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NAVIGATING COMPLEXITY:

ENHANCING WAYFINDING IN ETLİK CITY HOSPITAL

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NAVIGATING COMPLEXITY:
ENHANCING WAYFINDING IN ETLİK CITY HOSPITAL

ABSTRACT

Türkiye has placed significant emphasis on city hospitals as part of its Health Transformation Program over the past decade. The city hospital concept includes individual health departments as separate building blocks coming together to form a large hospital campus. Although these huge building complexes offer numerous advantages, such as housing various departments with pronounced infrastructure and high bed capacity in a contemporary architectural layout, the complexity of circulation and wayfinding becomes challenging. The case study focuses on the newest city hospitals, built in the Etlik neighborhood of Ankara, Türkiye.

These problems were addressed using the space syntax method to analyze space-related problems and propose alternative solutions. The connectivity of the hospital was analyzed at two scales: neighborhood and building. First, the accessibility of the hospital campus is analyzed to document its circulation load on the neighborhood. Secondly, the most densely used hospital spaces which connect all the hospital towers mainly in the large ground floor area, were examined in detail due to its high complexity and resulting wayfinding problems.

The ground floor visibility graph analysis was modeled using the DepthmapX program. The second step involves assessing current plans and suggesting alternative scenarios using visibility graph analysis. The program identified spaces with high density, and alternative scenarios for those areas were proposed based on this knowledge to reduce complexity. In the end, comparisons of these scenarios were made, and discussions were provided.

The findings indicate that different plan alternatives in the hospital could lead to significant impacts on the connectivity and wayfinding problems. This study differs by making significant theoretical contributions to addressing the problems that arose from the large scale and high intensity of patients in city hospitals.

Keywords: Space Syntax, DepthmapX, Visibility, Wayfinding, Healthcare Architecture, City Hospitals, Türkiye

KARMAŞIKLIĞI AŞMAK: YÖN BULMA GELİŞTİRMEDE ETLİK ŞEHİR HASTANESİ ÖRNEĞİ

ÖZ

Türkiye'nin Sağlık Dönüşüm Programı kapsamında, şehir hastaneleri son on yılda ülkenin gündeminde yer almıştır. Şehir hastanesi konsepti, bireysel sağlık bölümlerinin ayrı yapı blokları olarak bir araya gelerek büyük bir hastane kampüsü oluşturmasını içermektedir. Bu büyük yapı kompleksleri, çeşitli bölümleri modern mimari düzenlemeyle yüksek yatak kapasitesine sahip bir altyapıda barındırması gibi birçok avantaj sunsa da, dolaşım ve yön bulma konusunda karmaşıklıklar bulunmaktadır.

Bu çalışma, Türkiye'nin Ankara ilinin Etlik mahallesinde inşa edilen şehir hastanesine odaklanmaktadır. Sorunlar, mekânsal potansiyelleri analiz etmek ve alternatif çözümler önermek için Space Syntax yöntemi kullanılarak ele alınmıştır. Hastanenin bağlantısı, iki ölçekte analiz edilmiştir: yakın çevre ve yapı kompleksi giriş katı. Öncelikle, hastane kampüsünün erişilebilirliği, mahalledeki dolaşım yükünü belgelemek için analiz edilmiştir. İkinci olarak, hastane kulelerini birbirine bağlayan en yoğun kullanılan hastane alanları, yüksek karmaşıklığı ve sonuçlanan yön bulma sorunları nedeniyle detaylı bir şekilde incelenmiştir.

Zemin kat bağlanırlık/bağlantılılık grafiği analizi, DepthmapX programı kullanılarak modellenmiştir. İkinci adım, mevcut planların değerlendirilmesi ve bağlanırlık/bağlantılılık grafiği analizi kullanarak alternatif senaryolar önerilmesidir. Program, yüksek yoğunluğa sahip alanları belirlemiş ve bu bilgiler doğrultusunda karmaşıklığı azaltmak için bu alanlar için alternatif senaryolar önerilmiştir. Sonuçta, bu senaryoların karşılaştırmaları yapılmış ve tartışmalar sağlanmıştır.

Bulgular, hastanedeki farklı plan alternatiflerinin bağlantı ve yön bulma sorunları üzerinde önemli etkilere yol açabileceğini göstermektedir. Bu çalışmada, şehir hastanelerinin büyük ölçeği ve yüksek hasta yoğunluğundan kaynaklanan sorunlar ele alınarak önemli teorik katkılar sunmak amaçlanmıştır.

Anahtar Kelimeler: Mekan Dizini, DepthmapX, Görünürlük, Yön Bulma, Sağlık Mimarisi, Şehir Hastaneleri, Türkiye

CONTENTS

M.Sc. THESIS EXAMINATION RESULT FORM ii
ETHICAL DECLARATION iii
ACKNOWLEGEMENTS iv
ABSTRACT v
ÖZ vi
NOMENCLATURE ix
LIST OF TABLES x
LIST OF FIGURES xi

CHAPTER 1 - INTRODUCTION 1

CHAPTER 2 – LITERATURE REVIEW 3
2.1 Healthcare Facility Design 3
2.1.1 Healthcare Facility Design Challenges 5
2.1.2 Wayfinding in Hospitals 6
2.2 Space Syntax 8
2.2.1 Space Syntax and Hospitals 11
2.2.2 Related Studies 12
2.3 City Hospitals in Türkiye 17
2.3.1 Etlik City Hospital 20
2.3.2 Access to Etlik City Hospital 24

CHAPTER 3 - METHODOLOGY 27
3.1 Comparison of Softwares 28
3.2 Analysis with Various Space Configurations 32
3.3 Connectivity Analysis 32
3.3.1 Etlik City Hospital Neighborhood Connectivity Analysis 33
3.3.2 Main Building Ground Floor Analysis 35
3.4 Scenarios 37

CHAPTER 4 – RESULTS AND DISCUSSION 45
4.1 Comparison of Softwares 45
4.2 Analysis with Various Configurations 46
4.2.1 Correlation Between Visibility Graph Analysis and Connectivity Analysis 51
4.3 Connectivity Analysis 52
4.3.1 Etlik City Hospital Neighborhood Connectivity Analysis 53
4.3.2 Main Building Ground Floor Analysis 58
4.4 Scenarios 60
4.4.1 Connectivity Comparison 62
4.4.2 Integration Comparison 65
4.4.3 Mean Depth Comparison 67

CHAPTER 5 - CONCLUSION 70

REFERENCES 73
APPENDICES 79
Appendix A – Base case connectivity analysis 80
Appendix B – 1st scenario connectivity analysis 81
Appendix C – 2nd scenario connectivity analysis 82
Appendix D – 3rd scenario connectivity analysis 83
Appendix E – 4th scenario connectivity analysis 84
CURRICULUM VITAE 85

NOMENCLATURE

Acronyms

CA	Connectivity Analysis
CAD	Computer Aided Design
VGA	Visibility Graph Analysis
VR	Virtual Reality

LIST OF TABLES

Table 2.1: Design types and complexity 4
Table 2.2: City hospitals, current activity statues and bed capacities 19
Table 2.3: Access options to Etlik City Hospital 26
Table 3.1: Programs that have been evaluated during the process 25
Table 3.2: Scenarios 39
Table 4.1: Examined programs advantages and disadvantages 46
Table 4.2: Mean values of Connectivity 77
Table 4.3: Mean values of Integration 77
Table 4.4: Mean values of Mean Depth 78

LIST OF FIGURES

Figure 2.1: Widening roads, Etlik City Hospital 6
Figure 2.2: Floor plan and picture of General hospital, which has abvious characteristics of axiality and open spaces 14
Figure 2.3: Floor plan and picture of 81 hospital; a compact layout, without open space 14
Figure 2.4: Floor plan and picture of Nanjing Hospital; some open spaces and axis running from north to south 15
Figure 2.5: Türkiye health regions 18
Figure 2.6: Etlik City Hospital layout 21
Figure 2.7: Towers and Maincore 22
Figure 2.8: Schematic distribution of ground floor 23
Figure 2.9: Etlik is located in Keçiören district 24
Figure 2.10: From AŞTİ, 19 minutes with car 25
Figure 2.11: From İvedik Subway station to Etlik City Hospital 25
Figure 3.1: Galleries between Adult and Children Emergency Departments 31
Figure 3.2: Etlik City Hospital during early construction 34
Figure 3.3: Etlik City Hospital during late construction 34
Figure 3.4: Applied scenarios by location 38
Figure 3.5: Scenario 1, the wall in red is moved 1 m. Between Orthopedics and Maternity Hospitals 40
Figure 3.6: Scenario 1, the wall in red is moved 1 m. 40
Figure 3.7: Scenario 1, the wall in red is moved 1 m. 41
Figure 3.8: Scenario 2, the wall in red is moved 1 m. 41
Figure 3.9: Scenario 2, the wall in red is moved 1 m. 42
Figure 3.10: Scenario 2, the wall in red is moved 1 m. 42
Figure 3.11: Scenario 2, the wall in red is moved 1 m. 43
Figure 3.12: Scenario 3, The red part on the wall will be removed. 43
Figure 3.13: Scenario 4, red parts will be removed. 44
Figure 3.14: Scenario 4, red part will be removed 44

Figure 4.1: Effect of the corridor size 47
Figure 4.2: Effect of making a common space 47
Figure 4.3: Effect of the room sizes 48
Figure 4.4: Effect of having various corridor sizes 49
Figure 4.5: Effect of corridor sizes on the longer room dimension 50
Figure 4.6: Effect of corridor sizes on the longer room dimension shared spaces ... 50
Figure 4.7: Effect of corridor sizes on the shorter room dimension..... 51
Figure 4.8: Connectivity analysis of the neighborhood before Etlik City Hospital construction 53
Figure 4.9: Connectivity analysis of the neighborhood after Etlik City Hospital Organisation 53
Figure 4.10: Connectivity analysis after configurations 54
Figure 4.11: Connectivity analysis of Etlik City Hospital neighborhood 54
Figure 4.12: Integration analysis of Etlik City Hospital neighborhood 55
Figure 4.13: Mean Depth analysis of Etlik City Hospital neighborhood..... 55
Figure 4.14: Visibility Graph Analysis of ground floor base case 59
Figure 4.15: Visibility Graph Analysis of groun floor after 4th case scenario 59
Figure 4.16: Connectivity Analysis of different state alternatives by numbers 62
Figure 4.17: Base case scenario connectivity analysis 64
Figure 4.18: 4th scenario connectivity analysis 64
Figure 4.19: Integration (HH) Analysis of different states alternative..... 65
Figure 4.20: Mean Depth Analysis of different states alternative..... 67

CHAPTER 1

INTRODUCTION

Hospitals are versatile, important and high-cost structures where people seek solutions to various health problems. Recently, significant developments have been made in hospital architecture with the development of technology. These developments not only provide the patient or visitor with a solution to the problem, but also help them get through this process with the least stress with a quality of space.

Türkiye has taken important steps in this regard by paying due attention to hospital architecture in recent years. According to information compiled from Ministry of Health sources, significant investments have been made in hospitals with the understanding of “Transformation of Health”. This program was published in 2003 and since then a new architectural approach is on agenda. Modern life support units, operating rooms equipped with international standards, high-tech laboratories, and prioritizes the comfort of patients with the "1 room for each patient" approach was put implemented in this ‘city hospitals’. Today, there are 23 city hospitals on service. Additionally, 11 city hospitals are either construction or design phases [1].

Along with city hospitals, offering many different units to those in need and responding to many different problems with their high bed capacity, as well as providing timely spaces with the development of architecture and technology, has opened a new door for researchers. City hospitals differ from many sample hospitals in terms of concept and size. Etlik City Hospital has opened its doors for service in 2022. This huge structure brought many advantages but also some disadvantages. Among these, difficulty in finding location and direction in large buildings and energy saving are important issues. In this article, a technological answer to these problems will be offered.

Various methodologies are currently available for conducting visibility analysis, with Space Syntax emerging as a prominent framework that offers efficient and effective techniques. Space Syntax encompasses a range of analytical methods aimed at understanding the spatial configurations of environments at both building and urban

scales. This study specifically utilizes DepthmapX, a software tool derived from Space Syntax principles.

DepthmapX facilitates several types of analyses, including Connectivity and Visibility, which are essential for assessing spatial relationships. Initial experiments were conducted to evaluate the software's performance across different spatial units, such as corridors and rooms. Based on these findings, scenarios were developed to enhance connectivity and improve accessibility.

The concept of location and orientation, which is one of the biggest problems we currently encounter in many buildings, is reconciled with the concept of visibility in this study. First, neighborhood scale has been examined in terms of connectivity analysis. It is aimed to find a conclusion about what foresight could we have before construction. Next scale is main building ground floor for detecting complexity decrease methods. To do so, visibility experiments were made to find what is the most used areas. Then scenarios were produced in that areas in order to decrease complexity. To test whether these scenarios whether helped or not, connectivity, integration and mean depth values were recorded in every step.

The objective of this research is to provide a user-friendly, time-efficient, and cost-effective approach for future construction projects. By leveraging the capabilities of DepthmapX, we aim to streamline the analysis process, ultimately contributing to more informed design decisions in architectural and urban planning contexts.

CHAPTER 2

LITERATURE REVIEW

This part provides explanation about the terms that had been used. Headlines: Healthcare Facility Design, Space Syntax and City Hospitals are examined.

2.1 Healthcare Facility Design

Architectural design is a set of purposes. As the purpose of construction changes, design phases also become more difficult. A framework is prepared to explain levels of hardness to design a building. Researchers described seven types of design which match four different levels of complexity and presented a chart [2].

Based on this chart (**Table 2.1**), a buildings' design hardness level can be detected. A hospital design meets many challenges in the chart. According to the scale of the designed hospital some of them might be selected together. With its pioneer design strategies, concept of seek for modern solutions, Etlik City Hospital can be classified under 'Visionary' Hospital. This study presents experiments and the results of these experiments to take this approach even one step further.

Table 2.1: Design types and complexity

Design Thinking Types	**Description**	**Design Expertise Levels**	**Description**
Result-Focused	Following 'the rules of the game', concentration on design conventions; customs and habits; the set ways of working within a field. Eg. Concentrating on the user and designing from their perspective	Naive	Choosing from a set of prescribed solutions and rules driven.
Convention-Based		Novice	Understands that design problems are individual and situated, and reacts to them. Possess design language acquisition.
Situation-Based	Understanding the design situation or context and creating a response specific for that particular setting. Eg. Identifying the 'core problem' of the problem situation.	Advanced Beginner	Able to steer the development of the design problem. Sees the bigger picture.
Strategy-Based		Competent	Can tolerate ambiguity and can actively steer the development of the design problem
Experience-Based		Expert	Has an implicit recognition of situations and a fluent, intuitive response
Developing New Schema	Designing the process itself and creating a design situation for themselves. A developed way of working that is imposed upon the problem. Eg. Reframing the design problem to develop something new.	Master	Practice is at a level of innovation and pushes the boundaries of the field.
Redefining the Field		Visionary	Work is explicitly aimed at redefining the design field.

2.1.1 Healthcare Facility Design Challenges

Healthcare design is a system which has a bunch of interacting parts. Despite numerous positive initiatives to make these interactions better and easier, healthcare facilities are still complex and very difficult to renovate after it has built. In order to save time and energy, these difficulties should be used as parameters and should be available as data in future studies.

Meeting regulatory requirements and standards is a significant challenge in hospital design and construction. Compliance with building codes, healthcare guidelines, fire safety regulations, and accessibility standards adds complexity to the design process and may require extensive revisions and approvals [3].

Hospital construction projects often face budgetary constraints and the risk of cost overruns. Balancing project costs with the need for quality materials, advanced technologies, and specialized equipment can be challenging. Cost estimation inaccuracies, unexpected site conditions, and delays in project timelines contribute to budgetary challenges [4].

Hospitals have diverse functional requirements, including patient care areas, diagnostic facilities, surgical suites, administrative spaces, and support services. Integrating these diverse functions while ensuring efficient patient flow, infection control, and staff workflow presents a complex design challenge [5].

Designing hospitals to prevent healthcare-associated infections and ensure patient safety is critical. Challenges include implementing evidence-based design principles, such as proper ventilation, hand hygiene stations, and spatial layouts that minimize cross-contamination. Construction practices must also adhere to infection control protocols to prevent microbial contamination during building phases [6].

Integrating advanced medical technologies, IT systems, and infrastructure into hospital design poses challenges. Designing infrastructure to support digital health systems, medical equipment connectivity, and telemedicine solutions requires coordination between architects, engineers, and IT specialists to ensure compatibility, accessibility, and scalability [7]. After the construction of Etlik City Hospital was finalized, roadwork projects were initiated (**Figure 2.1**).

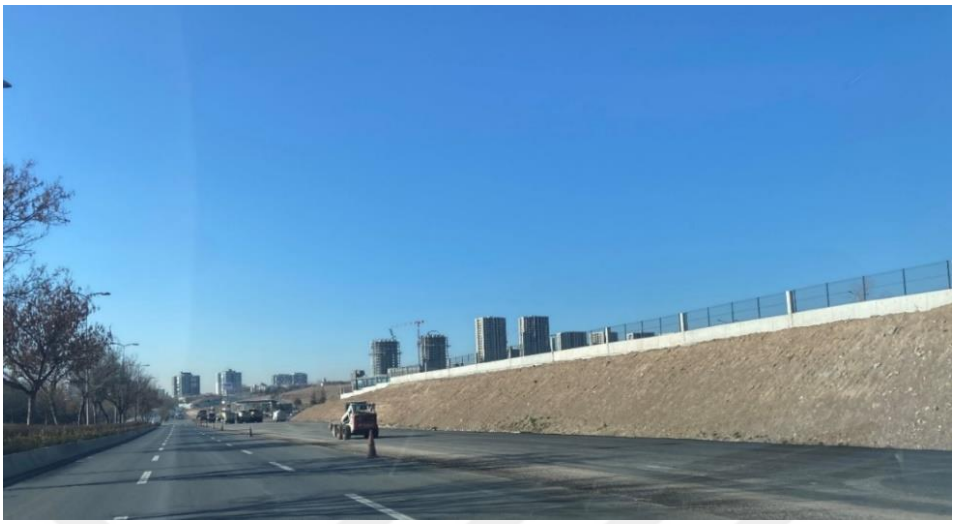


Figure 2.1: Widening roads, Etlik City Hospital

Hospital design and construction involve navigating a myriad of challenges related to regulatory compliance, budgetary constraints, functional requirements, infection control, technological integration, and sustainability. Addressing these challenges requires collaboration among architects, engineers, contractors, healthcare professionals, and regulatory authorities to create healthcare facilities that prioritize patient safety, staff efficiency, and environmental responsibility.

2.1.2 Wayfinding in Hospitals

Hospital architecture plays a crucial role in ensuring efficient navigation for patients, visitors, and staff within the complex healthcare environment. Wayfinding, the process of navigating from one point to another within a built environment, is particularly challenging in hospital settings due to their intricate layouts, varying levels of complexity, and the diverse needs of users. This literature review examines the prevalent problems associated with wayfinding in hospital architecture, explores contributing factors, and discusses potential solutions proposed by researchers and architects. The challenges can be listed as; complexity of hospital layouts, inadequate signage and information systems, environmental factors, user characteristics, technological interventions and human centered design approaches.

Hospitals often feature multifaceted layouts comprising numerous interconnected buildings, floors, corridors, and departments. Such complexity can lead to confusion among users, especially first-time visitors, resulting in difficulties in locating desired destinations. Research indicates that labyrinthine layouts contribute significantly to wayfinding problems in hospitals [8].

Poor signage and information systems exacerbate wayfinding challenges in hospitals. Studies have highlighted issues such as insufficient signage, unclear directional cues, inconsistent signage design, and inadequate information about department locations [9]. Ineffective signage can cause frustration and anxiety among users, impeding their ability to navigate the facility efficiently.

