RETHINKING FLEXIBILITY IN CONTEMPORARY HEALTHCARE FACILITIES

Implementation and Test of a Tool for Assessing Flexibility and Resilience of City Hospital Model in Turkey

Zeynep GUCLU
Furkan GULTEKIN

POLITECNICO
MILANO 1863

Politecnico di Milano
School of Architecture Urban Planning Construction Engineering | AUIC

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by
Zeynep Güçlü I 913163
Furkan Gültekin I 914390

Supervisor: Prof. Stefano Capolongo
Co-Supervisors: Arch. Andrea Brambilla

ABSTRACT

Constantly changing needs of people, technology and increase in world population affect healthcare sector's paradigmas dramatically. Healthcare facilities are the focal point of the physical environment in this case. One of the most essential challenges facing healthcare facilities is future uncertainty especially due to recently emerged issues like pandemic. In order to avoid these challenges or minimize the impact of them, healthcare structures should be developed to be flexible and resilient against new innovations and shortages.

Current regulations, legislations and standards do not fulfill today's fragile requirements. Therefore via one of the contemporary hospital models known as "City Hospital" in Turkey which is developed through public-private partnership, the deficiencies of flexibility and resilience towards changing health sector conjuncture and demands are discussed in order to develop an evaluation tool for planners when developing mega healthcare facilities that can immediately react to a variety of situations such as emergencies, crises, and rapidly evolving technology.

Developing an evaluation tool which focuses on a set of flexibility and resilience standards through megastructures taking into account current pandemic situations and public private partnerships' impacts for designers to assess healthcare structures projects during designing and planning phase in order to determine to what degree healthcare structures adopt and apply flexibility and resilience principles. This leads to a literature review regarding flexibility and resilience issues in current healthcare conditions. Moreover, by studying several contemporary examples of mega healthcare structures both from Turkey and Europe comparatively.

Regarding scientific and quantitative data during the examining state of the art, selected contemporary megastructure case studies and assessing them applying the ''Optimized Flexibility Assessment Tool'' (OFAT), it was resulted that there is a need of enhancing more detailed, multi-layered and extensive evaluation tool that includes current emerging circumstances through a more developed flexibility assessment for megastructures which addresses a broad perspectives and lowest uncertainty levels with additional criteria. Development and redefining of OFAT brings "Megastructure Flexibility Assessment Tool" (MeSFAT) as the outcome of systematically conducted research for assessing a mega healthcare facility during the design phase or after compilation in terms of flexibility and resilience.

The types of data that can be extracted from this report are expected to be tested in future study. The consequences of applying the method to a broader range of facilities on a local or worldwide scale should be the focus of future research.

ACKNOWLEDGMENT

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LIST OF ABBREVIATIONS & ACRONYMS

ATM	Automatic Teller Machine
BAC	Building Automation and Control
BDP	Business Data Processing
BIM	Building Information Modeling
BREEAM	Building Research Establishment Environmental Assessment Method
COVID-19	Coronavirus Disease
CSED	Çevresel ve Sosyal Etki Değerlendirmesi
CT	Computed Tomography
DKK	Danish Krone
EBD	Evidence-Based Design
EBRD	European Bank for Reconstruction and Development
ECG	Electrocardiography
EIB	European Investment Bank
EMG	Electromyography
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ETS	Environmental Tobacco Smoke
FGI	Foreign Government Information
FM	Maintenance and Facility Management
FTR	Fiziksel Tıp ve Rehabilitasyon
HEPA	High Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
IAQ	The Condition of Indoor Air
ICT	Information and Communications Technology
ICU	Intensive Care Unit
IFC	International Finance Corporation
IORT	Xoft Intraoperative Radiotherapy
IT	Information Technology
iHGF	International Health Facility Guidelines
KOIDB	Kamu Özel İdare Daire Başkanlığı
LCA	Life Cycle Assessment

LEED	Leadership in Energy and Environmental Design
MCH/FP	Maternal and Child Health/Family Planning
MeSFAT	Megastructure Flexibility Assessment Tool
MOH	Ministry of Health
NASEM	National Academies of Sciences, Engineering, and Medicine
NGO	Non-governmental Organization
NHS	National Health Service
NHS	National Health Service
NKS	New Karolinska Solna
OECD	Organisation for Economic Co-operation and Development
OFAT	Optimized Flexibility Assessment Tools
PCR	Polymerase Chain Reaction
PFI	Private Finance Initiative
PMR	Physical Medicine and Rehabilitation
POCT	Point-Of-Care Testing
POE	Post-Occupancy Evaluation
PPE	Personal Protective Equipment
PPP	Public Private Partnership
PTS	Pneumatic Tube Systems
PTT	Posta Telefon Telgraf
SCC	The Stockholm City Council
SEK	Swedish Krona
TC	Türkiye Cumhuriyeti
TR	Turkey
TTB	Türk Tabipleri Birliği
TUIK	Türkiye İstatistik Kurumu
USGBC	The American Green Building Association
WBS	Work Breakdown Service
WHO	The World Health Organisation
WSP	Williams Sale Partnership
YOK	Yükseköğretim Kurulu
YPK	Yüksek Planlama Kurulu

INTRODUCTION

00

00 INTRODUCTION

People's changing needs, technological advancements, and the growing global population all have a significant impact on the healthcare sector's frameworks. In this situation, the physical environment's focal point is healthcare services. Future ambiguity is one of the most significant challenges facing healthcare facilities, especially as a result of newly emerging problems such as pandemics. To prevent or mitigate the effects of these problems, healthcare systems should be designed to be adaptable and resilient to technological developments and crises.

Health-care structures are frequently built to last a long time, with at least 30-50 years of operation in mind. Structures must adapt to modern medical technologies and devices, population and observational trends, and legislative and regulatory reforms over the course of their lives. Historically, these systemic changes have emphasized the structure's capacity, and the standard reaction has been to "build for now and extend for future''. Even so, the rapid rate of transition in recent times, associated with a greater emphasis on sustainability, necessitates a closer examination of health structure project design (Nanda et al., 2019).

Existing rules, laws, and guidelines are insufficient to meet today's rapidly changing needs. As a result, the shortcomings of flexibility and responsiveness against evolving healthcare system conjuncture and expectations must be addressed.

In Turkey, since 2017, a modern hospital concept known as the "City Hospital" started to emerge as massive and diverse healthcare structures. The public-private partnership (PPP) funding system is used to establish these programs, which are implemented through the private firm's contribution to health systems. Because PPP is a fairly recent contribution in healthcare, it is essential to learn it from the start of the design process to the end of the construction process. Furthermore, since they are large and modern facilities, their adaptability to adjustments and efficacy throughout crises are uncertain. To mitigate this impact, they must be well-designed throughout terms of flexibility and resilience. This does not, though, imply that they are genuinely adaptable and robust. It is critical to assess their ability to respond to rapidly evolving circumstances, such as pandemics, and health-care demands. This can be explained by looking at the hospitals' adaptability and versatility requirements.

The aim of this research is to look at how the city hospital model can help with versatility and resilience in the face of changing health-care conditions and needs. It is to develop a detailed tool and technique for planners when proposing mega healthcare facilities that can quickly adapt to a variety of situations like emergencies, pandemic and technological developments.

THEORETICAL BACKGROUND

CITY HOSPITAL AS A NEW TYPOLOGY IN HEALTHCARE and EMERGING ISSUES

01

01 THEORETICAL BACKGROUND

1.1 A New Model in Healthcare: City Hospitals

Integrated Health Campus

Health campuses are areas where medical research and studies are carried out in close relationship with other units, with staff specializing in these basic disciplines of medicine and their own functional spaces. In such a region, there are other building units such as logistic support units, high level transportation and parking facilities, accommodation, shopping, social and cultural facilities.

In other words, the health campus; They are health campuses that contain the use of specialized hospitals, R&D laboratories and centers, techno parks, social facilities, hotels, shopping centers, accommodation and open areas as a whole.

In the historical process from the first hospital structures to today's modern hospitals, the definition and content of the hospital has improved. In the second half of the 19th century, with the work of Florence Nightingale, hospitals were brought clean and ordered for the first time and the foundation of the first modern hospitals was laid. Today, modern hospitals contain many contents besides cleanliness and order:
Hospitals;

- Trying to heal patients with space, medical equipment and health personnel
- Healing the patients,
- Prevents the spread of infectious diseases,
- Taking measures by constantly communicating with them to protect the health of the surrounding people,
- Scientific researches against diseases are carried out,
- It is a social institution that trains doctors and nurses for the health army of a country (Mutlu, 1973).

Since this definition was made by Asım Mutlu in 1973, there have been great changes in health paradigms until today. The concept of a patient-oriented healing hospital comes to the fore in integrated health campuses.

According to Ergenoğlu & Aytuğ (2007), patient-oriented design approaches lie at the basis of the concept of the hospital that heals. In their study examining the healing hospital concepts, Ergenoğlu & Aytuğ (2007) emphasized the need to regain the patient-oriented health campus understanding that exists in Anatolian culture. As a matter of fact, it started off with "an understanding that puts people at the center of the service, leaving aside institutional concerns and priorities (Ministry of Health [MOH], 2008).

From this point of view, as a result of the physical standards developed both within the building and around the buildings, health services come into being in the form of campuses just like in universities. Campus areas can accommodate many different types of services such as education, trade, recreation, sports and religious services, and can provide more qualified services in the different functional areas they offer. Compared to the hospitals that offer health services in the form of a single structure, this new physical form in healthcare facilities is highly effective, has a high level of mutual communication, has more common use, and can produce high added value thanks to their shared use in many subjects.

In health campuses, all health services are eliminated efficiently and quickly, ease of access to specialized information, time and space savings, reduction in costs, efficiency in staff organization, high level of infrastructure in social and hotel service quality, sufficient bed capacity and short-term patient discharge process. It stands out compared to other healthcare facilities with the opportunity to care for a big number of patients, saving in technology and other logistics units with environmental and sustainable projects (such as electricity, water, heating and cooling), regulated vehicle and parking level.

- Sufficient number of beds and improving bed quality,
- To improve the service of the specialized team surrounding the region,
- To apply new technologies in treatment,
- To develop new concepts (outpatient surgery, day hospital) in treatment services,
- To shorten the patient's hospital stay,
- To reduce hospital infections,
- To reduce patient transfers,
- Increasing patient safety,
- Increasing patient satisfaction,
- Increasing employee safety and satisfaction,
- To increase the workforce and service quality,
- To ensure the improvement of health service performance (MOH, 2008)

27 main regions determined with the slogan of a health city in each health region, a health campus was planned in sub-regions connected to them (MOH, 2008).

Environmental and Social Impact Assessment Report

City hospitals are Public-Private partnerships and these hospitals are built with the PPP-investment model The special purpose organisation seeks funding from multinational financial institutions , including export credit agencies to finance the developing of the project because the city hospitals projects are very high cost investment projects. One of the requirements that financial institutions put forward for lending is the preparation of the Environmental and Social Impact Assessment (ESIA) report.

An ESIA is a procedure to identify the potential environmental and social impacts and risks of the project and to develop mitigation measures appropriate to the project's structure and scale, in order to comply with good international practices and with the awareness that the project is an important public infrastructure project.
Mitigation measures should be included in the Environmental and Social Management Plan (ESMP) that accompanies this study. The ESIA Report and ESMP will form a basis for the decision of the lenders in the environmental and social assessment of the project. The ESIA study should be conducted to meet the requirements of the following international standards:

- European Investment Bank (EIB) Environmental and Social Standards (December 2013)
- European Bank for Reconstruction and Development (EBRD) Performance Requirements (May 2014)
- International Finance Corporation (IFC) Performance on Social and Environmental Sustainability Standards (January 1, 2012)
- IFC General Environment, Health and Safety Guidelines (30 April 2007)
- Environment, Health and Safety Guidelines for IFC Health Centers (30 April 2007)
- Sub-Sectoral Environmental and Social Guidelines on EBRD Healthcare and Clinical Waste Disposal (October 2009)

In addition to these standards, the project must comply with Turkish laws on the environment and society.

ESIA is a systematic process that predicts and evaluates the effects of a project in physical, biological, cultural and socioeconomic terms. This process is followed by determining appropriate mitigation measures to prevent, reduce, improve, offset or compensate for negative impacts associated with the project's structure and scale. The key steps of the ESIA process are shown in Figure 1.1.

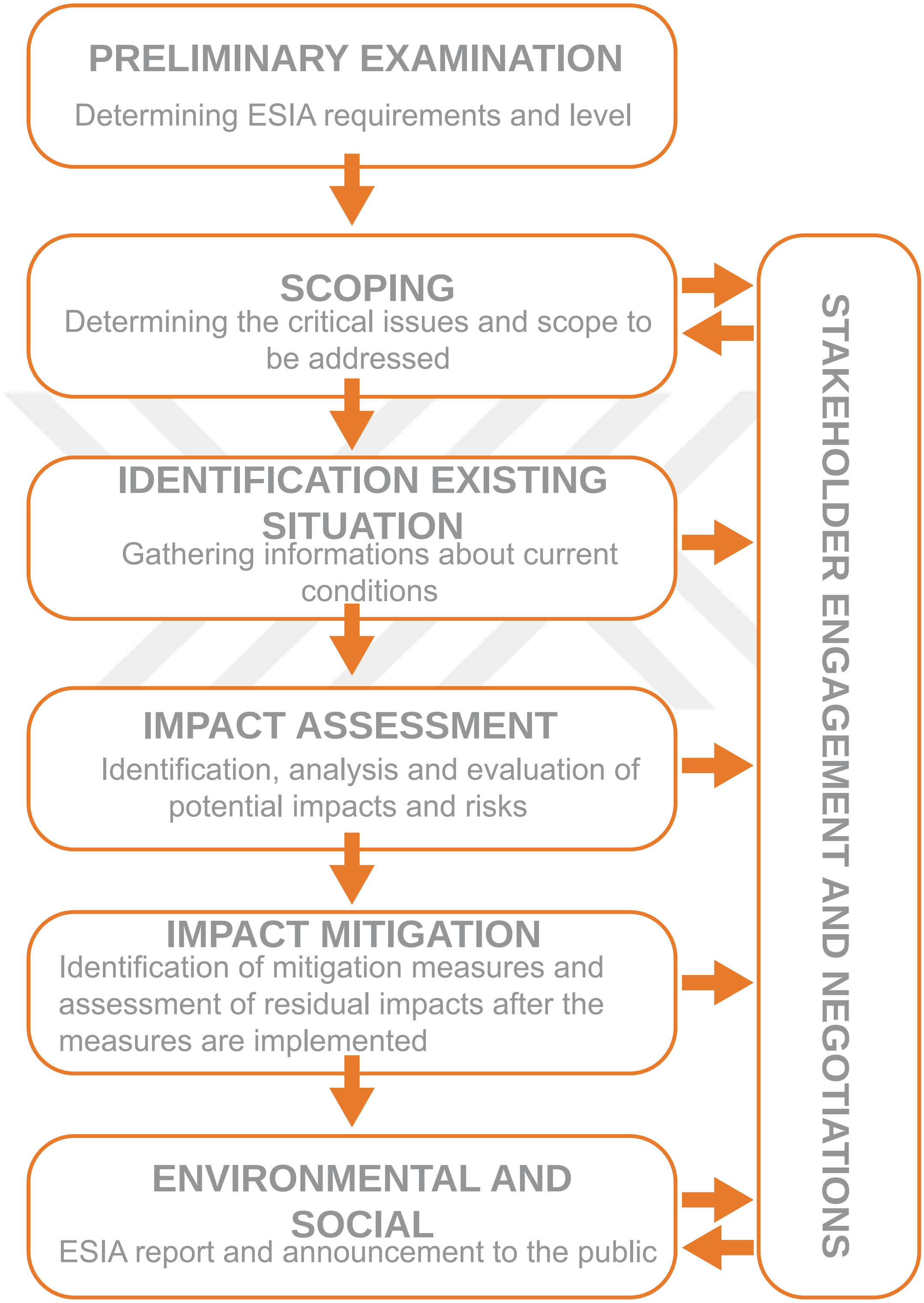


Figure 1.1: Environmental and Social Impact Assessment Process
(Source: Adana PPP Sağlık Yatırım A.Ş. (2014), edited by author)

Environmental and social evaluation of the project, related to construction works; Environmental and Social Impact Assessment (ESIA) studies are carried out to document and protect possible potential environmental and social impacts to provide, prevent or compensate mitigation measures. The purpose of the ESIA is to describe the project and its impacts on key environmental and social conditions. It also explains how the project was designed and how it will be implemented in order to minimize negative impacts and maximize its benefits. The ESIA predicts and evaluates the impacts on the physical, natural, cultural, social and socio-economic environment during the design, construction and operation phases of the project, and where possible, the Borrower must take to provide benefits to prevent, mitigate, correct, compensate or compensate adverse impacts. It is a study that determines the precautions.

When the effects of climate change and social problems more frequently are observed these days, it has become a necessity to be sensitive to environmental and social issues Air Quality, Noise, Water, Wastewater and Groundwater, Soil, Geological Hazards, Waste, Traffic, Ecology, Resettlement, Population Flow, Local Economy and Local Livelihoods, Community Health, Safety and Security, Access Services and Infrastructure, Occupational Health , Labor and Working Conditions and Cultural Heritage Impact assessment are covered by ESIA.

Green Hospitals

All structures consume energy both during construction processes and during their operations. Considering the increasingly dangerous loss of world resources, it is a fact that the greatest energy savings can be achieved from the buildings used every day.

For this purpose, both technical and architectural solutions emerge to the fore. Another important issue is environmental pollution. Wastes are generated constantly in daily lives and if not managed properly, they cause great damage to the environment that we live in.

Although all these are valid for any structure, the biggest difference can be observed in hospital buildings. Hospitals consume a high amount of energy because of the technological devices and also generate very frequent and abundant amounts of waste.

For this reason, if not managed properly, hospital buildings can digress from being a place where people can be treated, on the contrary, health-threatening situations can appear. Buildings whose negative effects on human health and the environment are minimized through better settlement, design, construction, operation and maintenance methods are called Green Building. With Green Buildings; It is possible to reduce the health expenses of the employees and lower operating and maintenance costs by reducing waste, increasing the indoor air quality, increasing the comfort and efficiency of the building user, especially energy and water savings. On average, Green Buildings consume around 30% less energy than conventional buildings. The American Green Building Association (USGBC) introduced a common definition to the concept of “Green Building” with the LEED Green Building certificate program it launched in the late 90s and started to rate the sustainability levels of buildings. For City Hospitals projects developed with the claim of supplying modern requirements, the concept of green hospital comes into focus in order to eliminate all these negativities.

LEED certification system is a rating system for designing green hospitals. The Ministry of Health in 2013 has determined the LEED certificate as a means of reaching the green hospital target by requiring the LEED certificate by the contractor company during the construction phase in hospitals with 200 beds and above (Özdemir, 2015).

Scoring system over 110 points is provided according to the LEED principles. Based on this scoring system, 40-49 points are called certified, 50-59 points silver certified, 60-79 points gold certified, 80 and above points are called platinum certified.

LEED certification is divided into categories according to different project types. The certification system required for green hospitals is the LEED BD + C certificate.

LEED certification scoring system:

SUSTAINABLE SITES
Construction activity pollution prevention
Environmental site assessment
Site selection
Development density and community connectivity Brownfield redevelopment
Alternative transportation - public transportation access
Alternative transportation - bicycle storage and changing rooms
Alternative transportation - low-emitting and fuel-efficient vehicles
Alternative transportation - parking capacity
Site development - protect or restore habitat
Site development - maximize open space
Stormwater design - quantity control
Stormwater design - quality control
Heat island effect - non roof
Heat island effect - roof
Light pollution reduction
Connection to the natural world - places of respite
Connection to the natural world - direct exterior access for patients

WATER EFFICIENCY
Water use reduction
Minimize potable water use for medical equipment cooling
Water efficient landscaping - no potable water use or no irrigation
Water use reduction - measurement and verification
Water use reduction
Water use reduction - building equipment
Water use reduction - cooling towers
Water use reduction - food waste systems

ENERGY & ATMOSPHERE AWARDED
Fundamental commissioning of building energy systems
Minimum energy performance
Fundamental refrigerant Mgmt
Optimize energy performance
On-site renewable energy
Enhanced commissioning
Enhanced refrigerant Mgmt
Measurement and verification
Green power
Community contaminant prevention - airborne releases

MATERIAL & RESOURCES
Storage and collection of recyclables
PBT source reduction - mercury
Building reuse - maintain existing walls, floors and roof
Building reuse - maintain interior nonstructural elements
Construction waste Mgmt
Sustainably sourced materials and products
PBT source reduction - mercury in lamps
PBT source reduction - lead, cadmium and copper
Furniture and medical furnishings
Resource use - design for flexibility

INDOOR ENVIRONMENTAL QUALITY
Minimum IAQ performance
Environmental Tobacco Smoke (ETS) control
Hazardous material removal or encapsulation (renovations only)
Outdoor air delivery monitoring

Acoustic environment
Construction IAQ Mgmt plan - during construction
Construction IAQ Mgmt plan - before occupancy
Low-emitting materials
Indoor chemical and pollutant source control
Controllability of systems - lighting
Controllability of systems - thermal comfort
Thermal comfort - design and verification
Daylight and views - daylight
Daylight and views - views

INNOVATION
Integrated project planning and design
Innovation in design
LEED Accredited Professional
Integrated project planning and design

REGIONAL PRIORITY CREDITS
Optimize energy performance
On-site renewable energy
Thermal comfort - design and verification
Stormwater design - quantity control
Heat island effect - roof
In addition, renewable energy systems recommended in city hospitals are:
Cogeneration-trigeneration systems
Gray water systems
Wind energy systems
Systems to benefit from solar energy

In the construction of new health buildings, while providing the renovation and repair needs of existing buildings, maximum sensitivity should be taken into account while using the limited resources of Turkey. It is aimed that the new healthcare facilities will be smart buildings that will fulfill the expectations and needs of today and allow the use of developments in medicine and technologyWithin the framework of the objectives and understandings mentioned above, the construction of the new building, old facilities and for repair and renovation of them, “Turkey’s Healthcare Building 2010 Minimum Design Standards Guideline” was prepared. Health facilities to be built with this guide; There will be structures where access is facilitated, modern health services are provided, and the latest information and technologies in medicine are applied. The quality of the service will be improved, and savings will be achieved by minimizing operating and repair costs

While designing of City hospitals, Turkey's Healthcare Building 2010 Minimum Design Standards Guideline have been taken into account. They are designed above the minimum dimensions due to their large size compared to other health facilities.

Distinguishing Architectural Features

City hospitals' architectural projects are the architectural projects prepared by the architect chosen by the contractor firm that won the tender. These architectural projects are prepared in line with the needs program provided by the Ministry of Health. City hospitals, like all other hospitals, consist of inpatient and outpatient areas and diagnostic, treatment areas and support and administration areas that serve them.

The standard scheme for a city hospital and the components of the three major units are seen in Table 1.1. There are inpatient spaces as multi-floor buildings and outpatient spaces areas in the city hospital plan systems, i.e. polyclinics, which link a wide mass of diagnosis and treatment. With the variations occurring together in all 3 major units, the plans are formed and altered (Nevrim, 2020).

In the systems of the city hospitals in operation, three different variations can be identified. The arms connected to the main core constitute the first one , the second is the Y-shaped towers on the main mass, and the third is the mixed-use of platform plan (matchbox on a muffin) and towers attached to the main mass. Table 1.2 indicates these schemes.

Inpatient Bed Wards
16 Bed Acute Care Unit
16 Bed Women's & Pediatric Acute Care Unit
16 Bed Prisoner Services
13 Bed Intensive Care Unit
13 Bed Women's & Pediatric Intensive Care Unit
10 Bed Cardiovascular Intensive Care Unit
12 Bed Newborn Intensive Care Unit
24 Bed Newborn Intensive Care Unit
13 Bed Trauma Unit
15 Bed Burn Unit
14 LDR Patient Rooms
10 Bed Newborn Nursery
16 Bed Post-Partum Unit
Clinics
Patient Admissions
General 12 Exam Room Module
General 24 Doctor Room Module
Diagnostic & Treatment
Endoscopy Unit
Radiology Department
Hyperbaric
Surgery Suite
Day Surgery Area
Pre/Post Operation Area
Emergency Service
Hemodialysis Center
Physiotherapy Center
Sterile Processing Department
Advanced Pathology Unit
Transfusion Center
Genetic Diseases Central
Support
Technical Services
Car Parking

Table 1.1: An Example of a Project Program
(Source : Design Evolution of Healthcare Buildings: City Hospitals as A New Building Typology in Turkey (2020))

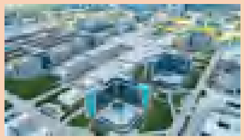
Lay-out	City Hospitals		
Arms attached to the main core	 ANKARA BILKENT CITY HOSPITAL	 KAYSERI CITY HOSPITAL	 KONYA KARATAY CITY HOSPITAL
Y-shaped towers on muffin	 ADANA CITY HOSPITAL	 BURSA CITY HOSPITAL	 ELAZIG FETHI SEKIN CITY HOSPITAL
Mixed type (Arms attached to the main core and Matchbox on Muffin)	 BASAKSEHIR CAM AND SAKURA CITY HOSPITAL		

Table 1.2: Lay-out of the City Hospitals in Use
(Source : Design Evolution of Healthcare Buildings: City Hospitals as A New Building Typology in Turkey (2020))

Instances of styles of bed room towers around the main center including diagnostic, treatment areas and administrative units are Kayseri and Bilkent City Hospitals. Towers attach to the major cores with bridges. It is possible to identify this configuration as the arms connected to the main center (see Figure 1.2 & 1.3).

Elazığ, Adana, Bursa are representations of City Hospitals composed of bed room towers situated on the diagnosis and treatment base combined with the out-patient spaces. These can be grouped as Y-shaped towers in the main mass. The most particular feature that distinguishes the two models from each other is the absence of bridges where the users connect to the treatment and diagnostic mass (see Figure 1.4).

The two architectural forms of the combination can be categorized as Yozgat and Eskişehir City Hospitals. By the bridge, blocks are linked to the center and also the blocks located above the center.

In Ikitelli City Hospital, there is a scheme where the towers are in the center as indicated Figure 1.5. The bed towers are starightly linked to the main mass by vertical circulation (Nevrim, 2020).

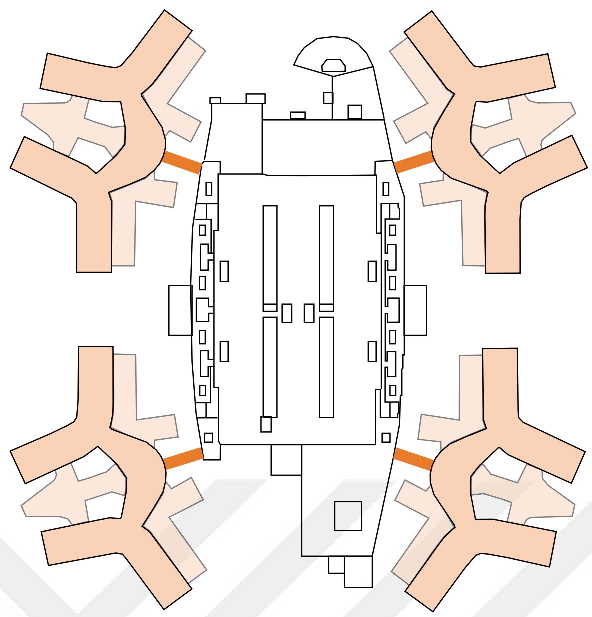


Figure 1.2: Kayseri City Hospital Top View
(Source: Author)

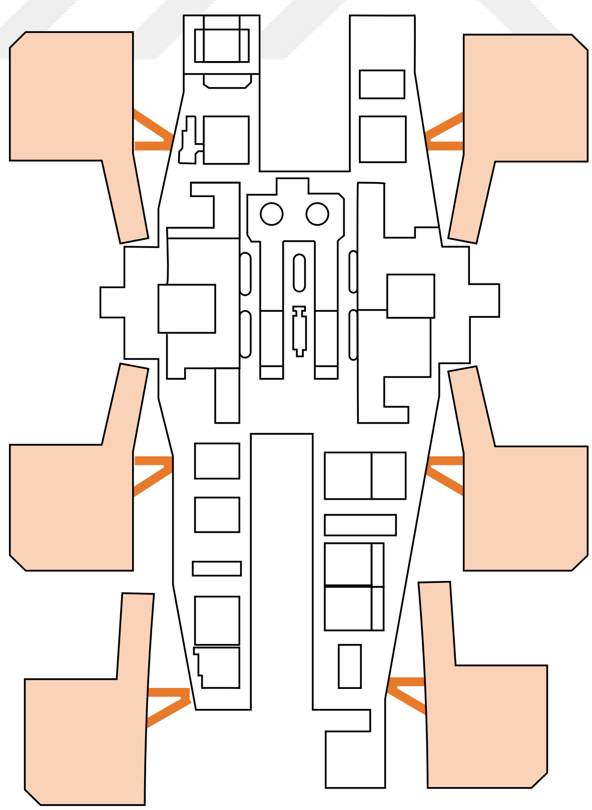


Figure 1.3: Ankara Bilkent City Hospital Top View
(Source: Author)

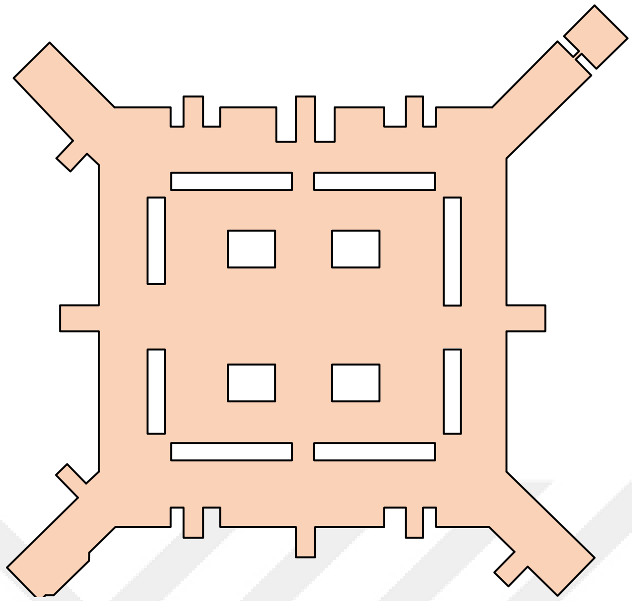


Figure 1.4 : Bursa City Hospital Top View
(Source: Author)

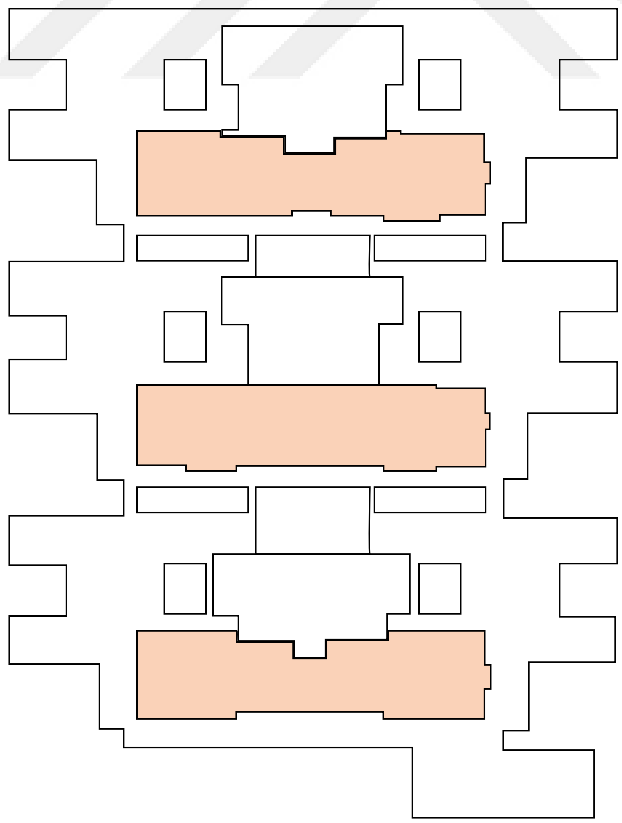


Figure 1.5: Istanbul Basaksehir Cam and Sakura City Hospital Top View
(Source: Author)

Nevrim (2020) claims that City hospital facilities are separated from other state hospital facilities by interior design project concept which leads significantly to architecture. One of the most noticeable variations in the spatial configuration of city hospitals is the planning of interior design programs. Interior design projects lead to various architectural differences between City Hospitals because of a lack of guidelines and standards for hospital interior design in Turkey. It is notable that interior design programs are commonly carried out for highly populated areas along with main entrance rooms, reception areas and special areas including units for children and hemodialysis, etc. Architectural components have similar qualities to state hospitals, such as flooring, wall and ceiling components used in city hospitals. In the public-private partnership model, as the interior design is developed and the contractor obtains utilities such as renovation, repair and cleaning under a defined budget cost, this has a positive effect on the efficiency and workmanship of the components (see Figure 1.6).

