarding movement routes/patterns and circulation in EDs:

4.2.1. Important elements to consider when designing for movement and circulation?
4.2.2. Challenges that may occur in the design of movement, circulation and accessibility?
4.2.3. Challenges when designing for different users, uses and requirements?

*EDs are complex environments that deal with a variety of users, use and injuries with a different process.

4.2.4. What kind of constraints that may affect the function of the design (Such as availability of sunlight, technology etc.) And why?

5. Current Design Situation regarding Density and Crowdedness (approx. 10 min):

This section will try to explore **Density and Crowdedness** as related and linked design criteria. It will focus on either a particular case study that the participant has designed or has been part of the design stage if possible or random project he did within healthcare and ED design or in other general applications.

5.1. How can it be predicted, analysed and evaluated in the design stage?

5.2. What kind of creative design solutions to overcome such issue in the design stage and after the occupation?

5.2.1.What can be done to reduce density and crowdedness in a complex environment such as EDs?

5.3. The effect of movement patterns/routes and circulations on density and crowdedness?

4

6. Current Design Situation regarding Privacy, Hierarchy, and Security (approx. 10 min):

This section will try to explore **Privacy, Hierarchy and Security** as a design. It will focus on either a case study that the participant has designed or has been part of the design stage if possible or random project he did within healthcare and ED design or in general applications.

6.1. How Privacy, Hierarchy and Security can be studied in a complex environment such as EDs it can be studied in the design stage

a. How are medical procedures taken into consideration in the design stage?
b. Should it be evaluated after occupation and use (post-occupant evaluation)?
c. How can it be evaluated (how you think that should be done)?

6.2. What makes a good design regarding Privacy, Hierarchy and Security

6.2.1. Important elements and challenges to consider in the design stage?
6.2.2. Challenges when designing for different users, uses and requirements and needs?
6.2.3. What kind of constraints that may affect the function of the design (Such as availability of sunlight, technology etc.) And why?

6.3. The design requirement for each user about Privacy, Hierarchy and Security.

6.3.1. Different Staff.
6.3.2. Patients.
6.3.3. Visitors.

6.4. How important is the following?

6.4.1. Visual privacy?
6.4.2. Acoustic privacy (over-hearing sensitive information)?
6.4.3. Visual connection (the ability and the need to see)?

6.5. What kind Analysis and tools are available to test the spatial function in term of the following:

6.5.1.Movement.
6.5.2.Circulation.
6.5.3.Accessibility.
6.5.4.Density and crowdedness.
6.5.5.Privacy.
6.5.6.Hierarchy.
6.5.7.Security.

7. Current Design Situation regarding Social Interaction (approx. 10 min):

This section will aim to explore **social interaction and communication** as important related and linked design criteria to movement by knowing who communicate with who throughout a workday (i.e., were doctors only talking to doctors, nurses to nurses, allied health etc.). Due to its relation to expanding the investigation to study EDs as potential communities of practice.

5

7.1. How important is designing spaces that support social interaction and communication?

7.1.1. How can the design and the layout encourage or discourage communication and social interaction between staff mainly?

7.1.2. How beneficial it is to have spaces that support social interaction and communication?

7.1.3. What kind of design criteria that encourage the social relation and communication?

a. Where users should do such activities from an architect's point of view in general?

b. What kind of creative design solutions that encourage these behaviours?

7.2. What do you know about Informal learning between staff in EDs through social interaction and communication?

Thank you for your time

Would you like to see the results of this research?

6

G. Staff Interview Form:

Interview Guide with Medical Staff (Doctors and Nurses) who are working in Emergency Departments

Welsh School of Architecture
Cardiff University
Bute Building
King Edward VII Avenue
Cardiff, CF10 3NB
Wales, UK
Tel: +44 (0)29 087 4430
Fax: +44 (0)29 2087 4623

The following is a guide that outlines the main structure of the interview with medical staff (doctors and nurses) who are working in Emergency Departments (ED). It is part of a study undertaken for obtaining a PhD degree about exploring current spatial analysis and social practices in emergency departments in hospitals.