Environmental factors, including architectural design elements such as lighting, color schemes, and spatial arrangements, also influence wayfinding in hospitals. Research suggests that environments with homogenous features or lack of distinctive landmarks can hinder spatial orientation and impede wayfinding [10]. Additionally, poor lighting conditions or overcrowded spaces may further complicate navigation for users, particularly those with visual impairments.

Wayfinding difficulties in hospitals are often compounded by the diverse characteristics and needs of users. Patients with cognitive impairments, language barriers, or mobility limitations face unique challenges in navigating hospital environments [11]. Moreover, the emotional and stressful nature of healthcare settings can affect users' cognitive functioning, making wayfinding more challenging.

Several studies have explored the potential of technology-based interventions to improve wayfinding in hospitals. Digital navigation systems, mobile applications, and interactive maps offer promising solutions to enhance users' navigation experience [12]. These technologies provide real-time guidance, personalized directions, and additional information about hospital amenities, thereby alleviating wayfinding difficulties.

Human-centered design principles emphasize the importance of understanding users' needs and preferences in designing hospital environments. Integrating user feedback, conducting usability studies, and employing participatory design methods can help

architects create intuitive wayfinding solutions tailored to users' requirements [13]. Involving stakeholders throughout the design process ensures that the built environment supports effective navigation for all users.

Wayfinding problems in hospital architecture pose significant challenges for patients, visitors, and staff, impacting their experience and operational efficiency. Addressing these challenges requires a multifaceted approach that considers the complex nature of hospital environments, user characteristics, and technological advancements. By implementing effective signage systems, incorporating human-centered design principles, and leveraging innovative technologies, architects and healthcare professionals can create hospital environments that facilitate seamless navigation and improve overall user satisfaction.

2.2 Space Syntax

Space syntax is an interdisciplinary approach that explores the spatial configuration of built environments and its impact on human behavior. Developed primarily by architects Bill Hillier and Julienne Hanson [14] in 1970s. Space syntax seeks to understand how spatial layouts influence social interactions, movement patterns, and other phenomena [15].

At its core, space syntax treats space as a social product, emphasizing the relationship between spatial structure and human activities. It utilizes techniques from graph theory and spatial analysis to model and analyze spatial configurations, representing buildings and urban spaces as networks of interconnected spaces and pathways [16].

Space syntax has gained popularity in urban [17], architectural [18], and environmental [19] [20] studies over the past few decades. These studies also have a wide range of application fields. They are used in social [21], environmental psychology [22] and economical results of architectural strategies [23]. It can be employed with different methods like Geographical Information System [24] or agent-based modeling [25] in order to produce spesific outcomes. According to these results, different analysis can be conducted including connectivity, visibility and mean depth [26].

Space Syntax can be employed for different fields and applications to address different problems. Transportatation developments [27], urban accessibility [28] and wayfinding problems [29].

These problems can vary according to type of building. In this study, insights are provided by Space Syntax researches related to hospitals.

During the maincore ground floor analysis, Visibility Graph Analysis (VGA) was used to detect the areas that we produced scenarios. Thanks to VGA, we found the most dense used areas. Then, scenarios are made and connectivity, integration and mean depth values are compared.

Space syntax offers a powerful tool for analyzing the visual connectivity of spaces through VGA. In this study, several key measures derived from VGA were selected to assess spatial connectivity.

Connectivity: Quantifies the number of direct visual links each space has with its immediate neighbors [30]. This measure reflects a space's ability to be seen from adjacent areas, providing insight into local integration. Connectivity has been used to evaluate people's navigation abilities and mental recognition of a space, particularly for first-time visitors [31].

Connectivity can be understood as the vibrant web of connections that each street shares with its neighboring streets, highlighting the number of direct links that weave our urban landscape together. A pathway (that can be a corridor, street or any kind of connection between two spaces) characterized by numerous connections to adjacent side streets exhibits a high connectivity value, indicating its importance in facilitating movement and access [32]. In contrast, for example a street with limited connections reflects a low connectivity value, suggesting reduced accessibility. This variation in connectivity can be effectively visualized using a color gradient, allowing for a clearer understanding of the urban landscape's navigational dynamics [33].

Connectivity is a critical factor in urban planning and architecture, particularly concerning pedestrian networks. It refers to how well different parts of a network are linked, influencing pedestrian movement and accessibility [34]. Effective connectivity analysis can reveal potential improvements in urban infrastructure, promoting walking

as a viable mode of touristic [35], historical [36] and built environment walkability [37].

Visual Integration: Indicates the overall accessibility of a space in relation to all other spaces within the system [38]. This measure captures the level of comprehension of the entire spatial configuration. Studies have shown integration to be a reliable predictor of wayfinding performance, especially for repeated visits [39].

The degree of integration of a street or a corridor significantly influences its topological distance to other streets or corridors within the larger space network [40]. A highly integrated street tends to have a shorter topological distance to all other streets, facilitating easier access and connectivity. Conversely, a street that is more segregated will exhibit a longer topological distance to its neighboring streets, indicating greater isolation within the urban system. This relationship highlights the critical role of street integration in shaping urban mobility and accessibility [33].

Visibility is a practical method used to enhance the legibility of a space. Through this analysis, studies have been conducted to determine the most effective placement of architectural elements such as staircases [41]. It can be cosidered as a tool while designers make decisions. It is also possible to carry out specialized analyses for buildings with specific user groups, such as hospitals, schools, and nursing homes [42]. Similar to connectivity analysis, visibility studies can be employed to control and determine human flow, ensuring that commercial spaces operate at maximum efficiency [43].

Mean Depth: Mean depth is determined by assigning a depth value to each space based on its distance from the original space. This involves summing these depth values and then dividing the total by the number of spaces in the system, excluding one. Lower mean depth values indicate more integrated locations, reguiring fewer steps to reach from the starting point. Higher mean depth values on the other hand suggest less integrated spaces which may be harder to access [44].

By incorporating these VGA measures, particularly connectivity, this study aims to provide a comprehensive assessment of spatial connectivity and its implications for user experience and wayfinding within the built environment.

Space syntax has applications in various fields, including architecture, urban planning, transportation planning, and interior design [45]. It helps designers and planners optimize spatial layouts for efficiency, safety, and user experience. By analyzing spatial configurations, space syntax provides insights into how built environments can be designed to promote social interaction, wayfinding, efficiency in spatial use and overall well-being [46].

2.2.1 Space Syntax and Hospitals

In this chapter space syntax theory and the relation with hospital circulation is identified. In addition different types of analysis methods and research areas which they are used are mentioned. In this way, various interpretations have been made. By analysing previous studies it is possible to develop an understanding what matters is shape of the geometry of the spaces.

The concept of "wayfinding" was first introduced in the 1960s by Kevin Lynch [47]. Lynch used the term to describe how people perceive and navigate urban environments. He identified paths, edges, districts, nodes, and landmarks as key elements that shape one's mental image of a place. Hospitals, like cities, require a clear hierarchy of circulation, such as primary and secondary corridors, to function effectively. Nodes and landmarks within hospitals, such as departmental entries, nurses' stations, and courtyards, act as reference points for navigation. Additionally, distinguishing between different zones within a hospital can enhance legibility, similar to city districts.

Hospitals often present wayfinding challenges due to their complexity, the unfamiliarity of first-time visitors, and confusing unit names on signs. While signage plays a crucial role, architectural design is also vital for effective wayfinding. Research by Carpman [48] demonstrated that signs alone are insufficient for guiding people in large, complex environments like hospitals. Mollerup [49] emphasized pre-visit information, architectural design, and clear naming as essential factors for successful wayfinding. Studies by Carroll and O'Neill [50] further noted that the complexity of floor plans significantly affects navigation, with simpler layouts and fewer decision points reducing confusion.

An integrated analysis of a hospital's layout, including field of view at entry points and corridor integration, can predict wayfinding success. Isovist analysis helps identify which entry points may pose more difficulties. The International Health Facility Guidelines suggest that understanding spatial relationships is crucial for effective circulation systems, aiding in wayfinding [51].

2.2.2 Related Studies

Accessibility in hospitals is crucial for patient care and staff efficiency. Defined as the ease of entering, using, or approaching something, accessibility ensures quick access to equipment and clear observation of patient rooms. Effective hospital design includes flexible spatial arrangements that support patient-staff interactions, clear circulation paths, and efficient transportation of equipment. The goal is to organize circulation to minimize decision points and maximize visual access, improving both wayfinding and overall accessibility. The study measured these aspects using indicators such as entry point views and corridor integration, focusing on patient-staff relationships and plan complexity.

One of the research on indoor navigation was the initial study to recognize essential elements of a building's path network, such as decision points, directional shifts, and distances, as significant predictors of challenges in wayfinding within complex structures [52]. Categorization of environmental factors influencing wayfinding circumstances were focus in another study: visual accessibility, architectural complexity, signage and room numbering practices, and floorplan layout [53].

Hospital design is a complex architectural task and considered as high cost projects. In addition to architectural standards applied in a design process, new tools are introduced by the space syntax community in the form of specified programs to provide an advanced method of assessing the effectiveness of any design configuration [54].

Another study focused on axial lines to represent the public corridor system, the ground floor plan of a 100-bed hospital analyzed to determine corridor integration values [55].

Conclusions from this study:

1. Visitors engaged in exploration tend to use corridors in proportion to their integration-n values. When in doubt about where to go, more visitors tend to gravitate to areas with higher integration values.
2. The distribution pattern of staff and visitors in a hospital building is similar to that of pedestrians in an urban setting, i.e., on average, more integrated spaces have more people. Program values are correlated with real behaviors of users.

Depending on these conclusions, the public corridor system in the ground floor of a 21-story hospital complex was analyzed [56]. One of the output from this work was, lower mean depth had a better opportunity to explore the entire hospital. This study confirmed the importance of corridor and node integration-n values as predictors of exploration and wayfinding, and it contributed the importance of the mean depth of the entry point as a factor for successful wayfinding.

Researchers continued their earlier work by adding two more large hospital complexes [57]. This study was aimed for explore connection between space syntax and spatial cognition. The results reconfirmed the value of space syntax analysis, and also suggested that connectivity is strongly featured in the cognitive maps of participants.

Conclusions from this study:

1. Syntax variables play an important role in suggesting which corridors will be used more the syntax value of the entry space had an effect on wayfinding by exploring and wayfinding visitors in hospital buildings.
2. More integrated corridors are also more likely to be “mapped” in cognitive knowledge, and thus may play a larger role in wayfinding.

In the later study researchers conducted a one-to-one scaled virtual reality (VR) of one hospital used in the earlier experiments [58]. This VR was totally devoid of all landmarks, people, smells, and other “real-world” variables. All the corridors had the same color, finish materials, and lighting. A comparison of the results with those from the real hospital building showed a remarkable similarity [59].

Later same experimental methods with 31 participants in three Chinese hospitals were applied [60]. The selected hospitals are diverse in regard to their principles of configuration. One is to a great extent based on principles of traditional Chinese architecture, due to obvious axis running from south to north, and many open spaces in front of the main buildings (**Figure 2.2**).

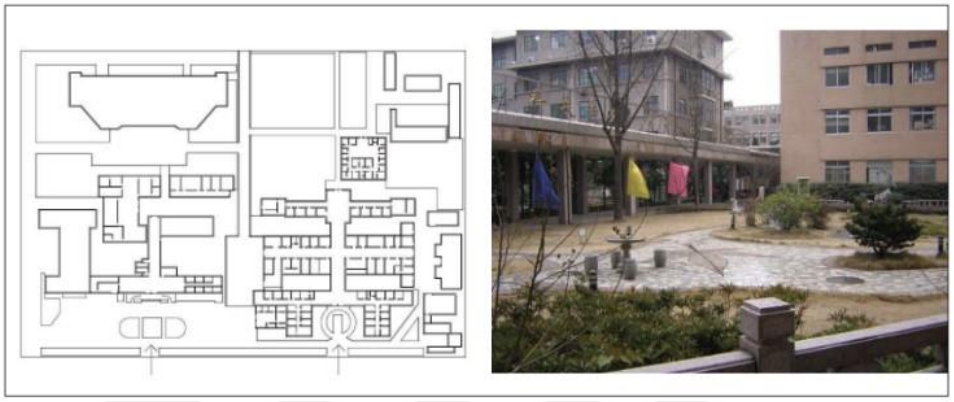


Figure 2.2: Floor plan and picture of General hospital, which has obvious characteristics of axiality and open spaces. (Source: Authors).

On the other hand, the second one has a strongly compact layout, with few characteristics of Chinese traditional buildings (**Figure 2.3**).



Figure 2.3: Floor plan and picture of 81 Hospital; a compact layout, without open space. (Source: Authors)

The third hospital shows an in-between situation in respect to the previous ones. (**Figure 2.4**). It also has some open spaces and an axis running from north to south. They reconfirmed the importance of integration values and applicable for all design types.

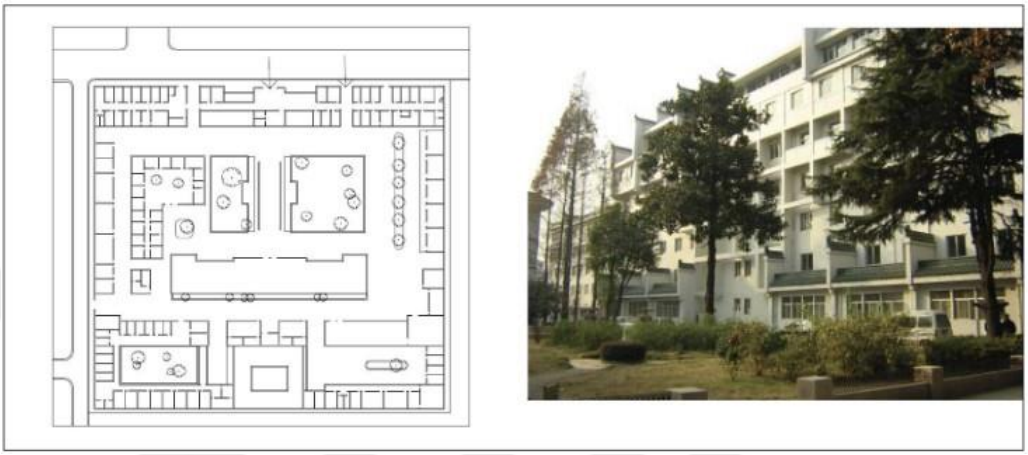


Figure 2.4: Floor plan and picture of Nanjing Hospital; some open spaces and axis running from north to south. (Source: Authors).

Hendrich and his colleagues developed a concept for nurses' movement to patients' rooms during their shift. The layout that has been used was not all floor or a unit but patients' rooms section. Nurses who were assigned to rooms with higher integration values entered those rooms and the nurses' stations more frequently. This suggests that 'altering the spatial properties of nurse assignment will change the way nurses move, either increasing or decreasing the number of trips to patient rooms and nurses stations' [61].

A different result from the same study suggested that there is a positive correlation between the number of entries into patient rooms and the total time spent there. So nurses who have more integrated assignments will enter patients' rooms and the nurses' station more frequently, spend more time in patient rooms, and have a better opportunity to interact with other nurses in the unit. All of these are factors in providing more opportunities for surveillance, more social support for one another, more time in patient rooms, and ultimately better care. This study demonstrated that considering

layout properties through space syntax techniques when creating nurse assignments could be beneficial to patient care.

In another study, researchers have worked on bed position impact on patients [62]. Analysis revealed that beds with lower integration (and lower control) were preferred for privacy, and those with higher integration values were disliked. In their other study, they add gender and ethnicity factor [63]. When split according to these divisions, the data showed no difference in terms of gender or ethnicity. However, people who were previously hospitalized chose more integrated locations. This is interesting because more integrated locations were also areas subject to greater potential surveillance and less privacy. This finding suggests that patients feel more secure when they are more visible (to the nurses), even if this means being in less private areas.

Another article explores how the spatial configuration of hospital wards impacts the work processes, communication networks, and overall quality of care provided to patients [64]. The study, conducted by Pachilova and Sailer [65], emphasizes the concept of "spatial intelligibility" - the ease with which individuals can understand and navigate the layout of a space - as a critical factor in hospital design.

The research involved an empirical analysis of six hospital wards across three National Heath Service hospitals in London, comparing intensive care units and nursing wards. It utilized space syntax to calculate spatial metrics like connectivity, integration, mean depth, and intelligibility. These metrics helped in understanding how different layouts influence the movement and interaction patterns of healthcare workers. Data collection methods included wearable devices to track communication patterns, shadowing staff to record work activities, and staff surveys to assess teamwork and communication quality.

Key findings suggest that wards with higher spatial intelligibility tend to foster better communication and teamwork, leading to improved care quality. Specifically, layouts that allow for clear visibility and ease of movement encourage more frequent and efficient interactions among healthcare staff. This, in turn, results in shorter activity durations and more effective care processes.

In conclusion, the research underscores that well-designed ward layouts with high spatial intelligibility can significantly enhance communication, teamwork, and ultimately the quality of patient care.

To summarize, space syntax is a popular method for analyzing user movements, particularly in complex structures like hospitals. It provides quick and practical insights that can lead to new findings and solutions. In Türkiye, healthcare architecture is particularly relevant with the development of city hospitals. We aim to explore how space syntax methods can be used to easily improve the accessibility of certain areas within these hospitals

2.3 City Hospitals in Türkiye

Healthcare systems in Türkiye is developing day by day. Since this field is crucially important, new approaches are standing out. ‘City hospitals’ are not only different from architecturally but partnership method.

With the announcement of the Health Transformation Program, Türkiye is divided into 29 main health regions (**Figure 2.5**) [66]. Health campuses are planned to expand limits of reachable department variety and make easy to access welfare. In this context, large-scaled hospitals constructed aiming quickly accessible in any region to respond any health problem. Mersin City Hospital is the first one which started to serve in 2017 for this purpose.



Figure 2.5: Türkiye health regions

As the pioneer of the city hospitals of Türkiye: Yozgat, Mersin, Isparta and Adana started to welcome patients in 2017. Kayseri, Elazığ Eskişehir, Manisa, and Ankara Bilkent City Hospital and Bursa City Hospital started to serve in 2018. In 2022 Etlik City Hospital opened as the second city hospital in Ankara (**Table 2.2**).

İzmir (Yenişehir) Tınaztepe City Hospital is awaiting approval from the High Planning Council and has a capacity of 1200 beds [67].

Table 2.2: City hospitals, current activity statues and bed capacities

	Name of the Hospital	**City**	**Phase**	**Bed Capacity**
1	Yozgat City Hospital	Yozgat	On service	475
2	Manisa City Hospital	Manisa	On service	558
3	Isparta City Hospital	Isparta	On service	755
4	Elazığ City Hospital	Elazığ	On service	1038
5	Eskişehir City Hospital	Eskişehir	On service	1081
6	Mersin City Hospital	Mersin	On service	1294
7	Bursa City Hospital	Bursa	On service	1355
8	Adana City Hospital	Adana	On service	1550
9	Kayseri City Hospital	Kayseri	On service	1607
10	Bilkent City Hospital	Ankara	On service	3704
11	Tekirdağ City Hospital	Tekirdağ	On service	480
12	Kütahya City Hospital	Kütahya	Construction continues	600
13	Konya City Hospital	Konya	On service	1250
14	Kocaeli City Hospital	Kocaeli	Construction continues	1210
15	Şanlıurfa City Hospital	Şanlıurfa	Construction continues	1700
16	Gaziantep City Hospital	Gaziantep	Construction continues	1875
17	Bayraklı City Hospital	İzmir	Construction continues	2060
18	İkitelli City Hospital	İstanbul	On service	2682
19	**Etlik City Hospital**	**Ankara**	**On service**	**3577**
20	Diyarbakır City Hospital	Diyarbakır	Construction continues	750
21	Rize City Hospital	Rize	Construction continues	800
22	Ordu City Hospital	Ordu	Construction continues	900
23	Samsun City Hospital	Samsun	Construction continues	900
24	Trabzon City Hospital	Trabzon	Construction continues	900
25	Aydın City Hospital	Aydın	Construction continues	1300
26	Antalya City Hospital	Antalya	Construction continues	1000
27	Denizli City Hospital	Denizli	Construction continues	1000
28	Sakarya City Hospital	Sakarya	Construction continues	1564
29	Sancaktepe City Hospital	İstanbul	Construction continues	4200

Hospitals are inherently complex structures due to their functional requirements. They are expected to bring together various units to provide a flow of activity tailored to

different user types. This complexity arises from the multitude of inputs needed to cater to diverse needs efficiently.