Figure 1.6 : Bursa City Hospital Waiting Area
(Source: https://www.yazgandesign.com/bursa-integrated-health-campus?pgid=kbapl82x-f23ff343-07aa-4970-b737-75c2e6b4a2f7)

Figure 1.7: Bursa City Hospital Intensive Care Units
(Source : https://ticari.tarkett.com.tr/tr_TR/node/bursa-sehir-hastanesi-5828)

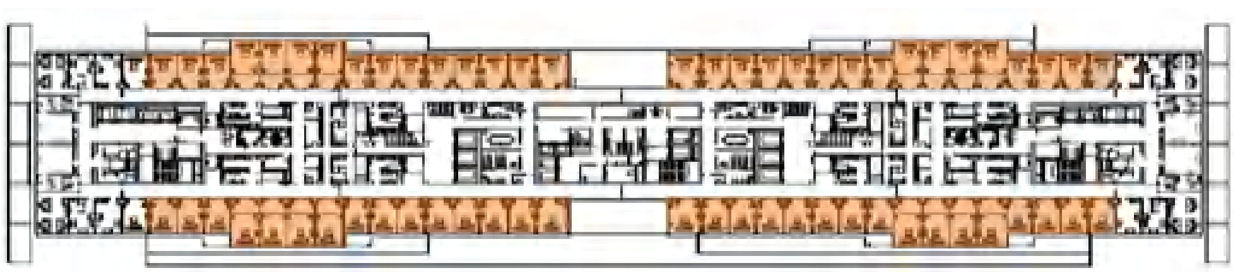


Figure 1.8: Intensive Care Unit Plan, Basaksehir Cam and Sakura City Hospital
(Source : Nevrim (2020),edited by author)

In the architectural and clinical design of the city hospitals, the most remarkable situation is the design of intensive care units as a single room. Intensive care units are constructed in other state hospitals in the style of an arena model divided by patient units with curtains or removable glass doors and coversIn city hospitals, pre and post medical operation, every room has independent sinks for the doctor to clean his hands (see Figure 1.7 & 1.8).

According to the Turkey’s Healthcare Building 2010 Minimum Design Standards Guideline, patient wards which have private bathrooms with a size of one or two persons are designed at City Hospitals. After 2010, patient rooms in public hospitals must be planned for a maximum of two people. However, there are patient bedrooms with more than 2 beds in some of the facilities that have been constructed and are still in service (Nevrim, 2020). As shown in Figure 1.9, in the bedroom and accompanying chairs, timber equipment and earthy tones are preferred to accommodate for lying as required.

A clinical and hygienic architectural concept is prevalent in these patient-oriented concepts by taking into account the impact of area on the healing time of the patient as a patient-centered approach to patient rooms (Nevrim, 2020).

Figure 1.9: Patient Room, Kayseri City Hospital
(Source : https://www.yazgandesign.com/kayseri-integrated-health-campus)

Nevrim (2020) states that in City Hospitals differentiated from other public hospitals, the most significant aspect is that elevators are supported as vertical elements of movement. Although escalators in the main halls allow vertical movement, the use of elevators is at the center of the mobility situation in these complexes. Moreover, even though stairs are designed, they are a fire exit and the major stairs are not planned for the patients' main pedestrian direction (see Figure 1.10).

Figure 1.10: Medical Avenue, Basaksehir Cam and Sakura City Hospital
(Source : Nevrim, 2020)

Even though amount of beds in city hospitals vary, the amount of beds in most of them is greater than in the large number of other public hospitals.Therefore, closed areas are also high. The existence of parking areas in these facilities is the most essential part that raises the space per room. Pre city hospitals, internal parking in public hospitals was not designed. Table 1.3 indicates The amount of beds, interior spaces and interior parking bays of some of the City Hospitals.

Hospital	Bed Capacity	Total Gross Area (sqm)	Parking Area (sqm)
Eskişehir City Hospital	1081	330.000	74.000
Bursa City Hospital	1355	460.000	120.000
Kayseri City Hospital	1607	465.000	110.000
Istanbul Basaksehir Cam and Sakura City Hospital	2682	1.000.000	300.000
Ankara Bilkent City Hospital	3711	1.300.000	226.000

Table 1.3 : Bed Capacity, Total Gross Area, Parking Area of Some City Hospitals
(Source : Design Evolution of Healthcare Buildings: City Hospitals as A New Building Typology in Turkey (2020))

The development of mobility diagrams inside the architectural designs is other aspect that separates City Hospitals from other state health facilities. According to the facilities rendered by the organization in the public-private partnership model, the sheets of various flow systems such as sterile, dirty stuff, food, inpatient, and outpatient are comprehensive and estimated. Accurate design of hospital flow diagrams assures the success of architectural building, operation performance and reliability (Nevrim, 2020).

Figure 1.11: Kayseri City Hospital
(Source : https://kayseriism.saglik.gov.tr/EN,77299/kayseri-sehir-hastanesi-genel-bilgilendirme.html)

The interior space is over-abundant because of the expanded bed size and testing and recovery areas and parking lots in the city hospitals. These facilities, where the transformation is feasible, are designed as compact systems. The extension of the size prompted the need for a major land. Table 1.4 displays the scale of the sites and the building areas of the facilities. Because the plots on this site are not accessible in the downtown of the city, most of them are found on out-of-city sites. The distances to certain locations in the city centre from city hospitals are indicated by Table 1.5 (Nevrim, 2020).

Hospital	Bed Capacity	Total Gross Area (sqm)	Ground Floor Area (sqm)	Site Area (sqm)
Eskişehir City Hospital	1081	330.000	65.000	189.000
Bursa City Hospital	1355	460.000	89.000	754.000
Kayseri City Hospital	1607	465.000	190.000	481.000
Istanbul Basaksehir Cam and Sakura City Hospital	2682	1.000.000	153.000	789.000
Ankara Bilkent City Hospital	3711	1.300.000	213.000	506.000

Table 1.4 : Site Areas and Ground Floor Areas of the City Hospitals
(Source : Design Evolution of Healthcare Buildings: City Hospitals as A New Building Typology in Turkey (2020))

City Hospitals	Eskişehir	Bursa	Kayseri	B.sehir Cam and Sakura	Ankara Bilkent
Distance to the Governor's Building	8.5 km	35 km	10 km	7.5 km	14 km
Distance to Kızılay Square					11 km
Distance to Eskişehir Şelale Park	8.4 km				
Distance to Municipality B. of Başakşehir				4.9 km	
Kayseri Kalesi			10 km		
Bursa City Square Shopping Mall		19 km			

Table 1.5: Distance from City Center of the City Hospitals
(Source : Design Evolution of Healthcare Buildings: City Hospitals as A New Building Typology in Turkey (2020))

Nevrim (2020) asserts that City Hospitals bring an extreme user and vehicle load to their places due to their capacity. Patient (outpatient), personnel, transportation, emergency and rescue flows are these. Tables 1.6, 1.7 & 1.8 indicate the amount of individuals and traffic subject to designing in relation to Bilkent City Hospital.

In addition to both of these, the patient spends a lot of distance between the units because of the growth of the size, particularly in the foundation component, and the length of the base is around 1 km in facilities with more than 1000 beds. It is seen where, while there are skylights in areas, amid the unavoidable depth of this foundation, there is a spot where visible sunlight is not used properly and there are spots that do not obtain any direct sunlight.

Hour	07:00 08:00	08:00 09:00	09:00 10:00	10:00 11:00	11:00 12:00	12:00 13:00	13:00 14:00	14:00 15:00	15:00 16:00	16:00 17:00
Sum	**7.232**	**7.232**	**3.616**	**3.616**	**2.712**	**904**	**3.616**	**3.616**	**2.712**	**904**

Table 1.6: Hourly Distribution of Outpatients to Bilkent City Hospital
(Source : Design Evolution of Healthcare Buildings: City Hospitals as A New Building Typology in Turkey (2020))

Hour	07:00 08:00	08:00 09:00	09:00 10:00	10:00 11:00	11:00 12:00	12:00 13:00	13:00 14:00	14:00 15:00	15:00 16:00	16:00 17:00
Sum	**4.339**	**4.339**	**2.170**	**2.170**	**1.627**	**542**	**2.170**	**2.170**	**1.627**	**542**

Table 1.7: Hourly Distribution of Automobile Access to Bilkent City Hospital
(Source : Design Evolution of Healthcare Buildings: City Hospitals as A New Building Typology in Turkey (2020))

	OUTPATIENT	PHYSICIAN	MEDICAL STAFF	SUPPORT STAFF	PATIENTS COMING FOR	VISITOR OF INPATIENTS	CLINIC PATIENT	PATIENTS TO BE SURGERY	INTERN	EMERGENCY SERVICE	SUM
Sum	**36.160**	**2.591**	**5.839**	**5.839**	**17.015**	**1.264**	**36.160**	**2.048**	**3.000**	**12.000**	**120.748**

Table 1.8: Daily Visitors to Bilkent City Hospital
(Source : Design Evolution of Healthcare Buildings: City Hospitals as A New Building Typology in Turkey (2020))

Figure 1.12: Ankara Bilkent City Hospital
(Source: http://www.eskisehirsehirhastanesi.com/diger-sehir-hastaneleri/ankara-bilkent-sehir-hastanesi/)

1.2 Public-Private Partnership as An Investment Strategy

On the Concept and Usage of Public-Private Partnerships in History

One of the most influential aspects of the discourse of neoliberalism is the political paradigm of public-private partnerships; it has, for instance, the arguments of quality and competitiveness, re-examines market-client relationships, and public services. In other words, it is often emphasized that in the neoliberal era, the perception of modern public management is now popular, and public-private partnerships have come to the fore as one of the most effective and important tools of this century.The model of public-private partnerships also converges with this understanding in terms of the sharing of costs and benefits between the two sectors, just as the understanding of current public management signifies the separation of the workload between the public and private sectors (civil society should also be added). It should not be overlooked, according to the heart of this strategy, that this form of partnership is based on a dialectical relationship where both sectors are somehow relying on each other, though, in certain cases, the risks and benefits may vary in percentage terms. Nonetheless, it should certainly be noted, according to the center of the theory, that both sectors and their patterns of operation follow a parallel course between them, even though the situation may vary in some circumstances (Yücel, 2020).

The Evolution of Public-Private Partnership in Healthcare

In the world, there is no state where healthcare is completely funded by the government. Although health coverage is generally accepted as the government's obligation, private capital and expertise are increasingly seen as welcome sources of growth and innovation. What is less evident, however, is the sufficient balance between public and private capital in health funding and management. Discussions on this subject are followed by debates on different mechanisms that ensure the best possible return for both taxpayers and the private sector. However, what is less evident is the proper balance between public and private capital in the funding and management of healthcare. Discussions on this subject are followed by debates on different mechanisms that ensure the best possible return for both investors and the private sector.

One such agreement is a public-private partnership (PPP). Building on two decades of experience in healthcare services PPP, authorities are gradually looking to address care delivery and wellbeing challenges with this model. The effect on total costs is much more substantive and sustainable as PPPs shift from repairing crumbling hospital systems to controlling care delivery. However, a greater degree of difficulty and complexity is introduced by wrestling down the rapid rate of medical costs.

Throughout the world, these collaborations are being established to make government and private businesses more responsible for protecting the most important national resource of each nation: its citizens' health.

Today, PPPs offer far more than buildings. In the 1990s, as the government had significantly underinvested in its National Health Service (NHS) hospitals, the United Kingdom was the matured ground for PPPs in healthcare. As a result, almost every new NHS hospital in the United Kingdom, around 100 buildings in 12 years, was constructed as a PPP. The idea expanded to other nations, and as bidders and the public sector strengthened the mechanism, the PPP model developed its own system of expertise. In Australia, Japan, Italy and other places, PPPs were not without controversy and some well-publicised failures enabled critics to point out the weaknesses of "privatising" healthcare. Still, valuable lessons appeared, and the model of PPP was constantly improved and modified. PPPs are characterized as a large collaboration between private contractors and the government, in which public sector contracts (usually on a long-term basis) with the private sector for the provision of a public service are a common feature (PWC, 2010) (see Figure 1.13).

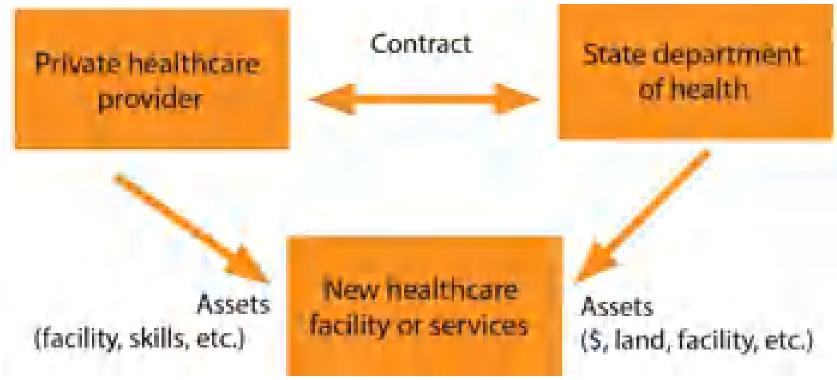


Figure 1.13: Generic Healthcare Example
(Source: PWC (2010), edited by author)

Traditionally, the PPP market has been calculated by the size of the deal or by the funds received for a new facility. By that measure, PPPs are broadening their presence; 2010 has seen record-setting PPP agreements around three continents. This alone suggests a strong demand for private capital to fund the hospitals of the future. According to Infrastructure Journal, $4 billion was revealed in hospital PPP deals in Europe in the first half of 2010. The biggest contract, EUR 1.5 billion, is the 700-bed Karolinska in Stockholm, Sweden, which is projected to be the world's largest PPP hospital. Another big project, the New Hospital of Vigo, Galicia, Spain, is a 1,465-bed hospital with a total of EUR 375 million (PWC, 2010).

While infrastructure projects remain largely dominated by these pioneering transactions, what is also becoming apparent is that infrastructure PPPs are increasingly expanding the demand for private capital and health expertise. PPPs are now providing much more than buildings. For instance, partnerships such as the Alzira project in Spain, that involves hospital and primary care facilities, have saved 25% of the expense of delivering care for the government. "The world's health systems will, within the next 15 years, find themselves in an unsustainable situation if they do not carry out a number of important changes in their health policies," said Alberto de Rosa, general director of the Ribera Salud Grupo, one of the partners in the Alzira project.

The Stakeholders: how success is determined by PPP players

In effective PPPs, stakeholders play vital roles: from providing a sufficient legislative structure that requires PPPs to take place, to financing organizations willing to invest in project firms, experienced consulting capacity to help both the public and private sectors manage these complex transactions, and strong service providers capable of assuming service responsibilities and handling risk. Figure 1.14 demonstrates a few of the features that, if they are to be successful, public and private sector parties need to recognize and accept.

First, each PPP stems from a need that is simple and well expressed. The need is characterized as the difference between the current condition and the optimal status, such as the gap between current and optimal outcomes for health. Secondly, in a true relationship, there must be a desire to work together. Thirdly, there must be sufficient rewards for each player in order to put the willingness into effect. The capacity of each stakeholder to perform to the required level is the fourth characteristic of a good PPP. Each player must, by agreed steps, be able to demonstrate the standard of their results. All of these questions center on the need for flexibility. Although comprehensive contracts obviously need to be regulated by PPPs, the contract structure must accommodate advanced methods, information technology, and demographic growth, and the subsequent shifts in governments' strategic priorities over time (PWC, 2010).

Figure 1.14: Critical Roles for PPP Players
(Source: PWC (2010), edited by author)

Transformation in Healthcare Services in Turkey (2002-2020)

The Health Reform Plan was a law, one of the health measures impacting the inventory of health care structures in Turkey. The 58th Government Emergency Response Plan, entitled 'Health for Everyone,' was declared on 16 November 2002 by the Ministry of Health. It is exactly the same as the reform in the 1990s. This plan's key priorities were;

1- The Ministry of Health's institutional and technical reform,
2- Participation in the scope of the General Health Care of all residents,
3- Under one canopy, gathering health organizations,
4- To make hospitals separate in managerial and financial terms,
5- Beginning "family medicine" practice,
6- To pay particular consideration to the welfare of mothers and infants,

7- Preventive distribution

8- Promoting participation in the health sector by the private sector,

9- In all public institutions, the transition of power to lower ranks,

10- Completion in priority growth regions of the shortage of health staff,

11-Implementation of a health-related e-transformation campaign as (MOH, 2016 as cited in Nevrim, 2020).

In order to transition to a patient-oriented system in the health system, the Patient Rights Unit and Patient Rights Board were set up and Quality Processes were developed in hospitals and research studies have begun on the satisfaction and desires of patients from the health service (Circular Date: 15.10.2003 Issue: 19499).

There was no architectural design competition for proposals for state hospitals in the 2000s. The way the contracts are received is by the Public Procurement Law (Atmaca & Demirgüç, 2016 as cited in Nevrim, 2020). With health reforms, the number of new hospitals grew during this time, but it took too long to complete the building of a hospital. The changes made to the public procurement legislation was the most significant indication in the fact that hospital buildings are being completed in a brief amount of time in the 21st century.

A design guide for healthcare structures, called Turkey Healthcare Buildings Minimum Design Standards, was released at the end of 2010, offering detailed information on healthcare structure architecture. A circular on challenges to be pursued in health structures came into effect in 2012. The technical and legal document for hospital construction is Regulation No. 2012/6, which also contains the specified requirements. The majority of these criteria are bedding services, ambulance units, operating rooms and intensive care units. The new architectural projects would also be in the direction of fulfilling these demands (Şener, 2017). Private Hospitals Laws, 2010 Design Guidelines, and 2012 Circulars determine, for the first time in Turkey, the minimum standards in hospital design and are now in operation.

By incorporating certain substances in 2007, the health transformation initiative began to be applied. The 2008 World Bank Study mentions the model of public-private partnership, which is perceived to be a fundamental shift in health care policy. The revisions can be described as follows, according to the OECD Health System Review Turkey 2008 report;

1) Granting more control and independence to hospital administrators in the handling of revolving funds as well as purchase and expenditure decisions
2) Additional performance-based payment system implementation
3) Accessing private sector medical (diagnostic) healthcare services by outsourcing (public-private partnership)

4) Develop networks of health knowledge
5) Conduct quality and productivity audits of hospitals (OECD, World Bank, 2008)
First, the Public-Private Partnership Legislation on the Health Sector was introduced in 2006 and a separate Public-Private Partnership Department was set up to pilot the health sector within the Ministry of Health. There are several public-private partnership projects expected to be implemented, including the construction of new training and research hospitals by the private sector (OECD, WB, 2008 p. 44-45).

Along with all these policy changes, health care programs in Turkey have continued to be built. Under the Ministry of Health, which was 548 in 1967, the number of hospitals reached 871 by 2017, the number of university hospitals was just 5 in 1967 and 68 in 2017, and the number of commercial hospitals was 76 in 1967 and the number of private hospitals was 571 in 2017 (TUIK 2017 as cited in Nevrim, 2020). In this period, new hospitals were established in several cities and towns in Turkey. Table 1.9 shows the increased number of hospitals. The idea in humanization of hospitals as seen in the world can be seen in these hospital concepts, where the projects are distinct from each other. In removing the modern hospital from the cold picture to the humane world, especially inpatient bedrooms, single or double patient rooms with preferred color and materials both inside and outside the hospital played a role.

The numbers of Community Health Centers, Family Medicine Units, Tuberculosis Dispensaries, MCH/FP Centers, Cancer Early Diagnosis, Screening and Training Centers, Specialty Medical Centers and Private Outpatients Clinics are included in the total. Reliable data in compliance with the description could not be obtained before the year 2000 (TSI, 2017 as cited in Nevrim, 2020).

The most important political input is health policy in developing countries such as Turkey. Investments in health are important for citizens and governments, too. In health care structures, the fact that space is inevitably political (Lefebvre, 1977) also finds its value. The shift in economic policies, consumer society outputs and the global flow of money have also been reflected in the health issue that is directly human-related. In order to regain health, healthcare has become a means of exchange, health centers and hospitals have entered economic competition and the health sector has become an important investment area for investors (see Table 1.10). The spatial reflection of these concepts is seen in the health policies in Turkey and the transformation of the structure of the healthcare architecture. With the development of city hospitals, the realization of a fundamental transformation of these reflections of health care systems is taking place. In 2017, City hospitals, which have been offered as a phase of the Health Transition Program and have undergone a dramatic transformation in health care systems, have continued to welcome patients through the private sector’s partnership with the public.

Years	Total number of medical institution	Number of inpatient medical institution	Number of outpatient medical institution	Total number of hospital beds	Number of hospital beds per 1000 population
2000	10 747	1 183	9 564	134 950	2,08
2001	10 581	1 199	9 382	140 710	2,14
2002	9 685	1 156	8 529	164 471	2,48
2003	9 183	1 174	8 009	165 465	2,46
2004	9 038	1 217	7 821	166 707	2,45
2005	8 870	1 196	7 674	170 972	2,48
2006	9 831	1 203	8 628	174 342	2,50
2007	11 839	1 317	10 522	178 000	2,52
2008	13 818	1 350	12 468	183 183	2,56
2009	15 205	1 389	13 816	188 638	2,60
2010	26 993	1 439	25 554	200 239	2,72
2011	27 997	1 453	26 544	194 504	2,60
2012	29 960	1 483	28 477	200 072	2,65
2013	30 116	1 517	28 599	202 031	2,64
2014	30 176	1 528	28 648	206 836	2,66
2015	30 449	1 533	28 916	209 648	2,66
2016	32 980	1 510	31 470	217 771	2,73
2017	33 587	1 518	32 069	225 863	2,79

Table 1.9: Number of Medical Institutions, Total Number of Hospital Beds and Number of Hospital Beds per 1000 Population, 2000-2017
(Source: Design Evolution of Healthcare Buildings: City Hospitals as A New Building Typology in Turkey (2020))

	Hospital beds/ 1000 population	In-patient admission 100 population
Selected Upper Middle Income Countries		
Brasil	3.1	NA
Mexico	1.1	5.5
Malaysia	2.0	NA
Romania	7.6	18
Thailand	2.0	NA
Turkey	2.6	7.6
Tunisia	1.7	8
Venezuela	1.5	NA
Total Upper Middle Income Countries	***3.3***	***6***
Selected OECD Countries		
Canada	4.1	10.0
Germany	9.3	22.6
Italy	5.5	18.0
Portugal	4.0	12.0
UK	4.2	15.1
USA	3.7	12.5
OECD Average	***7.4***	***16.2***

Table 1.10 : Hospital Beds and Admission in Turkey and Other Countries
(Source: OECD Health Data 2001, A Comparative Analysis of 30 Countries (2001))

The Tender Process and Scope of Public-Private Partnership Model

Since 2002, the Ministry of Health has initiated a people-oriented health transformation program aiming to ensure that citizens have equal access to quality healthcare services. One of the objectives of the Health Transformation Program in Turkey is to take into account diversity in the management of public health facilities, regional development and emerging technologies. In this direction, the ultimate goal has been to transform health facilities into structures that comply with world standards. In order to achieve this goal, it has been in search of a new system, taking into account the investment power of the public.

For this purpose, the Public Private Partnership investment model, which is frequently applied in America, Canada, England, Italy, France and various countries of Europe, has been examined by the top managers and bureaucrats of the Ministry of Health.

Various European countries examined the hospital implemented with this investment model and its applicability to Turkey have been identified. For this purpose, the Ministry of Health started to establish the legal infrastructure in 2005 with the law on adding an additional article to the basic law of health services numbered 5396. It was published with the decision of the Council of Ministers dated 3 July 2006 (Regulation on the construction of health facilities in return for lease and the renewal of services and areas outside the service areas in the facilities). The Ministry established an independent department under the name of the Department of Public Private Partnership in order to carry out these works and procedures. Later, the name of the department was changed to the Department of Public Private Cooperation. Finally, the Law No. 6428 on Building, Renewal, and Service, and Amendments to Certain Laws and Statutory Decrees by the Ministry of Health, through the Public-Private Cooperation Model, was published in the Official Gazette on March 9, 2013 and entered into force.

Public Private Partnership is defined as a financial model or a business partnership where the difference between commercial financial analysis and social benefit-cost analysis is covered by the public sector when a project cannot be fully financed by the private sector.

By applying the Public-Private Partnership (PPP) financing method in the health sector:

- Using private sector financing resources in public investments,
- The ability of the private sector to make fast decisions and to implement these decisions and the integration of their creativity into the project process, to share the risk,
- Establishing an infrastructure where everyone knows best and can do their main job,
- No cost is incurred on behalf of the public until the health facility is put into operation,
- Shortening of building construction periods of 8-10 years in public due to insufficient funds,
- Spreading of the investment burden on limited public resources over many years at the level of rent payment,
- It is aimed to commission services and areas other than medical services to be operated by the private sector (KOIDB Archives, 2014 as cited in Sönmez, 2014).

The following steps are followed in the implementation of public-private partnership system in Turkey:

- The Ministry gives the land or notifies the place of work.
- Bidders in line with the design prepared by the Ministry; They present their proposals including how they will make the investment, their detailed projects, the cost of the project, the investment cost of medical equipment and furnishings, how long it will be leased.
- Thus, the most advantageous bid is awarded.
- Investment construction is completed and rented to the Ministry of Health.

- For 25 years, services other than medical services are provided by the bidder. During this period, simple and major repairs of the health facility are also carried out by the entrant.
- 25. At the end of the year, the facility is delivered to the Ministry of Health with all the maintenance done (KOIDB Archives, 2014 as cited in Sönmez, 2014).

The Tender Process

The following stages are generally followed in the public-private partnership tender process:

- Pre-feasibility report is prepared.
- The approval of the Ministry of Finance is obtained on whether a free transfer is possible by establishing a construction right up to forty-nine years in favor of the Contractor.
- YPK Decision is taken (except for renewal projects).
- Preliminary project, feasibility report, basic standards document and tender document are prepared.
- Advertise (Official Gazette, No. 2 in Turkey and the high pressure in the newspapers and on the internet broadcasting abroad if necessary) will be published.
- Prequalification is determined.
- Initial Bids are received and ranked.
- After the initial Bids are evaluated, the Project with Equalized Conditions is determined.
- Final offers prepared according to the Equalized Conditions Project are received and the tender is completed with the negotiation process (KOIDB Archives, 2014 as cited in Sönmez, 2014).

The Scope of Tender Process

The City Hospital tender realized with the Public Private Partnership Model is much wider in scope than the tenders made with other known methods. In tenders made with known methods, separate tenders are made for building construction, medical equipment furnishings and various services. However, in tenders realized under the Public Private Partnership Model, all services except building construction, medical equipment, furnishings and medical services required for the operation of the facility are carried out with a single tender. The firm that won the tender is obliged to provide the construction and services. These services are:

- Building and land services
- Exceptional maintenance and repair service
- Common services management service

- Furnishing service
- Ground and garden maintenance service
- Other medical support services
- Spraying service
- Parking service
- Cleaning service
- HBYS application and operation service
- Security service
- Patient referral and accompaniment / reception center / help desk / transport services
- Laundry and laundry service
- Food service
- Laboratory service
- Display service
- Sterilization and disinfection service
- Rehabilitation service
- Waste management services (KOIDB Archives, 2014 as cited in Sönmez, 2014)

The construction period varies between 2.5-3.5 years depending on the size of the project. Services are provided for 25 years. At the end of this period, the facility will be delivered to the Ministry of Health, together with all the equipment and furnishings in it, as well as the maintenance and repair.

According to the feasibility made by the administration, the commercial areas to be planned within the facility will be given to the company that will take the tender and will be deducted from the rent to be paid for the facility. In this way, the cost of the facility to the Ministry of Health will be slightly reduced. Commercial Areas Under the Tender are as follows:

- Clinic Hotel
- Companion homes
- Nursery and nursing home
- Congress Center
- Open and closed car parks for commercial areas
- Fitness center
- Market & Bazaar
- Restaurant, Pastry Shop, and Cafe
- PTT Branch, Bank Branch and ATMs
- Taxi etc. transportation services
- Social aid foundations and association offices (KOIDB Archives, 2014 as cited in Sönmez, 2014)

Design Process in Public Private Partnership Model

Factors that affect the design process

Lawson (2004) determined the factors that make up the design knowledge as restrictive laws, designer, employer and user. In private sector investments, laws, designer, employer and user can be independent elements. However, in public investments, these four must be under the control and determination of the Public. In public investment, laws are not only restrictive but also determinative. There are many circulars and design guidelines that set design standards in public investments. The designer is guided by these circulars and guides.

In Public Private Partnership projects, the effect of the Public and Private Sector on the design information is directly (see Figure 1.15). This is because, due to the nature of the model, the public and private sectors share different responsibilities and risks.

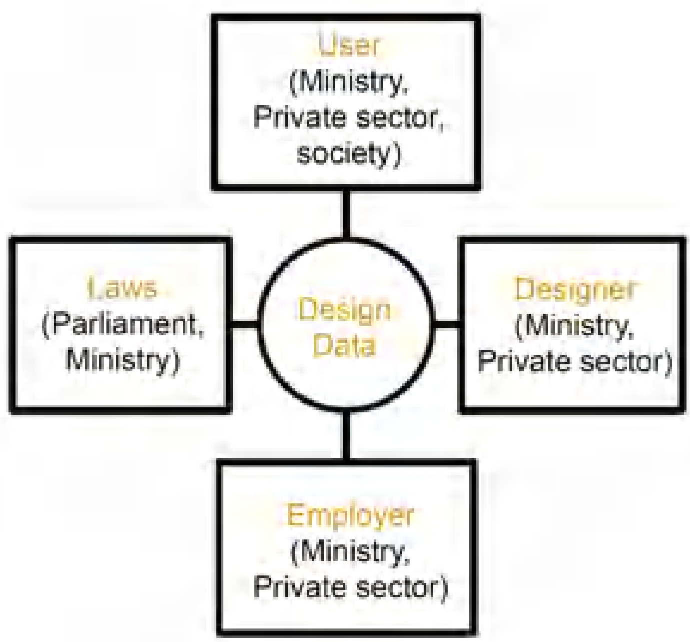


Figure 1.15 : Factors Affecting Design Knowledge in PPP Model
(Source : Lawson (2004), edited by author)

The Role of the Ministry of Health in Design

The public plays the role of user, designer, employer and legislator in Health Campus investments. The operation of medical areas on campus is under the responsibility of the Ministry of Health.

The operating room, clinical services, polyclinics, emergency service and all treatment areas (except rehabilitation) are the areas served by the Ministry. Therefore, the Ministry carries out all kinds of medical planning. The Ministry constitutes the preliminary project and the project that has equalized the conditions in line with the determined health policies and medical plans. Since there is no final project and implementation project responsibility, the Ministry keeps its expectations regarding the program as high as possible at the pre-project stage. As the employer, the Ministry of Health gives the Private Sector the task of finding the financing of the investment, drawing the construction project, making the construction and performing services such as services other than medical services and building maintenance for 25 years. The Ministry, which determines the operational standards for its service areas, does not give precise directions regarding interior design. In this way, it is possible to reflect the knowledge and experience of the private sector to the project (Sönmez, 2014, p.10).

