ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Research Article *Araştırma Makalesi* DOI: 10.54864/planarch.1710980

The Evaluation of the Proposed Operational Scheme for a Field Hospital Designed After an Earthquake Using the Space Syntax Method

Deprem Sonrası Tasarlanan Sahra Hastanesi İşleyiş Şeması Önerisinin Mekan Dizimi Yöntemi ile Değerlendirilmesi

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This research was produced within the scope of Gazi University Graduate School of Natural and Applied Sciences, Department of Architecture, Master's course titled Professional Practice and Ethics in Architecture by the first author, under the supervision of the other authors.

Received / Geliş Tarihi	31.05.2025
Revision Requested / Revizyon Talebi	26.08.2025
Last Revision / Son Revizyon	16.09.2025
Accepted / Kabul Tarihi	16.09.2025
Publication Date / Yayın Tarihi	15.02.2026

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Cite this article: Çoban, H., Soyluk, A. & Ürük, Z. F. (2026). The Evaluation of the Proposed Operational Scheme for a Field Hospital Designed After an Earthquake Using the Space Syntax Method. *PLANARCH - Design and Planning Research*, 10(1), 24-36. DOI: 10.54864/planarch.1710980

ABSTRACT

Most of the major earthquakes that have occurred over the centuries have resulted in serious loss of life. While some of these losses occur during the disaster, others occur due to inadequate health intervention after the disaster. Hospitals, which are one of the top priority structures that should not be destroyed in such earthquakes, are sometimes destroyed and sometimes cannot provide health services due to lack of capacity. In this case, field hospitals, which are established after the earthquake, play a major role for the necessary health interventions. The aim of this study is to develop a field hospital proposal under the criteria of frequently needed and accessible spaces. On February 6, 2023, the field hospitals established during the earthquake were examined through news sources. The units frequently used in the field hospitals examined, the data obtained from the literature, and the accessibility analyses conducted using the spatial layout method of the existing plan example were evaluated. As a result of these studies, an alternative plan scheme has been developed that can be applied anywhere in the world, based on the operational dynamics of the space, independent of regional, geographical, or socio-cultural conditions. As a result, it is seen that architecture and design criteria have an important role in the field hospital proposal designed with need-oriented and accessible spaces in order to save more lives in a short time in disasters.

Keywords: Emergency medical intervention, field hospitals, accessibility, space syntax.

ÖZ

Asırlardır meydana gelen büyük depremlerin çoğunda ciddi can kayıpları yaşanmıştır. Bu kayıplar afet anında yaşanırken bazıları da afet sonrası yetersiz sağlık müdahalesi sebebiyle yaşanmaktadır. Bu tür depremlerde yıkılmaması gereken en öncelikli yapılardan biri olan hastaneler kimi zaman yıkılmaktadır kimi zaman da kapasite yetersizliğinden dolayı sağlık hizmeti verememektedir. Bu durumda deprem sonrası kurulumu gerçekleşen sahra hastaneleri gerekli sağlık müdahaleleri için büyük rol oynamaktadır. Bu çalışma kapsamında amaç; sıklıkla ihtiyaç duyulan ve erişilebilir mekanlar kriterleri başlığında sahra hastanesi önerisi geliştirmektir. 6 Şubat 2023 tarihinde gerçekleşen depremde kurulan sahra hastaneleri haber kaynakları aracılığıyla incelenmiştir. İncelenen sahra hastanelerinde sıklıkla kullanılan birimler, literatürden elde edilen veriler ve mevcut plan örneğinin mekân dizimi yöntemi ile gerçekleştirilen erişilebilirlik analizleri değerlendirilmiştir. Bu incelemeler sonucunda; bölgesel, coğrafi ya da sosyo-kültürel koşullardan bağımsız olarak mekânın işleyiş dinamiklerinden hareketle dünyanın her yerinde uygulanması ön görülen alternatif bir plan şeması geliştirilmiştir. Sonuç olarak afetlerde kısa sürede daha fazla hayat kurtarabilmek için ihtiyaca yönelik ve erişilebilir mekanlar ile tasarlanan sahra hastanesi önerisinde mimarlığın ve tasarım kriterlerinin önemli bir rolünün olduğu görülmektedir.

Anahtar Kelimeler: Acil sağlık müdahalesi, sahra hastaneleri, erişilebilirlik, mekân dizimi.

Introduction

Disasters continue to occur frequently and in different ways from past to present. Earthquake, one of the most common natural disasters in our country and the world, causes great losses and damages related to human health such as death, injury and disability as well as economic and social losses.

While one of the reasons for the high number of dead and injured people after earthquakes is the destruction and damage to buildings, another reason is the problems and inadequacies in post-earthquake health interventions (Korkmaz, 2012).

Inadequate health interventions in the aftermath of earthquakes can cause people who are pulled out of the rubble with injuries to lose their lives after a short period of time. Hospital structures, which are the most important units that can provide health services in this life-critical process, are often damaged or destroyed in devastating earthquakes. Existing health structures that are not damaged cannot provide services due to lack of capacity.

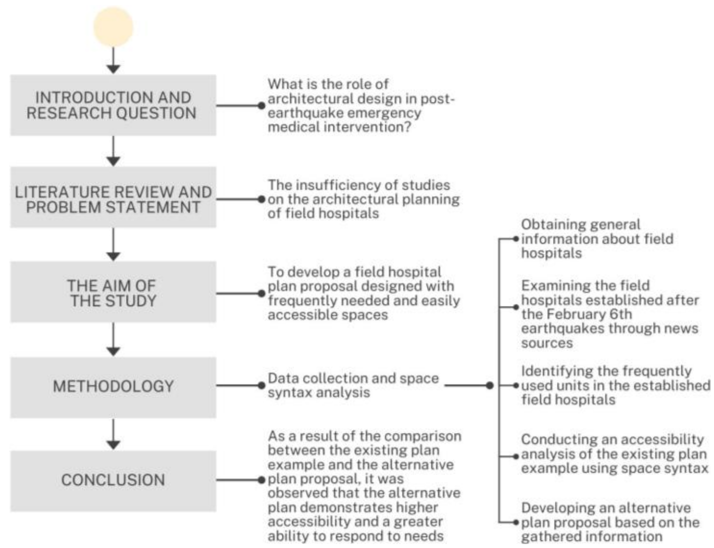
In devastating earthquakes and other disasters where hospital structures cannot function or are inadequate, field hospitals are established in the region and health services are provided. In order for a field hospital to operate adequately and effectively, the area where it will be established must be researched and determined in advance, necessary precautions must be taken before the disaster, drills must be carried out and correct planning decisions must be taken in advance so as not to cause a second disaster.