The researcher would like to ask you some questions about the emergency department. Your answers are appreciated, as the information you provide will be beneficial for understanding current conditions of spatial arrangements and functional use of Emergency Departments (EDs) in hospitals.

The interview will take about 75 minutes. Please do not feel obliged to answer a question if you do not wish to. Your response will be strictly confidential and used only for this academic research.

Please do not hesitate to ask any question and feel free to add your comments. Thank you for your time and feedback.

Please do get in touch if you have anything to add, contact details are listed below.

Researcher: **Mohammad Abukeshek**

Email: Abukeshekmk@cardiff.ac.uk
Tel (UK): 0044-7341717837
Tel (Jordan) 00962-799086661

Supervisor: **Professor Chris Tweed**

Email: Tweedac@cardiff.ac.uk
Tel (UK): 0044 - 2920876207

1

Date of Interview: _____. **ID:** _____

1. General Information (approx. 10 min):

This section in designed to gather general information about the participants regarding sex, age, working location, medical profession, total experience, working hours and weekly shifts.

1.1. Participant Sex:

- ☐ Male.
- ☐ Female.

1.2. Participant age range:

- ☐ Less than 24 years old.
- ☐ 25 – 34 years old.
- ☐ 35 – 44 years old.
- ☐ 45 – 54 years old.
- ☐ 55 – 64 years old.
- ☐ 65 years or older.

1.3. In which hospital do you work today?

- ☐ King Abdullah University Hospital.
- ☐ Jordan University Hospital.
- ☐ Hamza Hospital.
- ☐ Other: _____

1.4. What is your job position?

- ☐ Doctor
  - ☐ Residential doctor
  - ☐ General Practitioner
  - ☐ Emergency Medicine doctor
  - ☐ Specialist on-call doctor
  - ☐ Other: _____.
- ☐ Nurse
  - ☐ Triage Nurse
  - ☐ A&E Nurse
  - ☐ Other: _____.
- ☐ Paramedic (ambulance)
- ☐ Diagnostic Radiography
- ☐ Healthcare assistant
- ☐ A&E Reception Staff
- ☐ Porter.
- ☐ Other: _____.

1.5. Can you describe your duties and responsibilities in detail, please?

1.6. How long have you been working in the emergency department (total experience)?

☐ Less than 1 year. ☐ 1 – 3 years. ☐ 4 – 6 years. ☐ 7 – 9 years. ☐ Ten years and more.

1.7. How do you quantify the time you spend in ED?

1.7.1. How many weekly shifts (hours) you do work weekly?

1.7.2. How many members of staff usually in each shift (doctors, nurses, and others?)?

2. Medical Procedures in Emergency Departments (approx. 10 min):

This section will try to explore the medical procedures followed in EDs when dealing with patients, and how it is related to injuries types, classification, and treatment processes.

2.1. What types of patients you usually receive in EDs regarding their conditions?

2.2. What does it mean the terms below?

2.2.1. Medical Procedures in EDs?

2.2.2. Taxonomy of medical complaints (is a classification of injuries or medical complaints)?

a. Do you have a specific types/typology of taxonomy (of medical complaints or injuries)?

Ex. Anyone with chest pain might be dealt with differently

Ex. Chest pain - people with open wounds (people who are bleeding) - other non-emergency / non-essential (it is triage probably) … is there is something else?

2.3. Generally, describe the procedures when dealing with patients from arrival to admission or release?

"The participant will be asked to point out his/her answer on a two-dimensional layout for the floor plan."

2.4. How do medical procedures change because of different injuries, cases, and conditions?

2.5. Is there a classification or groping for different injuries that may share the same treatment processes?

2.5.1. If yes,

a. How can injuries be classified/grouped to follow a specific treatment process (depending on what?)?

b. How does the grouping?