The Role of the Private Sector in Design

The Private Sector is responsible for finding financing for investment, developing the preliminary project and creating the application project, making the application, keeping the entire facility maintained and operating for 25 years, providing services other than medical services. In other investment models, contractor companies significantly terminate their responsibilities with post-construction turnkey delivery. However, in the Public Private Partnership Model, the contractor company does not go out of the equation throughout the life of the building. It is both a user and an employer in terms of the services it will provide for a 3-year construction period and 25 years afterwards. Therefore, the role of the private sector in guiding the design knowledge from the pre-project to the implementation project stage is of great importance. Since the importance of the guidance to be made by the Private Sector is understood here, the tender process has been determined accordingly. The reason for the tender with the preliminary project is the thought that the project certainties to be determined by the public will create problems in the 25-year service procurement process. Along with the public private partnership model, the private sector also enters the formula determined by Lawson as investor, user, employer and designer (Sönmez, 2014, p.11).

Design Stages

Although the hospital program was initially determined and projected with a high percentage of accuracy, certain intervals of repair and maintenance are required in hospitals due to structural aging. There is no way to avoid this situation in the classical construction and operating model.

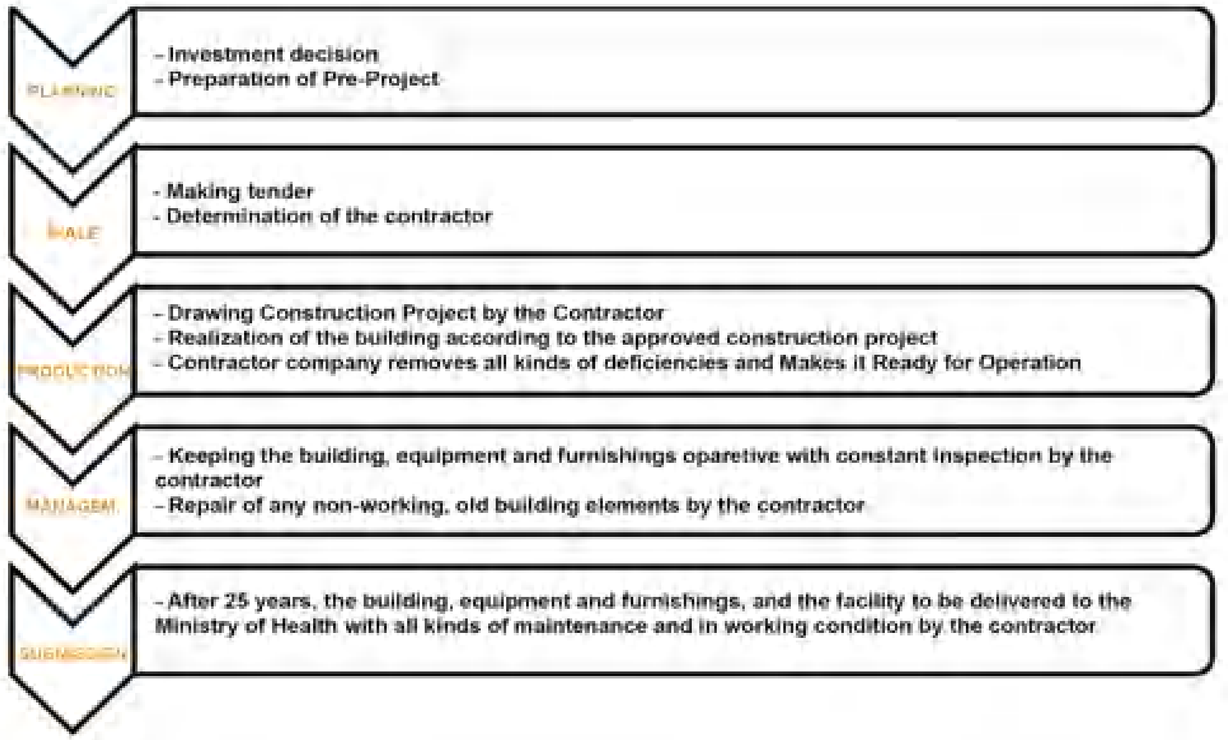


Figure 1.16: Project-Production-Management Process in Public Private Partnership Model
(Source: Sönmez (2014), edited by author)

On the other hand, in projects carried out with the Public Private Partnership Model, the project-construction-operation process works differently. The project-build-operation cycle in conventional models is interrupted with the Public Private Partnership model (see Figure 1.16). The contractor firm is obliged to develop the preliminary project after the tender and draw the construction project. Since all risks related to the construction project belong to the contractor firm, it has to do this in the best way. It is necessary to choose the best design and the most suitable material, considering the 25-year operation period and repairs. The way to minimize the maintenance and repair costs that the contractor company may incur in the future will be the right design, good material selection and correct application techniques (Sönmez, 2014, p.11-12).

The type of tender used in the model takes place in a different process than the known tender methods. Tenders are made with a preliminary project without a construction project. New project proposals can also be proposed by the contractors while the first bids are received in the tender. As a result of evaluations, which passed through a series of project meetings, a project with equalized conditions is created. With the equalized project conditions the tender continues. After that it is finalized as final bids are received. The firm that won the tender is in charge of preparing the final construction project (see Figure 1.17).

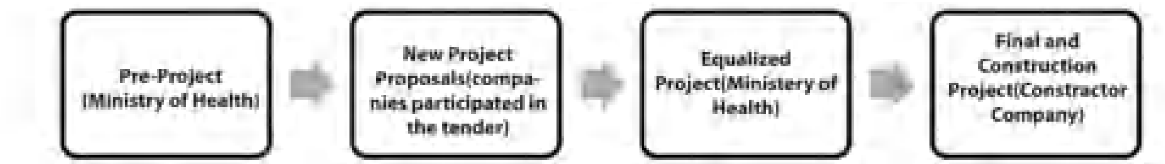


Figure 1.17 : Health Campus Design Stages
(Source: Sönmez (2014), edited by author)

Pre-Project

Sönmez (2014) states that preliminary project according to the law number 6428; "The project in which the necessary ground and land surveys are made according to the needs program of the facility, the information is taken from the existing maps, the plans, sections and views are specified based on the environmental impact assessments, if any, and the concept and basic design elements of the facility, the requirement list and other service areas are determined." states. In the Public Private Partnership Model, it was stated in the previous section that the Private Sector is both a user and an employer in the Health Facility due to 3 years of construction and 25 years of services. In order to ensure the efficiency of the services to be provided by the Private Sector for 25 years and the applicability of the design, a model was chosen that requires participation in the decision-making mechanism in design. According to this model, it was thought that starting work with an application project would cause the Private Sector to stay out of the design process. For this reason, it is aimed to ensure the cooperation between the public and private sector in the process until the completion of the implementation projects with the preliminary project, which can be considered as a project draft. The preliminary project includes floor plans with a scale of 1/200, sections and views with a scale of 1/500, a site plan with a scale of 1/1000, fire escape plans with a scale of 1/500, circulation diagrams, WBS (Work Breakdown Service) table, technical specifications, typical room drawings and room information table (see Figure 1.18).

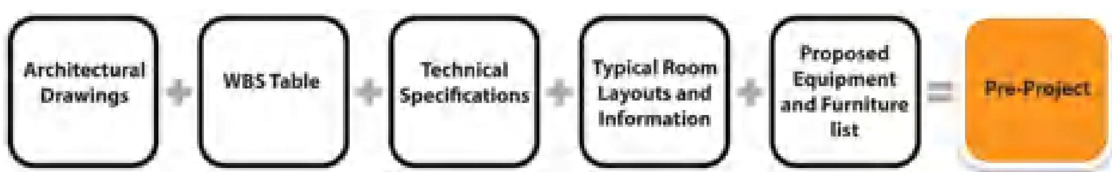


Figure 1.18: Pre-Project Content
(Source: Sönmez (2014), edited by author)

Programing

The preliminary project contains different features from the projects in classical investment models. The most striking of these is the difference in programming. Aydın (2009) emphasized that the spatial program should be correct and precise. He emphasized that the bed capacities of branch hospitals, all polyclinics and services should be determined precisely within the framework of a correct program. Of course, this precision is imperative in classical models where the contractor firm gets out of the post-construction equation. Otherwise, the applications to be made to complete the post-construction deficiencies will disrupt the design as well as lead to high costs. In the pre-projects of Health Campus, the spatial programming is not based on certainties, but on a pre-programming logic to be developed at the construction project stage. The spatial program will be completed with the improvements to be made by the contractor in the construction project.

In order to prepare a preliminary project, a general requirement list is prepared first. This list of needs includes the following information:

- Total number of beds in the health campus
- The number of beds in the branch hospitals and in intensive care units to be built.
- Treatment units and their numbers to be located in the facility
- Emergency departments and their numbers
- Number of operating rooms (specialized operating rooms are specified.)
- Separate numbers of imaging devices
- Total number of all polyclinics in the facility

With this information, preliminary project architectural drawings are completed. After the architectural drawings are completed, a detailed requirement program (desired requirement , program) is prepared. The table containing the desired needs program is called the WBS table. The striking point here is that the detailed requirement program (WBS) is prepared after the preliminary project architectural drawings. WBS not only specifies the location names and sizes, but also the locations in the project mass. Therefore, a preliminary project drawing is needed to prepare the WBS table. During the bidding process, WBS tables are the basis for the price offer. Pricing is made according to the field sizes in the WBS tables (Sönmez, 2014, p.14-15).

WBS Table

As stated by Sönmez (2014), it is possible to design a different WBS for each project. In the City Hospital Projects, a design in accordance with the original characteristics of the project was made. While the entire requirement program of the project is included in the WBS table, information is also given where all the spaces included in the requirement program will be located in the architectural project. The requirements program (Functional Program) and the architectural project (Architectural Layout) are combined in a single WBS table using separate hierarchies from part to whole.

Equalized Project

Different solution proposals can be presented for the project in the first bids submitted by the companies participating in the tender. However, in these proposals, it is not deemed appropriate to change more than 5% of the indoor area square meter with approaches that are against the conceptual design. After the initial proposals, appropriate changes can be made on the preliminary project, taking into account the different project proposals proposed as a result of the evaluation made by the administration. The final version of the preliminary project obtained with these changes is called the project whose conditions are equalized. After the project with equalized conditions is loaded into the data room, the tender process continues with the final bids. Project content with equalized conditions is shown in the Figure 1.19 (Sönmez, (2014), p.16).

Figure 1.19: Project Content with Equalized Conditions
(Source: Sönmez (2014), edited by author)

Final Project and Construction Project

Ministry of Public Works and Settlement states that (1985), "Application projects according to the approved final project of a certain building; These are the projects that are prepared to be used in the office and the construction site at every stage of the project, including the necessary developments for this stage, the architectural elements in accordance with the details, the dimensions of the static and the installation that affect the structure, the detail references and the description of the equipment."

After the tender is concluded, the contracted firm starts the final project and construction project studies. The final project and construction project is completed with the final approval of the administration, under the supervision of the administration at every stage. It is expected that the solutions regarding the changing architectural program will be developed by the contractor during the equalization process of the project conditions. It is understood that the design principles of Health Campuses should be well defined in order for these developments to be correct and for the public benefit. The contractor firm will use the data in the figure to develop the construction project (Sönmez, 2014, p.17) (see Figure 1.20).

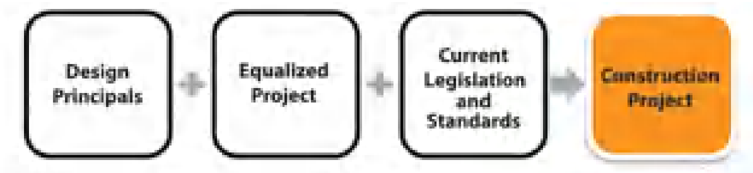


Figure 1.20: Data to Be Used for the Implementation Project
(Source: Sönmez (2014), edited by author)

Evolution process from Tender to Construction Project: The Case of Basaksehir Cam and Sakura City Hospital

Health systems in Turkey were initiated in 2003 under the name of ‘’ Health Transformation Program ’’ in order to develop quality, efficiency and accessibility of health. Within the direction of this transformation, the Ministry of Health of the Republic of Turkey has planned to establish 31 health campuses of different sizes and capacities in 27 provinces to serve 29 health regions, taking into account the healthcare needs, geographical positions, patient flow, accessibility and socio-economic structure of the region. Istanbul Basaksehir Cam and Sakura City Hospital serves to the 29th health zone. City Hospital projects have undergone major changes since the design phase as they are built under PPP-investment model as shown Figure 1.21 (Istanbul PPP Sağlık Yatırım A.Ş., 2017).

In the pre-project prepared by the Ministry of Health at the beginning of the tender includes 1850 bed capacity and 721 764 m² closed area, has been increased to 2682 bed capacity and 824 776 m² closed area in the equalized project phase, in the final construction project, 2862 total bed capacity and 1 021 265 m2 closed area was built (Sönmez, 2014).

Figure 1.21: Health Campuses Design Stages
(Source: Sönmez (2014), edited by author)

A tender invitation has been issued by the Ministry of Health of the Republic of Turkey for the construction of Ikitelli Integrated Health Campus Project to be supplied products and services.The tender was awarded to the consortium established by Emsas Construction Tourism Commerce and Industrial Cooperation, Surat Informatics and Technology Industry Commerce Cooperation and Saglık Kentleri Construction and Trade Service Management Company. Nonetheless, Istanbul Ikitelli International Health Services Investment and Management Corporation,IHIC, was established and the agreement was signed on 25th of March, 2013 (see Figure 1.22). Detailed design, construction, equipment supply, financing and maintenance of the integrated health campus for 28 years is in IHIC' s responsibility. Providing all kinds of health services are under the responsibility of the Ministry of Health for 28 years (Istanbul PPP Sağlık Yatırım A.Ş., 2017).

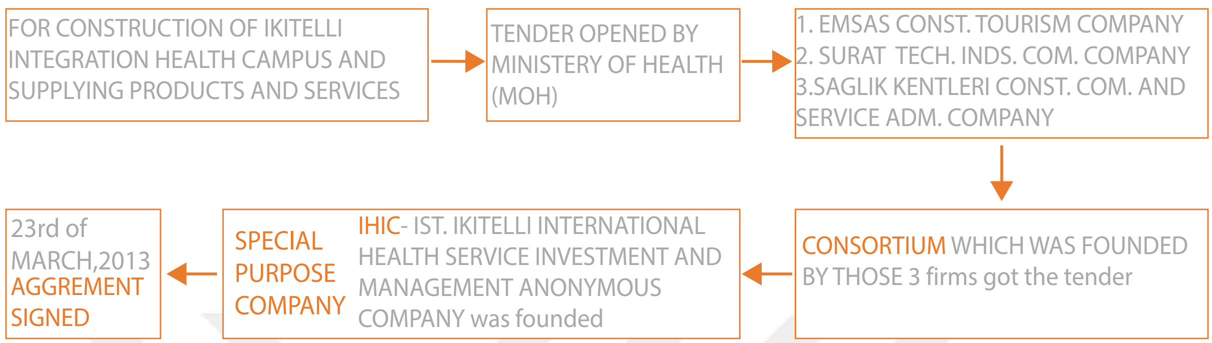


Figure 1.22: Process of Tender
(Source: Author)

Previously Istanbul Ikitelli Integrated Health Campus Project, now known as Istanbul Basaksehir Cam and Sakura City Hospital, including 443-bed General Hospital, 359-bed Oncology Hospital, 451-bed Children's Hospital, 451-bed Gynecology Hospital, 303-bed Cardiovascular Diseases Hospital, 347-bed Neurology and Orthopedics Hospital, 128-bed Psychiatry Hospital and a 200-bed Physical Therapy and Rehabilitation Hospital in the equalized project phase, is a health campus project with a total of 2682 beds (see Figure 1.23). The investment period of the project, which will be realized with the Public-Private-Partnership (PPP) investment model, is 3 years and the operating period is 25 years (Istanbul PPP Sağlık Yatırım A.Ş., 2017).

Figure 1.23: Istanbul Ikitelli Integrated HealthCampus Main Hospital Block
(Source: https://www.yurdakul.com/projects/ikitelli-entegre-saglik-kampusu)

The campus, which was originally planned to have a total gross floor area of 817 377 m², was planned to meet the healthcare needs of the provinces of the region, primarily Istanbul with its population of 12 697 164 at that time.

Sönmez (2014) states that some numerical data about the project with equalized conditions of Istanbul İkitelli Integrated Health Campus are as follows:

Proje Area: 730 000 m²
Bed Capacity : 2 682
Total Gross Floor Area : 824 776 m²
Amount of Closed Car Parking : 8181
Area of the Closed Car Parking : 271 293 m²
Green Area : 500 000 m²

Later, the consortium was dissolved and the tender was announced again.The winner of this tender is a consortium under the name of Istanbul PPP Health Corporation, a special-purpose company consisting of Ronesans Healthcare Investment Co. Inc. and Sojitz Corporation (see Figure 1.24).

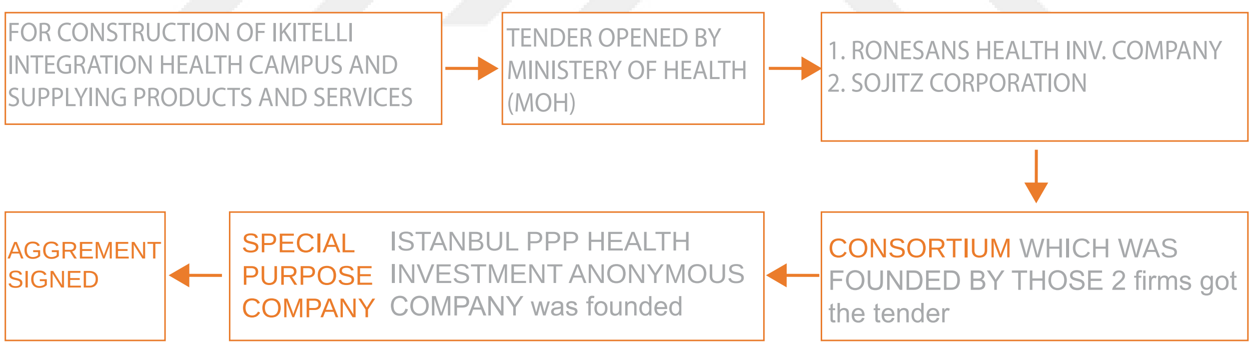


Figure 1.24: Process of Tender (Source: Author)

The name of the project was changed to Istanbul Basaksehir Cam and Sakura City Hospital ,including 469-bed General Hospital, 367-bed Oncology Hospital, 397-bed Children's Hospital, 459-bed Gynecology Hospital, 327-bed Cardiovascular Diseases Hospital, 311-bed Neurology and Orthopedics Hospital, 152-bed Psychiatry Hospital,200-bed Physical Therapy and Rehabilitation Hospital and it has been updated as a health campus with a total of 2682 beds in final construction project phase (see Figure 1.25). The construction project to be carried out with the Public-Private-Partnership (PPP) investment model,as in the project with equalized project phase, the investment period is 3 years and the operating period is 25 years (Istanbul PPP Sağlık Yatırım A.Ş., 2017).

The campus, which was originally planned to have a total construction area of 817 377 m² in pre-project, has reached a total construction area of 1 021 265 m2 with its final construction project.

Figure 1.25: Istanbul Basaksehir Cam and Sakura City Hospital Main Hospital Block
(Source: https://ronesans.com/en/ikitelli-city-hospital-largest-of-the-world/)

Some numerical data about the final construction project of Istanbul Basaksehir Cam and Sakura City Hospital are as follows:

Project Area: 789 031 m²
Bed Capacity : 2 682
Total Gross Floor Area: 1 021 265 m²
Amount of Closed Car Parking : 6421
Amount of Open Car Parking: 1713

Due to the passing into other hands of the contractor company and the requirements of the PPP investment model, many important criteria such as layout plan, WBS table, location of the hospital departments lost their validity and were updated again. The differences and similarities between the equalized project and the construction project are as follows.

Location of the Project Site

The project area is located in Istanbul Province, Küçükçekmece District, İkitelli Village, 1305 block, 1, 2 parcels (Sonmez, 2014). The location of Istanbul Basaksehir Cam and Sakura City

Hospital, formerly known as Istanbul Ikitelli Integrated Health Campus, has been constant from the beginning, and the health facility was established on the land provided by the Ministry of Health. The area is a sloping land with an average elevation difference of 55 meters in the east-west direction and its approximate area is 730 000 m² (Sönmez, 2014) (see Figure 1.26). After that, the land was enlarged and the construction project was built on the area of 789 031 m².

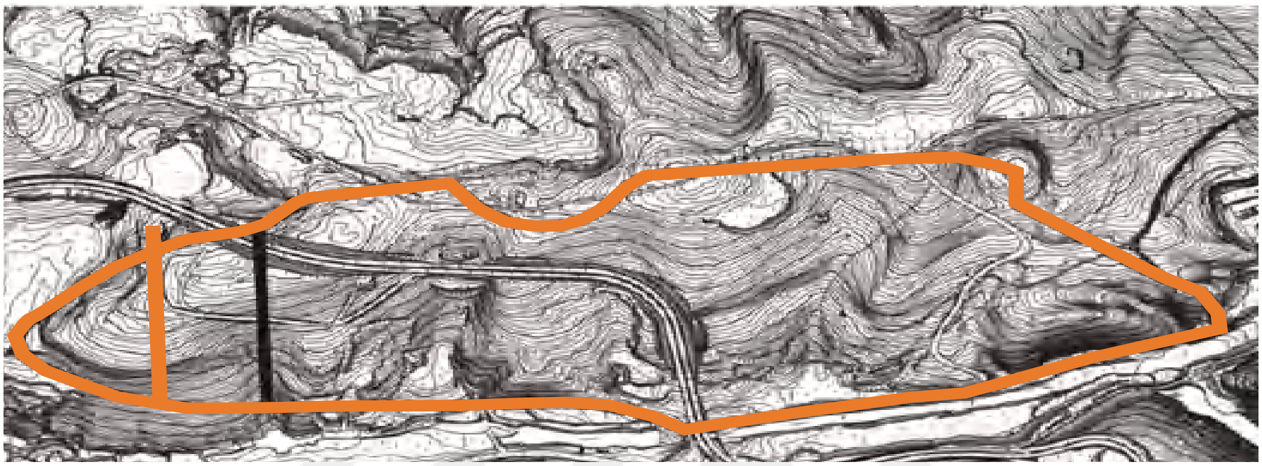


Figure 1.26: Istanbul Ikitelli Integrated Health Campus Topographic Map
(Source: Sönmez (2014), edited by author)

Analysing of Masterplan (Distribution of Units, green areas)

The campus settlement layout scheme in the equalized project drawings of Istanbul Ikitelli Integrated Health Campus and the healthcare facility layout plan in the final construction project are completely different from each other. This difference has brought many differences and changes with it.

In the equalized project the campus settlement consists of diagnosis and treatment and administration departments are constituted of main core and other branch hospitals surrounding it in the master plan scheme. Two different health facilities, the Main Hospital, which consists of 1 general and 6 branch hospitals, placed in the north of the land, and the Physical Therapy and Rehabilitation Hospital located in the south of the area. The Technical Service Building is in a central location between the Main Hospital and the Physical Therapy and Rehabilitation Hospital. A future expansion area is left in the south-west of the Main Hospital building in the site plan (Sönmez, 2014) (see Figure 1.27).

The campus layout scheme of the construction project is completely different from the settlement of the master plan in the equalized project.It is positioned as 6 branches hospitals rising up vertically on the main mass and polyclinics attached to the main core.The Physical Therapy and Rehabilitation Hospital is located in the south of the project site independently from the main mass, the High Security Psychiatric hospital is located in the northern part of the main hospital. The Technical Services building is positioned in the western part of the Main Hospital facing the main road. In the master plan, a future extension area is left to the east part of the Physical Therapy and Rehabilitation Hospital (see Figure 1.28).

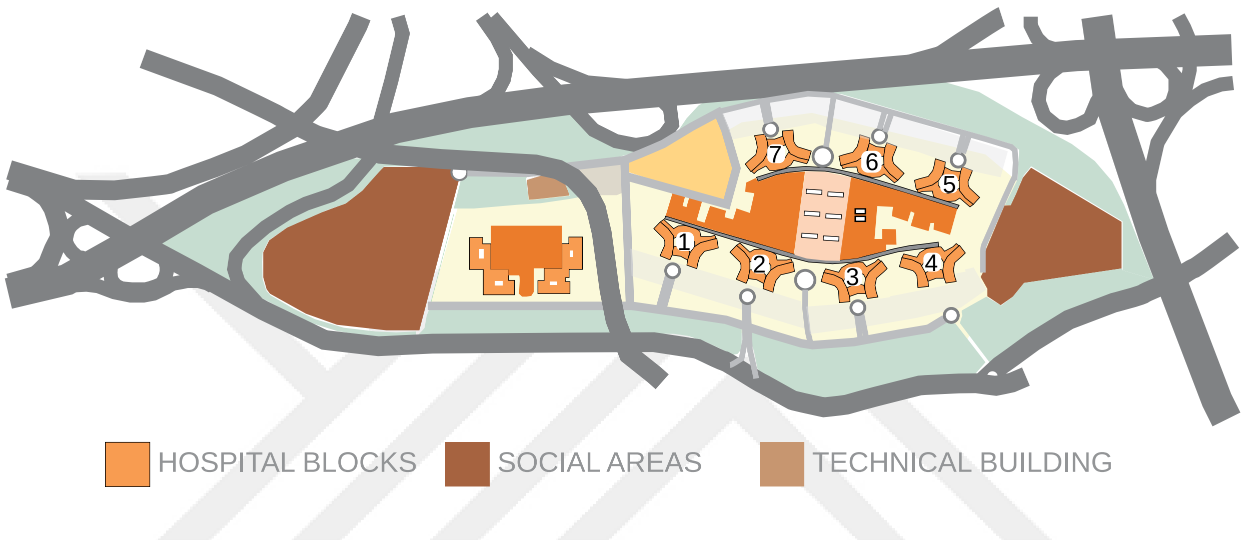


Figure 1.27: Istanbul Ikitelli Integrated Health Campus Master Plan Settlement (Equalized Project) (Source: Sönmez (2014), edited by author)

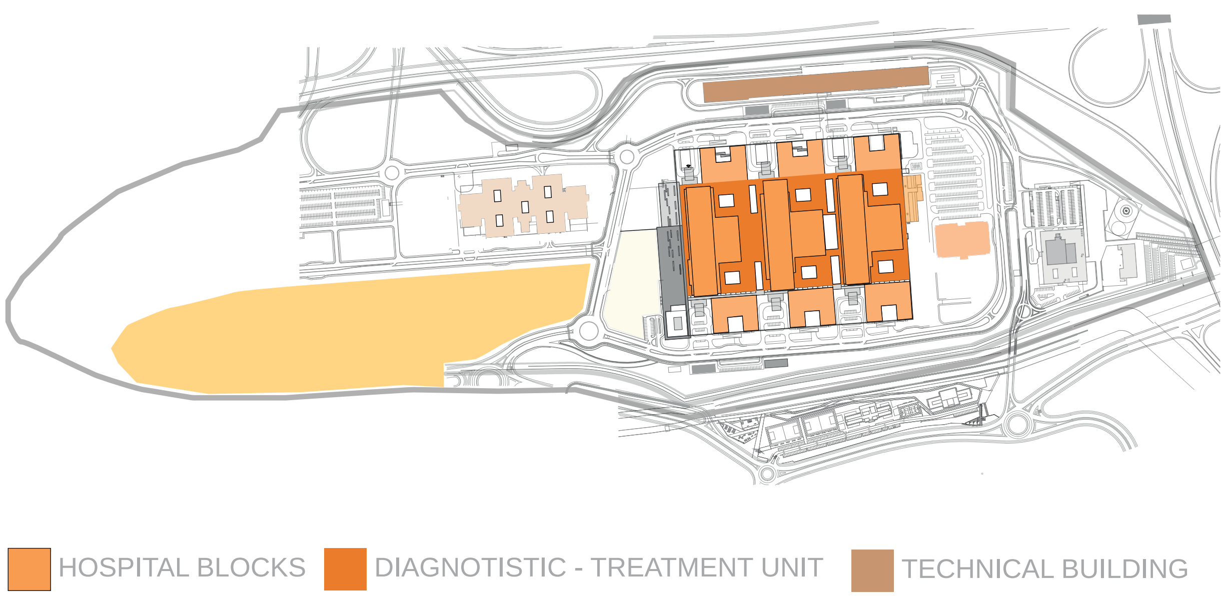


Figure 1.28: Istanbul Basaksehir Cam and Sakura City Hospital Master Plan Settlement (Construction Project) (Source: https://www.hayalgucu.com/project/detail/ikitelli-2700-yatakli-entegre-saglik-kampusu-208, edited by author)

Considering the green area distribution and project data in the equalized project, 500 000 m² green area is suggested. In addition to the outdoor landscape, green roofs applied in health facilities are also included in this area (Sönmez, 2014) (see Figure 1.29).

By the reason the layout settlement plan of the construction project is completely different, the green area distribution is also different. There is approximately 650 000 m² green area with green roof applications and landscape. Since the main core is enormous in terms of area, courtyards were created to benefit from the sunlight. Thus, while aiming for maximum efficiency from the sunlight, direct access to the outdoor area is provided from different locations of the main hospital (see Figure 1.30).

Figure 1.29: Istanbul Ikitelli Integrated Health Campus Green Areas (Equalized Project)
(Source: Sönmez (2014), edited by author)

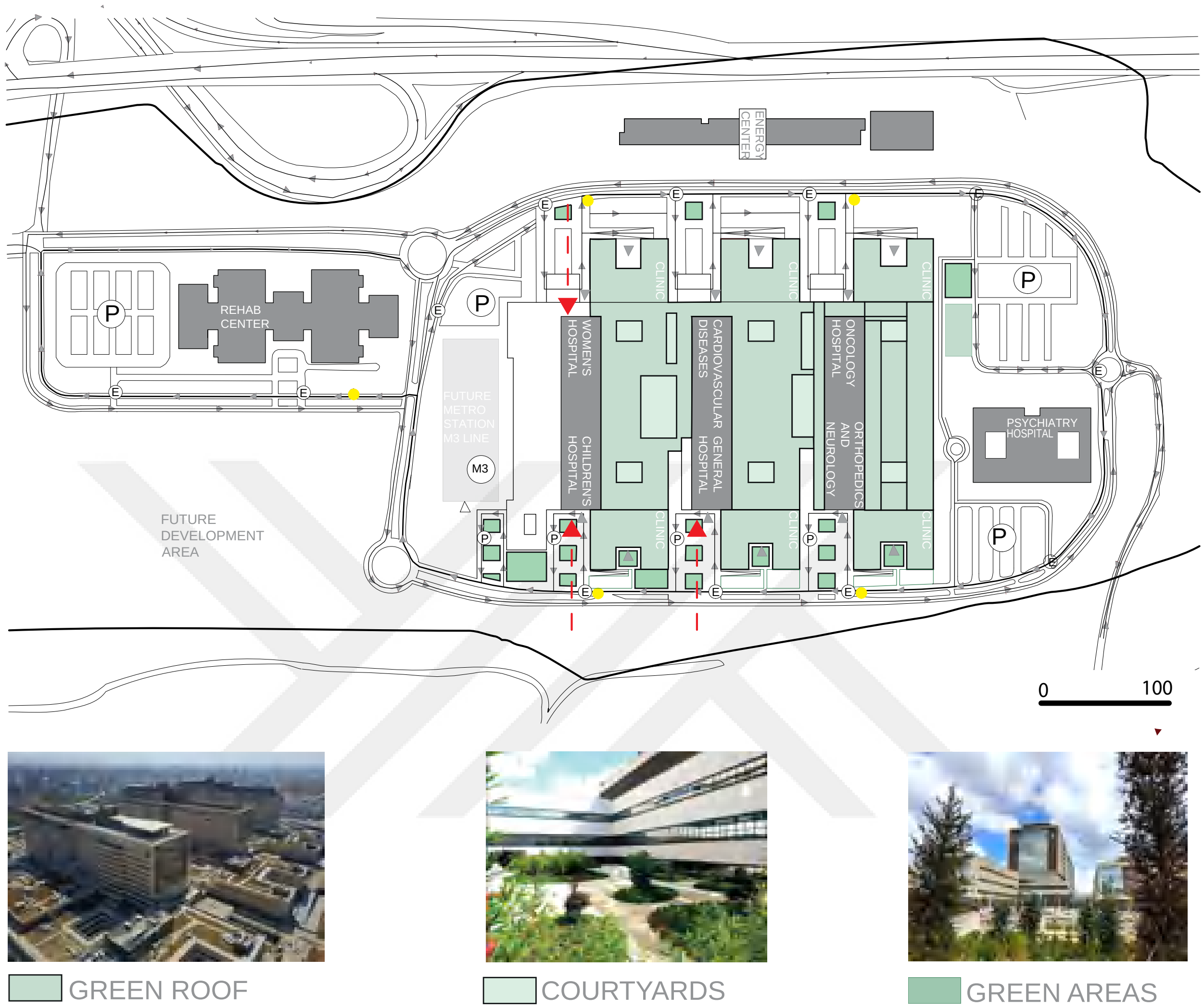


Figure 1.30: Istanbul Basaksehir Cam and Sakura City Hospital Green Areas (Construction Project)
(Source: https://www.hayalgucu.com/project/detail/ikitelli-2700-yatakli-entegre-saglik-kampusu-208, edited by author)

Separation of Circulation

The equalized project provides access to the main hospital from 11 different points. The entrances provided from the front of each bed tower are the main entrances of the branch hospitals. Patients coming to the polyclinic also use these entries. Entrances from 3 different points have been designed for the emergency service. The entrance on the west side is the Gynecology and Children emergency entrance, the entry on the east is the general patient emergency entrance, and the enty on the south is the ambulance entrance. Material entry is provided from the north of the Main Hospital. The northern part of the project site has been deemed suitable for the future metro station. A heliport on the roof of the diagnostic treatment mass directly associated with the operating rooms and emergency rooms by a lift.