As a result of the literature review, studies addressing the importance and structuring of field hospitals in disasters were examined, including those by Duruel and Çelebi (2019), Gök et al. (2023), Tekin et al. (2017), Dursun and Karakoç (2019), Yalbaz (2008), Bar-On et al. (2022), Işık et al. (2012), and Uzun (2023). However, it was noted that there is a lack of studies in the literature on the units and architectural planning of field hospitals The scope of this study regarding field hospitals is limited to the spaces that should be included in the layout plan according to needs, the relationship between these spaces, and the accessibility of these spaces for users. It is aimed to re-plan the spaces that should be included in line with the needs in a way to have high accessibility and legibility in post-disaster emergencies. Thus, it is foreseen that health services will be provided to more earthquake victims in a shorter time during a disaster by ensuring the correct planning of spaces such as registration-triage-examination areas especially in emergency cases for an earthquake victim brought to the field area. At the same time, it has been realized that health workers can provide better service in areas where accessibility and connection between spaces can be better provided in this life-threatening process.

The flowchart including the scope of work and analysis process is shown in Figure 1. Within the scope of the study; firstly, general information about field hospitals is given with the existing data obtained from the literature. Afterwards, the field hospitals established by our country and countries abroad during the earthquake on February 6, 2023, which caused great damage and loss of life and affected a total of 11 provinces, the epicenter of which were Gaziantep (7.7) and Kahramanmaraş (7.6), were examined through news sources. Furthermore, detailed information about the field hospitals that were established could not be found in the literature, except for news sources. Plan data for the field hospitals under review could not be accessed, but frequently used and needed units have been identified.

An alternative plan proposal was developed based on these needed units and as a result of the accessibility analysis carried out with the spatial arrangement method using the existing plan example obtained from the literature research. As a result, it is aimed to contribute to the literature on the most needed spaces and the importance of the accessibility of these spaces between each other in disasters by comparing the existing plan and the proposed plan.

Figure 1.
Flowchart of the scope and analysis process of the study (Created by authors)



Literature Review

The aim of the literature review is to examine the current state of knowledge on how to proceed with health services in the aftermath of an earthquake and the studies on field hospitals. The results obtained from the existing studies are of great importance for the progress of this study.

First of all, studies on the factors that are important for providing post-earthquake health services in accordance with their purpose were examined. In Duruel and Çelebi's (2019) study titled "Post-Earthquake Emergency Health Services Management and Current Practices", the practices within the scope of emergency health services in our country and in the world after the earthquake were investigated. It was concluded that the situations and solutions realized as a result of desk and field exercises, necessary initiatives should be taken to ensure that the interdisciplinary division of labor at the national level takes its place in the plans in a coordinated and confusion-free manner, and that health services can be provided faster and better quality in disasters.

The study titled "Hospital Crisis Management After a Disaster: From the Epicenter of 2023 Türkiye-Syria Earthquake" conducted by doctors Gök et al. (2023) at Medical Point Gaziantep Hospital was carried out by collecting the records of patients who applied to Medical Point Gaziantep Hospital during the earthquakes that occurred on February 6, 2023. It was determined that the most intense period of application to the hospital was the first 24 hours. Thanks to this study, we see that the planning of field hospitals should be done before the disaster and should be established urgently in the first 24 hours of disasters with systematic and accurate planning.

Tekin et al. (2017) examined the evacuation of hospitals, the establishment of field hospitals, and communication processes during disasters. The study found that ensuring safe transfer during the evacuation process, keeping field hospitals operational with the necessary units, and communication-logistics coordination played a critical role. These findings show that field hospitals offer an effective solution for ensuring continuity of healthcare services during disasters.

Dursun and Karakoç's (2019) study titled "Field Hospital in Disasters" was examined about the spaces in the architectural planning of field hospitals. In the study; it was determined that field hospitals established in suitable areas determined by performing risk analysis in disasters should be planned to include "administrative, admission, operational, logistics and humanitarian aid services" units. It is said that these units and the spaces in the sub-units of these units can be expanded, reduced or removed from the plan depending on the conditions during the disaster. It is also concluded that field hospitals may have to undertake tasks such as providing food aid and shelter to people affected by disasters as well as health services.

Yalbaz (2008) in his master's thesis titled "Field-Emergency Hospitals in Disaster-Emergency Management Process and a Research" mentioned the importance of water in the process of providing health services in field hospitals. He concluded that WC, bathroom, water supply and wastewater management should be included in architectural planning.

Bar-On et al. (2022) examined a civilian field hospital established during the war in Ukraine. The study found that field hospitals can be used not only in disasters but also in war conditions, and that the most important need is primary health care. The hospital, which served 6161 patients over six weeks, utilized triage, emergency services, outpatient clinics, pediatric health, obstetrics, surgery, orthopedics, psychosocial support, laboratory, imaging, pharmacy, and telemedicine units; training was also provided to local health personnel. These findings demonstrate that field hospitals play a critical role in both emergency response and the continuity of basic healthcare services.

Another study Işık et al. (2012) in their study "Disaster Management and Disaster-Oriented Health Services" mentioned the importance of triage areas that enable the classification of disaster victims as light, medium and heavy in order to provide health services to more patients as soon as possible in disasters with many disaster victims. With this study, it is concluded that triage areas are one of the first places that the disaster victims will encounter in the architectural planning of the field hospital.

In Uzun's (2023) study, the presence of field hospitals in disaster areas and their contribution to healthcare services following the February 6 Kahramanmaraş earthquake were evaluated. The study highlighted the role of these hospitals in providing emergency care and their function in alleviating the patient load on permanent hospitals. However, it was also noted that the number of studies on field hospitals, particularly in the context of the February 6 earthquake, is limited and their scope is insufficient.

The existing information obtained as a result of the literature review has contributed a lot to this study. However, it has been realized that there is a lack of studies on how the architectural planning of field hospitals should be and the interaction and accessibility of the spaces with each other.

Field Hospital

The word "Sahra" originates from Arabic and carries the meanings of desert and wilderness (URL-1). A field hospital is defined as a mobile medical facility or a mobile hospital that can provide emergency health services to the sick and wounded in the emergency zone in disasters and wars; portable, quickly set up and assembled, using health equipment, and the area where it will be installed is planned in advance (Bıçakçı & Nevruz, 2021).

According to the World Health Organization, the definition of a field hospital is listed as follows (Tekin et al., 2017):

- Rapid deployment and transport
- Expandable and contractible
- Self-sufficient
- Equipped with 10 or more beds
- Contains one or more operating rooms
- Has a basic laboratory
- Includes a mobile X-ray machine
- Comprises units with tent, inflatable, or container modules.