" Is it part of formal medical legislations or each hospital has his grouping system?"

c. How many groups and classification of injuries do you have? (people with Chest pain or open wounds)

d. How each classification/group is treated?

e. What are the differences in dealing with each group?

2.5.2. If No, what are the medical process and movement route for different enquires such people with Chest pain or people with open wounds (bleeding).

2.6. What does triage usually do?

2.6.1. What other duties the triage does differently than determining the priority of patients' treatments based on the severity of their condition?

2.7. What are the medical procedures when a group of people with emergencies come together? (car or bus accident)

"The participant will be asked to point out his/her answer on a two-dimensional layout for the floor plan."

3. Current Design Situation for the Emergency Department – Spatial Arrangement (approx. 10 min):

This section aims to understand how the department function in term of coping between spatial arrangement and medical procedures, and what changes may have happened since occupation regarding the department spatial performance and why?

3.1. Does the current spatial arrangement fit harmoniously with the different medical procedures you have?

3.1.1. If yes: Do you think it can be made better/improved? How?

3.1.2. If not:

a. What might be the problem … Where are the problems … in which spaces?

b. What might be causing the hindering of the processes?

c. What changes can be made to solve the problem?

3.2. What changes happened since you have started working in the ED regarding the following and why?

For Example:

3.2.1. The spatial arrangement / Layout:

3.2.2. The movement routes:

3.2.3. Spaces/areas of casual communication or social interaction and rest (formal or informal)

3.2.4. The medical procedures:

3.2.5. Technology:

3.2.6. Others:

" The participant will be asked to point his/her answer on a two-dimensional layout for the floor plan".

4. Current Design Situation regarding Circulation, Movement, and Accessibility (approx. 15 min):

This section aims to understand how the department function in term of **Circulation, Movement, and Accessibility**. In addition to see their relationship with spatial arrangements and medical procedures, and how they might be developed for a better performance.

4.1. How important is the following?

4.1.1. Circulation:

a. How important is it to have different circulation patterns for each user (doctors, nurses, patients and visitors)?

4.1.2. Movement (distance):

4.1.3. Accessibility:

4.2. What are the most important aspects of efficient movement and circulation for different procedures/patients?

4.3. For the current design of the emergency department in term of movement and circulation:

" The participant will be asked to point his/her answer on a two-dimensional layout for the floor plan".

4.3.1. Can you show me **GOOD DESIGN** regarding movement routs, circulation and accessibility?

4.3.2. Can you show me **PROBLEMS** regarding movement routs, circulation and accessibility?

4.3.3. What you did to overcome issues you may face regarding movement routs, circulation and accessibility?

4.3.4. What changes may have happened to improve and facilitate moving around the department (even if as small as moving some furniture or placing some partitions)

4.3.5. What changes can be made to improve the design of the ED regarding movement routs and circulation?

4.4. Can you show me on the map steps of the route you take when being part of handling a usual patient's case?

" The participant will be asked to point his/her answer on a two-dimensional layout for the floor plan".

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4.5. What are the spaces you have access to, and the areas you mainly use?

" The participant will be asked to point his/her answer on a two-dimensional layout for the floor plan".

4.5.1. If Possible, can you show me who can have access to each space in the department?

5. Current Design Situation regarding Density and Crowdedness (approx. 5 min):

This section aims to explore the functional aspects in term of **Density and Crowdedness** and how they are affected by spatial arrangement and medical procedures. In addition, ways of development and improve performance.

5.1. What happens if the number of patients has exceeded the maximum capacity of the room ?

5.1.1.What kind of solutions you have when such problem accrues?

5.1.2.Where do people go when its overcrowded? (specially before admission/in the waiting area).

5.2. What are the most spaces that get crowded in the emergency department? (the highly demanded ones)

" The participant will be asked to point his/her answer on a two-dimensional layout for the floor plan".

5.2.1.More specifically: In what days of the week or the month? And what times of the day mainly?