The open car parking areas planned in front of each branch hospital facilitate access to the outpatient layer. In addition, the closed parking lots planned in the basement floors are directly related to the bed towers and the diagnostic treatment mass (Sönmez,2014) (see Figure 1.31).

In the construction project, general patient entrance, material entrance, emergency room entrance have been designed separately. 4 separate emergency services serve for adults, children, trauma and gynecology.3 heliport areas are located on the roofs of the branch hospital towers. Contrary to the equalized project, the future metro station is built in the south of the main hospital. In addition, the open car parking areas planned in front of each branch hospital as well as the equalized project phase, facilitates access to the outpatient treatment layer, and the closed car parkings planned in the basement are directly related to the bed towers and the diagnostic treatment mass. Not only staff and visitor parking areas are separated from each other and direct access to staff offices are allowed to the staff from specialised parking areas but also to avoid losing of time for emergency patients, emergency paths are separated from visitor and staff paths (see Figure 1.32). Besides, emergency access and staff accessibility, patient and visitor circulations are separated inside of the hospital vertically and horizontally as much as possible. Thus, the density that occurs in health care facilities that operate 24/7 are prevented.

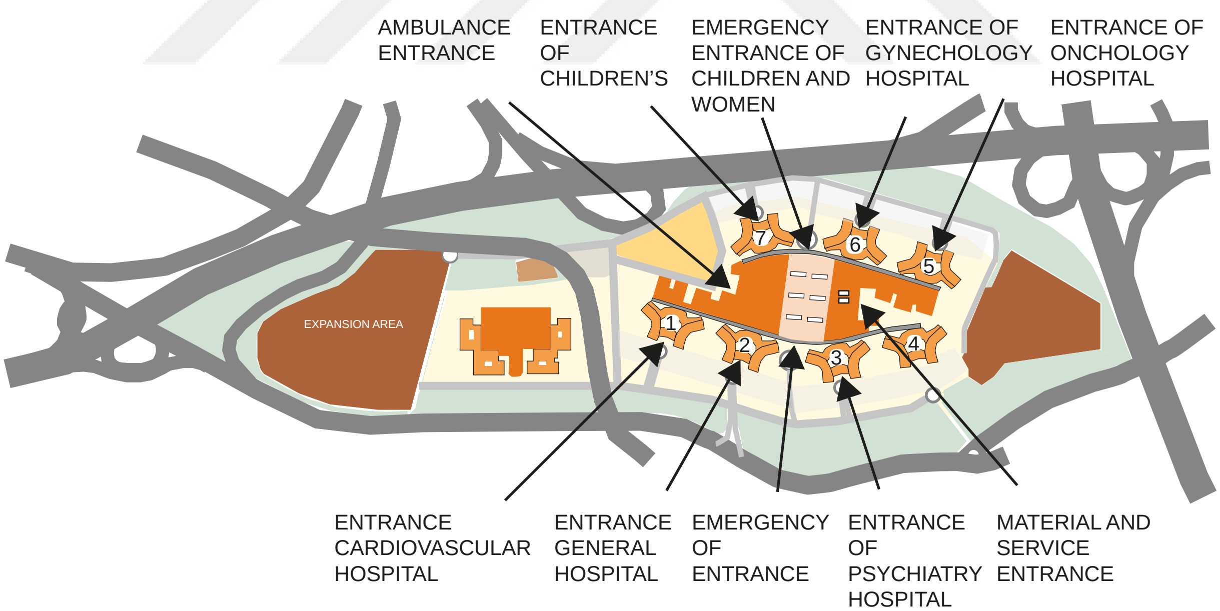


Figure 1.31:Istanbul Ikitelli Integrated Health Campus Main Hospital Entrances (Equalized Project)
(Source: Sönmez (2014), edited by author)

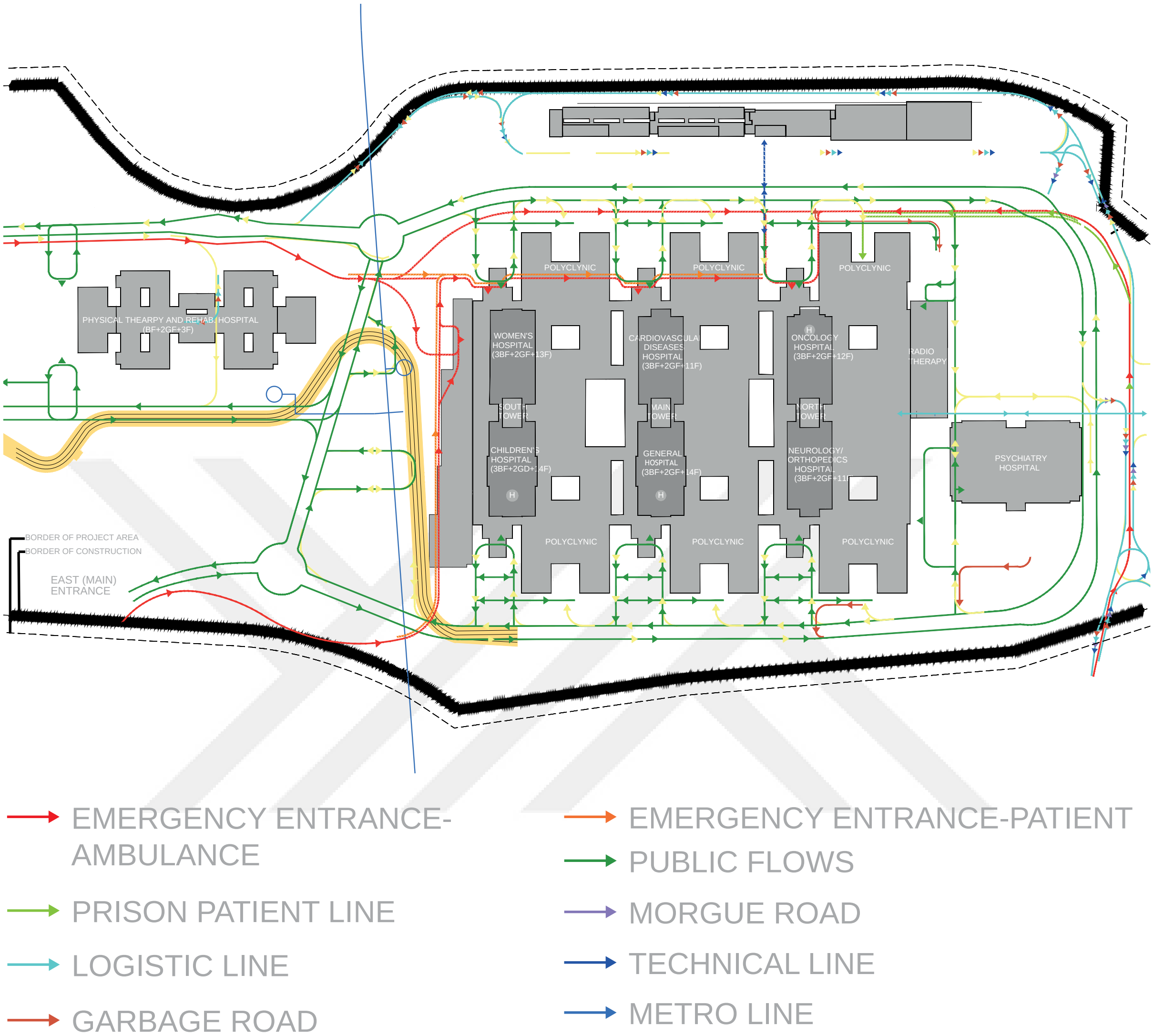


Figure 1.32: Istanbul Basaksehir Cam and Sakura City Hospital Entrances (Construction Project) (Source:https://www.hayalgucu.com/project/detail/ikitelli-2700-yatakli-entegre-saglik-kampusu-208, edited by author)

Space Organisation

Istanbul Ikitelli Integrated Health Campus is in a similar logic to the typical layout of the Health Campuses with the Diagnosis Treatment mass in the center and the organization of branch hospitals around the project in the equalized project. The distance between the two furthest ends of the diagnostic treatment mass is 636 meters, and the distance between the two furthest bed towers is 704 meters. The length of the main circulation corridor on the west side is 475 meters and on the east side is 590 meters.Because of its large size, the operating room, imaging and treatment areas in the Treatment and Diagnosis mass are divided and designed separately near each branch hospital tower (Sönmez, 2014) (see Figure 1.33). Sönmez (2014) asserts that the integrity of the Diagnostic Treatment is broken due to the excessive size in the Ikitelli Integrated Health Campus. Sönmez (2014) claims that since the Ikitelli Integrated Healthcare Campus is planned on a highly sloping land, the horizontal planning in the pre-project design is disrupted due to the slope of the area besides in the Ikitelli Integrated Healthcare Campus project, the horizontal relationship between the operating room and intensive care units has been achieved by taking the intensive care units in the branch hospitals on the east side of the land to the upper floors, however the horizontal relationship between the polyclinics and the diagnostic treatment mass could not be constructed.

In Basaksehir Cam and Sakura City Hospital, that is, in the construction project, a different type of master plan is designed, the distance between the two farthest ends of the Diagnostic Treatment mass is 417 meters, and the distance between the two furthest bed towers is 460 meters. The length of the main circulation corridor on the west and east sides is the same and is 378 meters (see Figure 1.34).

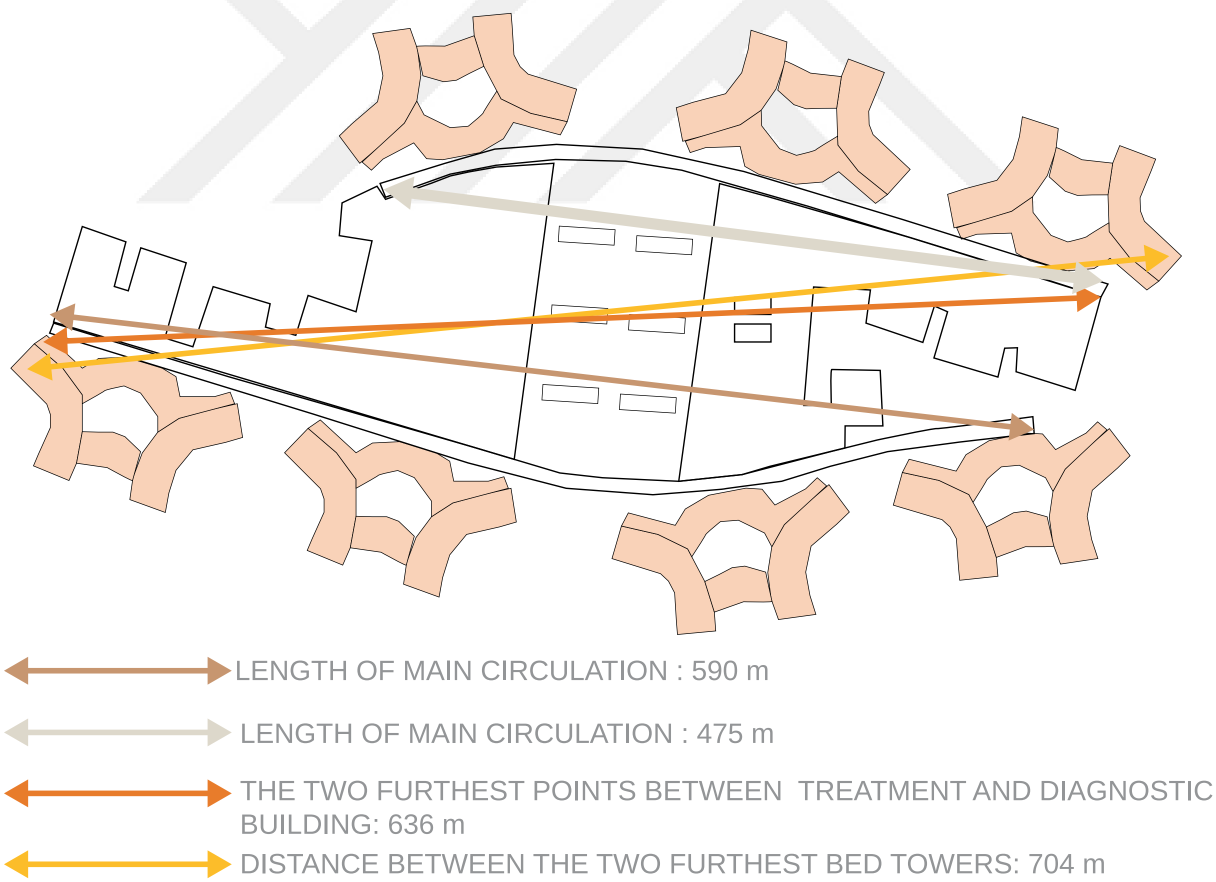


Figure 1.33: Istanbul Ikitelli Integrated Health Campus Main Hospital Mass Dimensions (Equalized Project)
(Source: Sönmez (2014), edited by author)

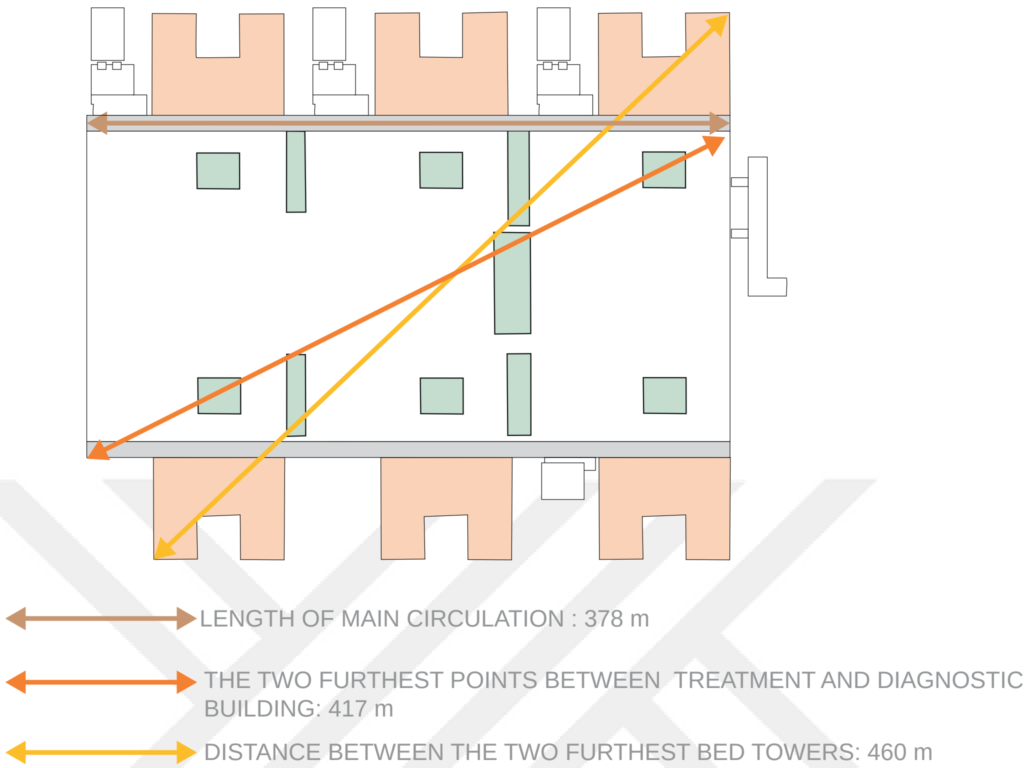


Figure 1.34: Istanbul Basaksehir Cam and Sakura City Hospital Mass Dimensions (Construction Project) (Source: www.hayalgucu.com/project/detail/ikitelli-2700-yatakli-entegre-saglik-kampusu-208, edited by author)

Discussion

Major changes have been experienced the reason of the PPP investment model in both the total gross floor area, the total bed capacity and the master plan layout during the period from the pre-project provided by the Ministry of Health to the final construction project.The total number of branch hospitals to be built has been constant from the very beginning and has not changed, but the plot size on which the project will be built has been slightly expanded in the final construction project phase.The project has been designed in a way that branch hospitals will be built around the diagnosis and treatment mass, but due to the slope of the land between east and west, problems have occurred in the planning of the project in the horizontal direction. Therefore, in the final construction project, the branch hospitals rise vertically on the diagnostic treatment mass in the center, hence a master plan design has been made that is diametrically opposite from the first stage. Because of the PPP investment model, the locations of the planned metro station in the pre-project phase and the construction project appear to be exactly opposite to each other, as well as different locations in the areas considered for future expansion. In both projects, special emphasis on separation of circulation of different users are placed , and have separated the circulation of patients, staff, materials and emergency services as much as possible from each other in order to avoid confusion and density.

1.3 The Challenge of Flexibility and Resilience

Flexibility Models in Healthcare Facilities

The concept of the hospital architecture flexibility includes a broad viewpoint. Tailored treatments are perceived by patients in terms of flexibility, while nursing personnel perceive flexibility mainly in organizational terms. Flexibility is seen by facility executives and managers based on patient treatment planning, workforce management and budget distribution. Functional spaces, their relation to other areas, structural grids, light & air conditioning, patient convenience represent flexibility regarding designers and engineers. In terms of architectural view, hospital project flexibility is not only seen in terms of project preparation, construction and implementation, but also in the capacity of facilities to respond to future needs without any physical alteration. Based on the amount of beds and facilities, flexibility in hospital construction must take into account the potential expansion effectively with a minimum period without any reconstruction. In healthcare facility design, flexibility begins well before the hospital's physical preparation. Health facilities services needed for a given number of patients are measured over a specific timeframe. The precise criteria are determined on the basis of the incidence rates, the average duration of treatment period and other factors, and the healthcare system is designed accordingly**.** The other type of flexibility is operational flexibility. Operational flexibility is versatility in the short run which can be used on a regular or weekly basis. Operational flexibility is inexpensive, swift and reversible. An instance of organizational flexibility is flexible furniture that can be designed in different contexts. Consultation spaces that are mostly occupied for a shortened period in a day can be converted easily into another atmosphere for the remainder of the day, i.e. temporary office space, conference rooms, panel discussion rooms, etc. Likewise, patient units that can handle various types of patients with evolving demand trends are the examples of operational flexibility (Babbu, 2016).

According to Babbu (2016), strategic flexibility is a long-term flexibility alternative mostly connected with a major improvement in the resources of a hospital project's life span. Due to the improved cash flow at later dates, strategic flexibility offers an alternative for the gradual extension of the facility programme. horizontal or vertical extension of hospital facilities can be covered by strategic flexibility. Medical facilities are built in such a manner in the face of strategic flexibility. This method, when the adjacent field is appropriate, it will extend horizontally. Likewise, healthcare building structures are developed to accommodate extra upper stories loads. If need is limited, the facility should have some flexibility so that a portion of the facility can be subjected to alternative use, along with analysis or some other acceptable reason. A healthcare facility can be designed flexible by involving different parts of flexibility; Adaptability, Convertibility and Expandability.

Adaptability

“Adaptability or Flexibility to adapt” is the capacity of the medical system to adjust to evolving medical demands without any environmental adjustment. It is short-term flexibility and an accurate solution for treatment to be provided efficiently. The facility can be built considering that, over its lifespan, multiple rooms have the potential to respond to altering medical demands. The explanation for the move could be to offer improved emergency attention that is very critical for patient visibility from the nursing station (Babbu, 2016, p.25).

Convertibility

“Convertibility or Flexibility to convert” means the capacity of the healthcare system to transform to a reasonable spending plan as a result of changing medical demands with a moderate adjustment to the current system. If there is a shift of materials, the idea of convertibility of space emerges; the shift of materials may be due to innovative development. In order to upgrade the current tools with the modern equipment, the new equipment may need additional square footage, unique types of materials and finishes, load patterns, special types of indoor conditions, for which current areas may have to be changed to the advanced materials. The physical room and interior atmosphere necessary for the new equipment is hard to foresee and medical facilities should also be designed incorporating this factor in order to transform the areas according to the hospital’s evolving requirements. Wherever practicable, the patient rooms should be divided with removable partitions to allow the areas easy to transform. Partitions can also be structured in such a manner that the requisite facilities can be comfortably accommodated (Babbu, 2016, p.25-26).

Expandability

The capacity of the medical facilities to extend horizontally or vertically according to altering medical requirements is “Expandability or Flexibility to expand”.Expandability is long time flexibility; significant reconstruction work is needed to be performed. The health service will extend horizontally and also vertically if the facility has been built in stages. Health advisors should still take into consideration that need will rise in the future; the current system must adapt to transforming need and be able to evolve horizontally or vertically. If demand rises, healthcare building structures must be built to hold extra levels in a manner. Structural components, such as bases, pillars, beams, etc., are built appropriately. In certain instances, at later dates, additional land is available, and can be used to extend the facility. The architect can still leave the choice open and plan the new facility in such a manner that a newly accessible area can be extended. Since it is very hard to anticipate the suitability of nearby land, the architect must therefore take this factor into account on a case-by-case basis. The merest an architect can do is not design the horizontal circulation dead end, it must be open end so that these open ended horizontal circulations can attach to new facilities as is required. Not only for extension aim, these open ended corridors are significant, but they also provide better for light and airflow intention. Construction equipment such as mechanical, electrical and plumbing systems are designed carefully, taking into account the potential expansion of facilities (Babbu, 2016, p.26).

Levels of flexibility

When contemplating a dynamic acute healthcare facility, four degrees of flexibility can be classified, ranging from a local level to an individual bed. Starting at the broadest level and working down to particular styles and techniques of flexibility that impact the entire healthcare institution and its associated outdoor areas, then down to specific structures, units, and rooms

Hospital Complex: the integration of both the facilities and exterior spaces that characterize the healthcare facility as a whole.

Building: a recognizable individual building within a larger system; in the case of healthcare institutions made up of single-block buildings, this level would share certain characteristics with the healthcare facility.

Functional Unit: a grouping of rooms with similar functions, such as wards, a surgical area, or a heating system plant.

Individual Room: an enclosed and delimited space within a functioning entity that can be identified separately, such as a room in a ward, a doctor's consultation room, etc. (Capolongo, 2012).

Space Flexibility and Standardization

Space characteristics are meant to a time which include space flexibility and space standardisation and the effect of hospital room flexibility and standardisation on medical treatment through the perspectives of construction practitioners are examined.It also discussed the integrated application of space flexibility and space standardisation with focus on the architecture of the physical environment in their paper explained that hospital facility architecture and allocation is critical due to the increasingly evolving world because of an increasing and ageing society (shifting demography); technology and advances in healthcare devices and care (developing technology); adaptive treatment modalities; and new patient care networks. Inappropriate areas for patient use can result in injury (Ahmad, Price & Demian, 2014).

What is a Flexible/Standardised Space?

What is a flexible space or space flexibility? This essentially is an area that is able to adjust over time, in order to switch in purpose or criteria for particular uses. These involve adjusting to potential developments and expectations of infrastructure customers. Pati, Harvey & Cason (2008) identified nine main concerns to address when planning a flexible medical facility. These are: to classify future hospital flexible spaces; improve patients awareness (distinguishability); organize personnel through groups to effectively handle medical ambiguities; to enhance the proximity of patient to health services at all periods; classification and connectivity of organizational departments; ability of units/departments to share functions; and to integrate flexibility and expandability support systems. Flexibility is also accomplished through: the principle of modularity; partial or fully interstitial areas; and the classification and segregation of functions.

Standardisation is related to specification, description, performance and fewer mistakes due to reproducibility. Standardisation includes along with sequence, selectivity, accuracy and precision assistance in creating comprehension of strategies and ethics with mutual concentrate. Relying on such definitions, it can be extended internationally to accomplish a simplified uniform process or product in different sectors. Reiling et al. (2004) observed that process standardization decreases memory dependency and encourages individuals unfamiliar with a particular method or product to use it in a comfortable and productive way that increases efficiency and productivity. Standardisation tends to make a specific method more efficient, quick, attractive, desirable, suitable and realistic.

Within a standardized room: height; shape; configuration; size and position of windows; position of doors; position of openings; position of bathrooms; and the number of recovery spaces needed by workers to use their medical instruments and provide hospital services are all defined over time. Standardized room designed by Arup, set with space around the bed for patient mobility and guest accommodation. The Building Design Partnership (BDP, 2004 as cited in Ahmad et. al., 2014) reported that most medical facilities in France are designed with typical prefabricated elements and structures to simplify the construction process.

The Impact of Space Flexibility and Space Standardisation on Healthcare Staff and Patients

Efficiency of personnel and patient security are two of the main factors for balancing space flexibility and space standardization (Ahmad et al., 2014). Pati et al. (2008) suggested that flexibility in infrastructure serves to protect the future of infrastructure by encouraging workers to operate in a fluid atmosphere that adjusts to future developments. The National Patient Safety Agency (2010:16) has reported that standardization “decreases costs, decreases cognitive effort, decreases the risk and facilitates to identify deviations from normal work.” Standardisation further promotes the sharing of expertise between multiple companies, thereby enhancing the efficiency of workers. Table 1.11 presents the space configuration driver effect and classification.

“Space Attributes”	Focus	Impact
Space Flexibility	Physical space	Growth
		Uncertainties
Space Standardization	Physical space Procedural process	Staff performance
		Patient care

Table 1.11: Focus of Both Space Flexibility and Space Standardisation (Space Attributes)
(Source: Impact of Space Flexibility and Standardisation on Healthcare Delivery (2011), edited by author)

The Challenge of Resilience During Covid-19

The coronavirus pandemic (COVID-19) has put immense strain on the global healthcare infrastructure, exposing the system’s interconnectedness and fragility. The immense burden of sickness and death that has put the functions of healthcare facilities around the world, as well as physically, psychologically, and financially, in jeopardy.

COVID-19 has reiterated the fact that healthcare is a system, and that each of its elements, no matter how small their function, can only ever be as durable as the system itself. Flexibility and agility are vital components of resilience, but they are often value-engineered out of structures built for optimum performance and lowest cost. If the model is to be more positioned in the future, it is a must to rethink our definitions of “value” and the effects of having too little space for manoeuvre.

Supporting areas

Sarah Wallwork, principal consultant in WSP’s UK healthcare advisory committee states that, “Hospitals are often the focus, but there are many other supporting areas of healthcare. Care homes hold considerably more places than hospitals, so if they were better protected, this could stop or slow down hospital admissions and deaths related to COVID or a future pandemic. We need resilience in all of these supporting areas – primary care, mental health, social care, community services – to give us resilience across the whole system.” While the National Health Service has recently started to incorporate “integrated care services” to pull together the many service agencies in a particular city, social care is run independently from healthcare, which is the responsibility of local governments. According to her, entering the scheme will boost resilience in a number of areas. For instance, companies in the care field would have provided greater access to personal protective equipment (PPE) by their healthcare partners: Acute hospitals have identified supply chains or may have been able to tap into a central procurement network, but nursing homes, hospices, and carers who visit patients in their homes could do nothing about it and failed to obtain any. According to a survey of WSP’s global customer base, this approach was largely common between many public and private healthcare networks, such as the NHS (WSP, 2020).

Building system maintenance

Another essential subject that now everybody needs to speak about is building system repair, which is an environment where prior economies might have hampered resilience. _"When COVID hit, hospitals that hadn't been performing preventative maintenance suddenly started looking at their filters or HVAC systems and realised they weren't good enough. The focus is now back on things that have been neglected for many years." WSP's Canadian healthcare team's mechanical director, Tomer Zarhi, states. Cleaning air ducts every ten years is a code requirement (WSP, 2020).

Digital Delivery

Providing treatment under the limits of social exclusion and using data to enhance service quality

- Urgent transitions to digital-first treatment in all treatment environments, including online appointments, surveillance, and automation in lieu of face-to-face communication
- Adoption of off-the-shelf technologies built on generic resources that are quickly 'bolted-on' to current services, posing usability and sustainability concerns
- Creating automated Command Centers that use real-time data to increase service quality and patient mobility through networks in order to better leverage resources
- Expanded programs, prescribing waivers, and other regulatory exemptions to enable the uptake of internet services and tracking
- In all fields, such as infrastructure, materials, and requirement, there is a need for data and analytics modeling
- At the organizational and system levels, there is an unmet need to synthesize various data sources and templates to provide implementable, functional perspectives (KPMG International, 2020)

Agile workforce

KPMG International, (2020) adapts to new ways of operating in response to framework requirements and employee expectations

- Owing to the deterioration of existing health worker shortages around the world, the emphasis has turned to roles and competencies instead of job names
- Cross-working and reconfiguration among offices and facilities are being guided by existing position flexibility, resulting in vastly improved teamwork
- Professional registration criteria and limits, such as staffing levels and breadth of employment, are being relaxed

- Enhanced coordination between civic volunteers and third-party resources supply versatile assistance while reducing the pressure on current personnel
- Growing questions about the consequences on physical and mental health, as well as a broader understanding of existing gaps in the healthcare workforce
- Human resource tasks, such as training and onboarding, are being streamlined rapidly
- Non-frontline employees are being moved to flexible and remote employment at a fast and wide scale

Regarding to KPMG International, (2020), despite the immense obstacles that health systems and practitioners face in reacting to the crisis, there are many global best-practice workforce frameworks from which to learn:

Rostering	In **China**, staff were divided into different teams, limited to a maximum of 4 hours of working in an isolation ward and rotated through isolation wards at different times. Teams were assessed and disinfected as a group to reduce the frequency of staff moving in and out of isolation wards. Before going off duty, staff had strict hygene protocols to prevent possible infection.
Staff ratios	In **UK**, staffing ratios have been relaxed in order to ensure the appropriate available nurses and specialists to cover the surge in patients and anticipated staff absence rates of up to 20 percent. Ratios of one nurse per patient in intensive care have been relaxed in favour of a teambased approach. This sees one specialist nurse for every six patients, supported by two nonspecialist nurses and two healthcare assistants.
Reserve workforce	**Iceland's** Ministry of Health released a call for reserve workforce volunteers to individuals in 13 different health professions (not currently working frontline and medical students) as a reserve workforce. To-date 1,000 professionals have signed up -a large number for Iceland's population- and a number of them have already been called for duty, mainly to assist in cases of outbreaks in smaller communities around the country.
Improved support	To support its more than 75,000 members, the **Canadian Medical Association** released resource for maintaining physician wellness during the pandemic and recently launched a Wellness Support Line.