City hospitals, or what we used to call hospital campuses in simpler terms, face the challenge of integrating specialized hospitals into one complex. Even within hospitals dedicated to specific departments (Such as eye hospitals or oncology hospitals), navigating through the layout can be challenging. For city hospitals, this complexity becomes even more pronounced.

In addressing this complexity, the focus is on finding solutions that streamline processes rather than adding to the user's burden. Time is of the essence in hospitals, so any system implemented should make tasks easier and help users reach their goals quickly.

To better understand and tackle this complexity, the study employs the space syntax method. Space syntax is a valuable tool in modern architecture and is frequently used for user analysis. It aims to analyze spatial configurations to provide insights into circulation patterns and user interactions within complex environments like hospitals.

2.3.1 Etlik City Hospital

Etlik is a neighborhood in the district of Keçiören in Ankara with the same name.

With a bed capacity of 4.050 Etlik City Hospital comprises 1.000 outpatient clinics, 125 operating rooms, 691 intensive care beds, and a total indoor area of 1.145,129 m^2. This health campus aims to ensure comfort, diagnosis, and privacy for patients. And beyond, it aims to provide health care at the highest level.

This hospital consists of a Diagnostic Treatment Building and three independent hospital blocks. Six hospital towers connected to this Diagnostic Treatment Building. These are General Hospital, Neuro-Orthopedics Hospital, Chest and Cardiovascular Hospital, Children's Hospital, Maternity Hospital and Oncology Hospital affiliated to the Diagnostic Treatment Building. The three blocks are Physical Therapy and Rehabilitation Hospital, Psychiatry Clinic and Medical Observation Clinic.

As mentioned earlier, this campus is the second city hospital in Ankara. Bilkent City Hospital analysis is a good reference to get to know Etlik City Hospital better.

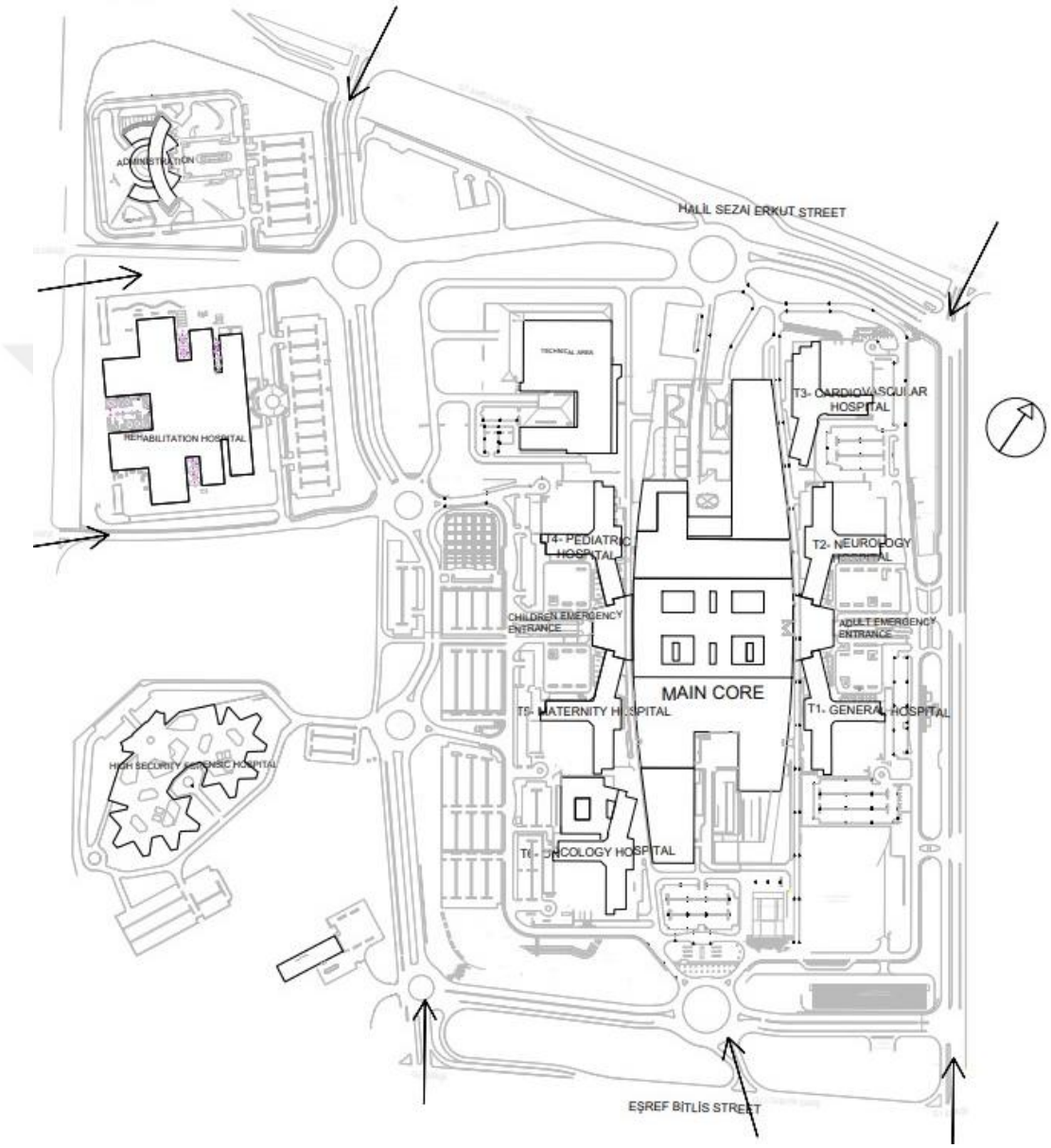


Figure 2.6: Etlik City Hospital layout

The city hospital has five main entrances. The northern entrance is located on Halil Sezai Erkut Street, opposite the Antares Mall. The south entrance is on Eşref Bitlis Street. (**Figure 2.6**)

Hospital Organization

Etlik City Hospital consist of different units each with special functions:

- Tower 1: General Hospital (Endocrinology and Metabolism Diseases Department, Gastroenterology, General Surgery, Internal Medicine, Medical Genetics, Opthalmology (Eye Diseases), Otorhinolaryngology (Ear Nose & Throat Department), Plastic Surgery, Psychiatry…
- Tower 2: Neurology-Orthopedics Hospital
- Tower 3: Cardiovascular Hospital
- Tower 4: Children's Hospital
- Tower 5: Maternity Hospital
- Tower 6: Oncology Hospital
- Physical medicine and Rehabilitation Hospital
- Main Core (Emergency Medicine Department, Microbiology Laboratory, Pathology Lab, Nuclear Medicine, Radiology Unit…)

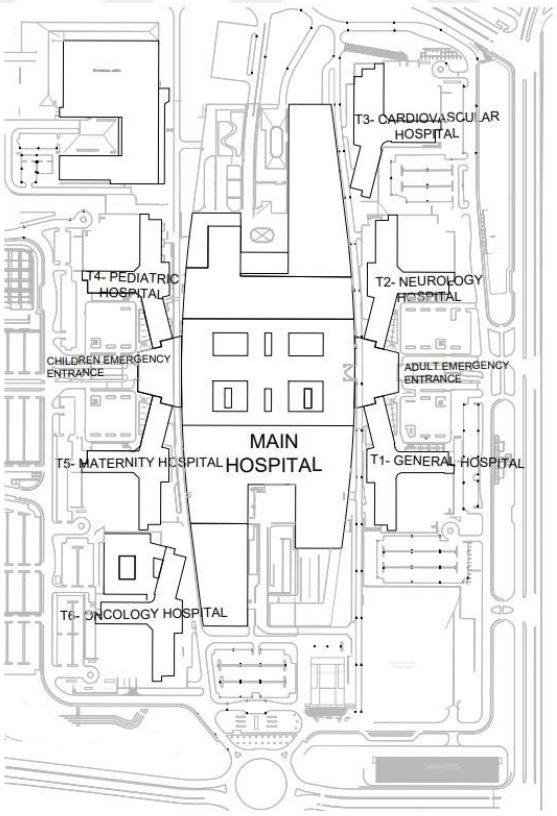


Figure 2.7: Towers and Maincore

As mentioned earlier, this campus is a set of hospital blocks. Tower 1-2-3-4-5-6 and maincore are connected through a common floor. Also, towers are connected through bridges at first and second floors. That means when a person walks in the adult emergency department, one can reach to their destination without an interruption. (**Figure 2.7**)

Hospitals in nature have already a complex arrangement due to the variety of functions and high number of occupants. City hospitals, on the other hand, comprises larger number of units and high capacities. (**Figure 2.8**). This proposes a challenge to solve accessibility problems. Way-finding is addressed by the hospital administration in two ways. Firstly, to cope with the complex arrangement, color coding was used to navigate visitors and staff. Some intersections needed further assistance for way-finding problems and it is solved by employing service staff to guide the visitors.

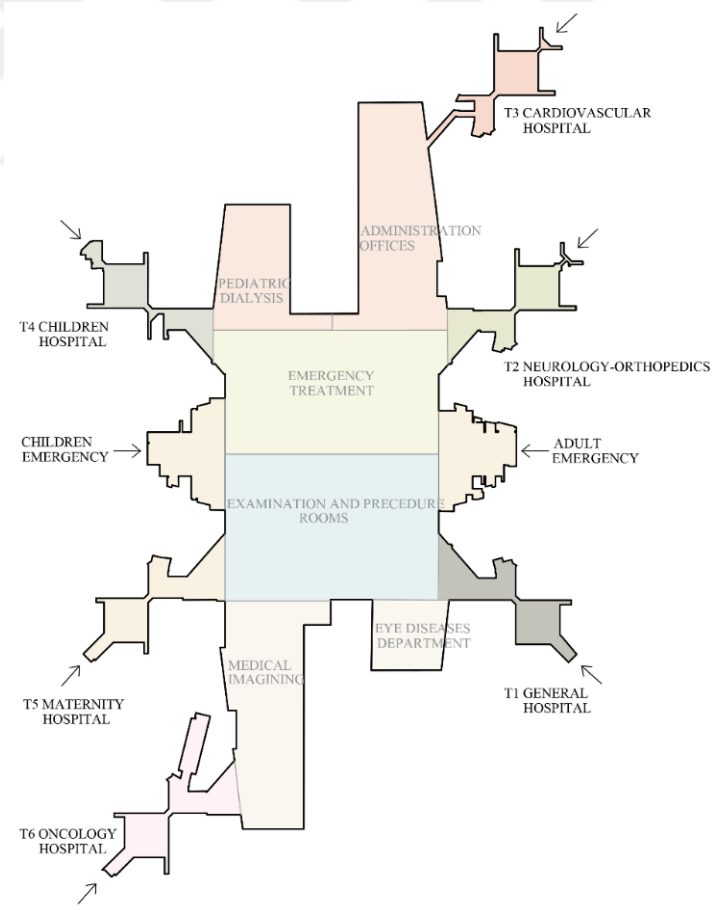


Figure 2.8: Schematic distribution of ground floor

This paper aims to analyze how users get to campus and circulation between blocks. According to this analysis, inference will be made on how time and energy could be saved with the help of architectural design.

2.3.2 Access to Etlik City Hospital

Etlik is one of the most crowded districts in Ankara with 32.200 population approximately (**Figure 2.9**) [68]. This area has a long history resulting narrow roads. These roads are not capable of carry the heavy traffic problem well. Morning and evening rush hours are really huge stress source. In order to overcome this problem, choosing public transportation may be one of the solutions. (**Table 2.3**)

Patients come from all around in Ankara to the city hospital. That means, there is an extensive transportation network.

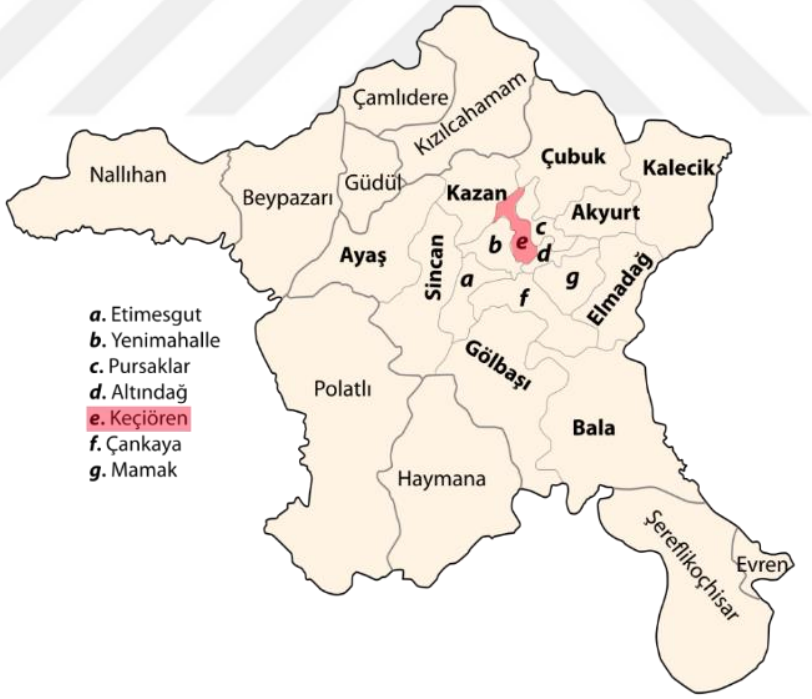


Figure 2.9: Etlik is located in Keçiören district [69]

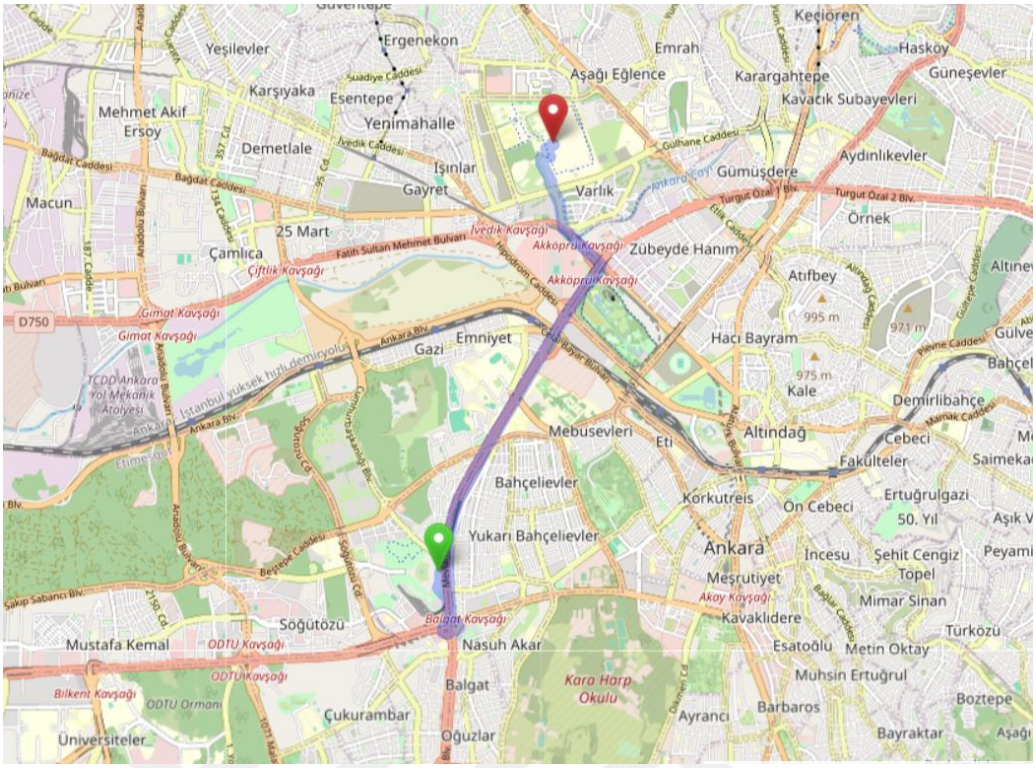


Figure 2.10: From AŞTİ, 19 minutes with car

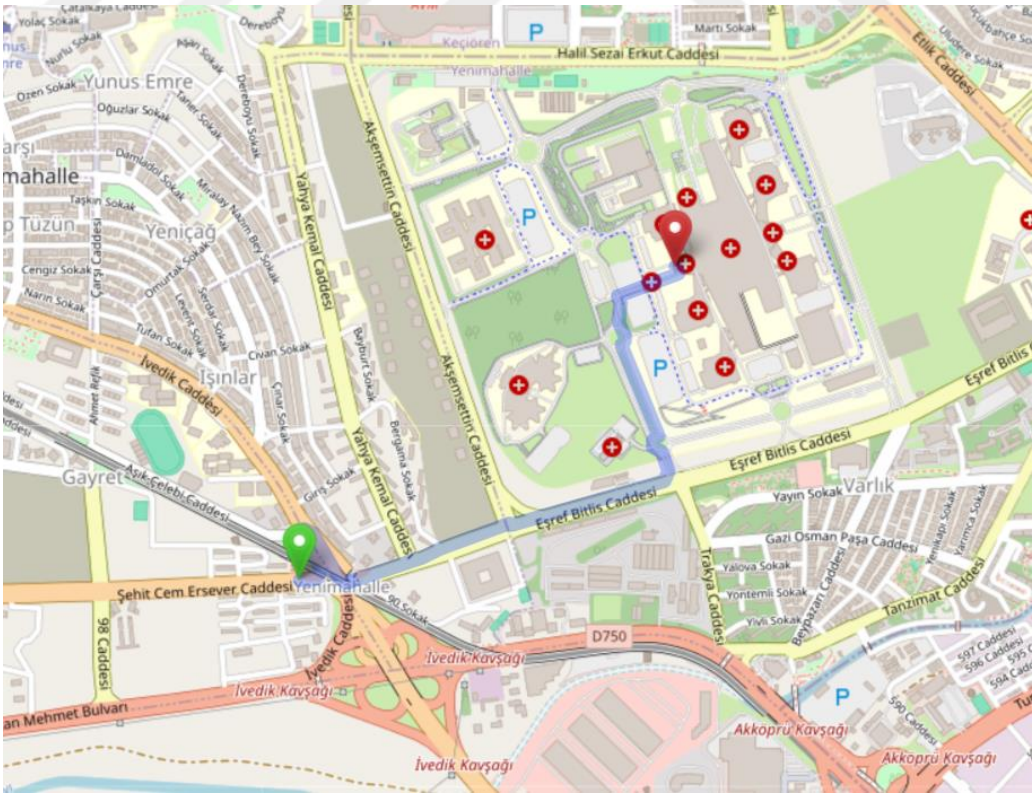


Figure 2.11: From İvedik Subway station to Etlik City Hospital

For those who come from other cities using an airplane, can choose to come with a taxi or a rented car. It will take approximately 30 minutes. Also, there is a bus going to city hospital as well. Those who choose this option should risk a long road and transfer. Numbered 442 K and 409 respectively will long one and a half hour in best scenario. (**Figure 2.11**)

For those who come from other cities by bus arriving AŞTİ (Ankara Intercity Bus Station), taking a taxi can be an option. Predicted arrival time is 12 minutes. Subway can be another option. For that, İvedik Subway Station will be target. After that, a bus rotation will be continued (206 numbered bus). This option will take longer time, approximately half an hour. (**Figure 2.10**)

Table 2.3: Access options to Etlik City Hospital

If	**Then**
Patient comes with airplane in Ankara Esenboğa Airport is starting point	Taxi takes 32 minutes in best case scenario
	Using public transportation (2 busses and 20 minutes walking) takes 1 hour 10 minutes
Patient comes with bus in Ankara AŞTİ is starting point	Taxi takes 13 minutes in best case scenario
	Taxi takes 19 minutes in worst case scenario
	Using public transportation (2 different subway line then 1 bus ring) 30 minutes in best case scenario
Patient is already in Ankara	Line 206 takes 13 minutes on the route of İvedik Subway-Etlik City Hospital (every 40 minutes)
	Line 409 takes 30 minutes on the route of Dışkapı-Etlik City Hospital-Akköprü (every 30 minutes)

CHAPTER 3

METHODOLOGY

This study aims to analyze end users' access to Etlik City Hospital blocks and their movements in and around them, starting with a literature review of the City Hospital concept in Türkiye. The objectives of building them, the capacities, and their locations nationwide are documented.