From past to present, field hospitals have successfully operated within the scope of health services not only in natural disasters but also in man-made disasters such as war. The idea of establishing field hospitals first emerged in 1859 when Swiss businessman Henry Dunant witnessed the Battle of Solferino. Seeing wounded soldiers left to die in battle led Dunant to consider the need for mobile medical units that could provide rapid and effective healthcare at the front (Dunant, 1862). These observations laid the groundwork for the fundamental principles of field hospitals and the historical development of modern emergency healthcare. Table 1 shows the historical development of field hospitals from the past to the present.

Table 1.
Historical development of field hospitals (Created by authors)

Year	Event	
1859	Battle of Solferino	Henry Dunant witnesses wounded soldiers being left to die. The idea of a field hospital emerges (Dunant, 1862).
1863	Establishment of the International Committee of the Red Cross	The foundation laid for the organization and management of field hospitals (URL-2).
1864	Geneva Convention	The legal basis for field hospitals established to protect the wounded and sick (URL-2).
1861-1865	American Civil War	Organization and treatment of the wounded improved in field hospitals (URL-3).
1914-1918	World War I	Field hospitals have become more modern in terms of mobile hospitals and technological developments (URL-4).
1939-1945	World War II	Field hospitals have become widespread and their capacity has increased (URL-5).
1950-2000	Cold War Era	Mobile field hospitals have been developed and advanced medical equipment has begun to be used (URL-6).
2000-Present	Disasters and Emergencies	Field hospitals are widely used in emergencies such as earthquakes and epidemics. (Bayraktar Sari & Jabi, 2024).

Field Hospital Types

Field hospitals come in three different types: tent-type, container-type, and mobile trailer-type (Manoochehry et al., 2018). Tent-type field hospitals are known to be more advantageous than other types in terms of installation, transportation, re-functionality and cost. According to the type and region of the disaster, the appropriate structure preference may be different. Even seasonal differences are important in choosing the appropriate structure for the region (Bıçakçı & Nevruz, 2021).

Field Hospitals Sub-Units and General Dimensions

The spatial organization of field hospitals established after a disaster is important in terms of the efficiency of emergency health services and patient safety. Patient admission and triage areas enable the rapid sorting of disaster victims according to their health status. These areas are located close to emergency treatment and surgical units to minimize intervention times. Surgical units, sterilization, laboratory, and drug storage areas should be located close to each other. This ensures the uninterrupted supply of medical supplies and the continuity of patient care. Intensive care units should be located so as to allow direct access to emergency response and surgical units. In addition, imaging areas should be located close to surgical and triage departments to enable rapid diagnosis and intervention. Staff rest, administrative, and logistical support areas should be located in a way that facilitates access to the hospital's central axis and optimizes the flow of materials and personnel (ICRC, 2020; WHO, 2021).

Figure 2, obtained by Korkmaz (2012) as a result of his investigations within the scope of his thesis, provides the minimum space requirements for the units that should be included in field hospital plans according to need and for the spaces within these units. These measurements have also been taken into account in the field hospital plan proposed within the scope of this study.

According to Figure 2, typical units in a field hospital include: entrance and registration area, triage, emergency treatment, surgical block, inpatient service areas, intensive care, laboratory, sterilization, storage, imaging unit, staff and administrative areas. International guidelines recommend that these units be planned to ensure functional relationships between them and ease of access. This arrangement ensures both the efficient use of space and enhances the overall organizational performance of the field hospital, thereby ensuring patient safety and continuity of service (WHO, 2021).

In addition to the spaces listed in the table, at least 48 m² of additional space must be added for spaces such as laundry rooms, bathrooms, and toilets. In this case, the total building area is 1110 m². When 555 m² of indoor circulation space (50%) is added to this area, a field hospital area of 1665 m² is obtained. If other areas (helicopter landing area, staff parking lot) are added to the 1665 m² field hospital area when needed, an area of 2825 m² is required. If a helicopter landing area is not required, the total area can be 1925 m². Consequently, when 40% of the total area is added as an outdoor circulation area to accom modate services such as generators, transformers, and water tanks and to ensure smooth operations within the area, the total field hospital setup area is approximately 3500 m² (Korkmaz, 2012).

Figure 2.
Field hospital units and minimum required area measurements (Korkmaz, 2012, pp. 57-59)

I) Administrative units	Min. area
Healthcare facility disaster command center	12 m²
Press-media and public relations center	12 m²
Checkpoint	12 m²
TOTAL	**36 m²**

III) Operation unit part 2	Min. area
Emergency treatment unit	18 m²
Wound care and minor intervention unit	12 m²
Inpatient ward for internal medicine patients	72 m²
Internal medicine and coronary intensive care unit	72 m²
Quarantine	30 m²
Operating room	30 m²
Surgical service	72 m²
Surgical intensive care unit	72 m²
Radiology department	54 m²
Blood bank	54 m²
Laboratory	54 m²
Pharmacy	24 m²
Medical equipment storage	36 m²
Orthopedic splinting	18 m²
Labor and delivery room	18 m²
Level 3 neonatal intensive care unit	18 m²
TOTAL	**654 m²**

II) Operation unit part 1	Min. area
Waiting area	18 m²
Patient registration	12 m²
Triage	18 m²
Patient decontamination unit	24 m²
Trauma resuscitation area	36 m²
Adult resuscitation area	36 m²
Pediatric resuscitation area	36 m²
Temporary monitored observation area	36 m²
TOTAL	**216 m²**

IV) Logistics department		Min. area
Public health unit area		12 m²
Elective examination rooms	1: Internal medicine, cardiology, pulmonology examination room	18 m²
	2: Pediatrics, gynecology and obstetrics examination room	18 m²
	3: Ophthalmology, otolaryngology, orthopedics, urology, dermatology examination room	18 m²
	4: Neurology and psychiatry examination room	18 m²
Personnel services area		36 m²
TOTAL		**120 m²**

Field Hospitals Setup Areas

An open area can be preferred for the establishment of field hospitals, as well as structures of public institutions and organizations or private institutions that have not been damaged in the disaster area. The structures that may be suitable in this direction (Kadıoğlu et al., 2009):

- Government offices
- Schools
- Gyms
- Stadiums
- Mosques
- Parks
- Hotels
- Guesthouses

In addition, Bıçakçı and Nevruz (2021) mention another issue for architects and engineers in their study as follows: When planning new hospital buildings in a region, the design of spaces that can be used as field hospital areas against possible disasters or the possibility of converting them into such areas should also be taken into consideration during the planning phase. The factors to be considered for the field hospital setup area are shown in Figure 3.