Figure 1.35: Global Best-practice Workforce

(Source: KPGM International (2020), edited by author)

Operational resilience: Capacity management and supply chain

When organizations look back on their issues after the COVID-19 pandemic, one of the clear consequences would be an awareness of the full complexity of the supply chain, including possible vulnerabilities and vital threats for a wide variety of scenarios. Keeping patients and caregivers safe by organising existing resources and critical materials (KPMG International, 2020):

- Critical deficiencies and a lack of logistical maintenance of essential materials, such as safety devices, medications, and equipments, have made handling and caring COVID-19 patients much more difficult
- In a time of market-wide deficits, the collapse in global production as factories stall or close has exposed an over-reliance on domestically varied 'just-in-time' supply chains in healthcare
- To various degrees, teamwork, redistribution, and repurposing have aided in addressing these barriers
- Local logistics have proven difficult to guarantee that front-line healthcare personnel receive fresh supplies on a periodic manner
- There is an unfulfilled demand for dynamic modeling to forecast needs by position over time

Hubei province, which was affected first by the outbreak, is one of China's most important manufacturing hubs. International coordination collapsed when governments realized the size of PPE that would be expected. Exporters halted imports, leaving retailers in a futile search for caps, gowns, gloves, and goggles, vying with foreign competitors as well as domestic suppliers. The World Health Organisation (WHO) called for a 40% rise in PPE production in March, advising that supply chain instability – "caused by increasing need, panic purchasing, hoarding, and misuse" – was endangering the lives of frontline medical staff. "The global supply chain just stopped because everyone wanted the same product at the same time, even though they didn't need it at the same time," says Mathias Elmfeldt, a hospital logistics expert with WSP in Sweden. "That created a lack of trust in the system, and that was right – you can't trust an imperfect system (WSP, 2020).

Financial governance

According to KPMG International, (2020) a contemporary and changing economic world, handling short- and long-term cash flow issues is a concern

- Disruption is slowing supplier revenue generation, although fixed expenses such as wages and operations remain steady, placing considerable economic strain on providers
- Cash burn is rising, but daily financial data isn't offering enough insight in a competitive market where performance, cash flow, and access to capital are all under threat at the same time
- Cash flow systems are being updated on a regular basis — even monthly — to account for instability and disturbance
- Financial stress analysis and forecasts was a primary concern, with short-term projections being used to reach out to borrowers and funders seeking forbearance and assistance
- Budgets have been postponed in many nations and regions, and current budgets have been made outdated when policymakers introduce large-scale stimulus packages

Developing new care models

KPMG International, (2020) asserts thatCOVID19 has a strong and indirect effect on health treatment

- Both procedures and therapies are being delayed by infection prevention steps, resulting in a major decrease in capability and patient traffic
- To overcome this, more advanced treatment models are being used, such as online triage and patient paths, such as remote supervision through virtual wards
- Non-traditional care environments, such as hotels, convention centers, and other 'pop-up' services, are becoming more common
- Other illnesses, ranging from cancer to urgent medical conditions, are facing increasing backlogs, with an unprecedented 28 million surgeries being deferred worldwide
- Dividing patients with COVID-19 positive or suspicious cases from those that are unaffected to avoid further dissemination is a daunting challenge
- Routes and resource planning are being centralized to help organize usage, such as emergency care facilities
- Digital command center techniques are increasingly being used to inform decision

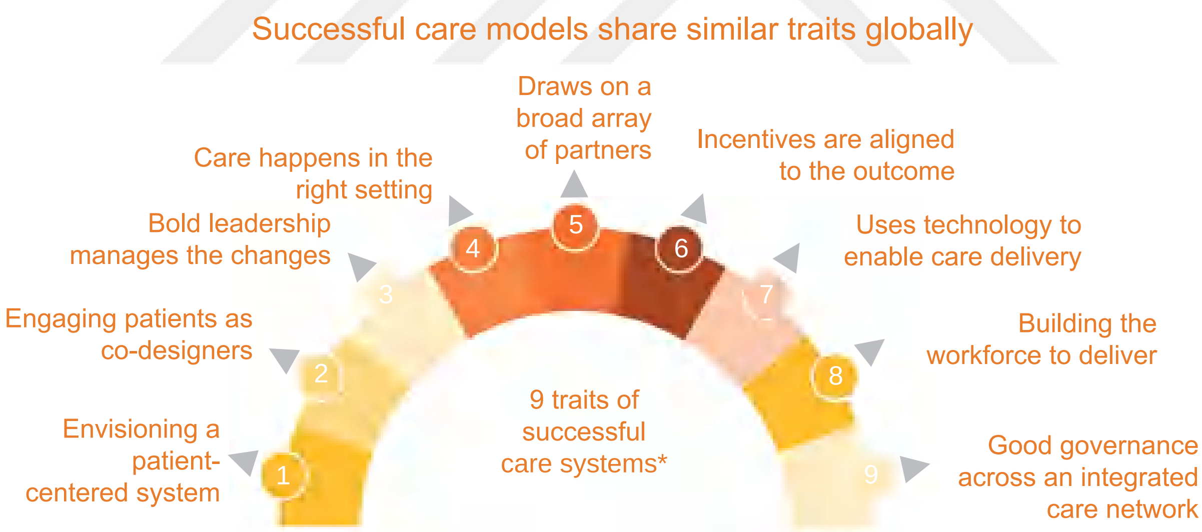


Figure 1.36: Delivering Healthcare Services Closer to Home
(Source: KPMG International (2020), edited by author)

KPMG COVID-19 resilient recovery matrix for healthca-

The following maturity matrix can help healthcare organisations understand where they are on their journey to adapt and respond to the challenges posed by coronavirus. If you have any questions about the matrix, or your self-assessment, please contact us to discuss further

	AD-hoc	Organised	Managed	Agile
01 Digital delivery	-Temporary workarounds and solutions as issues emerge -No coordinated responsed based on existing strategy	-Individual or group tasked to respond to virtual care and remote work issues -Emerging coordinationwit-hout	-Coordinated response management for business continuity -Management of select remote working and virtual solutions	-Digital issues managed flexibly with a strategic response aligned to established and emerging tools
02 Agile workforce	-No modelling of needs -No clear view of current gaps -No view of the tasks versus skills and competencies of staff -Little attention to wellbeing -Constrained silo working	-Basic modelling of needs -Some coordinated view of current workforce gaps and tasks versus skills and competencies -Emerging focus on wellbeing -Constrained silo work dominates	-Modelling of needs performed -Clear view of current workforce gaps and tasks versus skills and compete-cies -Wellbeing plans in place -Multidisciplinary team working	-Dynamic real-time modelling -Multidisciplinary teams deployed according to tasks and competencies rather than roles and job titles -Strong emphasis on wellbeing
03 Developing new care models	-Reactive problem solving -No clear single view or model of patient flow and resources -No central coordination -Fixed and inflexible pathways	-Individual or group oversight of care pathways providing some central view and coordination -Some modelling of needs -Emerging flexibility in pathways	-Central coordinated view of care pathways and current status -Modelled flow and resources -Managed and flexible pathways	-Dynamic responsive care pathways with a clear overview of patient flow and resources -Multi-stakeholder central coordination and communi-cation -Population risk-based capacity planning across services
04 Resilient operations	-No single point of truth and/or conflicting view of current status -No clear view of current gaps -No modelling of needs -No central coordination	-Individual or group tasked with coordination and oversight -Emerging view of current status/gaps and risks -Some modelling of needs	-Coordinated view of current gaps and risks with central coordination -Established model of needs -Flexible and responsive, with some degree of resilience	-Responsive real-time modelling of needs with centralised analysis of scenarios and risks -Adaptive and resilient by design -Established event monito-ring
05 Financial governance	-Current financial position not clearly established -Loose grip on financial control -No recovery planning initiated	-Current financial position known or path to establish that, with control mechanis-ms in place -Emerging recovery planning	-Financial position known, with control mechanisms in place and scenario planning undertaken -Recovery planning established	-Financial position actively updated and modelled based on most likely updated scenarios -Recovery plan running in parallel

Figure 1.37: COVID-19: Recovery and Resilience in Healthcare: Global Insights, Practical Advice and Tools to Help Healthcare Leaders Build and Sustain a Resilient New Reality
(Source: KPMG International (2020), edited by author)

Existing Tools and Methods of Evaluation

Hospitals were designed decades ago in accordance with laws, patient care typologies, technical possibilities, and societal demands that are vastly different from those of today, with little mention of flexibility or sustainability (Bottero et al., 2015). These fundamental topics are a more vital issue than ever taking into account today's healthcare circumstance and newly emerged issues like COVID-19 pandemic. However, how flexible existing or contemporary healthcare facilities are is a big question. In order to understand and analyze related topics to flexibility with quantitative data, there is a need for a scientific method or evaluation tool. Therefore a literature review for existing flexibility evaluation tools was conducted regarding discussion topics mentioned previously. 3 of the most appealing tools were chosen to be analyzed.

OFAT: Optimized Flexibility Assessment Tool

This Assessment Tool was created with the aim of determining the degree to which the basic concepts of the Flexibility model have been met. It was created to assess flexibility of healthcare facilities at the design and planning phases by Elshazly & Ghazy (2020), and it serves as a kind of monitoring mechanism for designers to improve their ideas. Often, it can be used on internal structures to determine how well they meet the requirements, principles of flexibility, and, as a result, what needs to be changed as necessary.

The newly optimized method tests flexibility, and is a wider concept that incorporates the Open Building approach, after refining and developing the initial evaluation method which is "Assessment Tool for Open Building Flexibility" by Zanchi E. (2015) as cited in Elshazly & Ghazy (2020). The Evaluation Tool consists of 9 measurement criteria, each of which is subdivided into separate research criteria, each of which is given a score ranging from 0 to 10. As a result, assessing the building's versatility. A description of all measurement and interpretation criteria is included with the evaluation method.

The assessment parameters are defined as following:

- Shape
- Structure
- Facade
- Building Plant
- Expandability
- Restrictions
- Technology
- Exchangeability of Large Equipment
- Functionality

After implementing the evaluation tool there is a certain range for the final result. Those five ranges are as follows:

- 0 to 20%: definitely not a Flexible Building
- 21% to 40%: following some principles, but it cannot be considered a Flexible Building
- 41% to 60%: following several principles of the Flexible Building approach
- 61% to 80%: it can be considered a Flexible Building but with some aspects to be improved
- 81% to 100%: model of Flexible Building

SUSTHEALTH: A Multidisciplinary Sustainability Evaluation System for Operative and In-Design Hospitals

The Sustainable Healthcare project created an original multidisciplinary assessment method that is deliberately intended to measure and promote a hospital's global sustainability by taking into account natural, social, and financial concerns in order to include a holistic assessment of the hospital based on an acceptable definition of sustainability. The scheme, which was designed to be clear, easy, and efficient to use, incorporates the key measurement to boost sustainability, and is structured in a hierarchical structure: basic metrics are embedded in a list of guidelines, which reflect the most important factors and the most appropriate starting points for improving the hospital's sustainability. Eventually, they are split into five macro-areas of sustainability: social, economic, and environmental. A grading process was carried out according to the Analytic Network Process method by Saaty in 2005 to take into consideration the multiple interconnections among the various components of the system. This encouraged the development of a weighting method focused on the views of diverse focus groups, which included consultants and practitioners from various healthcare fields, to take into account multiple users' points of view and, most significantly, the human element. The introduction of the appraisal method to a hospital allows for the determination of the structure's general viability (Bottero et al., 2015).

The problem of promoting sustainability in hospitals and creating a new model to be used as reference for new realizations was also analysed by prof. U. Veronesi (Capolongo 2001 as cited in Bottero et al., 2015), with a committee led by architect R. Piano, who outlined ten concepts that could guide the hospital of the future, focusing mostly on the social and partly on the environmental realms, while ignoring the economic domain. Patients' convenience, the building's proper location within the urban environment, the interaction between medical personnel and patients, the perception of unity and cohesion within the facility, and a strong and productive organisation (in terms of successful diagnosis, treatment, and rehabilitation) are all highlighted. Furthermore, the suitability of the technologies (plants and medical equipment), the versatility of the system building-plant for potential upgrades, and the hospital's position as a research center are all being considered (Bottero et al., 2015).

The financial, environmental, and social aspects of a healthcare structure should all be weighed when assessing its long-term survival. The Sustainable Healthcare Assessment System is applied from the ground up, with these basic and intertwined macro-areas becoming the base of the pyramid (Buffoli et al. 2013). The role and effect of the macro-areas on the sustainability of an operational healthcare facility or an in-design hospital are weighted differently in the assessment framework (Bottero et al., 2015) (see Figure 1.38).

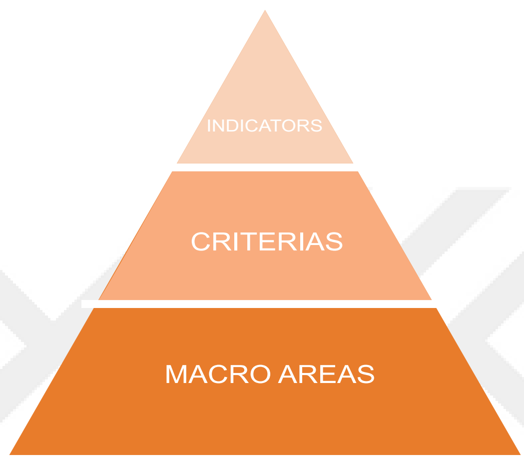


Figure 1.38: Hierarchical organization
(Source: Improving Sustainability During Hospital Design and Operation (2015), edited by author)

For each indicator, a score is given ranging from 0 (worst performance) to 5 (best-in-class) based on questionnaires, interviews, or quantitative assessment. In terms of metrics based on a straightforward assessment of users' happiness and viewpoint (hospital users involve not only patients, but also employees and visitors), the highest value is given if a large proportion of interviewees give affirmative responses, with the received score then declining along with the users' feedback. Rather than earning scores in a cumulative or progressive manner, metrics measured by interviews or objective measurements earn points in a cumulative or progressive manner (Bottero et al., 2015).

Figure 1.39: Global SustHealth System for Operative Hospital According to the Structure of the Macro-areas, Criteria and Indicators
(Source: Improving Sustainability During Hospital Design and Operation (2015), edited by author)

Figure 1.40: Global SustHealth System for In-design Hospital According to the Structure of the Macro-areas Criteria and Indicators

(Source: Improving Sustainability During Hospital Design and Operation (2015), edited by author)

POE: Healthy and Sustainable Hospital Evaluation—A Review of POE Tools for Hospital Assessment in an Evidence-Based Design Framework

Hospitals are high-performance, dynamic structures that need continuous development. Few instruments measure operational or therapeutic qualities, but many do so for the built environment. The aim of this paper is to evaluate and analyze recent methods for assessing the healthcare building environment, as well as to see how they quantify fitness, sustainability, or both by Post-Occupancy Evaluation (POE). In the area of healthcare quality management, a literature review was performed, and 13 POE instruments were used and evaluated using Ulrich's Evidence-Based Design (EBD) method. To evaluate the physical environment's strengths, a number of tools and methodologies have been established. This arose as a result of a growing appreciation of the advantages that a healthy physical atmosphere can bring to users and stakeholders. Post Occupancy Evaluation (POE), identified as the method of consistently comparing actual structure output after construction and occupation, is a very successful and well-structured method. By contrasting construction performances with explicit human requirements, this method of receiving input on a building's success considers the design not just from an architectural standpoint, but also from mental and cognitive considerations. It may be used for a variety of purposes, including ensuring that the outcomes fulfill the desired operational objectives and consumer needs. POE can also be perceived as a technique for making structures more environmentally safe (Brambilla & Capolongo, 2019).

General Information

- Tools' Structure
- Item Sources and Selection
- Economic Purpose
- Territorial Development
- Recurrent Topics

EBD Health-Related Topics

- Safety Enhancement
- Visual Environment
- Staff and Doctors' Space Features
- Patient Room Features
- Wayfinding Features
- Family/Visitors' Space Features
- Audio Environment

Sustainability Topics

- Energy consumption

- Water use
- Material sustainability
- Environmental pollution
- Thermal comfort
- Waste management
- Construction choices
- Energy sources
- Site management
- HVAC efficiency
- Management of environmental policies
- Heat island effect reduction
- Passive environmental strategies
- Sustainability education
- Green rating tools
- Transportation sustainability
- Life Cycle Assessment (LCA)
- Lighting efficiency

Other Topics

- Occupants education & services
- Organizational quality
- Maintenance and Facility Management (FM)
- Urban and social integration
- Food services
- Building survey/commissioning
- Design process
- Building appearance
- Innovation/research
- Satisfaction surveys
- Construction process
- Cultural issues
- Materials data & certification
- Transportations
- Costs and budgeting
- Professionals involvement
- Space ratio
- Bonus points
- Regional priority (Brambilla & Capolongo, 2019).

RESEARCH GAP & METHODOLOGY

EXPLANATION OF THE RESEARCH PROCESS

02

02 RESEARCH GAP & METHODOLOGY

2.1 Research Gap

Problem Statement

After 2017, a new hospital model called “city hospital” in Turkey began to take place as huge and complex healthcare facilities. They built with high amounts of bed capacity and unavoidably huge masses by coming together of different departments at 22 different locations. This hospital model gathers many diagnostic and treatment units in one large complex center.These structures, which are introduced with the private sector’s commitment to the healthcare services, are created with the public-private partnership (PPP) investment model. PPP plays an important role to be studied from the beginning of the design phase to the end of construction phase since it is relatively a new input in healthcare. Besides, since they are huge and new complexes, their adaptability to changes and effectiveness during emergencies is an ambiguity, in order to minimize this effect, they must be well designed in terms of flexibility and resilience. However, this does not necessarily mean that they are truly flexible and resilient. It is essential to examine their responsiveness to the constantly changing conditions, emergencies like pandemic and needs of the health sector. This can be demonstrated by evaluating the adaptability and flexibility criteria of these hospitals.

Hypothesis

The national and international design criterias and standards, which are based on when planning megastructures like city hospitals, are not fully implemented. Even if applied, these criterias are stated by the authorities and written sources that they contain great deficiencies in adaptability to today’s principles of flexibility and changing conditions such as emergency situations.

Aim & Objectives

Aim

The aim of this study is to examine the issue of flexibility and resilience to the changing health sector conjuncture and needs through the contemporary hospital model called “City Hospital’’ built with public-private partnership. It is to create a comprehensive tool and methodology for designers while proposing mega healthcare facilities that can easily respond to different circumstances such as emergencies, disasters and changing technological improvements.

Objectives

The intention of this research strategy is to create an evaluation method for designers and architects to use and test mega healthcare structures already built or during the design and planning phases based on a detailed set of flexibility and resilience standards discussed in current literature, healthcare standards, case studies, and documented interviews. This tool is to be used to assess the degree to which healthcare services adhere to and enforce flexibility standards.

Research Questions for the State of the Art and Empirical Phase

- What is the state of the art in terms of healthcare design flexibility in literature?
- In terms of flexibility, what are the optimal healthcare guidelines?
- Which contemporary examples of hospitals built with PPP model in Europe incorporate a flexibility concept to guarantee long-life span?
- How much do leading healthcare architecture firms in Turkey accept and incorporate flexibility values into their projects?
- How do Turkish companies interpret the PPP investment model in healthcare design?
- What is the most ideal assessment tool to evaluate flexibility in healthcare design?
- What are the most important factors that affect flexibility to be considered when designing and building a mega healthcare facility with PPP model?
- Is the existing flexible assessment method enough to evaluate mega structure healthcare facilities?
- What are the criterias for determining whether or not a mega structure healthcare facility is flexible?
- How healthcare facilities respond and adapt to COVID-19 pandemic?
- What are the main principles of a resilient and flexible hospital design against COVID-19 pandemic?
- Are PPP investment models resilient during COVID-19 pandemic?

2.2 Methodology

To collect current data on the research subject, a systematic and transparent method for determining, analyzing, and describing the existing literature was used. Using qualitative and quantitative analytical methods, the aim is to discuss and indicate flexibility and resilience issues of healthcare through the city hospital model. This report used a six-step process to gather details, providing a theoretical context for the city hospital, COVID-19 and PPP investment model, a literature analysis of flexibility principles, guidelines, emergency issues and investment model. International examples of contemporary healthcare facilities, case studies about city hospitals in Turkey, structured interviews with Turkish architectural firms which took part in the design or construction phase of these projects, critical review & optimization of the assessment tool for flexible mega structures and healthcare resilience (see Figure 2.1).

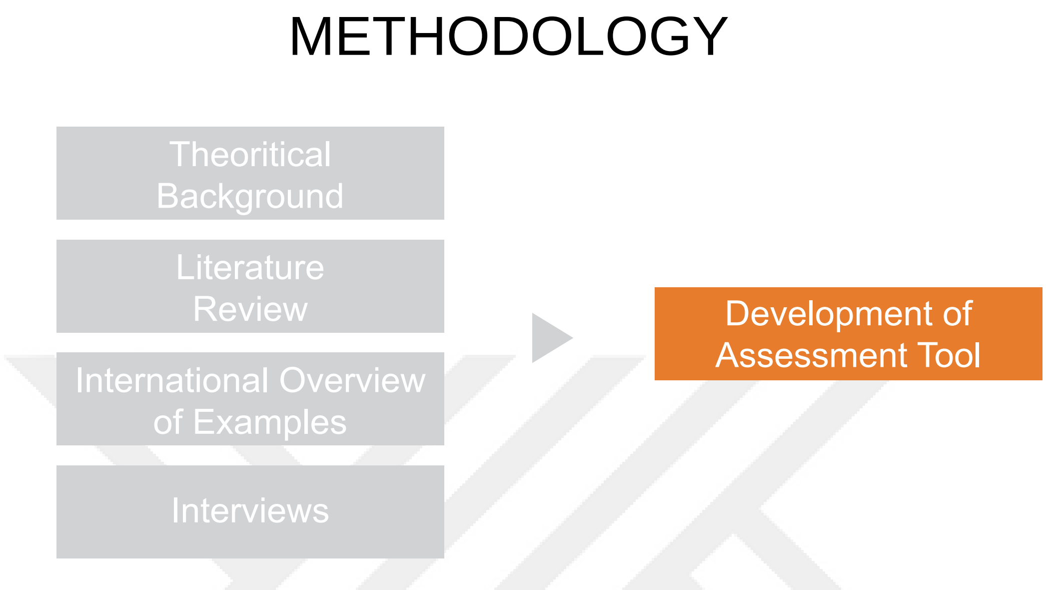


Figure 2.1: Research Methodology
(Source: Author)

Theoretical Background & State of the Art: Investigation from Literature, the Best Practices and Case Studies

To begin, keyword searches were performed to identify potentially applicable studies published in English and Turkish during the theoretical context stage. There were two stages of keyword combinations developed. The main scope of the research was described at the first level using the keywords “HEALTHCARE”, “HEALTHCARE FACILITIES”, “INVESTMENT MODEL” or “HOSPITAL ARCHITECTURE”. The following keywords were used in the second-level research: “CITY HOSPITAL”, “PPP”, “CHALLENGES”, “SUSTAINABILITY”, “STANDARDIZATION”, “FLEXIBILITY”, “RESILIENCE” or “COVID-19” in order to explore and understand the concept of current Turkish healthcare strategy and new trend in hospital model. As for the third level, the keywords used are: “DESIGN”, “METHODS” or “STRATEGIES” or “TOOLS” to have a smaller frame that reflects exclusively on the architectural design and planning of the healthcare structure. Although examined hospitals vary in location, a common ground was created regarding investment model, bed capacities and operation dates. The focus of the study is on city hospitals, there are two main types of city hospitals. One of them is hospitals built with the public-private-partnership(PPP) investment model and the other one is built as state hospitals. The case studies examined in this study contain city hospitals built with the PPP investment model. While there are small-scale hospitals in some of the city hospitals’ campuses, such as psychiatry and recovery hospitals, these hospitals are not listed within the framework of this research. Case studies consist of contemporary examples with operation dates from 2017 to date. Architectural drawings of city hospitals are difficult to access, as confidentiality agreement is signed between the contractor firm and the state, and many of the city hospitals are still under construction. Therefore, city hospitals with accessible architectural drawings were the focus of the study. Since the city hospitals were very new at the time of this research, there was not enough time to accumulate practical data. For this reason, case study methodology is backed up with deep theoretical research. Using research databases such as Google Scholar, Academia, ResearchGate, Jstor as well as YOK Tez, which includes academic papers that are registered to Turkish High Education Board, a comprehensive series of descriptive comparative research using combinations of those keywords were performed. Any research that used the keywords in the title or abstract was included in the search. Additional pertinent findings were derived from the reference lists of the defined papers. 47 of the 151 references compiled were carefully read and processed after copies and unrelated content were removed. 32 references were chosen specific to the research criteria and emphasis on the following topics: city hospitals which is a new model in the healthcare sector, PPP investment method, flexible ideas designing a healthcare facility and how future large-scale hospitals should be designed (see Figure 2.2).

The theoretical background has been divided into two parts in order to provide a complete understanding of the idea of city hospitals and PPP investment model. It has been able to recognize flexibility and adaptability as the most vital issue regarding emerging circumstances for city hospitals in Turkey along with comparison to international situation of healthcare due to the analysis of chosen literature, and that the future hospitals should be designed using strategies that enhance flexibility.

Second, different components of keyword pairs were established in the literature review phase. The first stage was recognized as a major focus of chosen subject using the keywords “FLEXIBILITY IN HEALTHCARE FACILITIES”, “RESILIENT HOSPITAL” or “FLEXIBILITY PRINCIPLES IN HEALTHCARE.” The conducted analysis for the second stage used the keywords: “FLEXIBILITY STANDARDS”, “EFFECT OF FLEXIBILITY”, “HEALTHCARE DESIGN GUIDELINES”, “FEASIBILITY OF PPP DURING COVID-19” or “RESILIENCE AGAINST COVID-19” to depend mainly on ideas and facts on flexibility criteria in order to limit the field of focus. Likewise, accessing research databases mentioned, a detailed series of descriptive comparative study using a mixture of those keywords were performed. Any research that used the keywords in the title or abstract was included in the search. The gathered information was subjected to qualification requirements that included articles and content importance to flexibility in healthcare, with the goal of filtering out of scope results for the relevant keywords. The gathered references were then screened based on two factors: To begin, the research should be properly considered and look at creative ways to incorporate flexibility into healthcare design. Second, each reference’s quality was assessed based on its methodological framework, methods, and whether or not the publication was peer-reviewed.

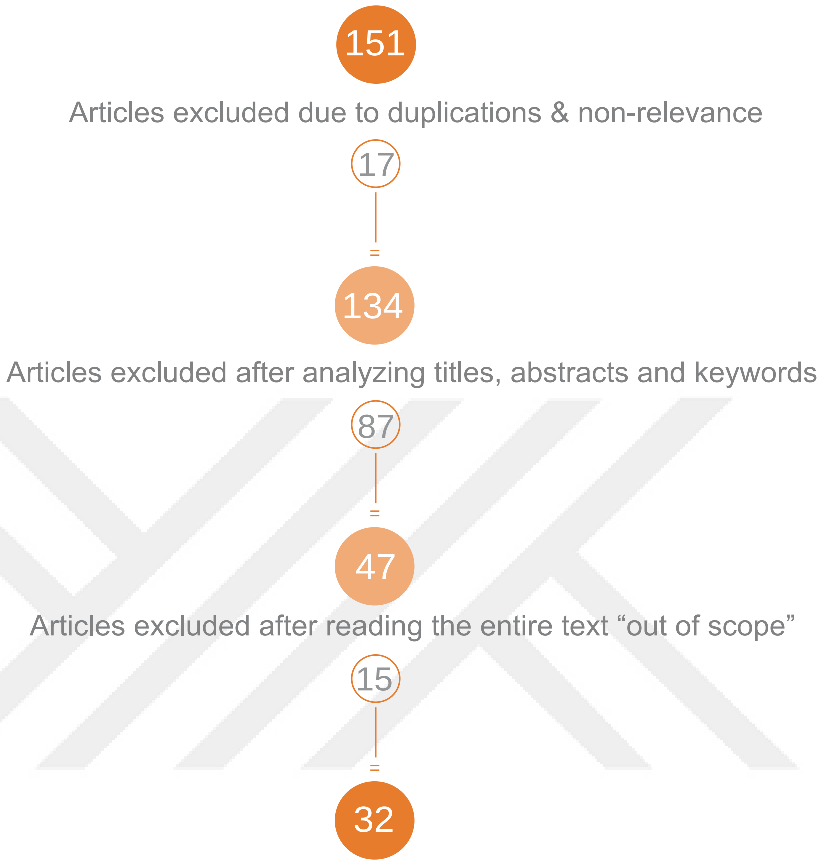


Figure 2.2: Prisma Diagram of Theoretical Background Methodology
(Source: Author)

Among the 238 references extracted, 78 were carefully examined and assessed after copies and irrelevant content were removed. 36 references were chosen specific to the research criteria and emphasis on the following topics: Space versatility in healthcare infrastructure, flexibility strategies, and their effect on hospitals (see Figure 2.3).

The layout of the literature review has been developed to address the following issues in order to produce a comprehensive perspective of flexibility in healthcare and its important elements (definitions of flexibility principles, flexibility concepts, impact of space flexibility, standardization of space, strategies for new hospital design and levels & types of flexibility, healthcare design guidelines and emerging issues). Thanks to the gathered published papers, conventional and groundbreaking flexibility concepts were recognized. Flexibility and resilience have been identified as the most evolving and trending concept in healthcare facilities, and future hospitals should be designed based on techniques that satisfy these issues, according to a review of selected literature. Researching such guidelines was necessary in order to gain a full understanding of the elements of flexibility that had been met, as well as to develop a set of expanded and improved requirements that would result in more efficient healthcare facilities. Relying on a rigorous set of flexibility and resilience criteria discussed in existing literature, healthcare norms, case studies, and recorded interviews, the goal of this research approach is to develop an assessment system for designers and professionals to use and analyze mega healthcare systems that have either been constructed or are in the design and construction phase.

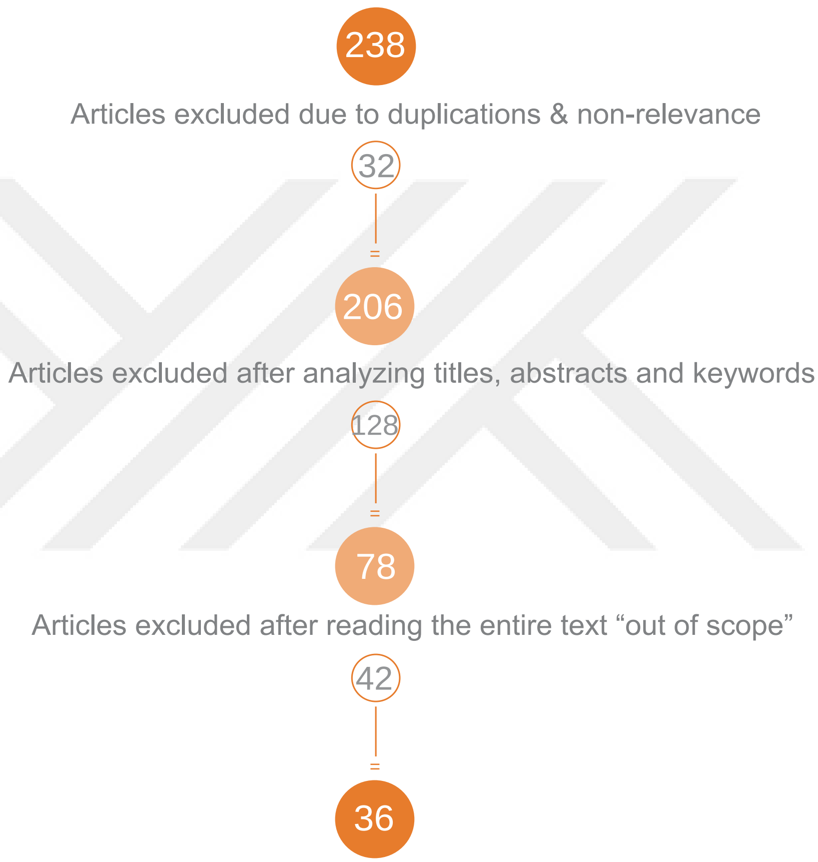


Figure 2.3: Prisma Diagram of Literature Review Methodology
(Source: Author)

Following a summary of the literature on healthcare design flexibility, applicable data was obtained. Data regarding real practices and the particular context in terms of flexibility and the PPP model were to be derived from selected examples of European hospitals during this stage. Relying on a rigorous set of flexibility criteria discussed in existing literature, healthcare norms, case studies, and recorded interviews, the goal of this research approach is to develop an assessment system for designers and professionals to use and analyze mega healthcare systems that have either been constructed or are in the design and construction phase. Investigating those examples was necessary in order to gain a thorough understanding of the facets of flexibility and resilience that

had been met and applied, as well as to develop a set of expanded and improved practices that will result in more optimized future healthcare facilities.
The following keywords were used to build combinations: ‘’PPP in HEALTHCARE’’, ‘’SUPER HOSPITALS’’ and ‘’FLEXIBLE HOSPITALS’’ in order to collect the most applicable flexible criterions and its relations to PPP model**.** Four parameters were used to display the gathered references: First, the selected practises should be by the leading firms in the field of healthcare design. Second, the availability of considerable flexibility strategies and design principles and PPP investment model. Third, bed capacities should be to a certain extent in order to have such examples that have similar conditions as city hospitals. Lastly, all selected hospitals have started operating after 2010. As a result, among 15 examples of contemporary hospitals in Europe, three of them which met stated criterias were chosen to be studied in detail. (New Karolinska University Hospital, Aarhus University Hospital and Southmead Hospital). Break down, comparison & in detail critical reviews of all the three healthcare structure features to be taken into account while designing and constructing an adaptable, convertible and expandable healthcare facility in order to deal with the emerging problems of healthcare design.