In Etlik City Hospital, the densest areas are the ground floor of the main mass and the campus circulation. In addition, the campus has a complex circulation which connects numerous spaces and various departments to each other. These spaces are also object to various user profiles, such as visitors, medical staff and service staff. Therefore, visitor level selected. First detailed sample area is the ground floor of main core. Second one is the general layout of the campus.

To find out the density and connectivity diagrams general layout of hospital and ground floor (adult emergency department) drawings' will be transferred into DepthmapX program. Assumptions and examinations will be based on this space syntax program outcome.

To produce a visibility graph analysis, selected plans has been drawn in one file and converted a DXF file to work on. Then these plans imported in DepthmapX and visibility graphs had been produced.

Outcomes shown that some specific areas and corridors are colored in red. Based on this coloring, new alternative plans had been drawn to suggest easily percept passages.

This wayfinding problems in Etlik City Hospital examined under two scales in this study:

1. Neighborhood scale
    - Connectivity analysis
    - Integration analysis
    - Mean Depth analysis

2. Ground floor analysis
    - Connectivity analysis
    - Integration analysis
    - Mean Depth analysis

3.1 Comparison of Softwares

Within the scope of the study, programs that can reflect user movements were considered. To do this, space syntax and agent-based modeling programs have been examined. (**Table 3.1**)

AnyLogic is a software tool designed for agent-based modeling, which allows users to simulate individuals by assigning them specific traits such as speed, pathways, and stops during their journeys. While it offers numerous powerful features, mastering the program and developing prototypes requires a significant investment of time and resources.

NetLogo is a foundational tool for simulating human actions and interactions. Yet, it was ultimately not selected because its user interface was not as user-friendly as we required, and there were doubts about whether it could generate results quickly enough to meet our project timeline.

The Syntactic plug-in for Grasshopper facilitates the creation of very precise and professional solutions. Nevertheless, it was dismissed from our options because of worries regarding the time required for implementation and its adaptability to our needs.

Table 3.1: Programs that have been evaluated during the process

Program	Primary Domain	Supporting Organisation	License	Programming Language	Operating System
AnyLogic	Agent-based general purpose; also supports discrete event and system dynamics simulations	The AnyLogic Company; Oakbrook Terrace, Illinois, USA	Proprietary; Free Personal Learning Edition available	Java	Linux, macOS, Windows
NetLogo	Social and natural sciences; Help beginning users get started authoring models	Northwestern University, Evanston, Illinois, USA	free and open-source software, released under a GNU General Public License (GPL).	NetLogo	Cross-platform
Grasshopper-Syntactic as Plug-in	Primarily used to build generative algorithms, such as for generative art	David Rutten at Robert McNeel & Associates	Free trial version, used in related program (Rhino3D)	Rhinoceros 3D computer-aided design (CAD)	Windows 2000 and later, MacOS
depthMapX	Spatial networks of different scales	Alasdair Turner from the Space Syntax group	Open Source	Salascript R and python	Windows 2000 and later, MacOS

The decision to select the DepthmapX program for space syntax case studies is grounded in empirical evaluation and practical considerations.

- Integration with CAD Software: depthmapX typically works with plans and layouts created in Computer-Aided Design (CAD) software. It can import plans in various formats, such as DXF (Drawing Exchange Format), which is a common format used in CAD.

- Open Source and User-Friendly: Being open source means that depthmapX is freely available for anyone to use and modify. Its user-friendly interface makes it accessible to both researchers and practitioners in architecture, urban planning, and related fields.
- Rapid Iteration: One notable advantage of depthmapX is its ability to quickly produce different versions of spatial network models. This facilitates iterative analysis, allowing users to explore various design scenarios or hypotheses efficiently.

Limitations: Despite its strengths, depthmapX does have limitations, such as its reliance on DXF format and the need to switch to another DXF-supported program for plan adjustments. This can potentially disrupt the workflow if frequent modifications are required. Also, it is noteworthy to mention that in every single change in plan, user needs to produce a new DXF file and reload it again. It also effects the efficiency about timing.

Overall, depthmapX is a valuable tool for conducting spatial analysis and exploring the spatial properties of built environments, particularly in the context of space syntax studies. Its ease of use, open-source nature, and rapid iteration capabilities make it a popular choice among researchers and practitioners in the field.

As previously discussed, updating the DXF format necessitates restarting the entire process from scratch after any modification. This repetitive cycle constitutes one of the major challenges encountered in this study. However, this is not the sole issue at hand.

The current program facilitates two-dimensional edits and calculations. Nonetheless, it falls short in detecting architectural features such as galleries and voids related to upper floors, which are discernible in cross-sections. In real-world scenarios, these architectural elements significantly influence visibility and accessibility, thereby impacting both aesthetic and functional aspects of the design. For instance, maincore has many galleries in its own (**Figure 3.1**).



Figure 3.2: Galleries between Adult and Children Emergency Departments

Moreover, the inability to accurately render and analyze these three-dimensional elements in the software leads to potential oversights in structural integrity and spatial dynamics. For instance, voids and galleries play crucial roles in natural lighting and air circulation within a building, affecting the overall environmental quality. Addressing these limitations through future software enhancements could vastly improve the reliability and comprehensiveness of architectural planning and visualization tools.

Future research should prioritize the development of advanced algorithms capable of integrating three-dimensional architectural complexities into the DXF format. Incorporating machine learning techniques to predict and rectify potential design flaws could also be beneficial. Additionally, cross-disciplinary collaboration between software developers and architects would ensure that the digital tools evolve in alignment with practical architectural needs.

In conclusion, while the current program offers a framework for two-dimesional editing, the incorporation of three-dimensional architectural elements and the refinement of the DXF updating process are imperative for advancing the utility and accuracy of architectural design software.

3.2 Analysis with Various Space Configurations

In this section, experiments pertaining to the program were executed, focusing on a visually comprehensible visibility graph analysis.

Configurations of various room, corridor and open space configurations in order to understand the mechanism of the visibility analysis. This allowed us to produce new scenarios and record higher connectivity values. In this section headlines will be emphasized, results will be discussed in later results section.

- The effect of the corridor size
- The effect of creating a common space
- The effect of the room sizes
- The effect of having various corridor sizes
- The effect of corridor sizes on the longer room dimension
- The effect of corridor sizes on the longer room dimensions of shared spaces
- The effect of corridor sizes on the shorter room dimension

3.3 Connectivity Analysis

This analysis focuses on understanding the physical connections between spaces along the identified corridors. It delves into the structural layout, intersections, branching pathways, and potential bottlenecks, evaluating the efficiency and effectiveness of these connections. Results are important in order to make comparison for new scenarios.

a) **Integration Values:** Visual integration assesses the extent to which a space is visually linked to other zones within a structure or city, gauging the ease with which individuals can observe and be observed from various vantage points

within that space. This concept enables the examination of how the arrangement of a building or urban environment influences human behavior and mobility. One of the best prediction and evaluate integration accessibility is Visual Integration [HH] for visibility.

b) **Mean Depth Values:** In the Space Syntax method, visual mean depth is a metric employed to evaluate the accessibility of a specific point within a graph. This involves identifying the shortest path with the least number of turns from a node to all other nodes in the graph. The sum of these paths is then divided by the total number of nodes in the graph (excluding the focal node) to derive the mean depth value. Despite the resemblance in trends to prior metrics, it is important to emphasize a significant inverse relationship between visibility and mean depth.

3.3.1 Etlik City Hospital Neighborhood Connectivity Analysis

In this section, the connectivity of the Etlik City Hospital campus with its surroundings is presented through connectivity analysis. The campus is situated on a 1.145,129 m^2 area. Before construction, the area already had heavy vehicle use. We tried to show that it is possible to make a pre-construction analysis regarding the use of a building of such a scale (**Figure 3.3**) [70]. There are seven alternatives for access to this large area. These entrances can be listed as three entrances on Eşref Bitlis Avenue, two entrances on Akşemsettin Avenue, and two entrances on Halil Sezai Erkut Avenue.

After construction (**Figure 3.4**) [71], vehicle and pedestrian traffic in the area increased. Stops were placed in different areas of the campus for public transportation.

The area and surroundings of Etlik City Hospital were redrawn in a CAD environment using a screenshot taken from OpenStreetMap. The obtained DXF file was then analyzed in the DepthmapX program for connectivity analysis of the specified area. The connectivity, integration, and mean depth values before and after the construction were compared, and inferences were made about the accessibility of the region. Certain measures are being taken at a specific scale, and interventions are being made regarding transportation, but the vehicle density cannot be ignored. The aim is to reveal the mathematical relationship of a structure and its surroundings on this scale. By

doing so, it is intended that such simulations applied beforehand will provide the necessary reference for infrastructure preparations in new constructions.



Figure 3.3: Etlik City Hospital during early construction

A city hospital generally serves patients coming from different regions of the city. Therefore, the accessibility of the hospital is of great importance. Proximity to public transportation networks and main roads ensures easy accessibility to the hospital. The Etlik City Hospital is conveniently accessible by public transportation. Thus, users can reach the section relevant to their preferred alternatives.



Figure 3.4: Etlik City Hospital during late construction

The conducted study recorded an increase in connectivity values in the region following the organization of the Etlik City Hospital campus. By providing an alternative to the transition between Eşref Bitlis Avenue and Halil Sezai Erkut Avenue outside Akşemsettin Avenue, the traffic flow in the area has been made smoother.

3.3.2 Main Building Ground Floor Analysis

The initial step involves analyzing connectivity analysis of base case scenario. The purpose is to prioritize analysis on these corridors, which are critical in terms of both length and traffic flow.

City hospitals consist of integrated hospital blocks that converge at the ground floor, presenting many intersections and connections. This interconnected places generate a complex network of paths and functions that need to be optimized to address circulation effectively.

It is important to understand these relationships while designing efficient circulation systems within the hospitals. Different departments are connected with the help of a diagnostic building main floor. This feature can lead some confusions for wayfinding and make some concerns about accessibility. Mentioned issues are not subject just for patients but also for medical staff.

It is expected from designers to offer smooth and clear navigation paths for visitor and staff. Different departments or in other words multiple blocks in that case can make a labyrinthine structure, making it difficult for users to find their destinations. Effective signage, design elements like strips on the floor or technological solutions like simple applications can help mitigate these navigation challenges.

Additionally, one of the major headlines is the optimization of patient and staff flow. Efficient circulation is requested to minimize delays and ensure timely access to medical services. Strategic planning of corridors, waiting areas and service points can be involved in enhancing circulation within the hospital. Simulation tools can be employed to model and predict circulation patterns for design decisions.

Another important input for an optimum design is that it should be accessible for all users, including individuals with disabilities. Ensuring that pathways are wide enough

for wheelchair access, offering ramps and elevators, and incorporating tactile guidance for visually impaired users.

Future research and development should focus on innovative solutions to address these circulation challenges. This could involve the integration of smart technologies, such as real-time occupancy tracking and adaptive traffic management systems, to dynamically adjust and optimize circulation based on current conditions. Collaboration between architects, engineers, and healthcare professionals is crucial to develop holistic and effective solutions that enhance the functionality and user experience of city hospitals.

In conclusion, the city hospital concept presents unique challenges due to the convergence of various hospital blocks on the ground floor. Addressing these challenges requires a comprehensive understanding of the relationships and interactions between different spaces and the implementation of strategic design and technological solutions to optimize circulation and accessibility.

When producing scenarios, references were made through these relationships. The goal was to achieve more visible spaces with small interventions and ultimately express the impact mathematically.

In the process of scenario development, the relationships between different spaces and their functions were meticulously analyzed. By understanding these relationships, it was possible to identify key areas where minor adjustments could lead to significant improvements in spatial visibility and functionality.

For example, adjusting the placement of partitions or altering the flow of foot traffic can enhance the visibility of critical areas such as emergency exits, information desks, and treatment rooms. These small interventions not only improve the overall user experience but also contribute to the safety and efficiency of the hospital environment.

Furthermore, the impact of these interventions was quantified using mathematical models. By applying principles of geometry, statistics, and computational analysis, the design team could predict the outcomes of various changes and optimize the layout accordingly. This data-driven approach ensures that the interventions are both effective and measurable, providing a solid foundation for continuous improvement.

The process of offering scenarios for hospital design involved a detailed examination of spatial relationships and the implementation of targeted interventions. The use of mathematical models to quantify the impact of these changes allowed for a precise and scientific approach to enhancing the visibility and accessibility.

After completing the DepthmapX analyses, the changes were compared, and how the proposed scenarios affected the values was recorded. In this study, three different comparisons were made:

- Connectivity Comparison
- Integration Comparison
- Mean Depth Comparison

The mathematical implications of the changes are included in the results and discussion section.

3.4 Scenarios

The aim is to reevaluate elements believed to reduce visibility values and conduct a pioneering study by experimenting within a simulation. The study consists of two steps. In the first step, the visibility graph analysis of the base case scenario (Scenario 0) was produced using the depthmapX program. Connectivity, integration, and mean depth values were recorded. Based on the insights drawn from this analysis, scenarios were generated.

Initially, it was observed that high density is between orthopedic and women's hospitals. The first decision was to expand this corridor (Scenario 1). Next, based on the density observed in the corridor that has medical imaging ophthalmic department symmetric to the building block, the expansion of that corridor was also planned (Scenario 2). The removal of the drywall between the pediatric emergency and pediatric hospital is the third addition (Scenario 3). Finally, to enhance visual communication in the adult emergency department with other building blocks, transitions between triage rooms have been introduced (Scenario 4). It should be emphasized that in the second step, scenarios were applied cumulatively. In each

scenario, a new scenario was added as values increased, meaning that the decisions from the first and second scenarios are also included in the third scenario (**Table 3.2**).

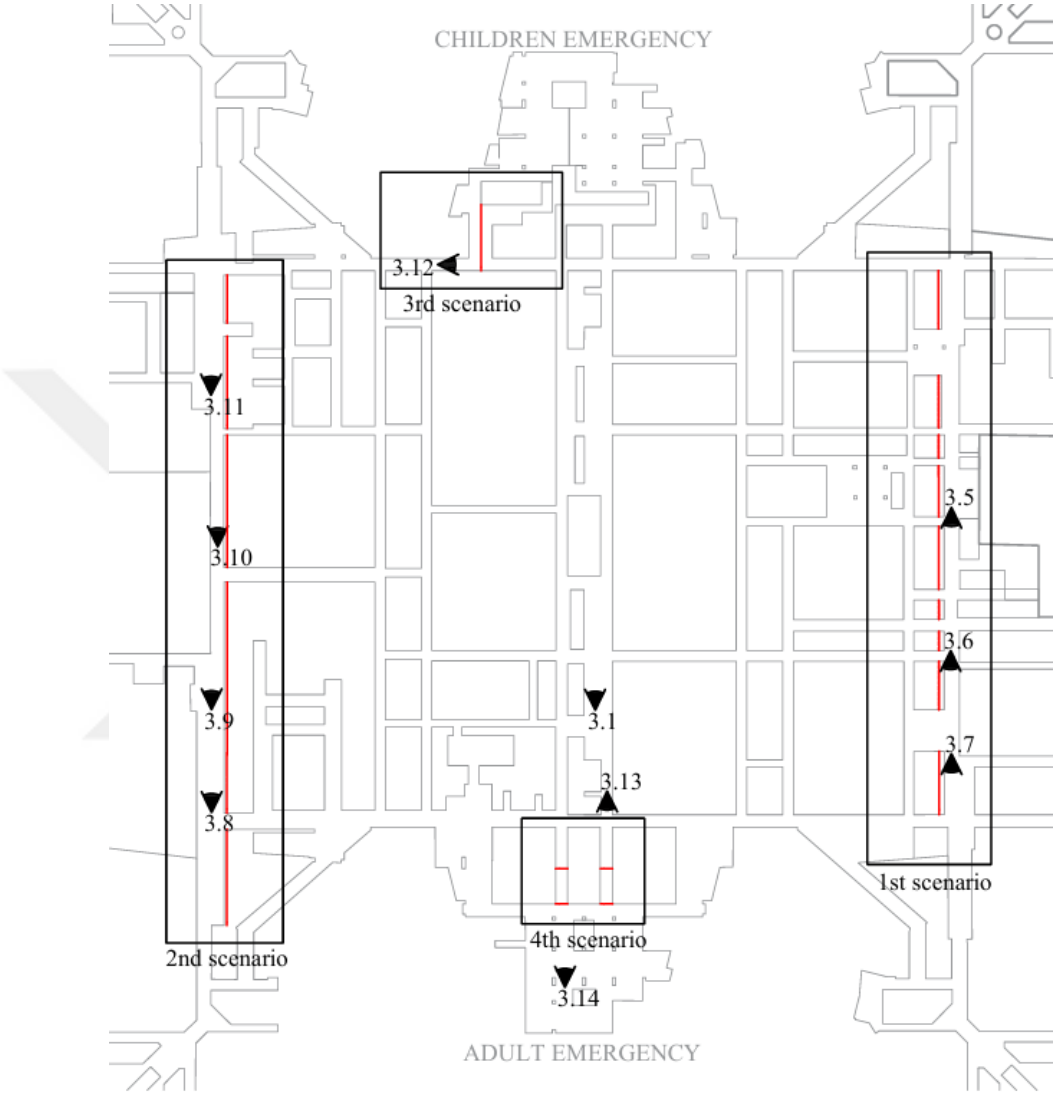


Figure 3.5: Applied scenarios by location

(Modifications have been illustrated with red dashed lines)

Table 3.2: Scenarios

Number	Location	Scenario	Figure(s)
0	Base Case Scenario	Current state	
1	Between Orthopedics and Maternity Hospitals	Corridor is enlarged (1m).	3-5, 3-6, 3-7
2	Between General and Oncology Hospitals	Corridor is enlarged (1m).	3-8, 3-9, 3-10, 3-11
3	Children Emergency	Blockage removed.	3-12
4	Adult Emergency	Triage rooms were separated.	3-13, 3-14

The primary focus of these adjustments was to enhance the connectivity values directly associated with visibility metrics. This involved implementing urgent changes within the adult triage rooms and waiting areas to augment the connectivity factors. By specifically targeting these areas, efforts were made to improve the overall connectivity values between different sections and departments, ensuring a more seamless and efficient flow of movement. This enhancement was crucial for optimizing patient and staff interactions, reducing wait times, and improving the overall functionality and user experience of the hospital.