Figure 3.
Factors to consider for site selection in field hospital setup (Created by authors)

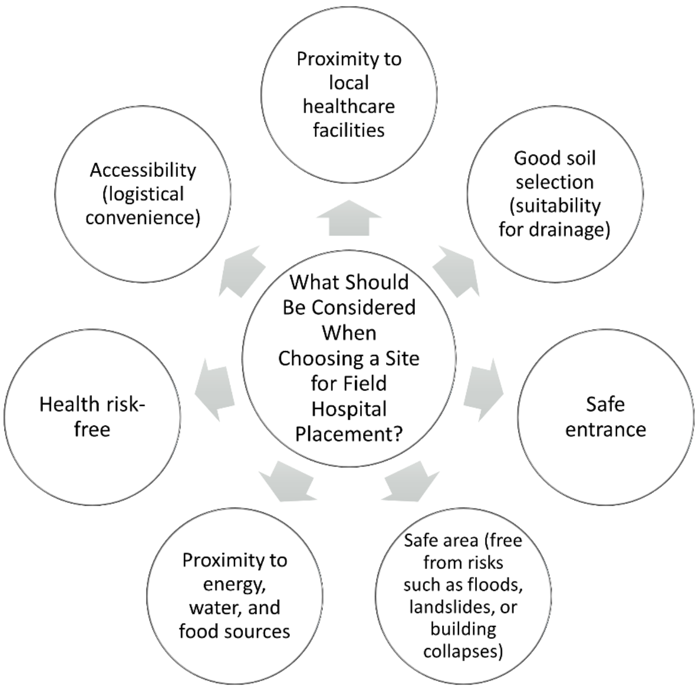
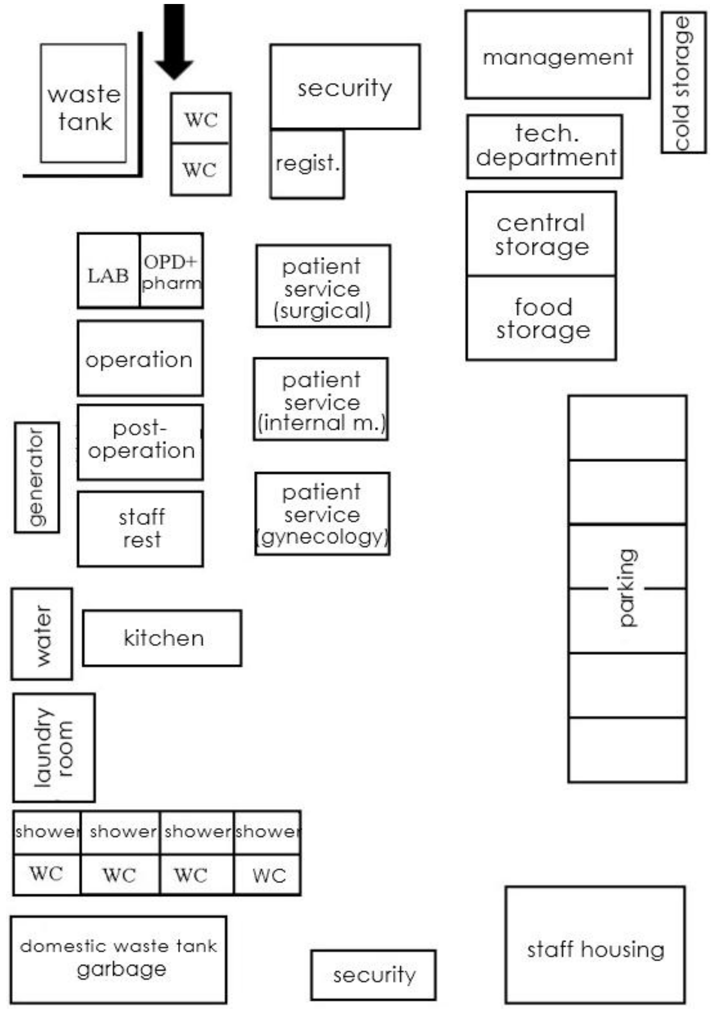


Figure 4.
Example of a rough layout of a field hospital (Yalbaz, 2008, p. 78)



Field Hospital Layout Plan

The study by Saral and Koçak (2024) titled "Organizational Structures of Hospital Disaster Plans in the World and Turkey," examined within the scope of architectural planning in emergency healthcare facilities, addresses the architectural and organizational structure of hospital disaster plans. The study emphasizes that the interaction between units within the hospital and the spatial arrangement during disasters and emergencies directly affect the efficiency of healthcare services. Particularly in field and temporary hospital plans, the importance of a spatial organization that allows easy access between registration, triage, emergency, examination, laboratory, and inpatient services is highlighted. It is also emphasized that the architectural plan should be designed to be flexible, modular, and adaptable to areas of different sizes.

Benitez et al. (2019) systematic review highlights that layout planning in healthcare facilities should be evaluated based on multidimensional criteria such as patient, staff, and material flows, functional relationships, cost, safety, and well-being. The findings of the studies reviewed show that the distance and functional proximity between emergency departments, intensive care units, operating rooms, and imaging units are critical in terms of service efficiency, response time, and patient safety. It is also noted that inappropriate spatial designs increase costs in the long term, reduce staff efficiency, and negatively affect patient well-being.

No examples of layout plans for field hospitals could be found in the literature. Therefore, as stated by Yalbaz (2008) in his thesis, the rough layout plan example in Figure 4 was used in the evaluation within the scope of this study.

Accessibility in Healthcare Facilities

Accessibility in healthcare facilities is not limited to the physical presence of the building; it also encompasses the effectiveness of spatial relationships between functional units within the hospital and the speed at which users can access these units. The continuity of movement between units such as the emergency department, outpatient clinics, laboratories, and inpatient wards directly affects service efficiency for both patients and healthcare personnel. In spatial planning, designing circulation areas between units in a clear and safe manner and developing arrangements that allow users to move quickly and smoothly within space are among the key factors that increase the level of accessibility in healthcare facilities (Gezer, 2014).

User satisfaction in hospital spaces is influenced not only by the individual functions of the spaces but also by the level of accessibility between functional units. Seamless connections between outpatient clinics, emergency services, laboratories, and inpatient services enhance spatial quality, while weak continuity negatively affects the efficiency and continuity of healthcare services. In such a situation, dissatisfaction arises in both the patient and staff experience (Selçuk & Edirne, 2024).