It was critical to explore to what degree flexibility concepts are relevant in large-scale hospitals after researching and evaluating the flexibility concept by examining existing literature, relevant values and already constructed practices. The following are the keyword variations that have been identified for the case study selection process:‘’INTEGRATED HEALTH CAMPUS’’, ‘’CITY HOSPITALS’’, ‘’CITY HOSPITALS with PPP’’ in order to identify the most appropriate city hospitals that are classified under mega structure concept. Although examined hospitals vary in location, a common ground was created regarding investment model, bed capacities and operation dates. The focus of the study is on city hospitals, there are two main types of city hospitals. One of them is hospitals built with the public-private-partnership(PPP) investment model and the other one is built as state hospitals. The case studies examined in this study contain city hospitals built with the PPP investment model. While there are small-scale hospitals in some of the city hospitals’ campuses, such as psychiatry and recovery hospitals, these hospitals are not listed within the framework of this research. Case studies consist of contemporary examples with operation dates from 2017 to date. Architectural drawings of city hospitals are difficult to access, as confidentiality agreement is signed between the contractor firm and the state, and many of the city hospitals are still under construction. Therefore, city hospitals with accessible architectural drawings were the focus of the study. Finally, among 18 city hospitals in Turkey, 7 of them with required criterias were selected as case studies and extensively investigated in terms of flexibility and future proofing implementation, architectural and spatial organization, along with general background information related to PPP investment model. Since the city hospitals were very new at the time of this research, there was not enough time to accumulate practical data. For this reason, case study methodology is backed up with deep theoretical research.

After evaluating certain factors of each case study that illustrated the key flexibility methods, an assessment tool from “Elshazly W. & Ghazy A., 2020” which developed based on an assessment tool by “Zanchi E., 2015” was used to analyze each case study in terms of nine evaluation parameters: form, layout, facade, building plant, expandability, constraints, technologies and functionality with a ranking system that awards a score between 0 and 10 points for each parameter. It was possible to analyze the degree of flexibility of each case study by rating them in terms of the Flexible Building definition and extracting new concepts that were not stated previously in the theoretical parts with the help of this method. In addition, conducted interviews were held in conjunction with the investigation of the case studies to learn how the flexibility standards are considered or applied by designers and leading companies in Turkey in the area of healthcare design and development with relatively big scale projects (city hospitals) when designing and constructing.

Validation through Structured Interviews

The aim of the structured interview is to learn how flexibility concepts are considered during the design and planning of healthcare facilities, and then implemented, by communicating a series of designed multiple choice, scaling, and open questions with Turkey’s leading and most successful firms in the healthcare design sector.

This method is used to ensure that each interview receives the same set of questions in the same sequence. This means that responses can be correctly gathered and that outcomes can be compared with others.
This interview shows how flexibility factors are tackled and implemented to different scale healthcare facilities which are designed or built by Turkish firms in Turkey or abroad meanwhile how mega-structured city hospitals built under PPP investment model are interpreted by these companies.

Research and logical evaluation was used to structure the interview questions. Structured interviews will be held with leading healthcare design companies in terms of project size and sales, as well as 11 Turkish firms with background in healthcare facilities design in Turkey or abroad.
The selected healthcare design firms are as following:

- Zoom Architecture
- Has Architects
- Norm Architects
- Vero Concept Architecture
- Geyran Architecture
- Selda Gümüşdoğrayan Architects Office and Company
- CAA Studio
- RSG Interior Design
- Yazgan Design Architecture

- Hayalgücü Design Architecture
- Tabouret Interior Design

The structured interviews are divided into four parts, each of which explores a different subject. The responses to questions are often close-ended, but open-ended questions are often used at the conclusion of the formal interviews to encourage firms to clarify and provide longer replies that explicitly show their perspectives on flexibility of healthcare design and PPP investment model. The formal interviews are published entirely in English. Interviews can also be completed online using the Forms App survey administration application, which can be found at the following links:

Structured Interview URL: https://forms.app/form/601fb1c97128cf2dbf04d503
The structured interview are divided into four main parts (see Figures 3.95 to 3.99):

•General Information
•Definitions
•Based on Constructed Projects
•Other Considerations

The first part, General Information, is organized to help readers understand what percentage of healthcare projects per company designs and plans out of all the projects they work on, as well as how much flexibility standards are used on such projects. The second part, Definitions, has the goal of defining which levels (Complex, Building, Space, etc.) the flexibility is implemented. Following that, Based on Constructed Projects looks at which basic techniques and principles the companies use when constructing and preparing healthcare facilities. Finally, in the Other Considerations part, the companies are asked to answer 3 open-ended questions on all other factors or flexible perceptions related to the PPP investment model on the healthcare design process, as well as 3 other questions about the impact of the customer and flexibility on the design process. On the other hand, one of the drawbacks faced during the formal recruitment process is that only 3 of the 11 companies approached have agreed to participate in the interview. As a consequence, results and comparisons were made based on the information provided.

Empirical Phase: Optimizing and Testing

Finally, by reviewing and examining case studies of city hospitals by using the Optimized Flexibility Assessment Tool developed by Elshazly and Ghazy, (2020) and experts' viewpoints and discussions in literature, the deficiencies in evaluating mega healthcare facilities regarding flexibility were discovered, resulting in a more thorough view of the complexities and multidisciplinary essence (emergency conditions, investment model etc.) of the theme of healthcare flexibility. As a result, the findings emphasized the need for more elaborated, multi-layered, and rigorous evaluation standards that take into account emerging issues like pandemic by developed assessment that tests a broader range of concepts/principles like investment model with the least amount of bias and complexity possible for mega healthcare facilities. This tool analyses structure's flexibility, not as an architectural concept but with a broad perspective. The developed assessment tool is an effort to provide a kind of control mechanism for designers of mega healthcare structures to improve their proposals, and it can even be used on already operating ones to determine how well the building meets the requirements and today's principles of flexibility and resilience.

The redeveloped tool was created by reviewing the original one in order to learn about the content of evaluation and categories of parameters, scoring methods used. Through this review, a critical analysis was developed to illustrate the strengths and shortcomings of each parameter according to state of art and theoretical background.

The aim is to develop and define a method that offers an analytical, empirical, and reliable evaluation of mega healthcare facilities based on their level of observance with flexibility principles. The assessment's findings are intended to show which elements of the building can be improved and which can be called a flexible megastructure model in a comprehensive way. It's also being used as a kind of control mechanism for designers to assess the flexibility of their ideas. Often, it can be used on existing structures to determine how well they meet the standards and principles of flexibility in such huge projects like city hospitals.

RESULTS FROM THE STATE OF THE ART INVESTIGATION

LITERATURE REVIEW, CASE STUDIES AND INTERVIEWS

03

03. RESULTS FROM THE STATE OF THE ART INVESTIGATION

3.1 Literature Review Results

The adoption and implementation of technology and also contribute to process quality and accountability must be promoted by hospital architecture. It must have a smooth convergence of clinical needs with problems in construction planning and design. Along with the advancing technology, the life expectancy of healthcare facilities gradually decreases and some health systems making redundant with this change, while others are reproved. The hospitals which are constructed for today's conditions will not be sustainable in the future. Tomorrow's hospital will have areas that lead to the healing process (Harsvardhan & Gupta, 2012).

Hospital obsolescence lifespans are decreasing, with today's hospitals having a lifetime of just 40 years. Now it's time to think about how emerging technology, healthcare processes, and infrastructure upgrades can be implemented without having to create brand new structures to handle these developments. More than 80% of diagnosis and treatment practices will shift and improve over the next 20 years, moving to prophylactic and other innovative non-invasive approaches (Stevan, 2011 as cited in Elshazy & Ghazy, 2020)

Recovery and care periods are permanently influenced by negative and positive interactions experienced by the patient in the medical setting. The criteria defining the consistency of the patient-focused architecture are room, anonymity, comfort, variety and connectivity are therapeutic environments (Gupta, Kant & Harsvardhan, 2009).

Patient- centered mentality will be placed at the center of the design of state-art of hospitals. Their treatment with their participation would be encouraged by patient-focused architecture. Dignity of humans would be respected in patient friendly hospital design architecture rather than technology. The habitat of patients where nature is a part of design and privacy,comfort, protection and security will be ensured to users. The architecture that provides a more humane and sensitive treatment shaped according to the requirements and worth of the patient will prevail (see Figure 3.1).

The hospitals are dissimilar and overspecialized complexes. State of the art hospitals will have areas that promote the healing process. The potential to turn healthcare facilities into friendly areas for healing has an acceptable design and architecture. A healing atmosphere can be formed by nature's primordial powers such as the sun, wind water and earth which impress on wellbeing. Functionality and atmosphere should be mixed together in a convenient, healthy and visually appealing setting to provide healthcare.Healthcare facilities should be the gratifying places in the universe. Green building will involve future's hospitals which will contribute splendid characteristics that consist of preservation of the habitat, saving water, energy production, reclaimable goods and green energy use. A positive effect on the rehabilitation and health of patients are resulted by a well-well designed hospital (Gupta, Kant & Harsvardhan, 2009).

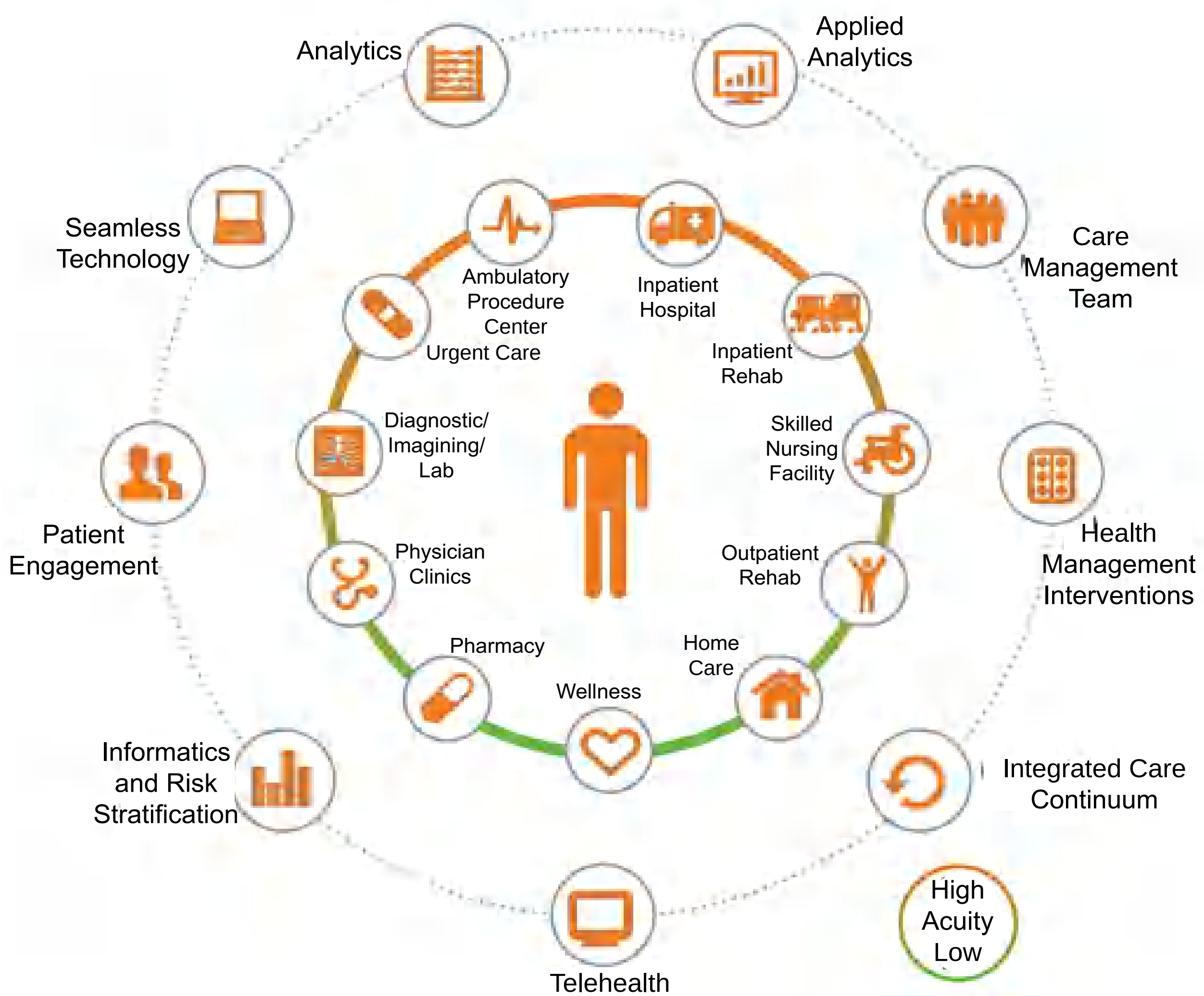


Figure 3.1: Patient Centred Experience
(Source: UK Healthcare 2015-2020 Strategic Plan, edited by author)

Future Hospital Planning Approach

Planning and design of hospital complexes have been repeated patterns in the last six-decades, which appears to be in a loop. Private hospitals, modern patient room codes, proposals for effective planning of nursing homes, and architecture for healing environments; all have in the past been the focus of architectural thought and then interest has declined, but all will undoubtedly increase again. Hospital managers and designers are in collaboration for potential planning hospital issues linked to marketing sentiment, emerging technologies, and evolving attitudes for healthcare delivery (Sprow, 2011).

The book name of Planning Hospitals of The Future belong to Sprow R. in 2011 which include ten ideas driving hospital planning in future as following: Rethinking patient flow in hospitals, Integrating information and technology, Way-finding is more than signs, Dealing with flexibility and change repeatedly, Interior design standards and systematic approach, Fast response to new service needs, Upgrading to meet new technical standards, High-productivity planning for surgery, Responding to emerging medicine volume and Opportunities for bold masterplanning.

Rethinking patient flow in hospital

Making reservations by patients, accessibility to correct places along with their visit and collected and stored medical and economical knowledge are ahead of the departmental boundaries besides expanded shared digital datas across the hospital network, smooth and continuous visit for users as possible to be lusted for. Rather than an outdated departmental structure, hospitals are talking about offering service receptionists to guide patients along the lines of the now-disappeared big department store, offering central registration points to collect specific information for the records only once, and utilizing browser scheduling and monitoring programs that monitor patient arrival times, waiting periods and final result. Like more multifaceted retail purposes, the later stage in this direction could be where consumers are shown the details on arrival and waiting time and any reaction above the specified target gives them an excuse and an award (Sprow, 2011).

Integrating information technology

The combination of information technology is the integration of the other side of this point of view of activities. Only a few years ago, out of fear, clinical personnels were not able to use some devices like a keyboard because of lack of technology. But in today’s world, progressing technology obligates us to use computers as a necessary fixture while contacting patients. Smartphones and the systems of communication are linked to a wireless network. Some old technology systems such as the call system for nurses are adapted to the new technology from the legacy system. Linked to data collection and faster response are some examples of these adaptations. Facilities need more area without folders which refers to a paperless environment. This paperless environment takes the place of clipboards, forms and rooms full of paper files that includes more computers, keyboards, server closets, printers, shredders, and fax machines, plus storage for all of their equipment (Sprow, 2011).

Wayfinding is more than signs

As part of a market share emphasis, an improved operational consideration for the patient experience ensures that existing standards including certain infinite traditional indicators (and worse still, painted lines on the ground) are substituted by more details, more interactive solutions. The technological advances to assist patients and caregivers manage healthcare and allow it more available to them are digital desks, electronic guidance systems, and simple and modular scheduling, also without signage (Sprow, 2011).

Dealing with Flexibility & Change Repeatedly

Healthcare facilities are peculiar in being a form of structure with a long average life cycle for individual rooms however a relatively short lifespan. Health facilities are commonly occupied for 50 years or longer, unlike private or college buildings, but specific rooms may be shifted or modified in only seven years, as treatment practices and innovation of equipment at the same time. Simplicity of use, successful wayfinding, advanced technology and a therapeutic atmosphere is prepared thornly while ignoring for a rather long time that individual rooms will continue to exist. Standardized and modular rooms are increasingly embraced in healthcare facilities, in contrast to be personalized to the particular service requirements or the wishes of a specific donor. Within just a few years, a geriatric cardiology unit, or a new imaging room, or be transferred to office operations are later formed by today›s child examining area. Constructing a smaller number of larger yet streamlined rooms is much more compact and effective (Sprow, 2011).

Interior Design Standards

The interior architecture of hospitals would be represented by the ability to prepare for and encourage accelerated transition ensures that a larger, more adaptive approach, thus new and refurbished and current parts of one building will co-exist and appear like parts of a coordinated entity. In achieving this cohesive look, developing and retaining design specifications is an essential method. Evaluating inventory quality early on and committing to decisions that can be maintained at a high degree for the long term are of interest to the housekeeping workers. Interiors of the hospitals must be able to combine with the times and in tiny increments to cope with change because healthcare facilities are enormous, continuously changing buildings. A partial shutdown to permit another fresh version, contrast hotel or retail environments looking to be introduced is never an alternative, and the actual healthcare world 24 hours/7 days a week/365 days a year places particular emphasis on interiors and materials not found in most styles of buildings (Sprow, 2011).

Fast response to new service needs

Genuinely high speed initiatives to bring high-income and widely recognizable programs are chased in hospitals as soon as possible, as facilities hire medical personnel and reinforce their areas of specialization in response to business conditions. Hospitals with important priorities for completely new imaging instruments or expert services to facilitate recently attended staff are finding that accelerated design and premium-time construction efforts have been crucial because of the economic realities. The assistance of seasoned facilities program managers and a comprehensive approach to construction requirements, interior design, and patient flow challenges in order to cope with these circumstances are needed in hospitals which are always exposed to limited time to discuss solutions and create reasoned output. When each unit starts to operate, a considerable monthly income which will be produced , each week becomes crucial (Sprow, 2011).

Upgrading to meet new technical standards

Places such as dialysis rooms and clinics, which have just lately been built, now need to follow more strict patient and workers protection and disease management requirements, which need further comprehensive design than just a simple correction. Farther than a basic storage are needed for electronic orders input and supply monitoring needs (Sprow, 2011).

High-productivity planning for surgery

Operational healthcare facilities, dated buildings, often spread on various floors or in different sides, feel that investing in bigger, more efficient and more versatile surgery services makes sense. Units situated close to highly mobile pre-operative areas with 20 or more standardized operating theatres that can act flexibly as preoperative holding for ambulatory patients and treatment for ambulatory and inpatient surgery have been built. Wards and rehab beds are organized into masses, thus during the day, ups and downs are observed by workers throughout the workload. Surgical quarters, with a few specialized rooms, are built for multi-specialty use as required. Surgery rooms are now being upgraded to provide minimal-access surgery and tele - health services with more versatile ceiling-mounted utility booms and innovative lamps that incorporate powerful and flexible LED lighting, flat-screen software and recording devices. The difference between surgical and imaging operations and criteria for construction is blurred by equipped with latest surgical units (Sprow, 2011).

Responding to Emergency Medicine Volume with New Care Models

Promotions and the place to start for a large proportion of patient acceptance is the emergency room which is also the main entrance, and hospitals are very worried about making it more efficient and attentive to patient needs. One typical solution is the idea of private room healing understanding, which provides a vast number of private recovery rooms such that with all of their treatment, each patient and their families are typically taken exclusively to a special ward. Urgent care procedures are reduced and much of the acceptation process can be carried out in the room directly. treated and attended to, instead of the traditional logic of being kept for long stretches of hours in the reception area. Pleasure is much stronger and standardized rooms that are versatile will better respond to transformation in use. Decreasing the need for accommodation for waiting areas provides more functional space (Sprow, 2011).

Opportunities for Bold Master Planning

Rather than the traditional facility planning and master design approach for a gradual perspective of development and facility demands, usually eventuating in the standard multi-wing hospital, modern planning explores options to correct-size facilities and modify the distribution process every 10 years apart from completion. The movement of mergers and building more effective, smaller hospitals in a neutral location is followed by aging public hospitals. Large metropolitan education institutions are looking for options to upgrade obsolete aging facilities, merge services and, in some situations, even replace the entire institution with a modern, smaller building that combines greater productivity and often lower personnel and running costs (Sprow, 2011).

Strategies for New Hospital Design

Proper conceptual architecture of healthcare facilities plays an important role in effective healthcare delivery by integrating evolving needs of healthcare from time to time.
It offers a change to the company to deal with the potential developments in terms of technical development of equipment, advancement in the manner of distribution of treatment, organizational changes and resolve concerns related to rise of visitor numbers in the hospital.
Although these developments are obvious and precise estimation is not feasible, therefore, healthcare architects should understand the potential flexibility as one of the essential requirements for design planning. Architectural components that contribute towards rendering scalable healthcare architecture and require special attention of the design professional are classified below in (Babbu, 2016).

Operational Approaches

Flexibility at the functional unit level, according to Capolongo (2012), can be achieved through a variety of typological-spatial and organizational techniques. These methods can have an effect on surface flexibility, whether fixed or variable, as well as organizational problems. The following are the constant surface typological-spatial solutions:

Networked Information Systems aims to provide consistency in the transfer of information by using a properly built Information System for remote control of activities related to testing, training, and healthcare, as well as to allow for real-time information exchange and the ability to efficiently administer and sustain any internal change in a healthcare facility without hindering healthcare practices or creating delays in the current design's renovations.

Building Automation and Control (BAC)10 programs combine systems and technologies to execute automated control functions and actions (repetitive programmed) depending on the user's individual needs and demands. In addition to surveillance and security systems, computer, information, and communications systems, these systems can monitor environmental or technical management systems. Both softwares, products, and energy resources needed for automatic operation, optimization, and tracking of management and manual behavior are referred to as BAC in healthcare facilities. This serves the system to ensure its security, environment, and energy efficiency.

Flexible financial coordinations, since hospitals are constructed by public-private partnerships (PPP) in the majority of cases currently, it is critical that the contract awarded for its realization and service be able to enable a specific degree of potential operating flexibility. The use of project finance to fund public works is extremely advantageous. However, it is important to consider the limitations of adaptability and versatility.

Outsourcing support services: Certain basic services, such as employees for hotels, restaurants, parking, sterilization, and so on, may be simply outsourced by naming subcontractors. When an accident necessitates the alteration of operation through invitation to tender, certain services that can be purchased but do not provide direct processing can easily be reassigned or reprogrammed without any external plant or strategic re-planning on the hospital operator's side.

Information systems services for multi-functionality, Information systems and ICT communications equipment must be designed to take into account the room's versatility. This is why interactive walls are so common. These dynamic walls enable the building and ICT systems to work together.

Spatial Approaches

Structural grid is a systematic planning and organization of structural members which are columns and beams that support the superstructure. It is clear that wider the column spacing, potential versatility would be more as functional spaces can be planned with minimal interference of columns in between the functional spaces. If the column spacing will be more, at one side it is simpler to plan spaces but then on the other hand the structure will also be heavier, the width of the beam will be more and the cost of building will also be more expensive. If the column spacing is smaller, the construction can be economical but at the same time future flexibility would be much less as it is hard to get bigger spaces without intermediate columns. The challenge for the healthcare builder is therefore to maximize the column spacing such that optimum efficient spaces can be accommodated or interchanged if there is a need to do so in future. Consultation room, patient's room, wards, operating rooms, corridors plays a key role in determining the column spacing. Also allocation of parking in the basement and configurations of basement parking, if designed below the footprint of the healthcare building, is a significant parameter for evaluating the column spacing (Babbu, 2016) (see Figure 3.2).

Figure 3.2: Typical Floor of the Primary System of INO Hospital, 8.4m x 8.4m Structural Grid
(Source: Kendall (2005), edited by author)

Open Building Concept is a modular framework where floor plates of hospital buildings are produced without the internal configuration on the basis of the total gross area of the project. The living area is separated by an effective structural grid into a variety of quadrants. The space between four columns denotes one quadrant. If 8.0Mx8.0M is the structural grid, the scale of the quadrant is 8.0M x8.0M. Set mechanical risers are positioned in each quadrant. An appropriate "punch through" mechanism is given at the centre of each quadrant. A portion of concrete slab without reinforcement is each 'punch through' square. The square 'punch through' provides the possibility of vertical penetration for vertical circulation, mechanical mechanisms or light shaft at either position in the floor plate. Four sleeves for potential vertical drainage piping are positioned at the base of each column (Babbu, 2016) (see Figure 3.3).

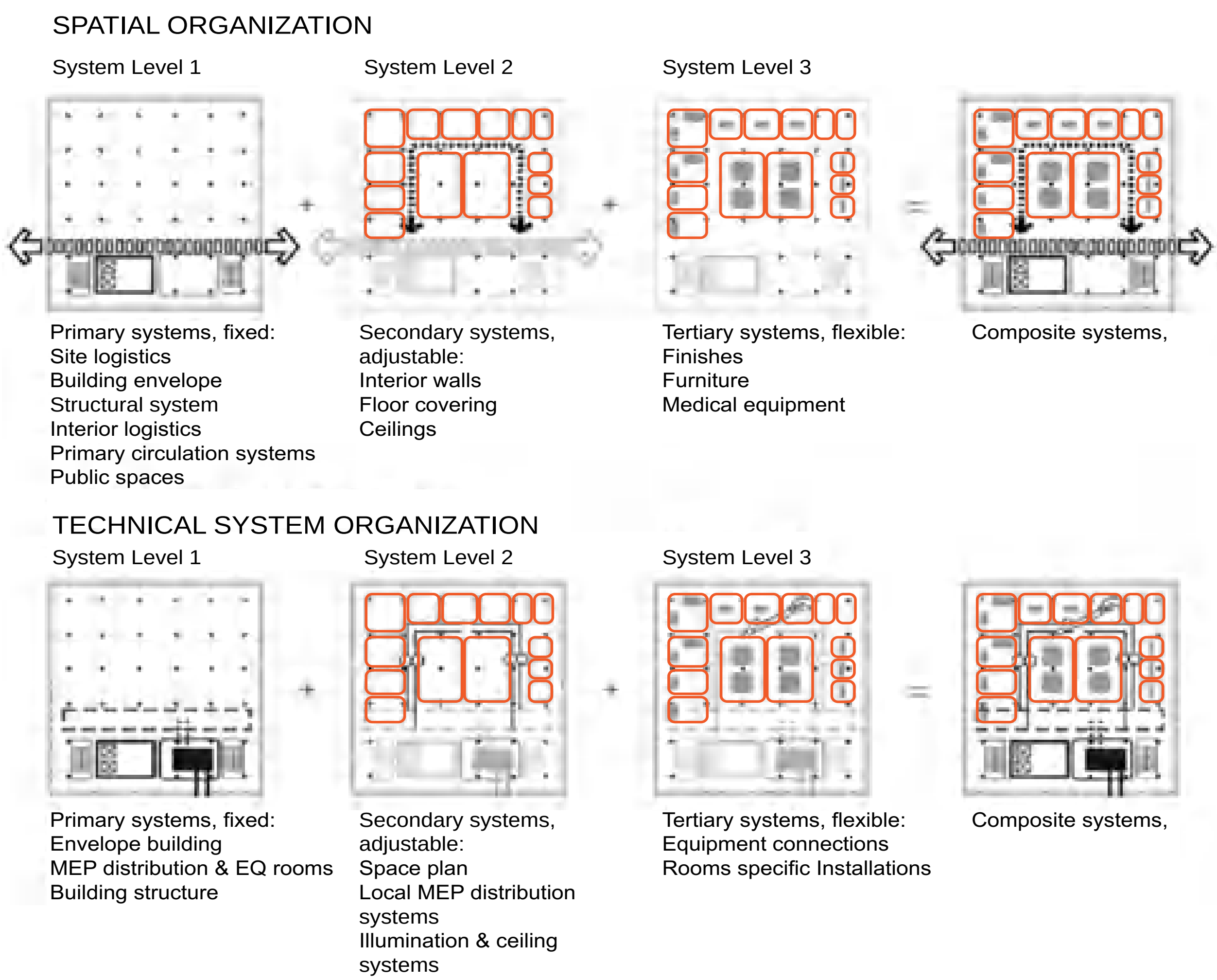


Figure 3.3: Open Building System Levels
(Source: Allison (2015), edited by author)

Capolongo (2012) disscuss structural flexibility as follows:

Multi-point load bearing construction with wide spans, same structural modulation helps guarantee internal adaptability and flexibility. This form of construction may be made of steel, precast concrete, or laminated wood. Steel systems are chosen for optimum versatility and adaptability, and vertical circulation components and operating blocks can be installed in well-planned places.

Suspended structures (floating floors) have a load-bearing framework in the middle and a fixed load-bearing structure on the building's envelope. As such two structures are combined, the interior space becomes more flexible, with no structural components along the way.

Prefabricated modular components, prefabricated modular units constructed of steel, PRC, or wood make up the structure. This method is effective in cases of expansion or contraction, but it is ineffective in cases of internal organisation changes.

Oversized load-bearing structures, It is important to extra large structural components so that the structure will accommodate additional floors or other volume additions that may have an effect. Oversizing structural components is generally based on projections of how the extension will occur, with the understanding that exaggerating this growth will result in loss of material and a substantial increase in expense.

Location of Vertical Transportation System In determining the degree of versatility, the position of elevators, staircases, ramps that serve as a vertical transport mechanism within the hospital building play a crucial role. Not only is it impossible to move these buildings, but it is very expensive. If these facilities are not designed to take into account the potential expansion of the hospital building, the relocation of these facilities may pose a significant problem which may affect the operation of the hospital to a large degree and even involve a full shutdown of the hospital function. It is also still desirable, taking into consideration the potential growth requirements, to build the operation center (Babbu, 2016).

Ceiling Height is a very critical requirement for potential flexibility in healthcare designs. Operating rooms, imaging rooms etc usually needs larger floor to ceiling height in contrast to other usable places in the hospital facilities. It has been found in numerous healthcare buildings that generally 3.6 M floor to heights of floor have been preserved for all the spaces not including operating rooms. It has been found in numerous healthcare buildings that usually 3.6 M floor to floor heights have been held for all the spaces except operating rooms. This will reduce the scope of flexibility in future if another set of operating rooms are to be made at any other floor. An improved floor to floor height is recommended to deal with technical advancements in the field of medical and imaging equipment that could need greater vent volumes, additional arrangements in the roof and/or floor, etc. for its construction and operation.

In consideration of the potential stability alternative, the floor-to-floor height of all hospital building floors must not be less than 4.0 M in order to prevent any expensive systemic change at a later level (Babbu, 2016) (see Figure 3.4).