The strategic modifications in the triage and waiting areas also considered the psychological comfort of patients and their families, creating a more open and navigable space that reduces stress and anxiety. By enhancing connectivity through thoughtful design, the hospital environment becomes more intuitive, thereby improving operational efficiency and patient satisfaction. These improvements underscore the importance of integrating visibility and connectivity metrics into the planning and development phases of healthcare facilities to achieve a holistic enhancement in service delivery.



Figure 3.6: Scenario 1, the wall in red is moved 1 m. Between Orthopedics and Maternity Hospitals

(Source: Author)

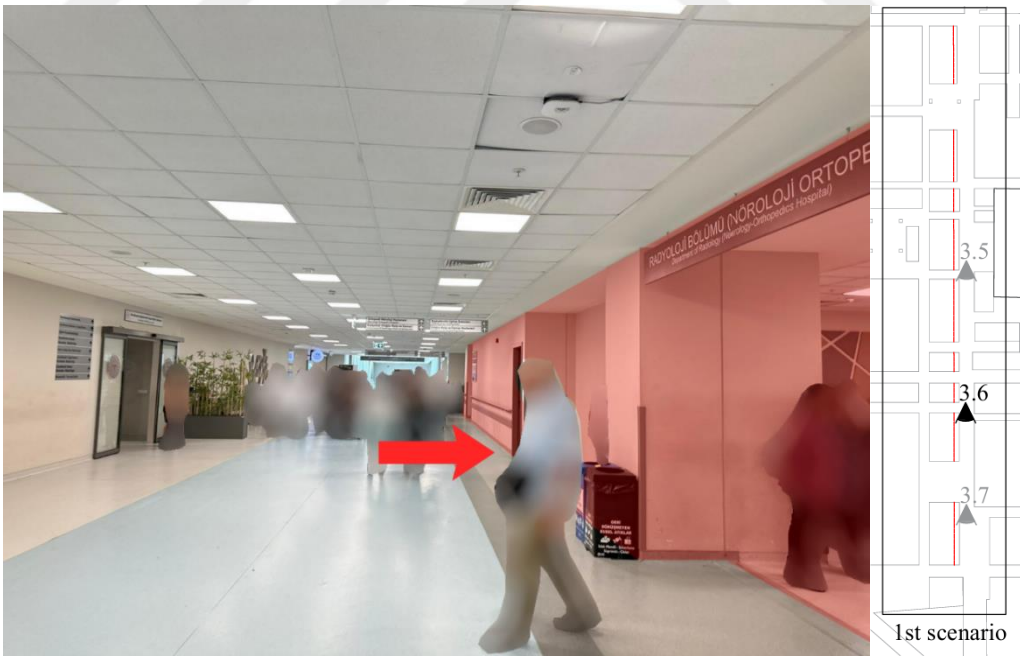


Figure 3.7: Scenario 1, the wall in red is moved 1 m.

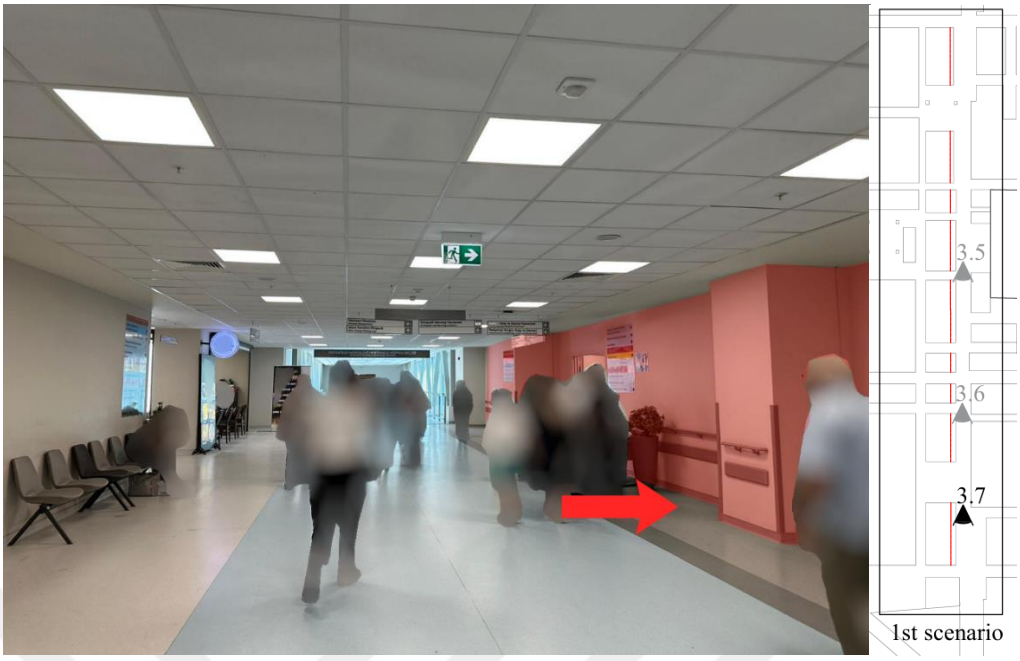


Figure 3.8: Scenario 1, the wall in red is moved 1 m.



Figure 3.9: Scenario 2, the wall in red is moved 1 m.



Figure 3.10: Scenario 2, the wall in red is moved 1 m.



Figure 3.11: Scenario 2, the wall in red is moved 1 m.



Figure 3.12: Scenario 2, the wall in red is moved 1 m.

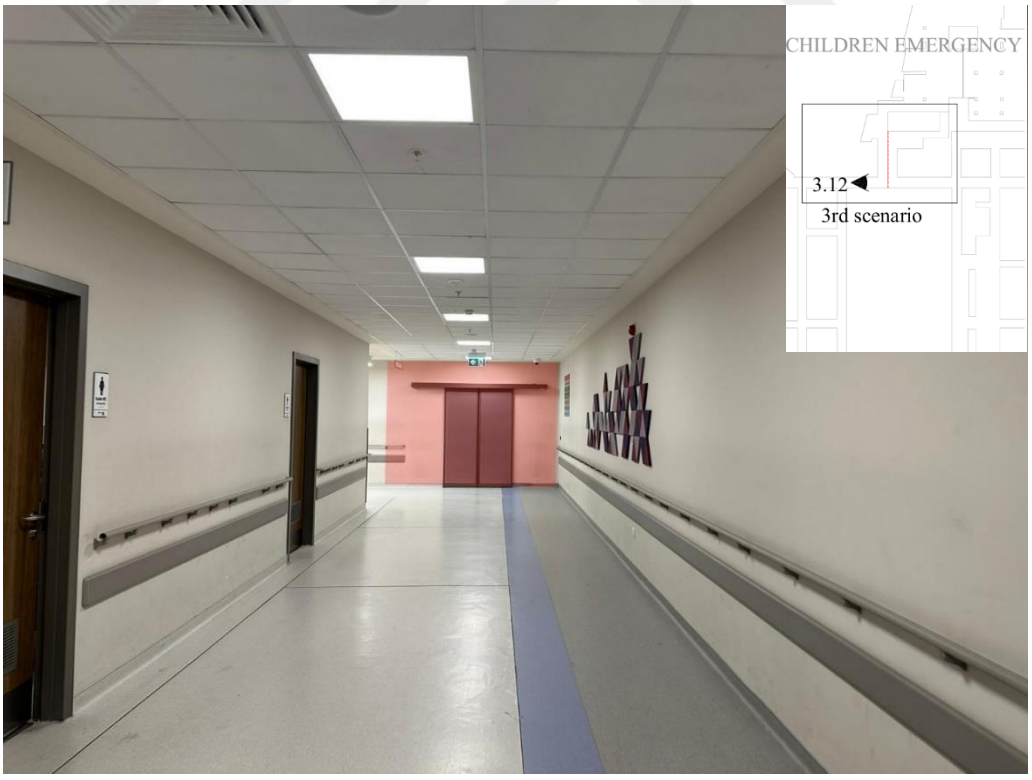


Figure 3.13: Scenario 3, The red part on the wall will be removed.

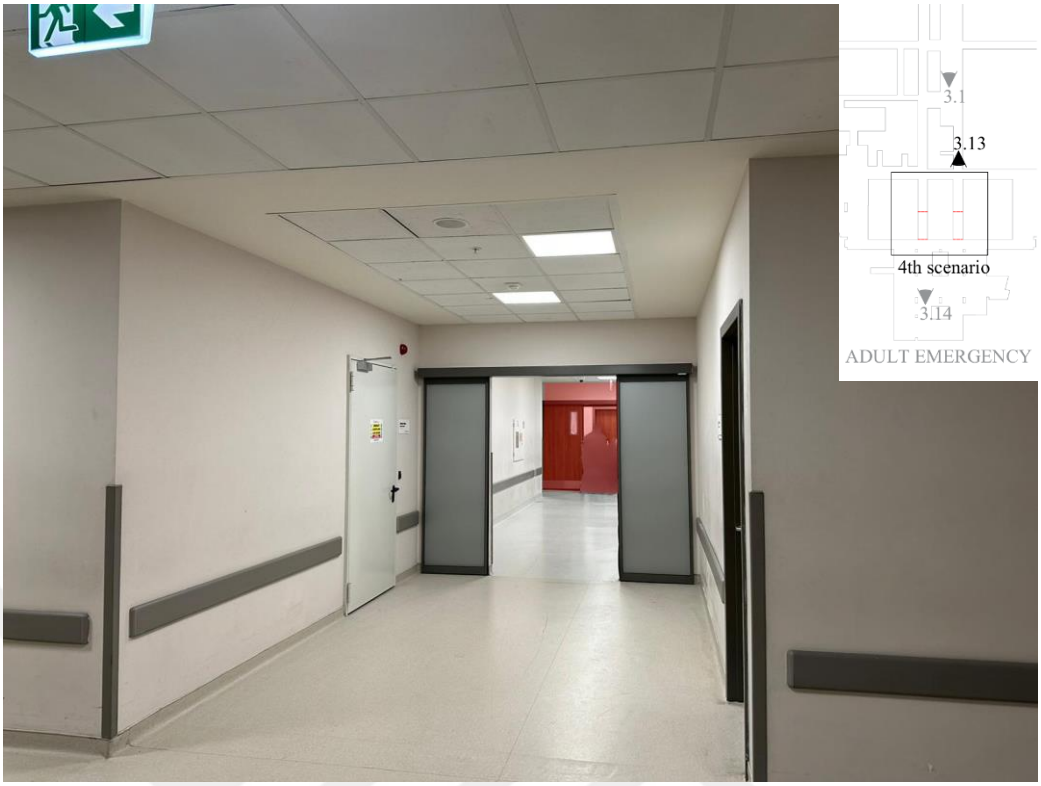


Figure 3.14: Scenario 4, red parts will be removed.



Figure 3.15: Scenario 4, red part will be removed

CHAPTER 4

RESULTS AND DISCUSSION

This study involves two different scale analysis. First, Etlik City Hospital with its surroundings to understand what are the changes in environment. Second, first floor of main building analysis to examine how to enhance our traditional wayfinding understandings. To examine program parameters better, a DepthmapX experiment conducted. According to outcomes, new scenarios added to current plan layout in order to follow a holistic approach.

4.1 Comparison of Softwares

Different softwares have been experimented during study (**Table 3.1**). As mentioned above, these programs are well-studied and structured ones. Yet, the each of them has advantages and disadvantages. During the process we focused what will work for us the best. DepthmapX is the most matched one with our requests.

From the beginning we wanted to produce fast scenarios in the very short amount of time. Best results were gained by DepthmapX. And we had the most important advantage about the simplicity in that program. Because we wanted to produce an idea that anyone can apply without a long preparation. It was easy to learn and even during construction phase it is possible to produce rapid simulations compared with other programs. (**Table 4.1**)

DepthmapX has been chosen due to its open-source nature, user-friendly interface, and the ability to quickly produce prototypes.

Table 4.1: Examined programs advantages and disadvantages

Program	Advantage	Disadvantage
AnyLogic	Human traffic can be precisely modeled using speed and time duration, allowing for accurate simulations of movement patterns. Instant moves and special cases can be effectively analyzed. An extensive library of pre-built components and support for agent-based modeling enhance these simulations by enabling realistic interactions between individual agents and their environment.	The outcome data is insufficient for explaining different types of spatial analysis. The free personal learning version has a limited library. The interface is confusing and requires high capacity.
NetLogo	The interface is easy to use, allowing for rapid prototype production. Additionally, graphical support is available. [72]	Behavioral patterns alone do not provide sufficient information to observe differences in connectivity patterns. NetLogo is not capable of handling very complicated models, especially those involving abstract concepts.
Grasshopper-Syntactic	Clear bubble diagrams can effectively illustrate movement schemes.	Access for professional users is limited, making it challenging to find examples and methods.
depthMapX	It is open source and supports various plug-ins, making it a popular choice for space syntax case studies. Its accessibility and user-friendly nature also contribute to its ease of learning.	Certain scales may require a high-capacity computer to run efficiently. However, when the program encounters issues and fails to run, it often lacks feedback to pinpoint the problem.

4.2 Analysis with Various Configurations

Depending on analysis what we have learnt in methodology chapter we examined to enhance current connectivity, if connectivity has been enhanced, scenario recorded and another scenario added. If there is a decrese in values, scenario of interest retreated.

- The effect of the corridor size

Initially, corridors of varying widths were drawn between the same units (**Figure 4.1**). In Diagram 1, the corridor width was designed to be twice that of Diagram 2. As a result of this comparison, it was observed that units with wider spacings between them corresponded to colors with higher visibility-connectivity values. It indicates that wider corridors have higher values of connectivity and integration numbers.

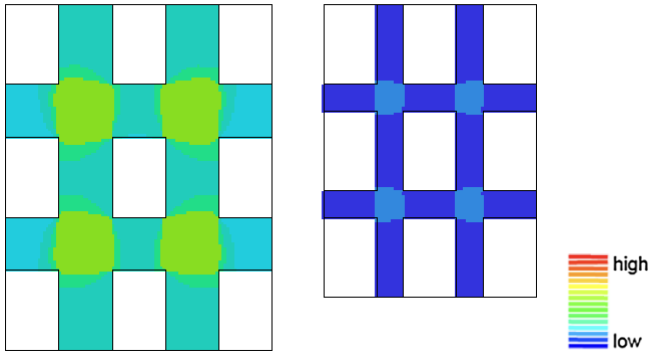


Figure 4.16: Effect of the corridor size

Left Diagram: Room size 1 corridor width 2 unit

Right Diagram: Room size 1 unit, corridor size 1 unit

The experiment of widening corridors to increase connectivity values serves as an important reference in this context. After this outcome, scenario 1 which is enlarging 1 m the corridor between Orthopedics and Maternity Hospitals was conducted after this examination. Connectivity and integration values has increased and mean depth values has decreased as expected.

- The Effect of Creating a Common Space

In the context of the same design, an exploration was undertaken to investigate the correlation between the dimensions of shared spaces and corridors by eliminating the central unit (**Figure 4.2**).

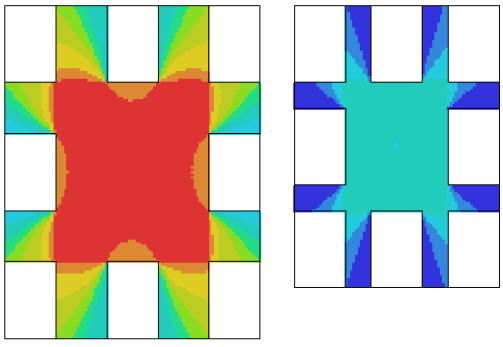


Figure 4.2: Effect of making a common space

Diagrams 3: Room size 1 unit, corridor width 2 unit

Diagram 4: Room size 1 unit, corridor width 1 unit

This adjustment led to a striking visual transformation, as seen in Diagram 4, where corridors, now half the width of those depicted in Diagram 3, interconnect. The resultant effect is a compelling shift in color dynamics.

This observation underscores the pivotal role played by corridor width in shaping the perceptual experience within the shared space. Scenario 2 has been added taking this inference into account. Corridor between general and Oncology Hospitals drawn 1 m enlarged to increase connectivity values.

After this change, an increase in connectivity and integration values was observed, while mean depth values decreased.

- The Effect of the Room Sizes

Following these steps, a comparison was made between corridors of the same width connecting units of different sizes (**Figure 4.3**). Diagram 5 illustrates a floor plan where larger units are linked with narrow corridors, while diagram 6 represents a version where smaller units are connected with the same corridor width. At this stage, no dramatic difference was observed between the two floor plans. However, it was noted that the navy blue color, indicative of lower values, was partially more pronounced in Diagram 5. It was inferred that corridors linking larger units possessed lower connectivity-visibility values.

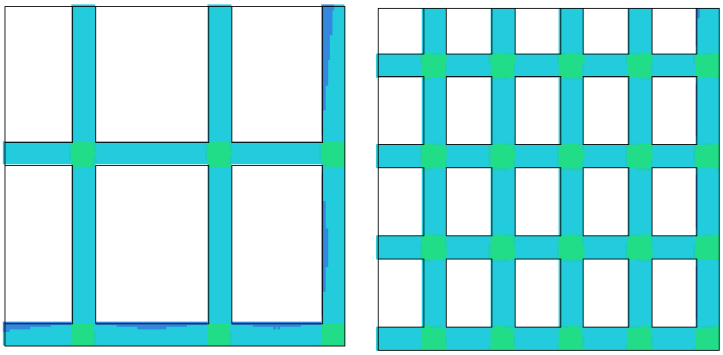


Figure 4.3: Effect of the room sizes

On the left diagrams: room size is 4 units, corridor width is 1 unit

On the right diagram: room size is 1 unit, corridor width is 1 unit

This result suggests that despite similar corridor widths, the spatial arrangement of larger units might contribute to a slightly decreased perception of connectivity and visibility within the environment.

- The effect of having various corridor sizes

To make an inference about the continuity of wide corridors, different plan diagrams were drawn (**Figure 4.4**). Diagram 7 represents a floor plan where corridors of consistent width interconnect. In contrast, Diagram 8 depicts a scenario where narrowing corridors result in decreased color values at their intersections.

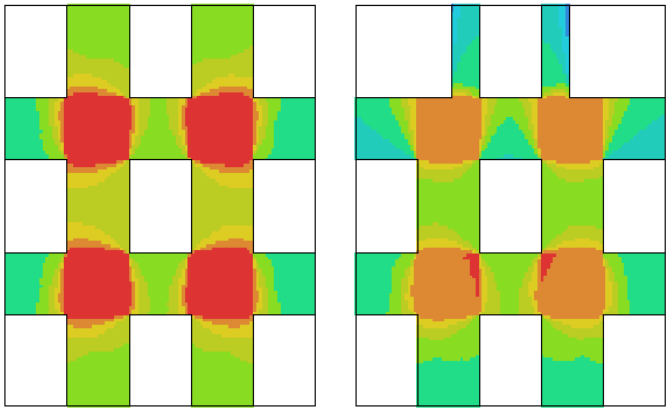


Figure 4.4: Effect of having various corridor sizes

On the left diagram: room size is 1 unit, corridor width is 1 unit

On the right diagram: room size is 1 unit, corridor width is narrowing from 1 unit to 0.5 unit

This observation suggests that the reduction in corridor width at intersecting points leads to diminished spatial connectivity or visibility within the environment.

- The effect of corridor sizes on the longer room dimension

To understand the relationship between the structure's form and the direction of corridor width, variations were tested in both horizontal and vertical dimensions (**Figure 4.5**). In Diagram 9, wide corridors are aligned with the shorter side of the structure. Conversely, in Diagram 10, corridors aligned with the longer side of the structure resulted in colors representing higher values.