5.3. What might be the cause of density and over crowdedness in such departments?

5.3.1.What changes can be made to improve the design of the ED regarding density and over crowdedness?

6. Current Design Situation regarding Privacy, Hierarchy, and Security (approx. 15 min):

This section aims to understand how the department function in term of **Privacy, Hierarchy, and Security** their relationship with spatial arrangements and medical procedures. In addition, ways on development and improve performance.

6.1. How important it is to have the following:

6.1.1.Privacy:

6.1.2.Hierarchy:

(Hierarchy in architecture is defined as "The articulation of the importance or significance of a form or space by its size, shape, or placement relative to the other forms and spaces of the organization").

6.1.3.Security:

6.2. Who are the actual occupiers / users of each space in the ED?

" The participant will be asked to point his/her answer on a two-dimensional layout for the floor plan".

* The researcher will list all spaces in the ED in one sheet with an option to choose the different users

This question will provide the researcher with the following:

- Private areas for staff only, other type of staff depending on their positions and duties.
- Simi private spaces, for different staff and patients.
- Simi public spaces, for different staff, patients and visitors.
- Public spaces, for patients and visitors.

6.1. How important is the following?

6.1.1.Visual privacy?

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6.1.2.Acoustic privacy (over-hearing sensitive information)?
6.1.3.Visual connection (the ability and the need to see)?

6.2. For the current design of the emergency department in term of privacy, Hierarchy and security:

" The participant will be asked to point his/her answer on a two-dimensional layout for the floor plan".

6.2.1. Can you show me **GOOD DESIGN** about privacy, Hierarchy, and security?
6.2.2. Can you show me **PROBLEMS** about privacy, Hierarchy, and security?
6.2.3. What did you do to overcome issues you may face regarding privacy, Hierarchy, and security?
6.2.4. What changes may have happened to improve privacy, Hierarchy, and security (even if as small as moving some furniture or placing some partitions)
6.2.5. What changes can be made to improve the design regarding privacy, Hierarchy, and security?

7. Current Design Situation regarding Social Interaction (approx. 10 min):

This section aims to understand the department function in term of **social interaction and communication** by exploring who communicate with who throughout a workday (i.e., were doctors only talking to doctors, nurses to nurses, allied health etc.) and their relationship with spatial arrangements and medical procedures. In addition, ways on development and improve performance. Along with the possibility to have a community of practice in EDs.

7.1. How important is talking and socialise with colleagues in the department (from same or different majors)

7.2. With who do you usually talk in the department?

7.2.1. Can you specify their positions?

7.3. What kind of communication may you have with other?

7.3.1. When is it within the working hours?
7.3.2. When is it within the break hours or at the end of a workday?

7.4. Do you talk about the following:

7.4.1. New knowledge and technology / medical related:
7.4.2. patients' cases and work related:
7.4.3. Social and private topics:
7.4.4. what other topics you may talk about?

7.5. Where do you usually talk, interact or socialise with others:

7.5.1. When is it within the working hours?
7.5.2. When is it within the break hours or at the end of a workday?

7.6. Do you have a specific space/room for communications, talking and socialising with other staff members?

7.6.1. If yes:
   a. Are they private for staff only?
   b. Are they where do you usually have your breaks?
   c. Who exactly uses these spaces/rooms other than you?
7.6.2. If not: would you like one? Would it be useful? Why?

7.7. For the current design of the emergency department in term communication and social activities

" The participant will be asked to point his/her answer on a two-dimensional layout for the floor plan".

7.7.1. Can you show me **GOOD DESIGN**?

7.7.2. Can you show me **PROBLEMS**?

7.7.3. What did you do to overcome issues that may have occurred?

7.7.4. What changes may have happened to improve the situation (even if as small as moving some furniture or placing some partitions).

7.7.5. What changes can be made to improve the situation?

Thank you for your time

Would you like to see the results of this research?

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