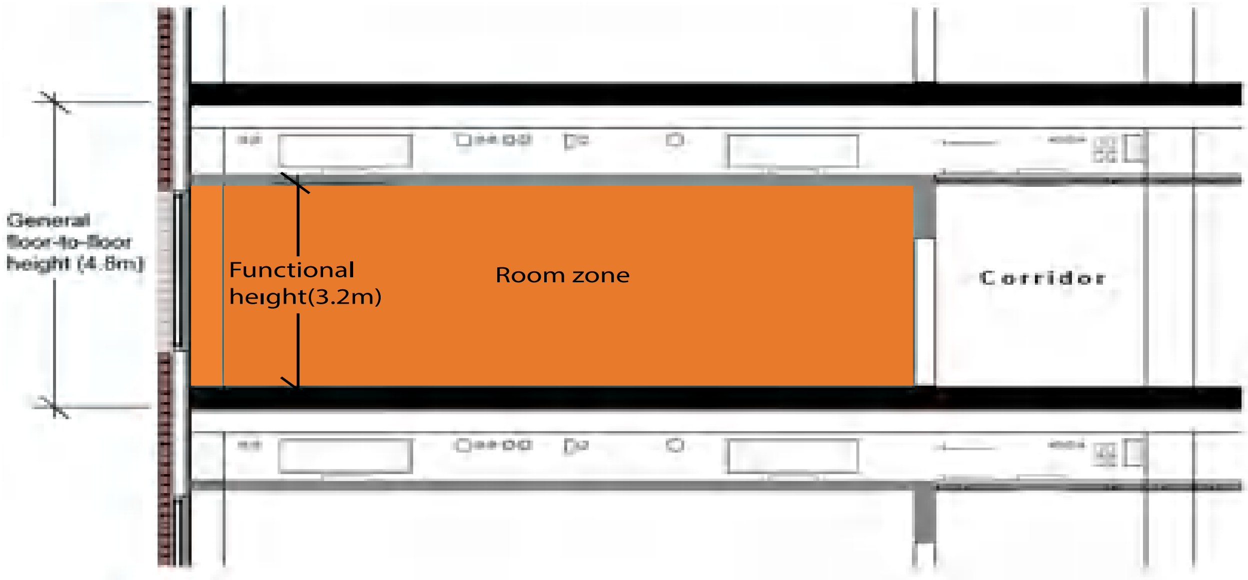


Figure 3.4: Floor Height and Clear Height of Hospital Room
(Source: Shang (2015), edited by author)

Location of Electrical, Mechanical and Other Hospital Services, the positioning of health facilities also plays a very significant part in the hospital building's potential growth. The transfer of these services, analogous to the vertical transport scheme, is a repetitive process and, in most situations, not advisable unless it is completely essential to do so. It is quite difficult to move these facilities and requires a partial or complete breakdown in the operation of the facility. It is still advisable, in terms of capacity, to provide any spare space that can support standby facilities in the case of unit malfunction or during equipment repairs. It is also prudent to have "soft spaces" next to these facilities so that they can satisfy the growing need for services in the future without affecting current facilities (Babbu, 2016).

Shell rooms, plans for construction activity change or expansion should be made ahead of time for places that can be abandoned incomplete but completed quickly and connected to plant facilities. Incomplete spaces, for example, are left undone in case of potential extensions to be used as wards as long as the amount of beds available is inadequate. In the same way, this area can be used for administrative offices, meeting spaces, accommodations, and so on (Capolongo, 2012).

Plant infrastructure grow, each usable unit's plant infrastructure areas should be readily accessible and able to support potential development. Plant infrastructure that can be installed in special areas such as interstitial spaces, suspended walls, or elevated floors is more efficient and practical (Capolongo, 2012).

Capolongo S. (2012) talks about building plants which are;

Modular, replaceable and maintainable plant, the hospital must provide built-in redundancy (sub-stations, construction plant spaces, refrigeration plant, and so on) that can be added or decreased on a modular system, as well as readily replaced or retained, that is both extremely energy efficient and commercially viable. There should be the option of reprogramming the main building plant system, including optimizing or reducing it as necessary, in the situation of transformation to various purposes, extension or contraction, or alterations regarding new healthcare demands. It would also be important to be able to replace individual plant parts without needing to redesign the whole facility. It is important to emphasize that the construction plant choices proposed have major consequences for energy efficiency, which is a problem that cannot be ignored in any project today.

Redundancy of space for plant, plant and technology areas should be adaptable and usable over time, designed and built in such a manner that any modifications and improvements to the construction plant can be accommodated.

Interstitial Space is a walk-through space connecting two consecutive, standard ground. It is a fully open area designed to accommodate diverse hospital facilities. The rearrangement of these facilities during their life cycle is simpler by having interstitial floors in the hospital, especially in hospital laboratories, operating rooms, intensive care unit areas, and therefore the expense of the lifecycle can be decreased. If the hospital has interstitial floors, vertical hospital expansion is therefore very straightforward, even as the height of the building rises (Babbu, 2016) (see Figure 3.5).

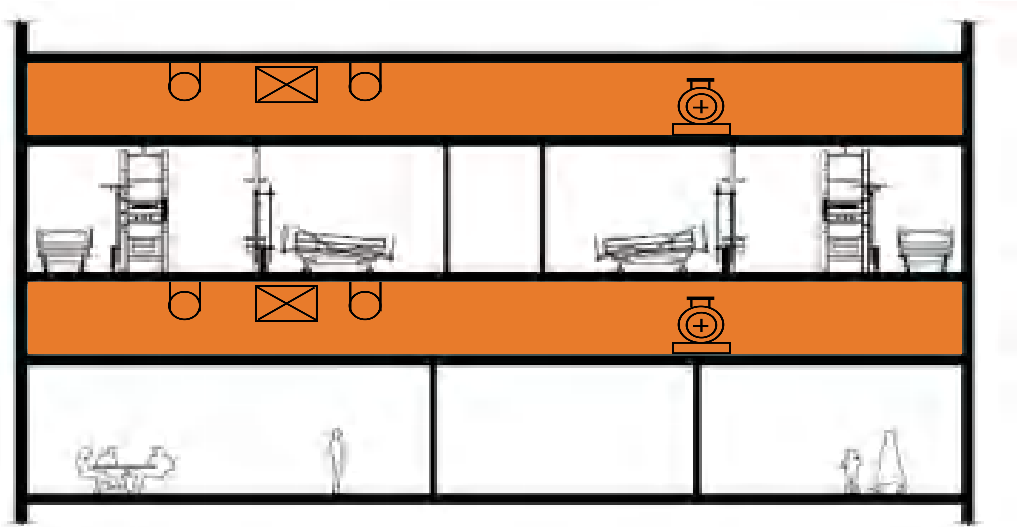


Figure 3.5: Interstitial Space Design for a Medical Facility
(Source: Babbu (2016), edited by author)

Capolongo S. (2012) indicates important possibilities about future expansions which are;

Existence of an unoccupied building plot is one possible solution, as it has been used in the past, that includes additional areas next to the hospital that are not constrained by urban design or environmental concerns.

Expansion of a Building, probability of expanding the whole functional unit vertically or horizontally: the functional unit's ability to stretch horizontally or by adding ground. Where there is a heavy demand for area in the operating zone, the working unit can often be expanded by connecting additional modules to it. Expansions are often accomplished by connecting fully prefabricated operating facilities to the current one.

Modifiability of the envelope (facade), the flexibility to change the building envelope is important. As it should be able to incorporate or subtract current openings in order to increase the amount of sunshine inside the structure or to create a new arrangement for a room that includes different openings than the present ones (Capolongo, 2012).

Capolongo S. (2012) stated that the importance of internal partition on healthcare facilitites in terms of flexibility;

The use of multi-layer internal dry partition walls, these strategies allow for operational and physical reconfiguration of the entire functional unit in the shortest time possible by reusing all or part of the partitioning components. Internal dry partition walls are made up of modules that are put together using mechanical repair processes that do not require the use of glues. As a result, these components can be quickly reinstalled or dismantled; however, these procedures involve a construction site for assembly. The wall's structural aspect may be realized as a grid made up of uprights and crosspieces with supporting panels added to all directions, or it can be made up of only upright components, which is a more compact arrangement in terms of construction and dismantling.

The use of movable internal partitions, these methods mean that functional units can be spatially modified by merely shifting components, and can also be accomplished by the person himself. Internal movable partitions may be easily transferred or converted to split a large space into multiple smaller spaces. By varying the degree of contact among adjacent rooms and temporarily joining/ dividing separate adjoining rooms, they permit a variety of versatile forms to use space. Sliding partitions, accordion dividers, and telescopic dividers are all examples of internal movable walls.

The use of movable furniture and vertical screening, using movable furniture and partitions that can be relocated on rails when desired. Where practicable, divide the space into subareas and provide the necessary privacy for such operations such as patient examinations on the wards. This type of strategy is useful in spaces that need to be sound-insulated from the other subareas.

Customizable humanization of the room, in order to permit customization and adjustment in the space, it is important to use equipment that can be modified and relocated, such as light that can be changed in modulation and color, shading elements, paint, and adjustable furniture elements.

International Healthcare Design Guidelines

This is the origin of worldwide standards for healthcare organizations preparation, briefing, architecture & development. These recommendations stress the achievement of findings that represent current practice in healthcare in a secure and suitable setting at an appropriate facility rate. They embody patient-focused, research-based, new and effective concepts of planning. Medical services have to be prepared effectively, informed correctly, constructed efficiently and delivered rapidly. In any aspect, they need to be sustainable as an important public utility. Therefore, without reducing the level of care, they have to carefully weigh the necessary characteristics and expectations against capital and operating expenses. After a good initiative, sustainability demands that the valuable experience of healthcare architecture be distributed rather than lost. To fulfill these main aims, these guidelines introduce the common awareness to the globe:

- Establish the minimum acceptable standards
- Maintain public confidence in the facilities which comply with these guidelines
- Provide a basis for the approval and licensing of healthcare facilities
- Provide guidance to designers on the special needs of healthcare facilities
- Consider the wellbeing, safety, privacy and dignity of patients, staff and visitors
- Eliminate design features that result in unacceptable practices
- Allow Health Authorities to require compliance with these guidelines
- Provide a knowledge base to inform future healthcare design consultants

These Guidelines will be evaluated, revised and extended constantly. Readers are invited to provide suggestions and to provide ideas for potential updates (“International Health Facility Guidelines”, 2019).

Environmental Impact

The aesthetics and form of a health facility shall be sympathetic with its immediate environment, either built or natural; for example domestic scale and treatments where built in a residential area. The building should enhance the streetscape (iHGF, part b, Planning, p. 07).

Landscaping

A suitable landscaping scheme shall be provided to ensure that the outdoor spaces are pleasant areas in which patients, visitors and staff may relax. The scheme should also ensure that the buildings blend into the surrounding environment, built or natural (iHGF, part b, Planning, p. 07).

Masterplan Development

The planning of a complex health facility is based on applying commonly recognised “good relationships” as well as taking into consideration site constraints and conformity with various codes and guidelines. A Masterplan is a fundamental planning tool to identify options for the current needs as well as projected future needs. Its purpose is to guide decision making for clients and designers (iHGF, part b, Planning, p. 08).

A Masterplan diagram is typically a simplified plan showing the following:

▪ The overall site or section of the site relating to the development
▪ Departmental boundaries for each level related to the development
▪ Major entry and exit points to the site and the relevant departments
▪ Vertical transportation including stairs and lifts
▪ Main inter-departmental corridors (arterial corridors)
▪ Location of critical activity zones within departments but without full detail
▪ Likely future site development
▪ Areas (if any) set aside for future growth and change
▪ Arrows and notes indicating major paths of travel for vehicles, pedestrians, goods and beds
▪ Services master plan showing the engineering impact, plant locations, availability of services and future demand (iHGF, part b, Planning, p. 09)

Site Planning

This chapter mainly emphasizes that healthcare facilities should minimize their impact on their environment, be in harmony with their surrounding and meet future facility expansion demands. Design of a master plan of healthcare facilities should be carefully planned from the very beginning to the future expansion. Regarding these manners three aspects were identified as follows: environmental impact, landscaping and masterplan development.

As the first one, environmental impact, the appearance and type of a health facility should be friendly with its immediate environment in terms of all manner. Landscape in harmony with healthcare facilities refers to pleasant outdoor spaces for all facility users. Last one is masterplan development related with important designing methods to determine solutions for the existing requirements along with future expected demands In order to meet the future demand for future physical expansion of the health facility structure, a suitable expansion area should be taken into account in designing master plan in the certain plot.

Loose Fit

Loose Fit is the opposite of Tight Fit. This policy refers to a type of plan which is not so tightly configured around only one operational policy that it is incapable of adapting to another. In Health Care, operational policies change frequently. The average cycle seems to be around 5 years. It may be a result of management change, government policy change, turn-over of key staff or change in the marketplace. On the other hand, major health facilities are typically designed for 30 years but tend to last more than 50 years. This immediately presents a conflict. If, for example, a major hospital is designed very tightly around the operational policies of the day or the opinion of a few individuals that may leave at any time, then a significant investment may be at risk of early obsolescence. The Loose Fit Planning Policy refers to planning models which can not only adequately respond to today's operational policy but have the inherent flexibility to adapt to a range of alternative, proven and forward looking policies. At macro Level, many of the commonly adopted health facility planning models, including those in the enclosures to these Guidelines, have proven flexible in dealing with multiple operational policies. At micro level, designers should consider simple, well proportioned, regular shaped rooms with good access to simple circulation networks that are uncomplicated by a desire to create interest. Interior features should not be achieved by creating unnecessary complexity (iHGF, part b, Planning, p. 09-10).

Change by Management

This concept refers to plans which allow for changes in operating mode as a function of management rather than physical building change. For example, two Inpatient Units can be designed back to back so that a range of rooms can be shared. The shared section may be capable of isolation from one or the other Inpatient Unit by a set of doors. This type of sharing is commonly referred to as Swing Beds. It represents a change to the size of one Inpatient Unit without any need to expand the unit or make any physical changes. The same concept can be applied to a range of planning models to achieve greater flexibility for the management. Also see other planning policies in this section (iHGF, part b, Planning, p. 10).

Overflow Design

Some functions can be designed to serve as overflow for other areas that are subject to fluctuating demand. An Emergency Unit Procedure Room or a Birthing Room may be designed specifically to provide an emergency operating room for caesarean sections in case the standard allocated operating room is not available. Any area that includes bed bays such as an Emergency Unit may be designed to absorb the available open space and provide room for additional beds in case of natural disasters (iHGF, part b, Planning, p. 10).

Progressive Shutdown

Even large facilities may be subject to fluctuating demand. It is desirable to implement a Progressive Shutdown policy to close off certain sections when they are not in use. This allows for savings in energy, maintenance and staff costs.
It also concentrates the staff around patients and improves communication and security (iHGF, part b, Planning, p. 10).

Open Ended Planning

“Open Ended Planning”: planning models and architectural shapes that have the capability to grow, change and develop additional wings (horizontally or vertically) in a controlled way. As an example, a typical health facility flow diagram which promotes open ended planning is represented in Figure 3.6 (iHGF, part b, Planning, p. 11).

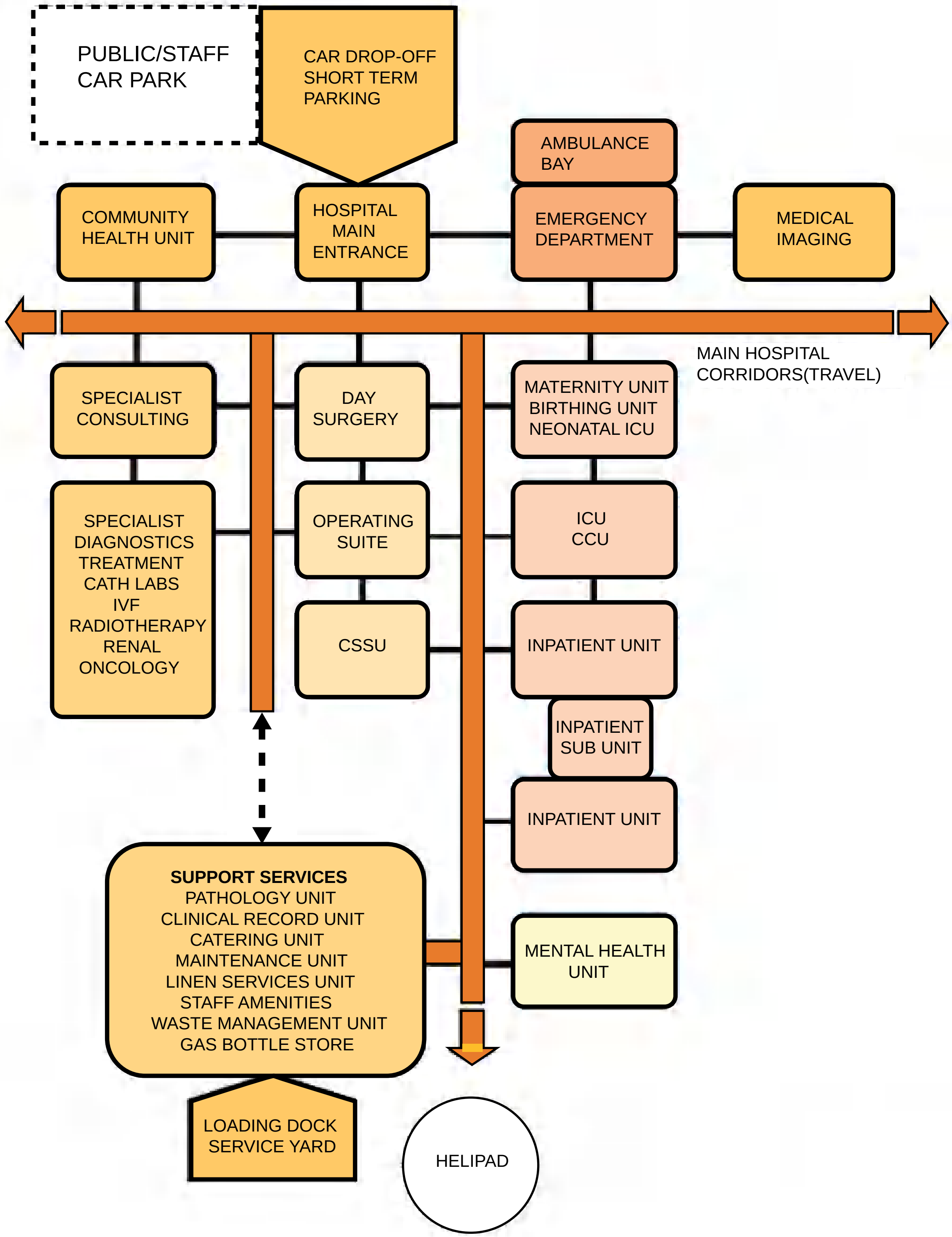


Figure 3.6: Open Ended Planning
(Source: International Health Facility Guidelines (2017), edited by author)

Modular Design

This is the concept of designing a facility by combining perfectly designed standard components. For example a designer may create a range of Patient Bedrooms, a range of utility rooms and other common rooms that are based on a regular grid such as 600 mm. These rooms can then be combined to create larger planning units such as an Inpatient Unit. The Inpatient Unit can then be used as a module and repeated a number of times as required. This approach, in the hands of a skilled designer, has many benefits. Modules can be designed only once to perfection and repeated throughout the facility. No redesign is necessary to adjust to different planning configurations. Instead the plan is assembled to adapt to the modules. Errors in both design and construction can therefore be minimised (iHGF, part b, Planning, p. 12).

Universal Design

This concept is similar to Modular Design. Universal Design refers to Modules (or standard components) designed to perform multiple functions by management choice.

For example, a typical patient single bedroom can be designed to suit a variety of disciplines including Medical/ Surgical/ Maternity and Orthopaedics. Such a room can be standardised across all compatible Inpatient Units. This will permit a change of use between departments if the need arises. Such Universal Design must take into account the requirements of all compatible uses and allow for all of them. The opposite of this policy is to “specialise” the design of each component to the point of inflexibility.

Other examples of Universal Design are as follows:
▪ Universal Operating Rooms which suit a range of operations
▪ Bed cubicles in Day Surgery which suit both Pre-op and Post-op
▪ Offices which are standardised into only a limited number of types for example 9 m2 and 12 m2
▪ Toilets may all be designed for disabled access or as unisex.

The main point of Universal Design is to resist unnecessary variation in similar components, where the change in functionality can be accommodated in one standard design (iHGF, part b, Planning, p. 12).

Natural Disaster

All health facilities should be capable of continued operation during and after a natural disaster, except in instances where a facility sustains primary impact. This means that special design consideration is needed to protect essential services such as emergency power generation, heating and/or cooling systems, water supply (if applicable), etc. Appropriate construction detailing and structural provision shall be made to protect occupants and to ensure continuity of essential services in areas where there is a history of earthquakes, cyclones, flooding, bushfires or other natural disasters (iHGF, part b, Planning, p. 13).

Concepts and policies

This chapter primarily addresses the key concerns of healthcare services being obsolete and out of operation in a short moment, less than the expected lifetime related to clinical, technical and organizational advances that happen increasingly everyday. This causes innovative architecture techniques and methods to be developed form the practical and organizational perspective from the preliminary process of designing in order to assure future proofing of the building by implementing flexibility concepts.Eight design strategies were identified as follows: loose fit, change by management, overflow design, progressive shutdown, open ended planning,modular design and universal design, natural disaster.

As for the first one, loose fit, it is more relevant to design models that allow adaptability based on physical configuration of the building to comply with growing demands. Shift by management, this applies to the operating features rather than the physical functionality in order to enable potential modification in areas without influencing the room sizes. The third one, overflow design, some operations can be planned to serve as overload for other fields that are exposed to changing needs. Progressive shutdown allows partial close down of certain areas when they are not in charge in order to save electricity, repairs and personnel expenses. Then open ended planning accommodate future expansion demand in terms of design templates and architectural forms that have the potential to expand, alter and build additional wings (horizontally or vertically) in a managed direction. Modular design and universal design that seem to be clearly associated as they lead to standardization of area and modules to be conveniently built, transformed and extended in the future in case of need for transformation. So setting up the standard proportions and criteria for some operations where these values can be implemented. Finally all healthcare facilities should be designed in such a way that they can continue to operate both architecturally and statically during and after natural disasters.

Patient Treatment Areas

Patients must be situated so that healthcare providers have direct visualization, as far as possible. This permits the monitoring of patient status under both routine and emergency circumstances. The preferred design is to allow a direct line of vision between the patient and the Staff Station. In large Emergency Units, treatment bed areas may be designed in clusters with a centralised staff station with maximum direct visibility of patients. Treatment spaces may be fully or partially enclosed to ensure that confidential information can be conveyed without breach of privacy and to provide security to staff. Treatment bed spaces should be designed as acuity adaptable - to suit any patient acuity in order to provide maximum flexibility for patient placement within the Emergency Unit (iHGF, part b, Inpatient Unit General, p. 16).

Inpatient Unit

There are a number of acceptable planning options for Inpatient Units including:

- Single Corridor; Patient and support rooms are clustered along a single corridor
- Double Corridor – racetrack; patient rooms are located on the external aspects of the space and support rooms are clustered in the central areas in a racetrack configuration
- Combinations: - L, T & Y shaped corridors, patient rooms are located along external aspects, support areas may be located in a central core area – refer to examples below.

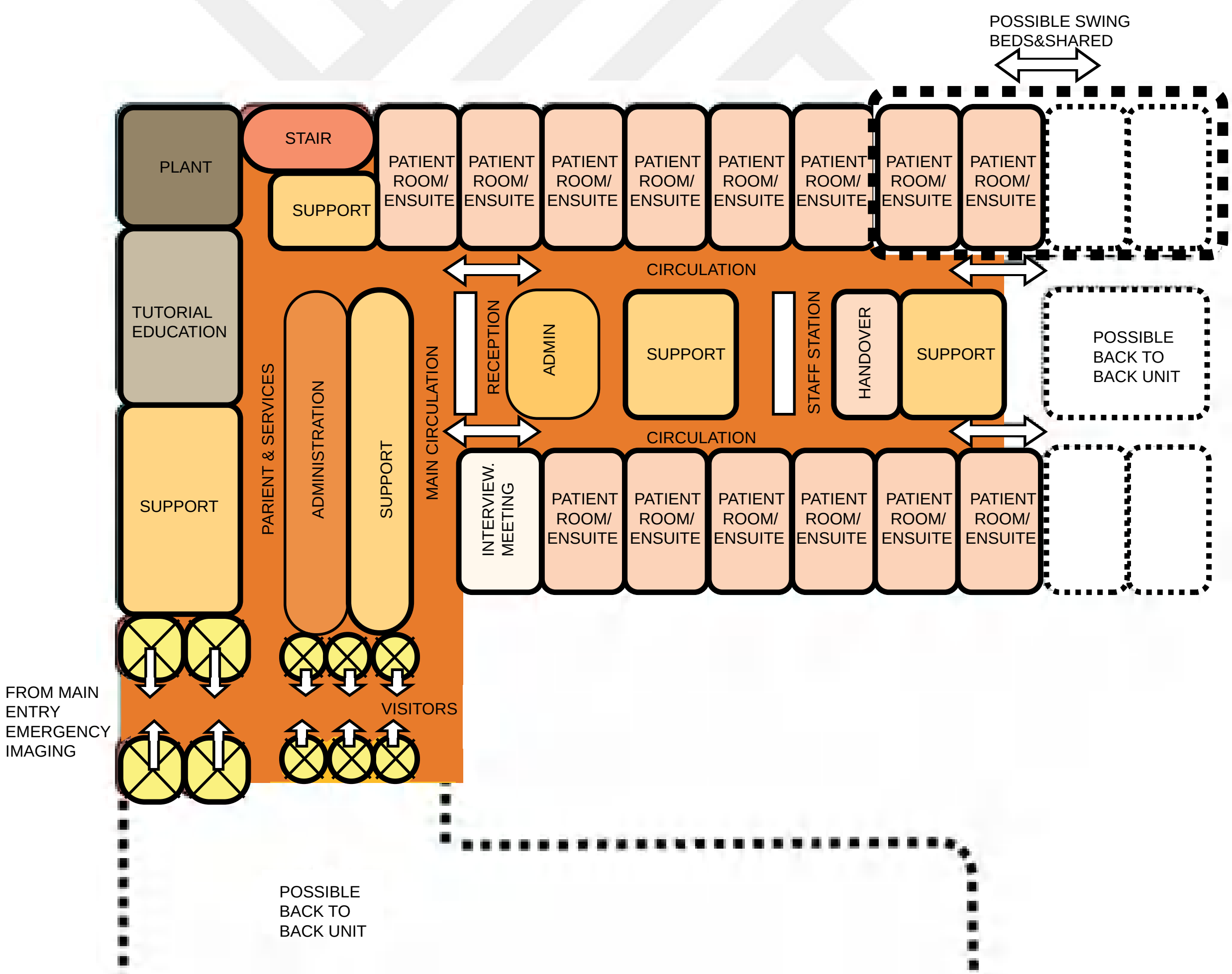


Figure 3.7: Double Corridor - Racetrack Model
(Source: International Health Facility Guidelines (2017), edited by author)

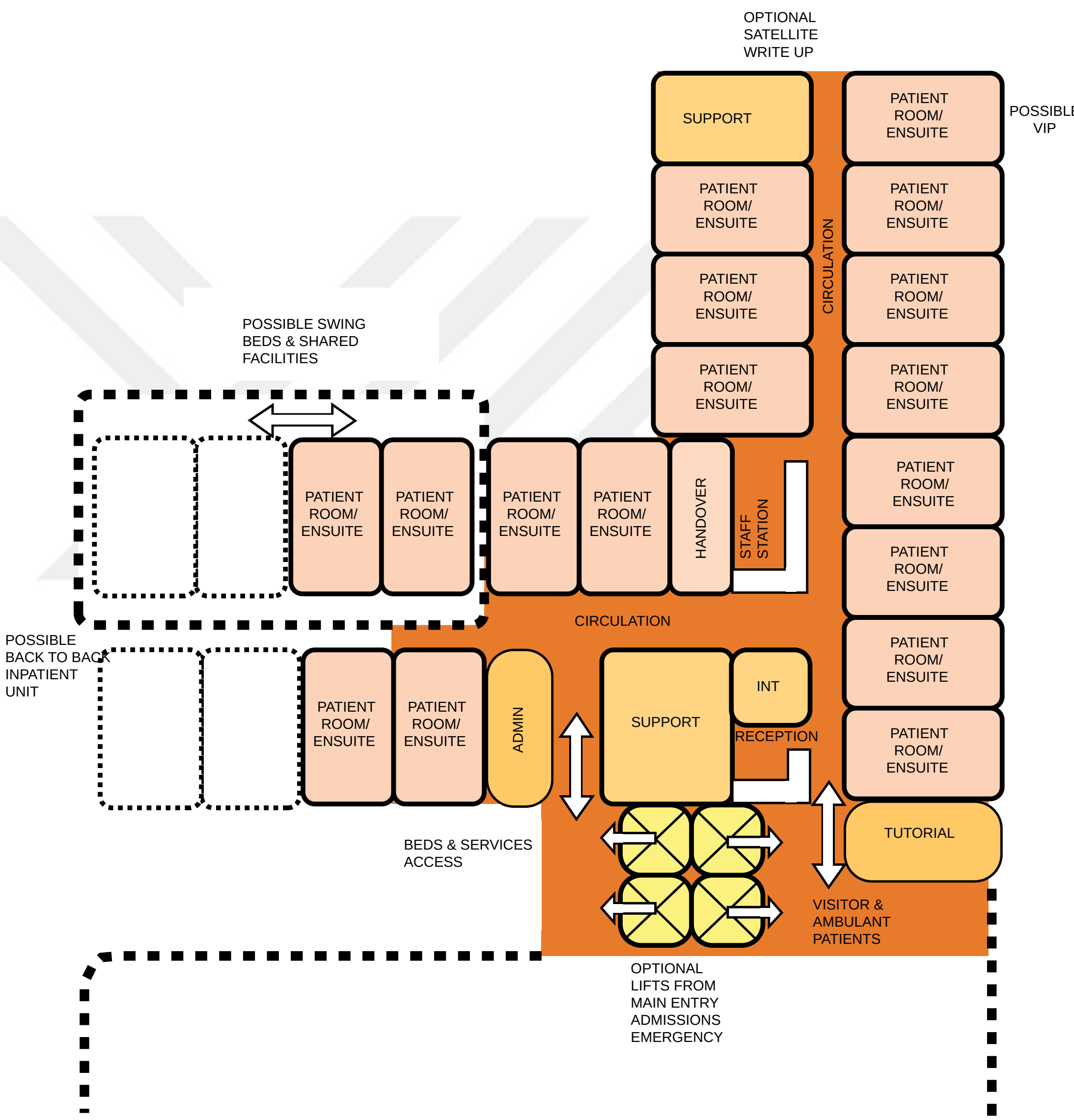


Figure 3.8 : L Shaped Corridor Model
(Source: International Health Facility Guidelines (2017), edited by author)

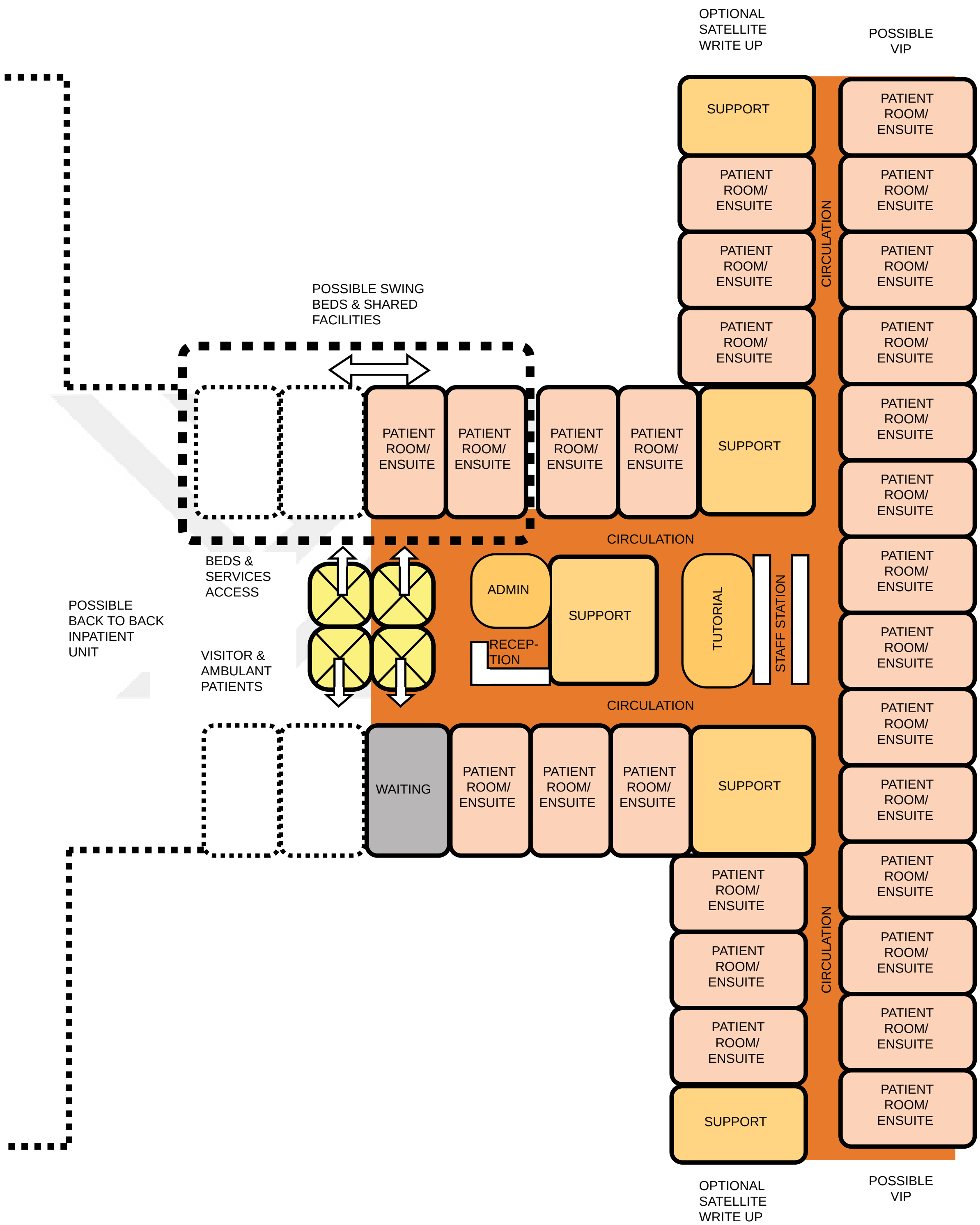


Figure 3.9 : T Shaped Corridor Model
(Source: International Health Facility Guidelines (2017), edited by author)

Outpatient Unit

Flexible operational models can be built into an existing unit using modular spaces and designs (iHGF, part b, Outpatient Unit p. 04).
Some of the critical considerations are:

- Flexibility in accommodating various types of use throughout different hours in the day
- Reception area should allow patients to move conveniently to and from the Consult and Treatment areas and accommodate high volume of patients, support staff, care-takers and mobility aids
- Interview rooms for support services such as social worker, cashier etc. to be conveniently located
- Sub Waiting areas may be located close to Treatment areas for patient and staff accessibility
- Staff must be able to move easily to and from Treatment areas and Reception/ Registration and Waiting areas; discreet and private work areas away from patients is recommended; staff areas may have restricted access to patients. It is important for the functional areas to work effectively together to allow for an efficient, safe and pleasant environment (iHGF, part b, Outpatient Unit p. 10).