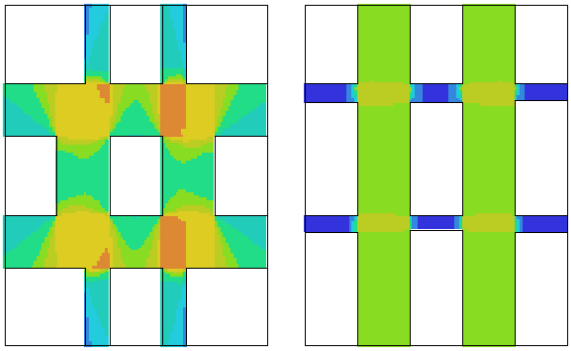


Figure 4.5: Effect of corridor sizes on the longer room dimension

On the left diagram: room size is 1 unit, corridor width is 1 unit horizontally, 0.5 unit for vertically

On the right diagram: room size is 1 unit, 0.5 unit horizontally; 1 unit vertically

It was observed that aligning corridors with the structure's orientation leads to colors indicative of higher values. According to the program, it was assumed that aligning wide corridors with the structure facilitates more accessible circulation.

- The effect of corridor sizes on the longer room dimensions shared spaces

Diagram 11, 12, and 13 were drawn for the visibility-accessibility analysis based on irregular corridor widths of the shared space (**Figure 4.6**).

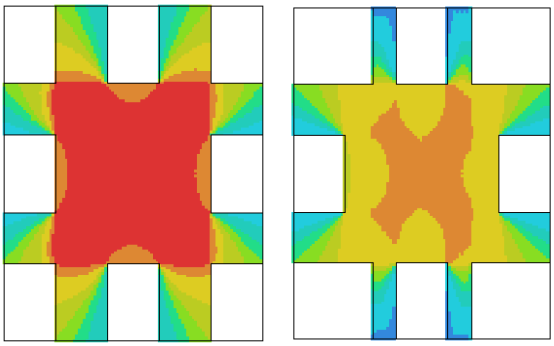


Figure 4.6: Effect of corridor sizes on the longer room dimension shared spaces

On the left diagrams 13: common space is 4 units, corridor width is 1 unit

On the right diagram 14: common space is 4 unit, corridor width is 1 unit horizontally, 0.5 unit vertically

Diagram 11 represents a shared space reached by corridors of the same width, while Diagram 12 includes vertically narrow corridors. In Diagram 13, it's observed that corridors narrowing at both ends result in a shared space with lower values.

Wide and consistent intervals offer the most accessible and visible shared space.

- The effect of corridor sizes on the shorter room dimension

To make inferences about the orientation of corridors leading to the common area, diagrams 14, 15, and 16 were drawn (**Figure 4.7**). The floor plan showing regular intervals is depicted as Diagram 14. In Diagram 15, horizontal corridors have been narrowed. Diagram 16 shows the version where horizontal corridors have been restored to their original lengths while vertical corridors have been narrowed.

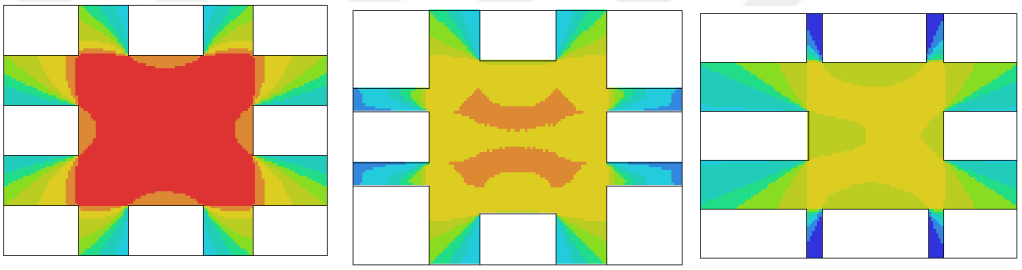


Figure 4.7: Effect of corridor sizes on the shorter room dimension

According to this inference, it was observed that narrowings in corridors extending along the longer side of the building have a minor effect, while narrowings in corridors extending along the shorter side have a major effect.

Based on this inference, the expansion scenarios for the main hospital corridors have been arranged according to the shorter side.

4.2.1 Correlation Between Visibility Graph Analysis and Connectivity Analysis

Visibility Graph Analysis (VGA) and Connectivity Analysis are related methodologies within spatial analysis, both of which can be performed using DepthmapX. Understanding the correlation between these analyses can provide deeper insights into spatial configurations and their impact on human behavior and spatial usability.

Visibility and Connectivity: Both VGA and Connectivity Analysis examine how spaces are linked, either visually (VGA) or through physical pathways (Connectivity Analysis). The more visually connected spaces are, the more likely they are to be physically accessible, suggesting a natural correlation between visibility and connectivity.

Both analyses aim to understand the integration of different parts of a spatial layout, with VGA focusing on visual integration and Connectivity Analysis focusing on physical or topological integration.

During this study, we first tested Visibility Graph Analysis (VGA) in order to understand program better. It was seen that VGA is easy to observe and make predictions about spaces compared with connectivity analysis. Ground floor VGA conducted for this reason first to examine which regions are most used. With that knowledge, we applied scenarios based on this outcome.

4.3 Connectivity Analysis

Based on these examinations connectivity analysis held in two scales:

1. Etlik City Hospital Neighborhood

The Etlik district experiences significant traffic congestion due to its dense population. This study aims to address key questions: How can we anticipate the benefits and drawbacks of large building developments before they are constructed? What measures can we implement to manage traffic loads through adjustments or removals? To explore these issues, a connectivity graph analysis is performed at the neighborhood level.

2. Maincore Ground Floor

The ground floor of the Maincore serves as a central hub for six towers, as previously mentioned. This block also houses diagnostic and medical imaging departments, which are heavily utilized. The initial step to improve connectivity and facilitate smoother transitions between the towers was to enhance visibility.

4.3.1 Etlik City Hospital Neighborhood Connectivity Analysis

Connectivity analysis of Etlik City Hospital neighborhood held in three steps:

1. Connectivity analysis before construction state
2. Connectivity analysis post construction state
3. Connectivity analysis after configurations



Figure 4.8: Connectivity analysis of the neighborhood before Etlik City Hospital construction

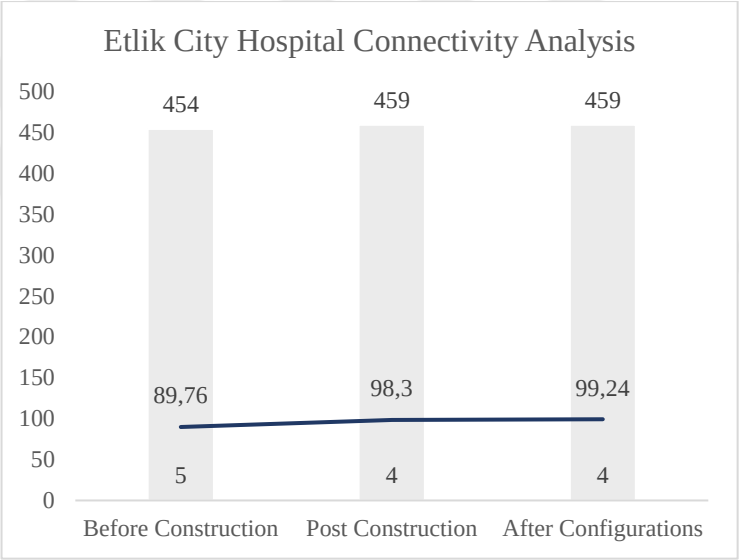


Figure 4.9: Connectivity analysis of the neighborhood after Etlik City Hospital Organisation



Figure 4.10: Connectivity analysis after configurations

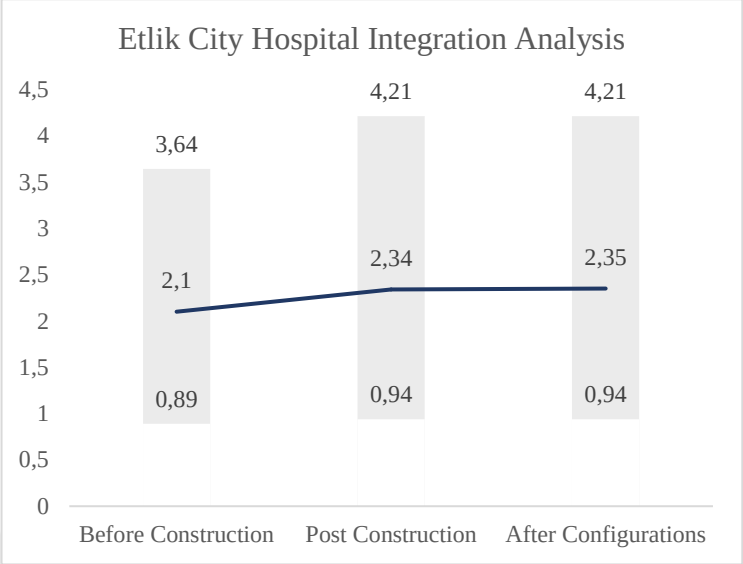
Figure 4.11: Connectivity analysis of Etlik City Hospital neighborhood



The connectivity value was recorded as 89,76 before construction. This value reached 98,3 after the organization of the campus. Finally, environmental configurations were made in order to decrease traffic load. These configurations include road-widening projects. Final value has reached to 99,24 (**Figure 4.11**).

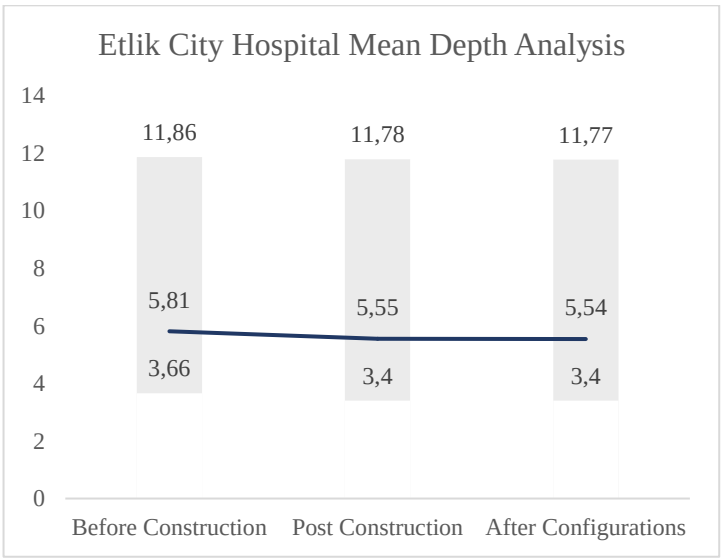
An increase in connectivity value signifies an increase in the connections or connection points between spaces. This indicates better-connected spaces and smoother and more effective movement for individuals.

Figure 4.12: Integration analysis of Etlik City Hospital neighborhood



Integration is a metric used to measure the connections between spaces in this context [73]. The higher the value of a space's "Integration HH," the stronger its connections with other spaces. Before construction, the Integration value was recorded as 2.03, while after construction, this value was measured as 2.34. After configurations this value reached 2.35 (**Figure 4.12**). This increase indicates that after configurations have more values of connectivity.

Figure 4.13: Mean Depth Etlik City Hospital neighborhood



Mean depth values are decreased from 5,81 to 5,55 and gradually to 5,54 as expected. This indicates that movement number that required for getting from some place into another is get decreased and now it is easier to arrive different locations (**Figure 4.13**).

The term "mean depth" is a concept used in Space Syntax analyses, indicating the overall depth or accessibility difficulty of a space. It is utilized to measure how deep or difficult it is to enter a space. If the "mean depth" value decreases, it generally indicates that the space is more accessible or open. In other words, the difficulty of entry has decreased. A lower "mean depth" value signifies that a space is more easily accessible or less deep.

Following the construction of the Etlik City Hospital, significant road widening has been implemented on Eşref Bitlis Street, and the changes in traffic measurements have been documented. This widening not only facilitates smoother traffic flow but also enhances access to the campus entrances. After new configuration the results indicate that connectivity and integration values increased while mean depth value decreased.

It is been trying to document at that stage connectivity values can be effected also by macro scale. It is possible to measure the change without construction and have predicts.

Etlik City Hospital, due to its strategic location, functions as a vital crossroads within the urban fabric. Following the completion of its construction, a detailed analysis of internal campus circulation was conducted using DepthmapX software, focusing on connectivity metrics. The analysis revealed a significant improvement in the connectivity average, which rose from 89.76 in the pre-construction state to 98.3 post-construction and 99,24 after configurations (**Table 4.11**). This enhancement underscores the success of the implemented design changes in fostering better movement within the hospital campus.

One major factor contributing to this increased connectivity was the strategic utilization of the area linking the campus's two heavily trafficked streets, Halil Sezai Erkut and Eşref Bitlis Avenue. By enhancing the connections between these key thoroughfares, the hospital effectively improved access and reduced travel times for both pedestrians and vehicles. This not only facilitated smoother internal circulation

but also alleviated congestion, making the hospital more accessible to patients, visitors, and staff.

Another noteworthy development post-construction is the heightened accessibility of Etlik Avenue. The improved connectivity of this major route has led to a surge in its use, reflecting the region's growing activity in terms of traffic. This increased usage indicates that the area around Etlik City Hospital has become more dynamic, with higher volumes of movement contributing to its vibrancy.

The Etlik neighborhood, which already experiences significant traffic congestion, is anticipated to face even greater traffic intensity following the construction of the city hospital. To facilitate transportation post-construction, road widening efforts and various configurations within the campus have been implemented on Eşref Bitlis Street. This study aims to predict the potential changes in traffic patterns that the new structure may bring to the area prior to its completion. By doing so, it is expected that the environmental impacts can be forecasted, allowing for solutions to potentially be finalized before the construction is completed.

The strategic design improvements, therefore, not only enhanced the internal circulation within the hospital campus but also had a positive impact on the surrounding urban area. By optimizing the flow of traffic and enhancing accessibility, the hospital serves as a crucial node in the urban network, improving overall connectivity and supporting the efficient movement of people and services.

This case study highlights the importance of considering connectivity and visibility metrics in the planning and development of large-scale infrastructure projects, demonstrating their significant impact on urban dynamics and accessibility. It also emphasizes the value of iterative design adjustments in achieving optimal spatial integration in complex facilities like hospitals. By continuously refining and evaluating design elements, planners can ensure that both the internal functionality and external connectivity of the facility are maximized.

In addition to the internal benefits, the enhanced connectivity has broader implications for the urban environment. Improved access routes and reduced travel times contribute to a more efficient urban system, facilitating economic activity and improving quality

of life for residents. This underscores the role of thoughtful urban design in creating sustainable and livable cities.

As a result of this analysis, it is possible to determine the expected increase in traffic density associated with new developments and identify the areas that will experience the highest levels of congestion. Consequently, this allows for the rapid presentation of infrastructure recommendations and solutions before the completion of the construction phase. This proactive approach aims to mitigate potential traffic issues and improve overall accessibility in the vicinity of the hospital.

Overall, the enhancements in connectivity and accessibility at Etlik City Hospital exemplify how strategic infrastructure planning can lead to significant improvements in urban mobility and functionality. The positive outcomes of this project serve as a model for future developments, highlighting the potential benefits of integrating advanced analytical tools and metrics into the design and planning process.

4.3.2 Main Building Ground Floor Analysis

Main building ground floor visibility analysis was conducted to produce a comprehensive connectivity analysis. This initial phase serves as a foundational draft for the subsequent, more detailed analyses. The visibility analysis provided crucial insights into how different areas of the building are visually connected, which is essential for understanding movement patterns and identifying potential wayfinding challenges.

Following this preliminary analysis, a more refined connectivity analysis was performed to obtain precise quantitative values. This analysis allowed for a detailed examination of how various scenarios impact the building's overall connectivity. By comparing the connectivity values before and after implementing the proposed scenarios, it was possible to measure the effectiveness of each modification.

The results from these comparisons revealed how changes in the building's layout, such as corridor widening and strategic placement of visible areas, influence connectivity (**Figure 4.14** and **Figure 4.15**). The analysis not only highlighted areas with improved accessibility but also identified sections that required further

adjustments. This iterative process ensures that the final design optimally enhances movement efficiency and wayfinding within the hospital.

Overall, these steps underscore the importance of using visibility and connectivity analyses in the design and evaluation phases. By meticulously comparing before-and-after scenarios, the study provided valuable data to inform design decisions, ultimately aiming to create a more navigable and user-friendly hospital environment.

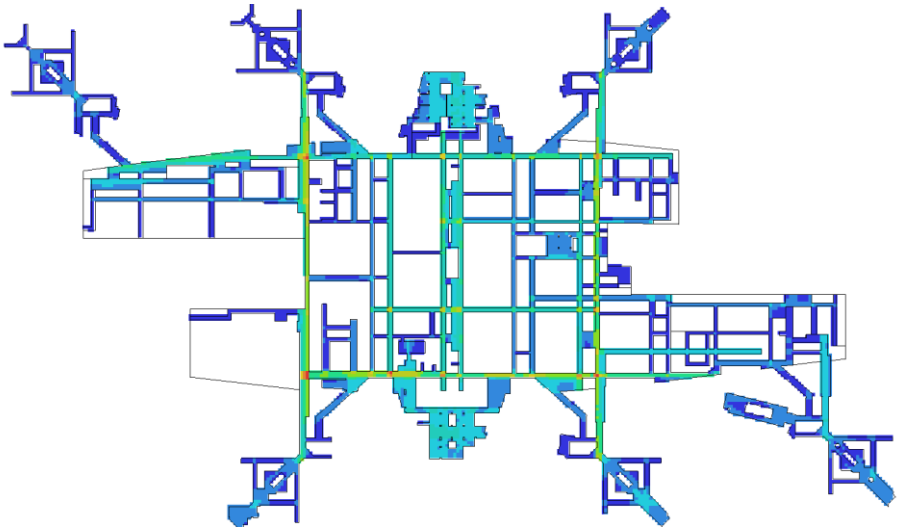


Figure 4.14: Visibility Graph Analysis of ground floor base case

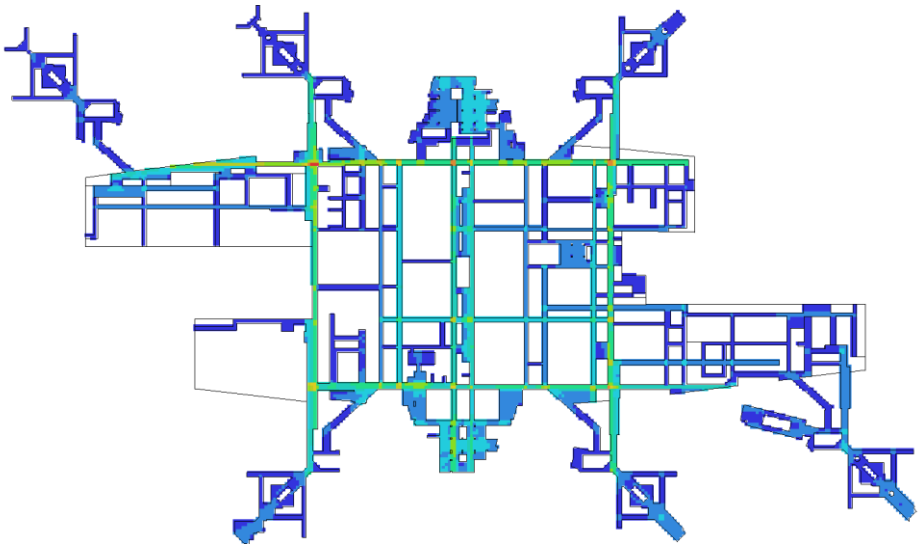


Figure 4.15: Visibility Graph Analysis of ground floor after 4th case scenario

In previous sections, it was mentioned that certain decisions were made regarding the scenarios based on demo tests conducted in DepthmapX. Visibility graph analysis is one of the fastest analyses to be simulated in the program. The primary reason for initially selecting this analysis is to easily demonstrate the relationship between visibility and connectivity. Following the visibility analysis, the positive values of the color data inspired further analyses. This approach underscores the importance of visibility graph analysis as a preliminary step due to its efficiency and the clarity it provides in understanding spatial configurations.