Increasing accessibility in the planning of hospital spaces is possible by improving the quality of patient care, optimizing staff task efficiency, and ensuring the most efficient inter-unit circulation. In planning, the analysis of the spatial relationships between functional units and the continuity of circulation routes are important for the rapid and uninterrupted provision of services. This minimizes time loss during emergency interventions, increases the task efficiency of healthcare personnel, and ensures the speed of user access to services. Planning spatial arrangements in this way facilitates intra-hospital transportation and strengthens accessibility by making the space understandable (Bayraktar Sari & Jabi, 2024). Furthermore, the layout of hospital circulation areas also plays a significant role in ensuring accessibility and ease of use, directly affecting users' ability to find their way around the space (Noraslı & Çınar, 2024).

Spatial accessibility is a critical parameter, especially in healthcare facilities that need to be set up quickly after a disaster, such as field hospitals. Positioning functional units in a way that is suitable for emergency response and planning movement between units in a way that is easy to understand ensures that users can access services without getting lost in space. In this context, spatial organization in field hospitals should be evaluated within the framework of accessibility principles, not only in terms of providing temporary healthcare services, but also in terms of providing a spatial layout that allows disaster victims to access the necessary spaces within a short period of time.

Material and Methods

As a result of the literature review conducted in the study, the scope of field hospitals was limited to the spaces that should be included in the layout plan in line with the needs and the accessibility of these spaces.

In this study, space syntax analysis method was used to analyze the accessibility and usability of the existing plan example and alternative plan proposal, as well as the data obtained as a result of the literature review and the information obtained through the news source.

Evaluating spatial decisions aimed at ensuring the uninterrupted operation of healthcare services during disasters using the space syntax method reveals the strengths and weaknesses of the existing plan example. This evaluation also provides a scientific basis for developing alternative plan designs that respond more quickly to needs.

The space syntax analysis method is a space reading method produced by a research team led by Bill Hillier and Jullienne Hanson at University College London (Çil, 2006). Hillier et al. (1996) state that the purpose of using the spatial syntax method is to study the design of buildings and cities by examining the relationship between human movement and space design. Movement is defined as the most important function of the plan that the space has.

Space syntax is a theoretical and analytical method that enables the analysis of spatial organization within the framework of social and physical relationships. This approach aims to interpret the formal characteristics of structures and settlements by relating them to user behavior and social patterns. The method treats space not only as a geometric arrangement but also as a configuration system that shapes social interactions (Hillier & Hanson, 1984). This study presents a unique contribution by revealing the aforementioned spatial relationships through configurational analysis, given that the temporary and modular structure of field hospitals differs from traditional healthcare structures.

Space syntax is considered a multifaceted analytical method that enables the interpretation of the relationship between social processes and both micro-scale interior spatial arrangements and macro-scale settlement organization (Hillier & Hanson, 1984).

In his study, Dursun (2007) describes the role of the space sequence method in architectural design as follows:

- In the dialog between the designed space and the architect, the spatial syntax method creates a language for generating ideas about the space.
- The spatial sequence method creates a link between science and design, leading to designs supported by evidence.
- In a design process that evolves through making and testing, spatial syntax serves as a tool for the architect to explore his/her thoughts and understand the possible effects of his/her ideas.
- The most important feature of the spatial sequence method is that it allows the architect to evaluate the buildings he designs not statically but as living organisms that can be experienced by the user.

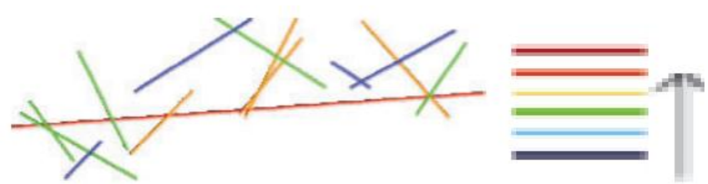
One of its most important features is that it is a numerical method that allows us to express and analyze the abstract features of space in a concrete way for the first time (Khosroshahi & Aydıntan, 2019).

An axial map is created by taking an existing map and drawing a series of intersecting lines across all areas of the urban grid, thus completely covering the urban grid and completing all circulation rings (URL-7).

Axial maps offer the possibility to define space through lines. They also form the basis for analyses such as integration, connectivity and intelligibility. Linear spaces, defined as potential movement behavior, are expressed by axial lines (Long et al., 2007).

Axial lines do not have a unit of measurement. It has a comparative measurement system, that is, it analyzes the relationship of the drawn axes to each other. The lines are colored from red to blue from the longest visibility range to the shortest visibility range (Ünkaracalar & Soyluk, 2023). Figure 5 shows this color value range. In connectivity analysis maps, the points where the lines intersect the most are determined as the most accessible areas. According to Hillier & Hanson (1984), connectivity analysis is defined as measuring the number of other areas connecting an area.

Figure 5.
Axial map representation (Kubat, 2015)



With the research methods used, an alternative plan proposal has been developed within the scope of determining the most needed spaces in the planning of field hospitals and the accessibility of these spaces between each other.

First of all, in order to determine the most needed spaces in field hospitals, many news sites about the field hospitals provided by Turkey and foreign countries during the February 6, 2023 earthquakes, one of the disasters of the century that we have recently experienced, were examined and information about the spaces used were obtained. A table was prepared with the information obtained and the places that should be included in the alternative plan proposal were determined.

Then, in order to analyze the accessibility and usability of the rough settlement plan example shown by Yalbaz (2008) in his study with the spatial layout method, the sample plan was first drawn in 2 dimensions in AutoCAD program. Then, the drawn plan was transferred to the DepthmapX program in dxf format so that it could be analyzed with the spatial layout method. Axial line maps and connection analysis maps were created in DepthmapX program. The maps were evaluated in terms of accessibility and usability. An alternative plan proposal was developed in the light of the findings obtained from the created maps, the data obtained from the literature review and the data on the field hospitals established in the February 6, 2023 earthquakes. The plan proposal was drawn in 2D in AutoCAD program and transferred to DepthmapX program in dxf format. The maps of the alternative plan proposal created in the DepthmapX program and the maps in the sample plan were compared and evaluated.

Results and Discussion

In this section, a plan proposal will be developed for a field hospital within the scope of post-earthquake health services, designed with accessible targeted spaces. The alternative plan proposal was developed with the data obtained from the literature review (such as criteria and dimensions), information obtained from news sources about the field hospitals established after the February 6, 2023 earthquake, and the determinations obtained from the existing sample plan as a result of space sequence analysis. Afterwards, the existing plan example and the new plan proposal were compared and their responsiveness to the criteria within the scope of accessible and needed spaces was evaluated.