The visibility graph analysis, owing to its rapid computation time, allows for a swift and effective exploration of spatial relationships within a given environment. By mapping out the visibility connections, one can deduce the degree of connectivity within the space, providing valuable insights into the spatial structure. The positive results indicated by the color values in the visibility analysis not only validate the initial assumptions but also pave the way for more detailed and complex analyses. These subsequent analyses can delve deeper into the nuances of spatial interaction and integration, ultimately contributing to a more comprehensive understanding of spatial dynamics. Therefore, the initial positive outcomes from the visibility graph analysis are crucial as they set a solid foundation for further exploratory and confirmatory spatial studies.

4.4 Scenarios

The findings from the experiments conducted with the depthmapX program indicate that densely populated areas can be identified through visibility graph analysis. Initially, we performed a visibility graph analysis of the ground floor and identified the two corridors depicted in the figure as the most congested areas. Another conclusion drawn was that adjustments made relative to the shorter side had a significantly greater impact. This reinforced our decision, confirming that the first two scenarios would indeed focus on these two corridors (**Figure 4.14** and **Figure 4.15**).

Subsequently, we understood how much the connections of shared spaces were strengthened through Experiment 3. Based on this, taking action in emergencies would be a prudent decision. Removing the barrier in the pediatric emergency department was a minimal intervention that proved to be highly effective. We documented this change and moved on to the final scenario.

The last scenario aimed to significantly enhance visibility in the adult emergency department, as the perception in the first space people enter is crucial for facilitating their experiences. To strengthen the view of the corridor connecting the two emergency departments, we altered the layout of the triage rooms. This adjustment would allow individuals entering the emergency department to directly perceive the long corridor, making it easier to reach their destination, even if it was on the other side of the building. Thus, we added the fourth scenario.

It is worth noting that there is no limit to these changes and interventions; one can make as many adjustments as their imagination allows. However, in large structures like these, we aimed to ground every step we took in our experiments and observations to avoid arbitrary decisions. In new implementations, these steps should be adapted according to the characteristics of the structure and user experiences, and scenarios should be developed accordingly.

Four different scenarios were sequentially integrated and compared against each other, provided there was positive progress observed. Each scenario's values were meticulously analyzed, and if a scenario showed favorable results, it was combined with the previous ones. This iterative process allowed for a comprehensive comparison of the values, facilitating a deeper understanding of how each scenario contributed to the overall spatial dynamics. By evaluating the aggregated outcomes, it was possible to identify the most effective configuration and make informed decisions based on the comparative analysis. This method ensured that the positive attributes of each scenario were retained and built upon, leading to progressively better results.

4.4.1 Connectivity Comparison

Figure 4.16: Connectivity Analysis of different state alternatives by numbers:

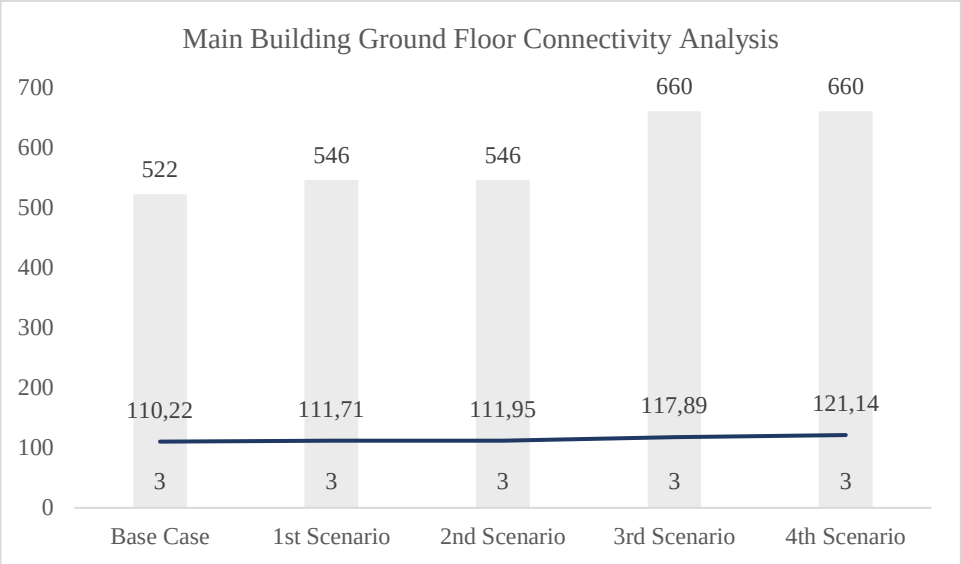


Table 4.2: Mean values of connectivity

Scenario	Location	Scenario	Connectivity
0	Base Case Scenario	Current state	110,22
1	Between Orthopedics and Maternity Hospitals	Corridor is enlarged (1m).	111,71
2	Between General and Oncology Hospitals	Corridor is enlarged (1m).	111,95
3	Children Emergency	Blockage removed.	117,89
4	Adult Emergency	Triage rooms were separated.	121,14

1st Scenario

1st scenario was about the corridor that has highest connectivity. To make a homogeneous distribution, firstly this corridor has been enlarged. Base case scenario has an average of connectivity 110,222 while new alternative has 111,714. New

connectivity value is higher because now corridor is more integrated with other spaces. (**Figure 4.16**)

2nd Scenario

2nd scenario was about symmetrical corridor which connects General Hospital and Oncology Hospital. In this corridor it is possible to observe the Eye Department and Medical Imagining crowd. It can be said that the most crowded intersections are that different departments' intermediate spaces. In order to generate a more relax waiting area and circulation spaces, 2nd scenario was aimed to decrease this stress. Wider corridors (1m) are offered for it. The value of connectivity average increased from 111,714 to 111,957 (**Figure 4.16**).

3rd Scenario

Following step was including the removal of blockage from Children Emergency Department. This drywall was a handicap for direct pass from Child Hospital and Oncology Hospital. It is recorded that new average number has changed from 111,95 to 117,89 (**Figure 4.16**).

4th Scenario

Last step was enhancing the Adult Emergency visibility by making changes in triage rooms. Triage rooms were blocked direct passage between Adult Emergency and Children Emergency. In order to decrease void density, 2 corridors are presented. New value is recorded as 121,14. Considering that the initial value of these experiment was 110,22 scenario made important changes in visibility values (**Figure 4.16**).

The presentation of the analysis results is conveyed through spectral color gradations in the image. A higher value in the visibility graph is depicted with a more pronounced red hue, while a lower value is represented in shades of blue.

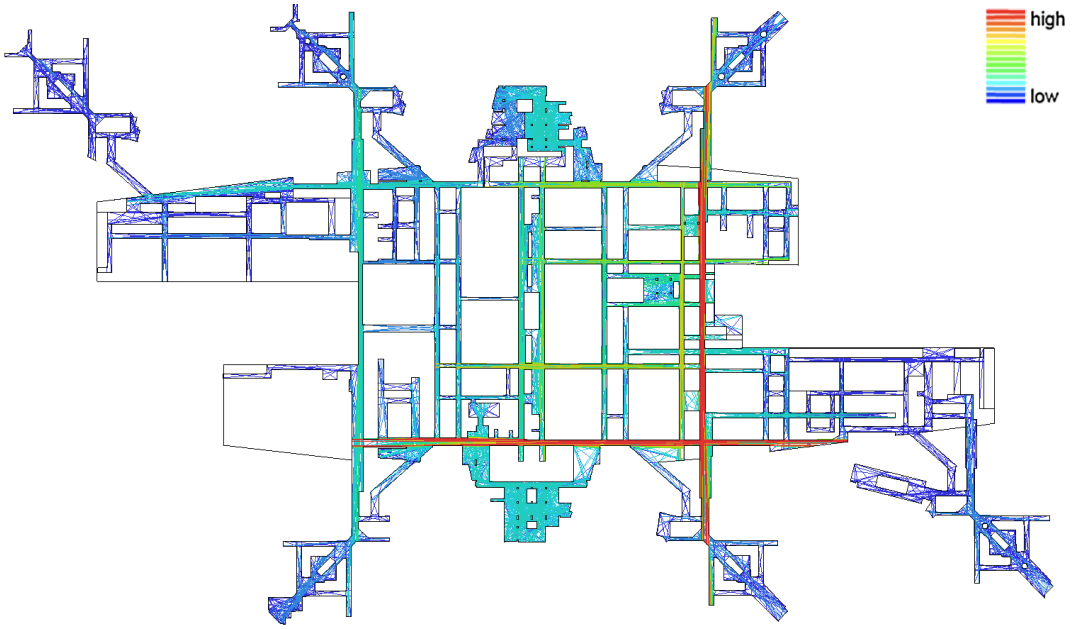


Figure 4.17: Base case scenario connectivity analysis

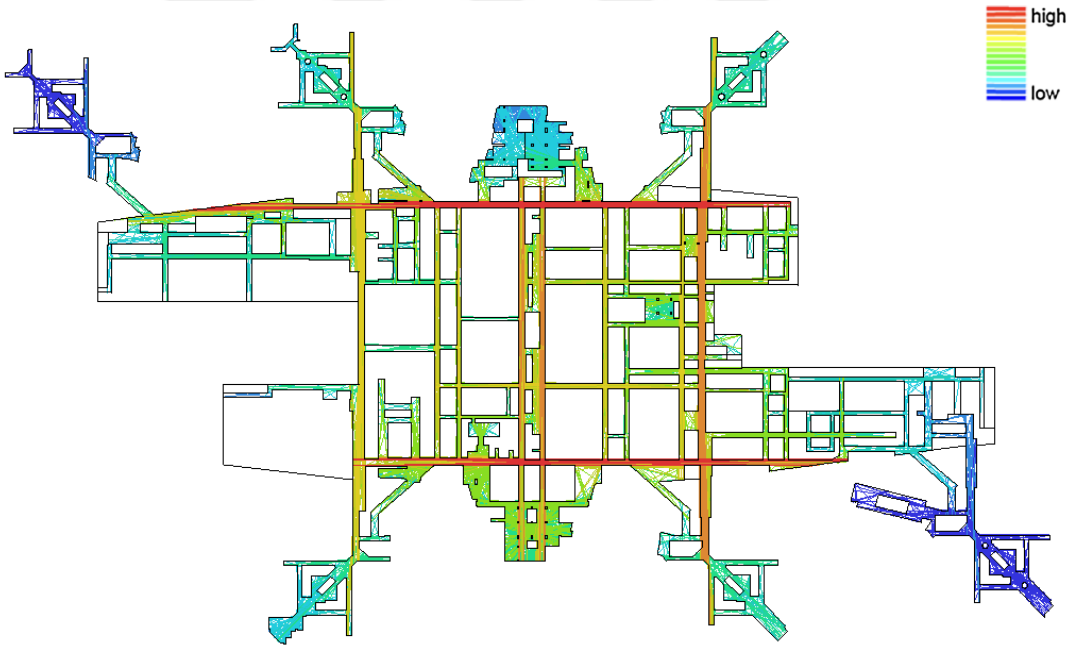


Figure 4.18: 4th scenario connectivity analysis

After 4th scenario, it is seen that new scenario is connecting blocks via larger corridors and spaces with higher interactions. Ground floor average connectivity value is increased from 110,22 to 121,14 (**Figure 4.16**). Both visibility and connectivity analysis were found important factors in order to extend accessibility. Higher values detected and at the end, changes are offered. When connectivity values increase, there is a rational rate of increase in accessibility.

4.4.2 Integration Comparison

Figure 4.19: Integration (HH) Analysis of different states alternative

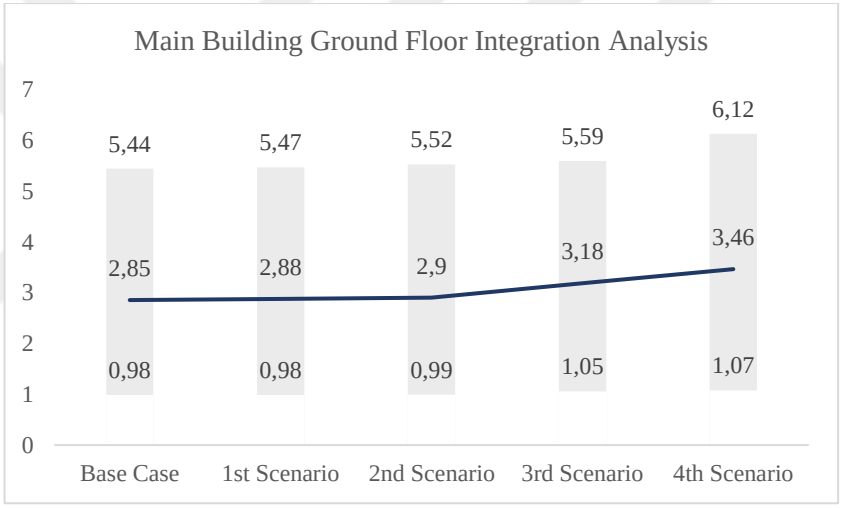


Table 4.3: Mean values of Integration

Scenario	Location	Scenario	Integration
0	Base Case Scenario	Current state	2,85
1	Between Orthopedics and Maternity Hospitals	Corridor is enlarged (1m).	2,88
2	Between General and Oncology Hospitals	Corridor is enlarged (1m).	2,9
3	Children Emergency	Blockage removed.	3,18
4	Adult Emergency	Triage rooms were separated.	3,46

The most integrated area has the highest integration value, indicates that it is more accessible or most accessible. Highest average integration value is observed as 3,464 after 4th scenario. Because there is closer relationship between spaces, after re-arranging of corridor widths and blockages removal (**Table 4.3**).

The analysis has demonstrated a gradual increase in integration values across different scenarios. In the first scenario, the corridor was enlarged by 1 meter, which had a noticeable impact on the integration numbers. The base case scenario exhibited an average connectivity value of 2,85 whereas the new alternative showed a slight improvement, raising the value to 2,88. (**Figure 4.19**)

Subsequently, the second scenario involved the enlargement of a symmetrical corridor by 1 meter, resulting in a new average integration value of 2,9. This incremental modification underscores the positive effect of corridor widening on integration metrics. (**Figure 4.19**)

The third scenario further enhanced these numbers, pushing the average integration value up to 3,18. This suggests that continued modifications, even if incremental, contribute significantly to improving spatial integration within the hospital. (**Figure 4.19**)

Finally, the fourth scenario introduced a major change, recording an average integration value of 3,46 (**Figure 4.19**). This substantial increase highlights the effectiveness of the adjustments made in this scenario. The correlation between visible areas and higher integration numbers is evident, reinforcing the importance of visibility in spatial design.

Overall, these scenarios illustrate that strategic modifications to the hospital's layout, particularly those enhancing visibility and corridor width, substantially improve spatial integration. Such improvements are crucial in optimizing the flow and accessibility within the hospital, ultimately contributing to better wayfinding and a more efficient use of space. This analysis underscores the value of iterative design adjustments in achieving optimal spatial integration in complex facilities like hospitals.

Building upon this sequential analysis, the four different scenarios were progressively integrated and compared, provided there was positive progress observed at each stage. Each scenario's values were meticulously analyzed, and when a scenario showed favorable results, it was combined with the previous ones. This iterative process allowed for a comprehensive comparison of the values, facilitating a deeper understanding of how each scenario contributed to the overall spatial dynamics.

By evaluating the aggregated outcomes, it was possible to identify the most effective configuration and make informed decisions based on the comparative analysis. This method ensured that the positive attributes of each scenario were retained and built upon, leading to progressively better results. This structured approach highlights the importance of iterative testing and refinement in spatial design, particularly in complex environments such as hospitals where the efficiency of space use is paramount.

The positive progression through each scenario demonstrates that even small adjustments in design, such as widening corridors, can significantly enhance the spatial integration and overall functionality of the hospital layout. This methodical analysis not only validates the design decisions made but also provides a clear roadmap for future improvements in hospital spatial planning.,

4.4.3 Mean Depth Comparison

Figure 4.20: Mean Depth Analysis of different states alternative

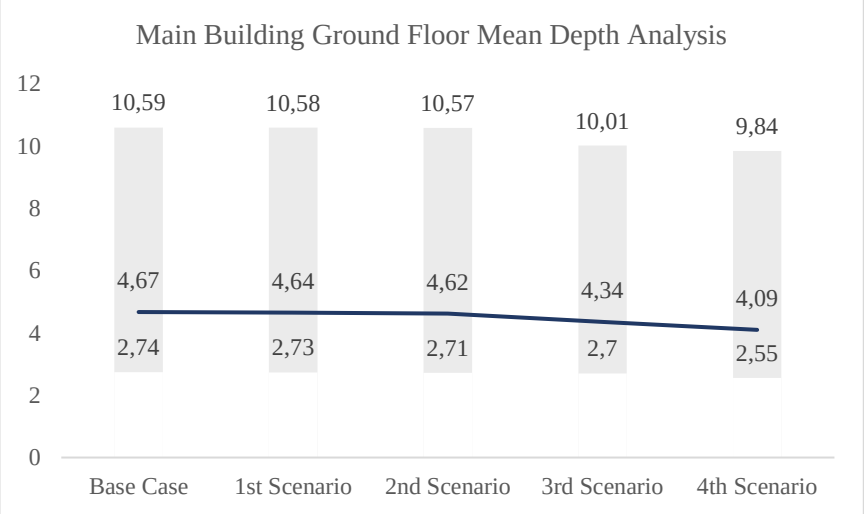


Table 4.4: Mean values of Mean Depth

Scenario	Location	Scenario	Mean Depth
0	Base Case Scenario	Current state	4,67
1	Between Orthopedics and Maternity Hospitals	Corridor is enlarged (1m).	4,64
2	Between General and Oncology Hospitals	Corridor is enlarged (1m).	4,62
3	Children Emergency	Blockage removed.	4,34
4	Adult Emergency	Triage rooms were separated.	4,09

Consequently, starting from the base case scenario with an average mean depth value of 4,67 there is a consistent decrease in this metric, reaching an average of 4,09 in the final scenario (**Figure 4.10**). This decrease in mean depth indicates that the paths within the hospital layout have become shorter and involve fewer turns.

In other words, the fourth scenario optimizes the hospital's layout by simplifying the routes and minimizing the number of turns required to navigate between different areas. This reduction in mean depth is a significant improvement, as it enhances the overall efficiency of movement within the hospital, making it easier for patients, visitors, and staff to find their way.

This trend demonstrates the positive impact of the iterative modifications made in each scenario. By focusing on reducing the complexity of the pathways, the final scenario successfully creates a more intuitive and accessible environment. This improvement is particularly crucial in a hospital setting, where ease of navigation can significantly affect response times and overall user experience.

The lowest connectivity average value was recorded in the base case scenario as 110,222 while the highest integration was recorded 121,141 after 4th scenario (**Table 4.2**).

The highest Mean Depth value is recorded as 4,67 while the lowest value (means it is less isolated, more integrated) was scored as 4,098 after 4th scenario (**Table 4.4**).

The primary motivation and driving force behind this study has been the construction of Etlik City Hospital. Observations made throughout the construction process have revealed that the biggest challenge faced in complex building constructions is finding solutions to accessibility and wayfinding issues. Moreover, in facilities such as hospitals, where time and energy must be used most effectively, the approach to these issues needs to be much more sensitive.