Field Hospitals Established After the February 6, 2023 Earthquakes

On February 6, 2023, the earthquake, which caused major damage and loss of life and affected 11 provinces, the epicenters of which were Gaziantep (7.7) and Kahramanmaraş (7.6), resulted in the establishment of approximately 34 field hospitals by 16 countries abroad and many field hospitals by ministries, municipalities and private companies in Turkey. According to information from Anadolu Agency (URL-8) website, a total of 77 field hospitals were established by the Turkish Ministry of Health in 10 provinces, some of which were able to perform surgical operations.

Information on field hospitals, for which the necessary data was available through various news sources, is given below.

Field Hospitals Established by Turkey

According to information obtained from Sevmedya (URL-9) website, the Eşrefpaşa Field Hospital, which is located close to the tent city established by the Izmir Metropolitan Municipality on the Hatay Expo road, has a medical office, patient wards with patient beds, an operating room, a mobile X-ray vehicle, a mobile dental unit, a laboratory, a mobile ultrasound unit and a pharmacy tent (Figure 6).

Figure 6.
Eşrefpaşa Field Hospital established by İzmir Metropolitan Municipality in Hatay (URL-10)

According to the information in Sabah (URL-11) website, the Ministry of National Defense Field Hospital, which was set up by the Turkish Armed Forces in front of Kahramanmaraş Necip Fazıl City Hospital in 9 hours and consists of 19 containers and 21 tents, has an emergency room, radiology, laboratory, sterilization unit, operating room, patient service and pharmacy (Figure 7). There are also support units that ensure the operation of these units.

Figure 7.
Field hospital established by the Turkish Armed Forces (TAF) in Kahramanmaraş (URL-11)

According to the information in Medimagazin (URL-12) website, a permanent field hospital with an indoor area of 2,000 m^2 was established in Hatay's Defne district with the coordination of the Ministry of Health, in cooperation with Kocaeli Metropolitan Municipality and with the support of MUSIAD Germany and France members (Figure 8). There are units such as laboratory, radiology, pharmacy, operating room, internal medicine, pediatrics, orthopedics, dermatology, infection, psychiatry, gynecology, emergency service, and patient service.

Figure 8.
Container field hospital established by Kocaeli Metropolitan Municipality in Defne (URL-13)

Field Hospitals Established by Spain

According to the information in Fair Fuar Magazine (URL-14) website, a field hospital with 36 tents has been set up by the Spanish Ministry of Foreign Affairs in Hatay Expo area (Figure 9). It is known that the field hospital, which has the capacity to serve approximately 200 patients per day, includes emergency services, orthopedics, gynecology, obstetrics, surgery, pediatrics, psychiatry, inpatient services, pharmacy, operating room and radiology units.

Figure 9.
Field hospital established in Hatay by Spain (URL-15)

Field Hospitals Established by USA

According to information published in T24 Internet Newspaper (URL-16), the field hospital, which was established by the US in the garden of Hatay Mustafa Kemal University Hospital in Antakya, has a 100-bed patient ward, emergency room, intensive care unit and operating room (Figure 10).

Figure 10.
Field hospital established in Antakya by USA (URL-17)

Field Hospitals Established by United Arab Emirates

According to information obtained from the website of Anadolu Agency (URL-18), a field hospital with a patient service with a capacity of approximately 50 beds was established by the United Arab Emirates in Islahiye, Gaziantep, with units such as operating rooms, emergency services, intensive care and family physicians.

Field Hospitals Established by Belgium

According to information obtained from En Son Haber (URL-19) website, Belgium has established a field hospital near the Kırıkhan State Hospital in Kırıkhan, Hatay, which is almost the size of a football field, with a water purification system, gynecology and pediatric units, surgical units, operating rooms, outpatient units, emergency rooms, radiology units and patient services, where at least 200 people a day can receive health services (Figure 11).

Figure 11.
Field hospital established in Kırıkhan by Belgium (URL-20)

After the February 6, 2023 earthquakes, information on field hospitals established in disaster areas is given. There are many more field hospitals established by Turkey and foreign countries in the news sites accessed, but the field hospitals that could not be reached with the information (units, spaces) that should be obtained within the scope of this study were not included in the study. It is aimed to contribute to the alternative plan proposal by creating Table 2 about the units in the 7 field hospitals whose information is given.

Table 2.
Distribution of units in field hospitals established after the February 6, 2023 earthquake (Created by authors)

Units	İzmir Metropolitan Municipality	TAF	Kocaeli Metropolitan Municipality	Spain	USA	UAE	Belgium
Operating room	√	√	√	√	√	√	√
Laboratory	√	√	√				
Pharmacy	√	√	√	√			
Patient service	√	√	√	√	√	√	√
Radiology (X-ray, ultrasound)	√	√	√	√			√
Emergency service		√	√	√	√	√	√
Obstetrics, gynecology and pediatrics			√	√			√
Surgical service				√			√
Intensive care unit					√	√	

Table 2. (Continued)
Distribution of units in field hospitals established after the February 6, 2023 earthquake (Created by authors)

Units	İzmir Metropolitan Municipality	TAF	Kocaeli Metropolitan Municipality	Spain	USA	UAE	Belgium
Orthopedics			√	√			
Psychiatry			√	√			
Examination room	√						
Outpatient treatment (OPD)							√
Internal medicine service			√				
Infection			√				
Family medicine						√	

In the table created; the most preferred units were determined. In addition to these units, according to the data obtained in the literature review (triage area, water and waste storage etc.) and considering the table with the dimensions obtained from Korkmaz (2012), it was aimed to develop the spaces in the rough layout plan shown as an example in Yalbaz (2008). When locating spaces, not only the individual functions of the units were considered, but also the accessibility between units and spatial relationships, in line with the information conveyed in the article.

Comparison of the Alternative Field Hospital Plan Proposal and the Existing Plan Example with the Spatial Sequencing Method

In addition to the existing plan, new units were added as a result of the data obtained from the literature review and the findings in Figure 2 and Table 2. While adding the units, the areas determined as a result of the accessibility analysis of the existing plan sample with the spatial arrangement method were taken into consideration.

The functional diagram of the alternative plan proposal created using the data obtained from the analyses is shown in Figure 12. The functional diagram shows the interaction and accessibility between units.

In the analysis performed in the DepthmapX program, the lines were colored from red to blue from the longest visibility range to the shortest visibility range. Firstly, an axial line map of the existing sample was created (Figure 13) and it was determined that most of the longest visibility intervals are located in the central axis of the area (some of which contain patient wards), while the shortest visibility intervals are at the edges of the area. The accessibility-oriented design of the spaces in the alternative plan proposal was realized in line with these findings.

Figure 12.
Functional diagram of the alternative plan proposal (Created by authors)

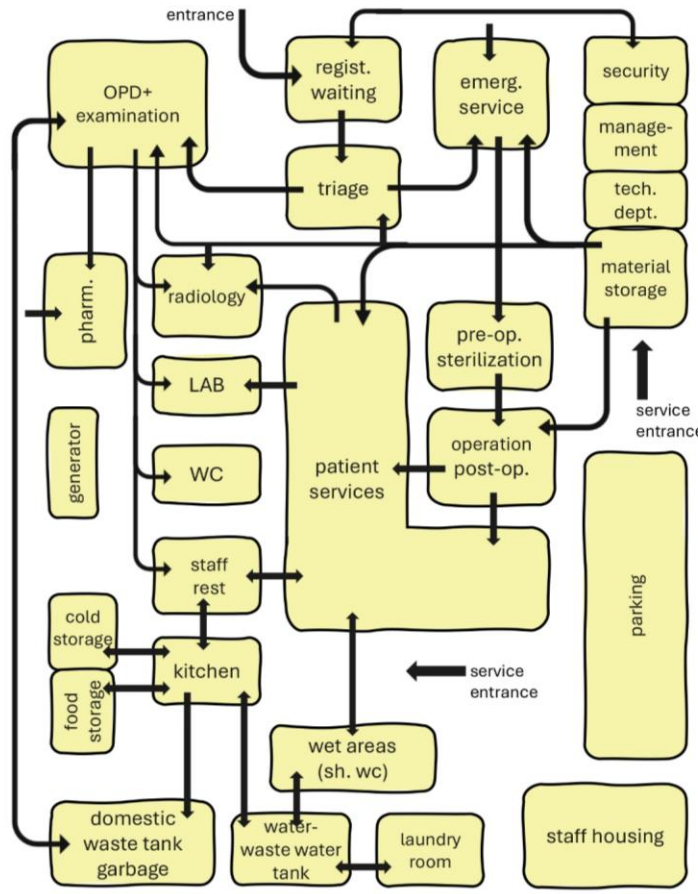
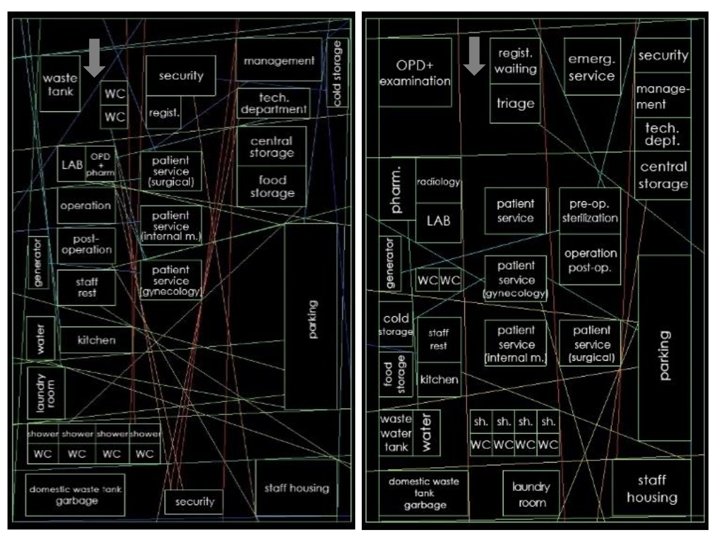
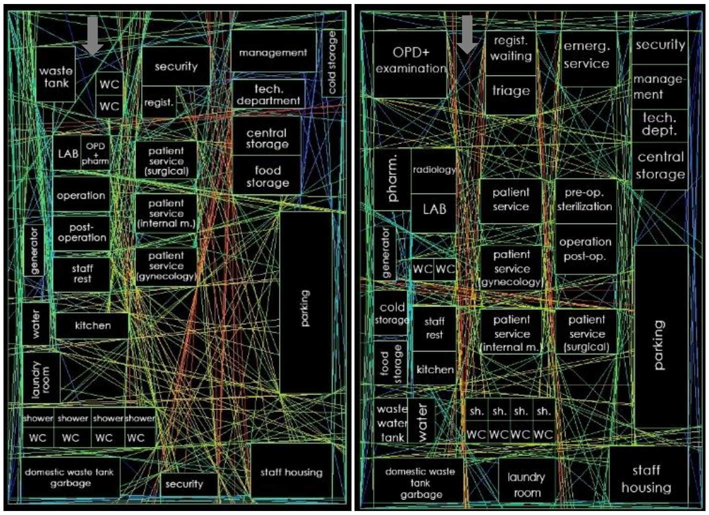


Figure 13.
Axial line map of the current plan example (left) and axial line map of the alternative plan proposal (right) (Created by authors).



In the connectivity analysis maps (Figure 14), high values indicate strong connections while low values indicate weak connections. Strong connections can be defined as more accessible areas.

Figure 14.
Connectivity analysis map of the current plan example (left) and connectivity analysis map of the alternative plan proposal (right) (Created by authors).



In the current example, instead of using the area with the longest visibility range and strong connections as an empty space, in the alternative plan proposal; in order to facilitate the accessibility of patients leaving the emergency and office area to the wards or operating room area, an area accessible by the doctor and the patient has been created by positioning these places where treatment-oriented and patient hospitalization takes place in the middle area with strong connections. This area, where patient hospitalization also takes place, also facilitates access to the shower, wc, kitchen and radiological imaging area if needed. At the same time, in the alternative plan proposal, strong connections are provided not only in the center axis but also between the units. In the existing plan, it was determined that the weakest connections were located at the edges of the area and in the alternative plan proposal, units such as warehouses, generators, waste tanks, etc. were positioned in these areas.

New units (triage, emergency service, radiology, pre-op sterilization, patient service, doctor's office, waste water tank) with the findings obtained within the scope of the study plan proposal was created by adding. In the alternative plan example, it is aimed to send the patients passing through the registration and waiting area to the emergency room or to the area where outpatient treatment and practice are located by determining the urgency levels in order to provide service to more patients in a shorter time in the triage area in case of a disaster. In the area where they are located, strong connections between these units, i.e. high accessibility, have been ensured. The emergency room is not located in a central area to facilitate access from outside. At the same time, the pharmacy unit is located in an edge area so that disaster victims who are not in the field hospital can easily reach it.

External circulation areas outside the units (40% of the area) are distributed proportionally. Figure 2 was used for the dimensions of the units. The examination and OPD (outpatient treatment) unit was designed in a larger scale and it was aimed to be transformed into a medical intervention and examination unit (such as orthopedics, dermatology, psychiatry) when needed. The post-operation post-operation unit also has more m² to be used as an intensive care unit if needed.