In recent years, numerous city hospitals have been constructed in Türkiye to improve the quality of healthcare services. These hospitals are notable for their large capacities and advanced technologies. However, the size and complex structure of city hospitals create significant wayfinding challenges for both patients and healthcare workers.

CHAPTER 5

CONCLUSION

This study aims to provide practical methods to enhance the efficiency of city hospitals, a critical step for the healthcare and architecture sectors in Türkiye. In this context, efficiency is limited to connectivity and accessibility.

The study addresses the challenges of hospital designs, particularly emphasizing that these challenges reach a much higher level for hospitals outside the traditional framework, such as city hospitals. It provides information about city hospitals in general, including the Etlik City Hospital, and presents analyses of its relationship with the surrounding environment, particularly focusing on the most utilized ground floor, along with the rationale and results of these analyses. Steps are examined in detail.

We utilized DepthmapX, a space syntax software, to conduct visibility graph analysis and identify areas with high traffic density within city hospitals. It allows for the assessment of visual connectivity and integration, providing insights into the accessibility and wayfinding potential of the built environment.

Using the visibility graph analysis in DepthmapX software, we identified the congested areas and applied various scenarios to these locations. For each scenario, we recorded and compared the values of connectivity, integration, and mean depth. The results demonstrate that even minor interventions can increase the accessibility, connectivity, and visibility of spaces within city hospitals. By employing these methods during the pre-construction phase, it is possible to observe changes from the baseline and implement improvements with limited budgets and short timelines.

The findings demonstrate that even minor spatial modifications can significantly enhance the efficiency of city hospitals. By strategically adjusting the layout, introducing new connections, or optimizing circulation patterns, it is possible to improve the overall connectivity and accessibility of the hospital environment.

One notable example is the scenario that focused on enhancing the connectivity of a heavily congested corridor. By introducing enlarged corridors, the connectivity and

integration values increased, suggesting improved accessibility and wayfinding for both patients and staff. Introducing larger corridors had a meaningful effects.

Another scenario explored having more open spaces, removing barriers between main arteries and open gathering areas has a meaningful effect. By rearranging the spaces and adjusting the visual connections, we observed an increase in the overall integration and a reduction in the mean depth, indicating better accessibility and spatial comprehension.

We selected shorter arteries, not the longer ones in order to maximize the effect. These scenarios were based on the examined configurations on DepthmapX. It was measured that shorter sides were more impactful compared with longer ones in rectangular morphology plan layouts.

These results highlight the potential of space syntax analysis and scenario testing during the pre-construction phase of city hospital projects. By proactively identifying and addressing potential bottlenecks and accessibility issues, design teams can optimize the layout and improve the overall efficiency of the hospital environment.

The application of visibility graph analysis and scenario testing in DepthmapX has proven to be a valuable tool for enhancing the efficiency of city hospitals in Türkiye. By focusing on connectivity and accessibility, this study demonstrates that even small-scale interventions can lead to significant improvements in the hospital environment.

The proposed methodology can be effectively implemented during the pre-construction phase, allowing for the identification and mitigation of potential issues before the actual construction begins. This approach not only optimizes the hospital layout but also ensures that the environment of new constructions and traffic meets the needs of patients, staff, and visitors while maximizing the use of available resources.

Although it is a very useful program in many subjects, it is hoped that in the future three-dimensional calculations can be included for multi-level and complex structures and more accurate results can be obtained.

In future studies, analyses can be customized according to user types. The movements of staff and visitors can be evaluated separately, allowing solutions to be tailored to each user. These studies can be supported by surveys. Additionally, an application can

be offered that incorporates design elements such as stairs, galleries, and openings, which can also affect the data related to the space.

By incorporating these space syntax techniques into the design process, architects and healthcare professionals can collaborate to create more efficient, user-friendly, and accessible city hospitals that contribute to the overall quality of healthcare services in Türkiye.

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APPENDICES

Appendix A: Base case connectivity analysis

Appendix B: 1st scenario connectivity analysis

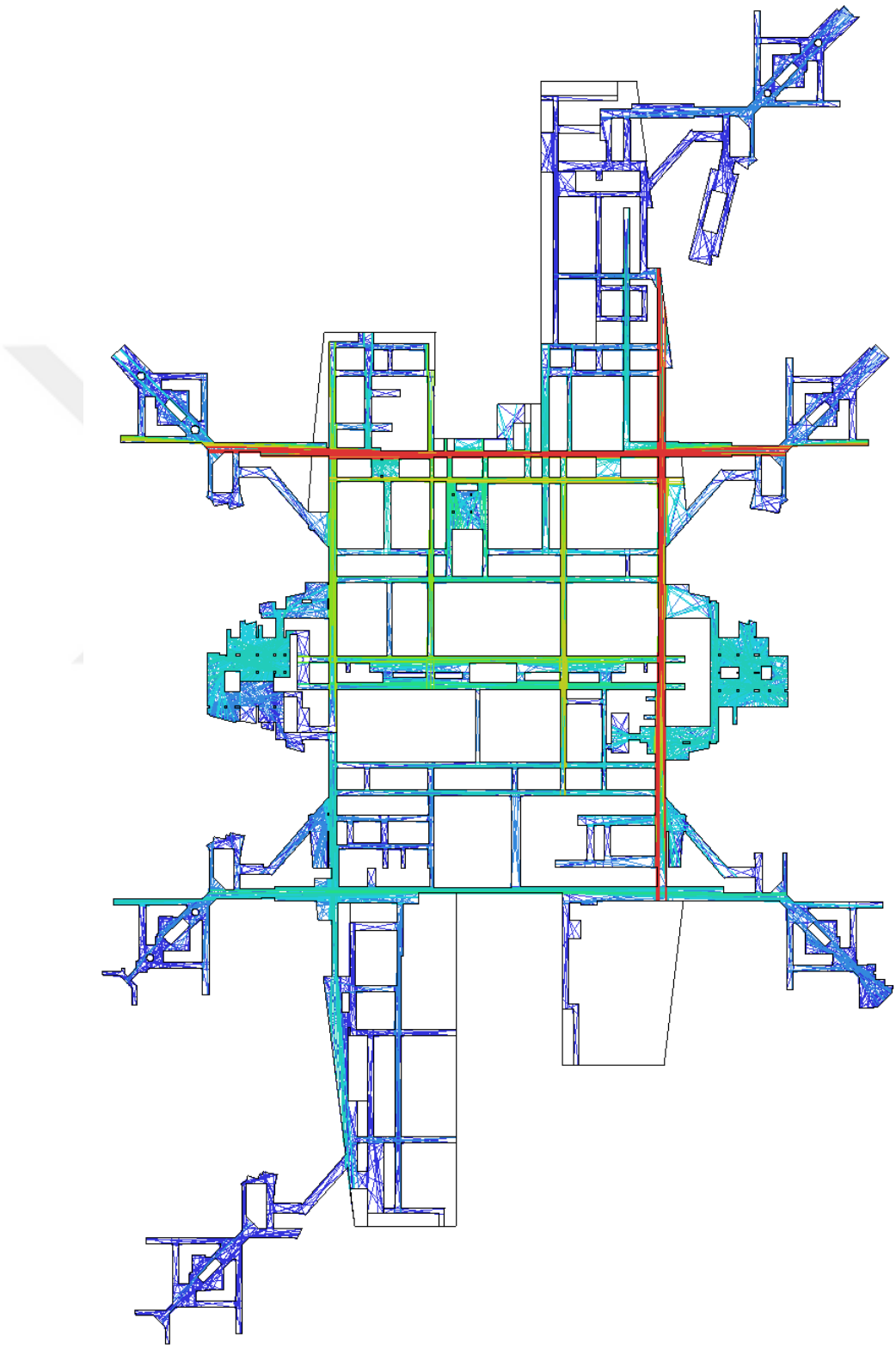
Appendix C: 2nd scenario connectivity analysis

Appendix D: 3rd scenario connectivity analysis

Appendix E: 4th scenario connectivity analysis

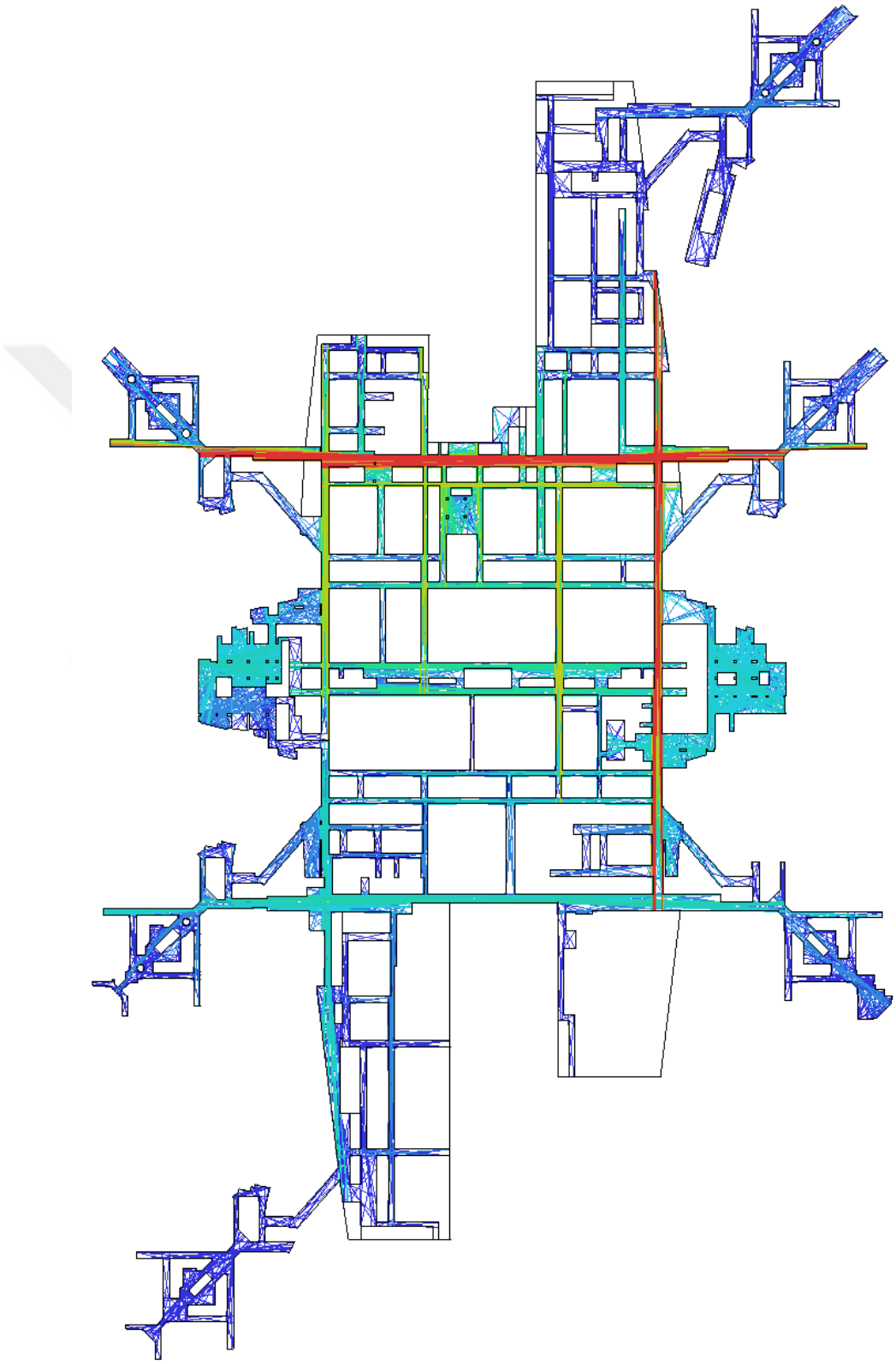
Appendix A – Base case connectivity analysis

Figure A: Base case connectivity analysis



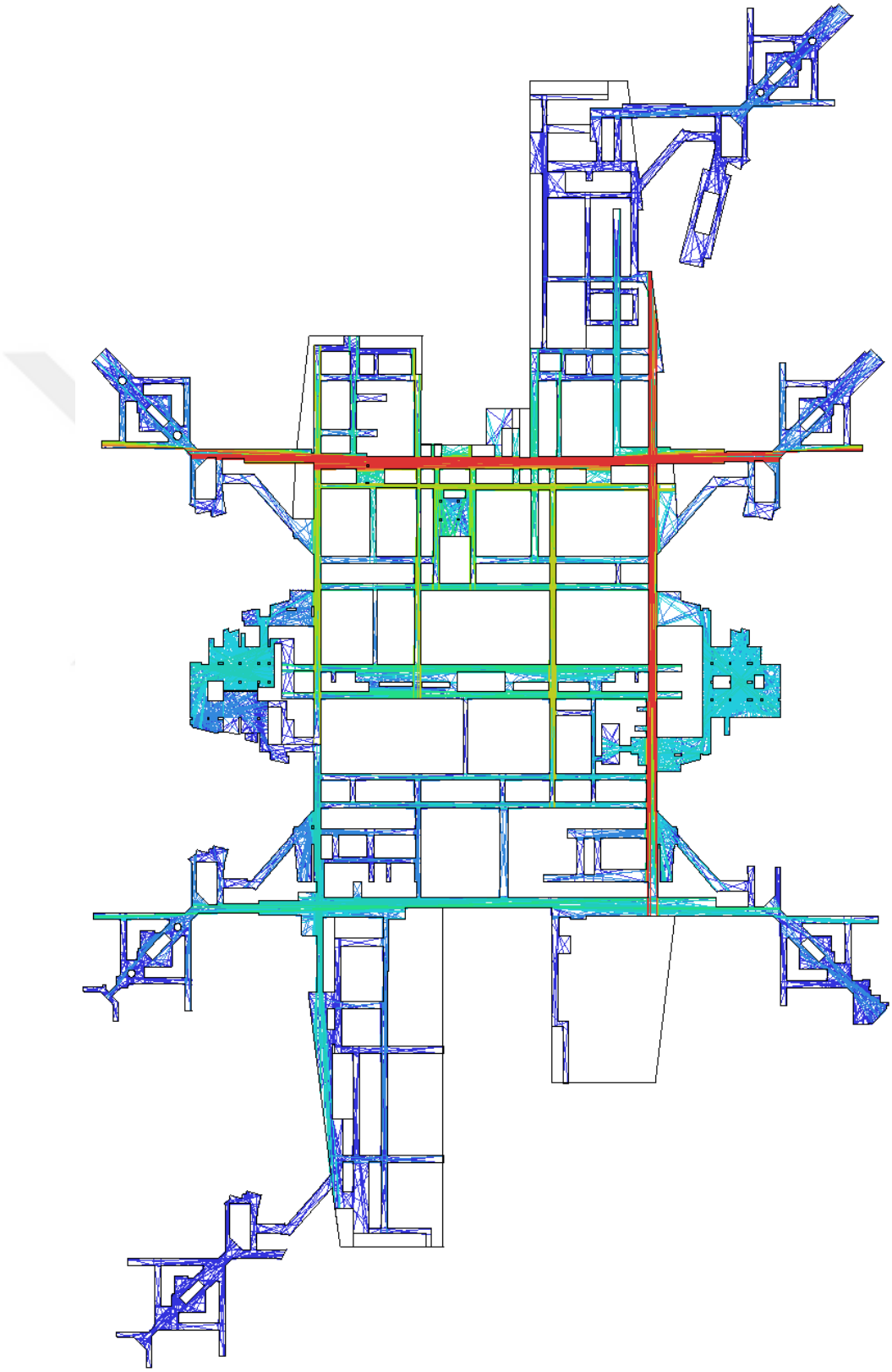
Appendix B – 1st scenario connectivity analysis

Figure B: 1st scenario connectivity analysis



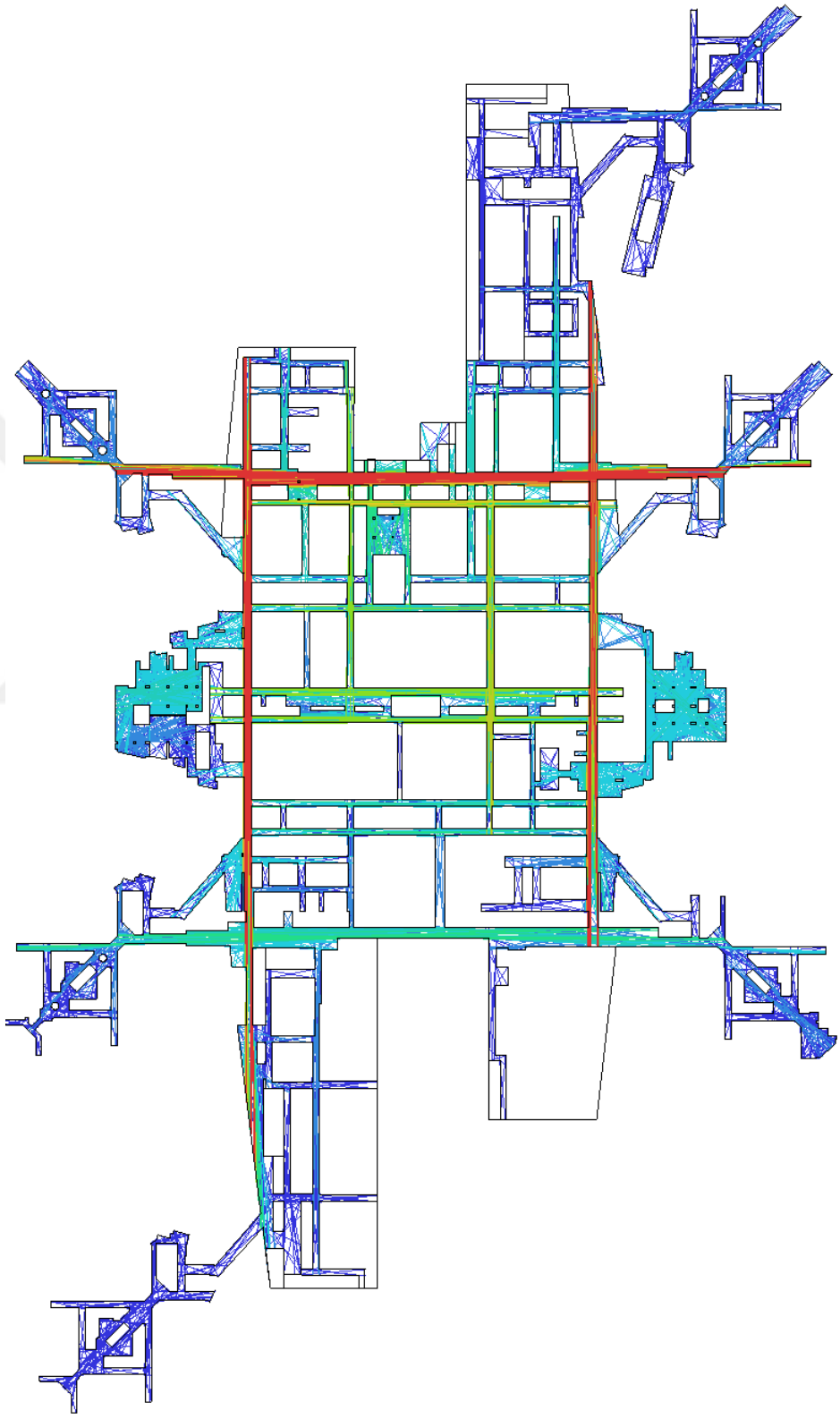
Appendix C – 2nd scenario connectivity analysis

Figure C: 2nd scenario connectivity analysis



Appendix D – 3rd scenario connectivity analysis

Figure D: 3rd scenario connectivity analysis



Appendix E – 4th scenario connectivity analysis

Figure E: 4th scenario connectivity analysis