In the alternative plan proposal designed by improving the existing plan example based on the analysis, the most preferred spaces were added and more accessible spaces were created. Thus, a space fiction has been created that allows a disaster victim patient to access the spaces needed in a short time.

Conclusion and Recommendations

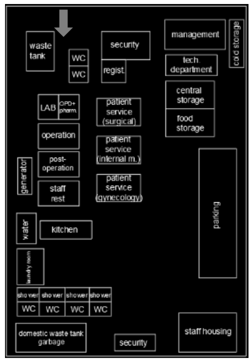
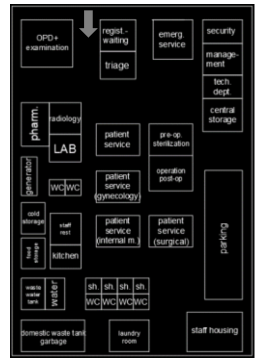
In most of the major earthquakes that have occurred in the world from the past to the present and in the most recent earthquake in our country on February 6, 2023, a significant number of lives have been lost. While most of these losses occurred during the disaster, some of them were caused by inadequate health intervention after the disaster. Unfortunately, hospitals, which are one of the highest priority structures that should not be destroyed in such earthquakes, are sometimes destroyed or cannot provide health services due to lack of capacity.

In this case, field hospitals, which are temporary health structures established after the disaster, provide great benefit for necessary health interventions. This study was affected by people who were able to survive during the earthquake but lost their lives due to inadequate or poorly planned health services after the earthquake.

The recommendations presented in this study are found to be practically applicable in terms of the rapid establishment and improved functional circulation of field hospitals. In particular, spatial arrangements aimed at strengthening access between critical units can be easily integrated into existing field hospital setup schemes. Furthermore, this study provides a guiding framework for future research with its findings regarding the spatial design of field hospitals. The results obtained lay the groundwork for more comprehensive investigations into different capacity needs, rapid response scenarios, and unit placement decisions, with the aim of guiding future academic work on the development of field hospitals.

Field hospitals are of great importance within the scope of post-disaster health services. The aim of this study is to examine the architectural planning of field hospitals before the disaster, to determine the required units and types, to determine the pre-installation area with the correct parameters and to develop an alternative plan proposal under the criteria of accessibility and required units related to field hospital plans, which are lacking in the literature. In the study, the existing plan proposal was developed and an alternative plan proposal was created by determining the spaces and dimensions needed in the field hospital with the data obtained as a result of the literature review and the information obtained through the news source. The space syntax analysis method was used to analyze the accessibility and usability of the existing plan sample and the alternative proposal plan. Space syntax analysis enabled the connection and accessibility criteria of the plans to be analyzed. With this method, strong connection points were identified in the field hospital planning for areas that can provide health services to more patients in a short time, and the strengths and weaknesses related to the placement of spaces under the accessibility criterion in both plans were determined.

Table 3.
Comparison of the current plan and alternative plan (Created by authors)

Criteria	Current plan example	Alternative plan proposal
The most needed units after an earthquake and the accessibility between units		
Adequacy and dimensions of the units (spaces)	It possesses most of the units that are identified as most preferred according to the needs. Additionally, it includes supporting units for the operation of these units (generator, water) and a shelter unit. Furthermore, the necessary units it should have are: Emergency service, radiology, triage, additional patient service, sterilization, examination room, and wastewater tank. It has been identified that the spatial dimensions of the laboratory, OPD, pharmacy, and services are insufficient. The entrance area does not conform to the registration-waiting-triage sequence. The dimensions of the parking area may be insufficient in case of excess demand.	It possesses most of the units that are identified as most preferred according to the needs. Additionally, it includes supporting units for the operation of these units (generator, water) and a shelter unit. Furthermore, some units have larger square meters than necessary to obtain convertible spaces if additional units need to be added according to the requirements. It is observed that the entrance area is suitable for the registration-waiting triage sequence. The dimensions of the parking area may be insufficient in case of excess demand.
Accessibility	The areas that patients need to access shortly after the registration area are not located in high accessibility points. Only the patient service units are located in the middle axis of the area, which is a part of the high accessibility zone. It is positive that units such as storages, generator, water tank, domestic waste tank, and garbage are located in areas with low accessibility. It has been observed that the connection between the inpatient service and the shower toilet is in a low-connectivity area.	The area located in the entrance registration-waiting-triage direction and the spaces that the patient needs to reach in the shortest time have a high level of accessibility. In the middle axis of the area, which has a high connectivity value for easy access for both doctors and patients throughout the area, there are units for patient treatment and accommodation. The accessibility values between other units are also high. The emergency service is positioned on the edge axis for direct access to emergency cases from outside. Similarly, the pharmacy is located in an area that allows external use. It is positive that units such as storages, generator, water, and waste tanks are located in areas with low accessibility but close to the required spaces.

It was concluded that the alternative plan proposal created according to the criteria in line with the findings obtained as a result of the literature review and analyzes has higher accessibility and responsiveness to the needs.

As a result of the researches carried out within the scope of this study, the insufficiency of the studies on field hospitals has been realized and it is thought that increasing the studies to be carried out in this field will enable correct and systematic decisions to be taken before the disaster and will prevent a random installation during the disaster. Thus, it will be ensured that the lives not lost during the earthquake will be kept alive after the earthquake with adequate and rapid health intervention.

This study, which was carried out within the scope of realizing the correct architectural design of field hospitals with need-oriented and accessible spaces, also shows that architecture is an interdisciplinary field involved in all kinds of service sectors, including human health in major disasters such as earthquakes.

In addition, one of the reasons why some field hospitals were established after the earthquake was that hospitals, which are the most important structures that should be built within the ethical principles of architecture and engineering and should not be damaged in the region, were destroyed during the earthquake. It is seen in this study that architecture should have ethical principles in designs in the field of health services, such as pre-earthquake hospital design or post-earthquake temporary health structures design, as in every field where it has ethical responsibility. In addition, the role and importance of spatial sequence analysis, which is the research method within the scope of this study, in the realization of an architect's design and its role and importance in evaluating existing designs has been realized.

Ethics Committee Approval Certificate: The authors declared that an ethics committee approval certificate is not required.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - HÇ, AS; Design - HÇ; Supervision – AS, ZFÜ; Resources - HÇ; Materials – HÇ, AS; Data Collection and/or Processing - HÇ; Analysis and/or Interpretation - HÇ, AS, ZFÜ; Literature Search - HÇ; Writing Manuscript - HÇ; Critical Review – AS, ZFÜ.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support

Use of Artificial Intelligence: Not used.

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