Intensive Care

The Combined Critical Care may include a High Dependency Unit, Intensive Care and/or Coronary Care, often located in a rural or regional hospital where flexibility of bed utilisation is important. This will allow short and medium term intensive care patients to be managed appropriately when required, and at other times, the Unit may be used for the more common cardiology or high dependency patients (iHGF, part b, Intensive Care Unit-General, p. 03).

Operating Unit

Smaller suites may favour flexibility of Operating Room use. Fixed equipment can preclude the multifunctional use of the room (iHGF, part b, Operating Unit p. 06). When planning for future developments the following trends should be considered:

- Increasing demand for digital operating rooms
- Increasing availability and use of robotic surgery
- Increasing use of imaging within the operating room particularly CT scanning, MRI and angiography
- Technological development of support, monitoring, diagnostic, treatment and procedural equipment

- Increasing sophistication of information systems

Demand for transparency about quality, safety and cost (IHGF, part b, Operating Unit p. 24).

Mental Health Unit

Rooms may be grouped into clusters that can be defined for distinct patient groups or gender; each cluster of rooms should include a recreational and lounge space to allow for patient therapy/ activities and flexibility for a variety of patient categories including access to outdoor areas with appropriate weather protection (iHGF, part b, Mental Health Unit-Adult, p. 04).

Rehabilitation – Allied Health Unit

The design philosophy of the Rehabilitation Unit should convey a friendly and inviting environment and should encourage community members to utilise the available facilities for rehabilitation purposes. A non-institutional, safe and supportive environment needs to be promoted. Building design must be flexible and adaptable to enable the unit to cater for varying client and service needs.

Buildings should be designed to cope with a wide range of possible conditions. The aim is to provide an environment that will allow the maximum mobility possible for each person. The Rehabilitation Unit will include access for disabled persons (iHGF, part b, Rehabilitation – Allied Health Unit p. 10-11).

Support Areas

Meeting rooms with tele-conference or video-conference facilities provide for meeting flexibility with remote staff. A large Meeting Room may be used for disaster management and Board meetings. If multipurpose meeting rooms are provided, they may be located to enable sharing by several services or Units. Meeting Room/s should have access to a pantry for food and beverages as necessary (iHGF, part b, Administration Unit, p. 05).

Administration Unit

A typical Administration unit, centrally located in a non-clinical zone within a health facility and including with sub units located together.

The following represents preferred external functional relationships:

- Visitors access from a main circulation corridor from the Main Entrance

- Separate entry and access for staff
- Service corridor access for service units such as Supply and Housekeeping.

(iHGF, part b, Administration Unit, p. 05-07).

Future trends that may affect the Administration Unit include:

- Management innovation that focuses on new ways of allocating scarce resources as the workforce becomes more adaptable, creative and mobile, requiring more flexibility
- Increased focus on developing talent of individuals in the workforce while robots perform the routine tasks; this may require fundamental organisational redesign
- An increased pressure on hospital management to reduce costs while increasing productivity and service, supporting an increasing population
- A greater use of technology and improved software to support managing the service, particularly portable devices which enables administrative staff to be more mobile with instant information sources available to make decisions (iHGF, part b, Administration Unit, p. 12).

Laboratory Unit

The Laboratory Unit may be planned as a series of modular laboratories, providing flexibility for change of function and equipment as necessary. Each module may be sized to accommodate a specific specialty and the equipment required, with the ability to adapt and reconfigure modules (iHGF, part b, Laboratory Unit-General, p. 04).

Medical Imaging Unit

It is expected that radiation dosages will continue to drop and utilization of imaging services will become more efficient, with fewer healthcare resources wasted.
Future new technologies (e.g., molecular imaging) could yield rapid utilization changes if these provide the clinical value that has been attributed to traditional advanced imaging during its recent boom (iHGF, part b, Medical Imaging Unit-General, p. 22).

The Engineering & Maintenance Unit

The Unit will require ready access to all areas of the hospital and in particular, to plant rooms and areas. Depending on the size of the Unit and the Operational Policy, considerable noise and fumes may be generated by the Unit and care should be taken in locating the Unit relative to other units such as Inpatient Accommodation Units (iHGF, part b, The Engineering & Maintenance Unit , p. 04).

Functional Flexibility

This section classifies different healthcare facility units based on functions highlighting the importance of creating a flexible physical environment for future transformation. Identifying how flexibility and adaptability can be applied to different units as patient treatment areas, inpatient units, outpatient units, intensive care, operative units, mental health treatments, support areas, administrations units, laboratory units and medical imaging units. As for the patient treatment areas, it identifies the recommended organization of space to enhance visual relationship between patient and nursing staff and to guarantee adaptability in the future. Moreover giving examples for different options of unit planning through three different layouts as follows: single corridor, double corridor and combinations:-L, T&Y shaped corridors. Thirdly, outpatient units, in order to provide future modifications, modular spaces and designs lead to creating flexible operational models which can be constructed into current area by the way should allow different utilization during the day. Combined Critical Care can be accommodated for short and medium term intensive care patients, meanwhile at other times, the Unit can be served as other functions. Operation rooms should handle different multifunctional use of space, and also be qualified spaces in order to meet the demands due to improving technology. Mental health consists of groups of patient rooms, in order to provide healing and flexibility to different types of patients, recreational areas should be accessible from each group of rooms. Support areas, introduce how they can be multi-functional and transferred to serve different kinds of functions. Administrative units should be designed more adaptable, creative, mobile and flexible, encouraging the use of scarce resources very properly and supported by developing technology. Medical Imaging Units have to be developed regarding increasing innovation in medical equipment because this technology in this sector has improved irresistible speed. As for the laboratory unit, it introduces how modularity can guarantee better use of areas in terms of expansion or reduction of area.

Flexible Hospital Design Against COVID-19

The current COVID-19 pandemic serves as a stark reminder that lockdown age has affected the way individuals and societies live, perform, and communicate, and that the urban landscape, both outdoor and primarily indoor environments such as dwellings, offices, public buildings, and entertainment centers, must be keep resilience (Capolongo, Gola, Brambilla, Morganti, Mosca & Barach, 2020). However, maybe the healthcare system is the one which is affected the most during this process.

The COVID-19 pandemic has thrown the world’s healthcare networks into disarray. The increase in diseases and sick critically infected patients has put healthcare infrastructures and hospitals to the test, requiring organisations to respond rapidly and adopt emergency management (Capolongo et al., 2020).

COVID-19 created unexpected stress on the healthcare system as it is questioning the capability of hospitals to endure and meet the highly increased demand. Hospitals are critical components of the healthcare system because they provide critical medical care to the public, particularly in times of crisis. They are diverse and fragile organisations that rely on vital external funding and supply chains that run at a high pace and capability with a small margin of error. Even a minor increase in admission volume will drive a hospital beyond its functional potential (Capolongo et al., 2020). Capacities of these structures are often designed to serve a certain amount of bed for patients with a very limited flexibility . However, pandemics like COVID-19 showed that standardized measures taken for future adaptations or transformations in case of need is not enough by itself. There is a need for deep research to understand this issue deeply in order to empirically extract design principles and strategies to be applied for more structured and reliable flexibility parameters for future healthcare facilities through analyzing COVID-19 pandemic and its relation with healthcare.

Healthcare facilities struggled to satisfy an unprecedented and unforeseen request for emergency care and Intensive Care Unit (ICU) beds for contagious COVID-19 and diseases in a comparatively short amount of time. The need for COVID-19 beds in emergency room departments around the world has skyrocketed, leading healthcare institutions to introduce contingency capacity steps such as improvements to emergency care settings, staffing limitations, and equipment constraints in order to increase access without sacrificing patient care efficiency (Capolongo et al., 2020).

In a relatively short period of time, hospitals failed to meet an enormous and unexpected demand for emergency care and ICU beds for infectious COVID-19 and diseases. The need for COVID-19 beds in acute care departments around the world has risen dramatically, prompting healthcare organizations to implement contingency capacity measures such as changes to emergency care environments, manpower limits, and supply shortages in order to expand availability without compromising medical care quality

Although COVID-19 posed a problem for healthcare facilities and the built environment outside of hospitals, organisations inside traditional healthcare facilities had to cope with two main issues. The first is to treat people with serious symptoms while still preventing the infection from spreading between patients, visitors, and healthcare staff. To fix the first problem, hotels, trade centers, and city parks were immediately turned into modern hospital spaces, unveiling a slew of institutional and safety problems that can be summed up by the structural difficulty of “detaching” a part like ICUs from the rest of the hospital. As a result, a substantial portion of the COVID-19-related operations were planned “on-site,” with ad-hoc and highly diverse strategies customized to the unique needs of each hospital, department (Capolongo et al., 2020).

In fact, it is estimated that more than two thirds of the healthcare real estate has reached the end of its life cycle and more than half is not adapted to the new organizational models and epidemiological demands (Capolongo et al., 2020). General state of obsolescence and rigidity has greatly contributed to the management challenges of this particular pandemic. Therefore, future hospitals would need to be adaptable to change, capable of protecting the health of a diverse range of patients, and capable of meeting the changing social, economic, environmental, and epidemiological needs of the communities in which they are situated. In such a situation, several design and managing strategies derived from current discussions and practical cases should be taken into consideration for resilient healthcare facilities.

Strategic Site Selection

Capolongo et al. (2020) states that the hospital is a significant feature of the urban context for a variety of reasons, including the need to accommodate a large number of users and guests, the size of the facility, and the financial supply chain. As a result, hospital location is a critical issue in design decision-making phases that influences the natural, social, and economic viability of healthcare systems as well as the quality of healthcare services. In recent times, healthcare developments have emphasized the importance of localization in the city's central areas; nevertheless, past and current events, particularly in the sense of an infectious outbreak, are questioning this pattern. Indeed, owing to the lack of accessibility expansion relative to the institutions' place in a crowded city centre, the opportunity to alter hospital areas or spread them outward has been often restricted. Understanding from prior pandemic management, the positioning of the post-COVID hospital near city limits will ensure both the restriction of flows beyond metropolitan areas, as well as the control of potential infection threats in large high-density city centers and connectivity from metropolitan areas. Around the same moment, a good geographic position offers the chance to expand to areas around the healthcare structure. Central areas, in other respects, would have regional hospitals capable of providing first-floor healthcare, as well as prevention and health promotion at the neighborhood level.

Infection Control by Typology Configuration

Hospital architecture typology variations are now distinguished mostly by horizontal layouts. This setting means that in an emergency, parts of the facility will be organized without affecting the whole layout of flows and routes. Treatment areas for infected patients should be separated by defined path separations, reducing cross-contamination and minimizing the use of vertical and horizontal links for different spaces, in order to ensure efficient emergency response. As a result, a hybrid typological arrangement with a central part attached to support pavilions may be a logical option with designated connections for emergency and logistics vehicles. In the event of a contagious emergency, the structures' independence or the provision of automated internal units cause various functional spaces to be isolated from the rest of the healthcare system without affecting regular operations. Providing outdoor areas around the healthcare facility area is often appropriate for accommodating portable structures such as tents, tensile structures, or other modular solutions to ensure the link to the facility and the relationship to emergency and services vehicle driveways (Capolongo et al., 2020).

Resilience Tools: Flexibility and Future-Proofing Methods

Resilience is one of the most critical obstacles that hospital systems must overcome in relation to healthcare emergency demands that can occur and vanish at any moment. Flexibility is an important factor to include in the healthcare facility construction phase, from the total project structure to individual functional and environmental components, in order to provide successful emergency response. If necessary, the hospital will extend the emergency department's capability as well as the amount of isolation rooms, **negative pressure rooms** that allow to reduce the risk of highly contaminated infections in the air throughout normal operations. Each space has a negative pressure in comparison to the exterior hallway, allowing air to circulate from the corridor into the room and out of the hospital due to the use of HEPA filters (Capolongo et al., 2020) (see Figure 3.10).

The existence of "lung" areas which correspond to **shell spaces**, empty and support areas among numerous lots and departments to allow for extensions, reorganizations, or isolation areas. Non-sanitary hospitals are conveniently transformable and can be outfitted at a low cost. For example, underground parking garages can be turned into a hospital with a high amount of beds after a conflict, or portable sports facilities can be reorganized. As a result, direct internal ties with the rest of the organization are needed to serve these regions. As a result, direct internal links with the rest of the hospital, as well as external connections with ambulances, are necessary (Capolongo et al., 2020).

Hospitals were required to implement a number of cross-cutting measures, including the establishment of buffer zones in **soft spaces** like between wards, the separation of infected and non-contaminated areas, and the transformation of acute care spaces (i.e., spaces already fitted with advanced systems such as suction, oxygen, negative pressure, and other advanced systems) beginning with operating rooms; establishing designated decontamination areas for healthcare staff for donning and doffing of personal protective equipment (PPE).

The use of **prefabricated blocks** was selected as a representation of how building progress can influence healthcare processes. Countless temporary designs have been proposed by designers all over the world, including tanks, inflatable systems, tent frames, modules, partition panels, and ships.

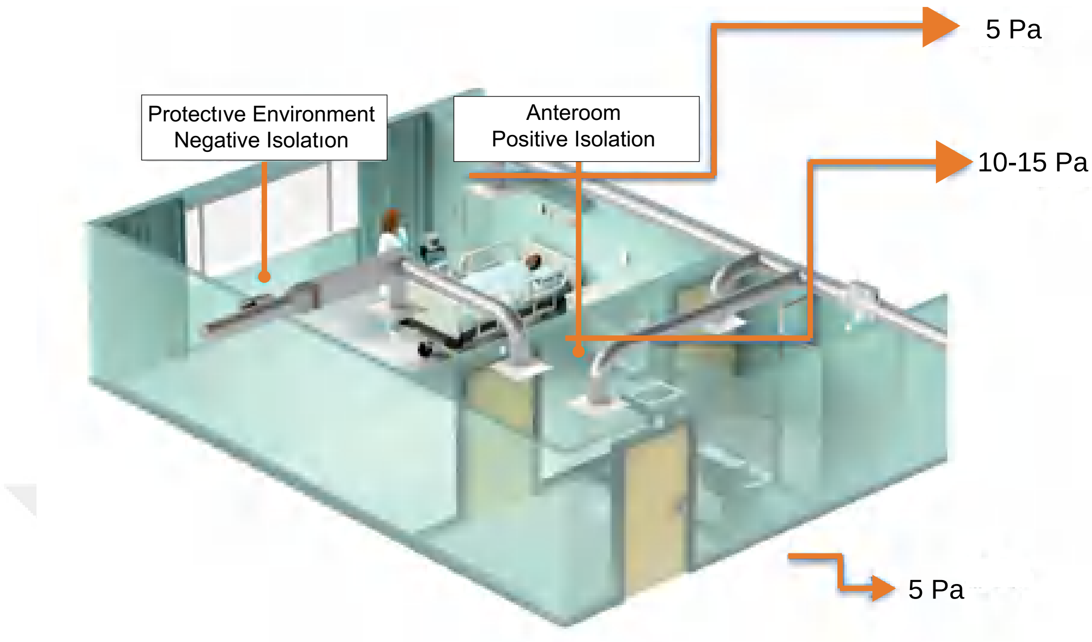


Figure 3.10: Negative Pressure Rooms
(Source: https://www.temizoda.org.tr/tr/makale/izolasyon-odalari-ve-tasimasi-gereken-ozellikler-83)

Management of Functional Programs, Access, and Flows

According to Capolongo et al. (2020), key element in emergency management is **separation of entrances and routes.** Around the same time, the emergency room must care for patients who have a potential infection while still managing all non-infectious patients and keeping them apart from the entry. As a result, two distinct entrances with separate directions and waiting and patient areas are suggested to differentiate ill patients by dedicated triage. Multiple decontamination areas for ambulances must be established outside, as well as spaces for the preparation of pre-triage tents. In the case of an incident, delivery is one of the most critical things to address within the functioning program.Staff access, as well as visitor access that are not led to the emergency room, must be separate. Flows that are usually distinguished by users and health staff must be able to be more isolated in the event of a contagious emergency, in order to split the movements of patients with potential or known illness by all users. Identifiable signs would effectively show temporary improvements in hospital routes in this respect.

Discussing **distribution of units** issue, the close link between the emergency room and the infectious disease wards necessitates a rapid connection for patient and healthcare worker movement. As a consequence, both spaces can be on the same floor, facilitating quick and horizontal links. The intensive care unit is one of the most impacted, necessitating the installation of extra filter areas for the fitting and undressing of healthcare staff. To limit personnel contact and the use of mobile diagnostic devices, segregated working areas from the main treatment area are advised (i.e. mobile ultrasound scanner, Point-Of-Care Testing POCT machines, X-ray diagnostics and mobile Computed Tomography CT). The availability of storage areas is often expected, which may contain a large volume of sanitary material, PPE, and hazardous waste in the event of an infectious emergency. Both regular hospital wards must expand the amount of single rooms in order to reduce the risk of nosocomial spread of any infectious agent. This can be accomplished with a series of bed head supports and mechanical plant equipment that enable rooms to be converted into **double rooms** in the event of a patient overflow (Capolongo et al., 2020).

User Centered and Evidence Based Design

To prevent potential disabling scenarios caused by COVID-like overwhelming circumstances, studies on **user-centered design**, and more broadly Universal Design, indicate that emphasis must be placed on the physical, psychological, and social needs of all users throughout stages of the design process. This is particularly true in hospital settings, where factors such as mobility, wayfinding, and convenience have a significant effect on various users (patients, healthcare staff, and visitors) during extreme situations. Inside medical settings, healthcare staff, in particular, exhibit higher-than-normal levels of anxiety, depression, insomnia, and pressure (Capolongo et al., 2020).

During the COVID-19 pandemic, **recharge rooms** for facilities were created, which are distinguished by natural design components that help medical staff to heal from a physically and mentally exhausting transition. These environments are designed to be tailored to the needs of the people, including noises, sights, and smells. The spaces make use of incorporating nature into urban environments - to create spaces with nature (both physical and virtual) out of underutilized hospital areas near intensive care units. In reality, studies have shown that looking at nature will help patients heal faster and minimize nursing anxiety levels (Capolongo et al., 2020).

Health Promotion by Regional Network of Healthcare

A capillary model called **hub & spoke** facilitates population access to care by eliminating patient movements throughout the territory, minimizing emergency room overpopulation, and mitigating hospital-based cross-contamination between patients and healthcare workers. For meeting the needs of disadvantaged users, these healthcare facilities should be designed as an interconnected hub between healthcare providers, healthcare and social programs, as well as NGOs and charitable organisations (Capolongo et al., 2020).

In the event of a healthcare emergency, the utilization and deployment of healthcare technologies for the smart hospital, as well as **telemedicine** services, will effectively assist and improve the health network and the tracking of users' health status (Capolongo et al., 2020).

Improved Quality of Care

Easy visual guides, wayfinding techniques, and interface nudges will help to prevent infection spread by specifically identifying danger zones, providing “mental anchors” for individual behaviors, and thereby decreasing mental stress and helping to match actions with the procedures to be practiced. Several healthcare services, for instance, have included tactile cues for guests and users to demonstrate the location of high-risk functional spaces and contagious impatient wards. Furthermore, several hospitals developed “pods” for low-acuity patients in order to ensure **patient safety**. Several facilities used techniques such as sticky tape on the floor, signage, and sign boards on the entrance that were strategically placed with annotations with special labels. They were created to minimize the risk of infection by removing the patient from the instruments that needed to be washed, minimizing the chance of contamination (Capolongo et al., 2020).

Indoor Air Quality and HVAC

Air quality in enclosed spaces is well recognized to play a direct or indirect role in mitigation, especially in areas with vulnerable individuals. The condition of indoor air (IAQ) is influenced not only by the outside air, but also by the existence of indoor sources that emit toxins that can alter the quality of the air. As a result, proper air circulation in all conditions must be achieved by technical and, where possible, mixed **ventilation systems**. It plays a vital role in ensuring effective treatment in the event of an emergency, including contagious diseases, but their service must be able to respond to a range of healthcare requirements in all circumstances, notably in emergency cases where air may be a source of infection diffusion. Heating, ventilation, and air conditioning (HVAC) systems must be adaptable, with the ability to change the type of air used (from recirculation to all-air systems) and the pressure applied (from positive to negative). Furthermore, with the use of advanced fabrics, their routine and consistent servicing, sanitation, and disinfection become strategic. As a result, next generation systems need to be equipped with solutions that allow for quick inspection and interference (Capolongo et al., 2020).

Innovative Finishing Materials and Furniture

Capolongo et. al. (2020) asserts that in relation to medical requirements, it is important to use high-performance, long-lasting, and easy-to-clean products in conjunction with monitoring and risk control practices. Innovative materials, such as eco-active and photocatalytic paints, must be incorporated to reduce the bacterial (and viral) load on finishing surfaces. They must also be distinguished by high efficiency and versatility in operation. It’s also important to look at and consider alternatives that have been used in emergency situations, such as washable textile products. Their use could be generalized to other sanitary places for social isolation, and they could be quickly washed, replaced, and/or removed in the event of a need, maintaining the spaces’ flexibility and durability. In addition to implementing best ventilation practices, cleaning items must be selected in relation to the finishing materials and furnishings in the environmental unit, taking into account the unique characteristics of each floor.

Digital Healthcare Technology

Both in the hospital and through the territorial healthcare network, emerging digital innovations will help patients' recovery and care processes. It can be used not only for routine medical procedures, but also in the event of an emergency. In reality, constant monitoring of health status and vital parameters through IT systems such as smartphones or wearable devices will ensure improved hospitalization management and, as a result, a more effective organization of medical settings. Furthermore, modular planning and prediction of Intensive Care Unit (ICU) and ordinary bed occupancy, both inside the same facility and through the territorial hospital network, will help - in real time - the potential redirection of ambulances to the most suitable healthcare facility. Moreover, constant monitoring and technical innovation provided for the remote use of certain electro-medical devices, reduces interaction with (infected) patients and hospital personnel and ensuring total control and resource efficiency. In addition, the patient will have a customized and committed experience for each patient by measuring their level of comfort and happiness using sensors and software linked to the Internet of Things. Finally, by significantly reducing paper-based health and institutional work by digital transformation, storage facilities and libraries may be repurposed for other purposes, such as computer rooms. All medical procedures that can be handled without human presence will be carried out in the near future by automated technologies, and healthcare providers will be able to properly monitor patients' personal records, ensuring that people at risk are better protected by personalized treatment routes. Rather than ever before, the new healthcare infrastructure is a "life saver," an engine in health, and a clear drop in healthcare costs (Capolongo et al., 2020) (see Figure 3.11 & 3.12).

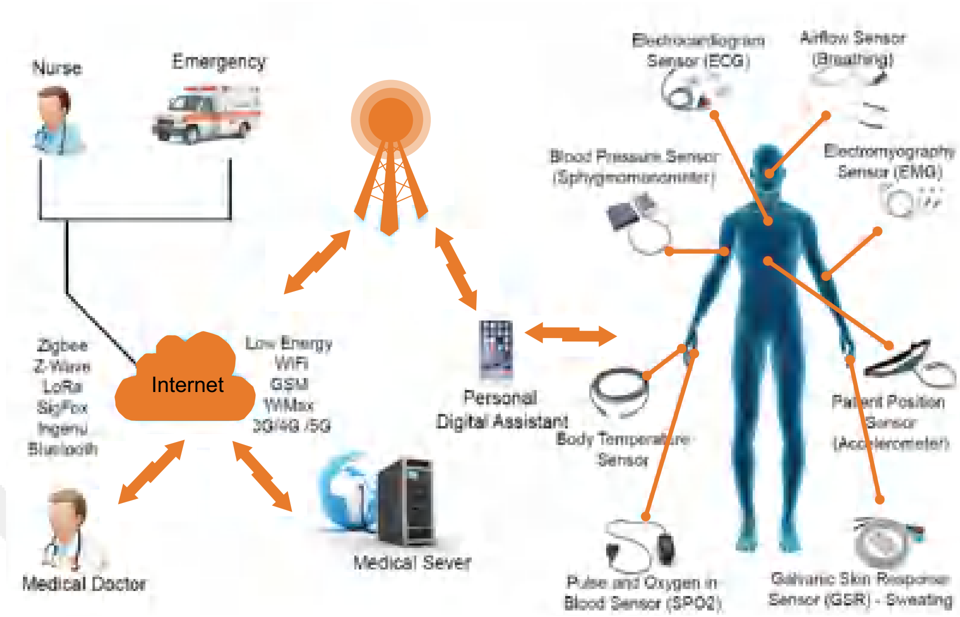


Figure 3.11: Illustration of an Architecture for Remote Healthcare Monitoring System
(Source: Rodrigues (2018), edited by author)

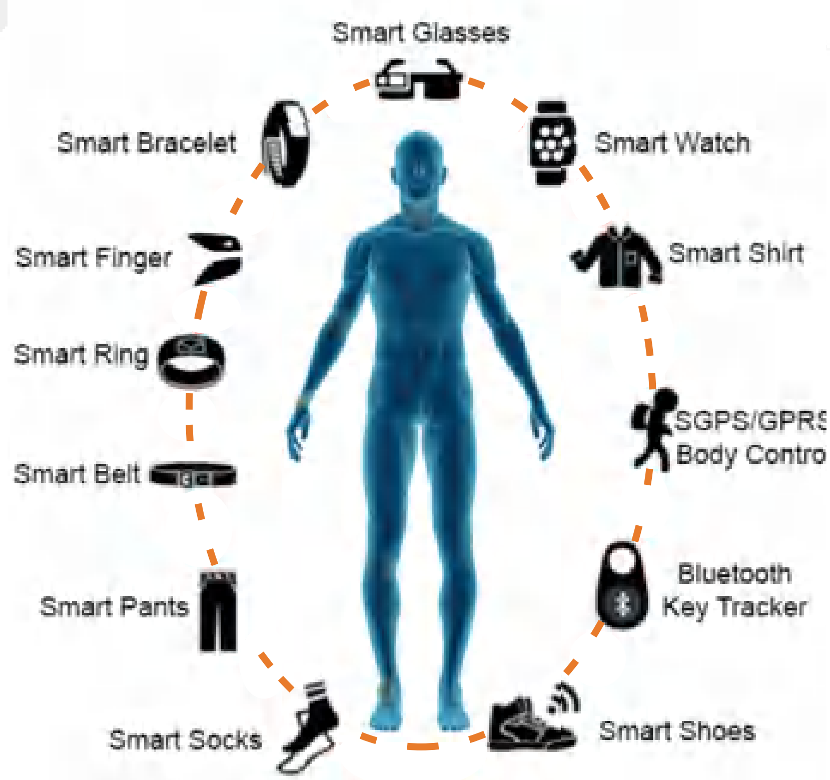


Figure 3.12: Different Types of Wearable Technology
(Source: Rodrigues (2018), edited by author)

A Resilient Investment Model: Public-Private Partnership

Improvement in Primary and Secondary care system's Integration

Maybe one of the most frequently cited PPPs in the literature for health care, this plan is known as "the model of Alzira." It brings the benefits of a decade-long track record as a framework for other PPPs that highlights the need for flexibility and continuous analysis. At least 20 other PPPs, a combination of infrastructure and clinical support programs, have been completed in Spain since the completion of the EUR 75 million Alzira hospital. "Adjusting responsibilities to demand changes is not a question of infrastructure, but a cultural change, and the work system between the board of directors and the professional staff in hospital and primary care" said de Rosa, director of Alzira. In order to become a 'flat' organisation, a new culture among professionals was necessary. The goal is to provide people with the best healthcare services, the best technology, the best efficiency, and the best amenities.

There are several lessons to be learned from this case. The city's residents have the luxury of visiting any doctor in the region, with their catchment hospital paying for 100% of the cost anytime it happens. Alternatively, the manager only saves 85 percent of the expense while outside patients visit the Alzira hospital. In order to retain patient confidence, there is a powerful opportunity to offer high quality care. The other issue is that it is important to provide flexibility and clarity. The partnership was on the edge of collapse in 2003, so the deal was revised in two key respects. First, the deal was originally exclusively for hospital services, but was renegotiated to cover primary care. This underlines the value of rewards being organized. The hospital director will minimize unnecessary visits to the hospital by handling primary care. Secondly, the government originally agreed to pay the hospital a capitalized rate which, with general inflation, rose annually. Health expenses were, however, rising at two to three percent above the rate of inflation. The deal was then renegotiated to raise compensation in accordance with the pace of medical inflation (PWC, 2010).

Reaction of PPP Model During COVID-19

PPP is not a long-term issue in the healthcare sector. There is barely new scientific data for consequences of this model's experience in healthcare. However, the constantly changing world's healthcare agenda is currently facing an emergency called COVID-19. This situation puts PPP' resilience, flexibility and feasibility into another test against harsh conditions of pandemic.

According to Baxter & Casady (2020), both humanitarian and (un)conventional PPP strategies have value in global public health, based on their legal status, epidemic focus, or industry focus. Governments have always "been tempted to involve themselves in long-term arrangements for the provision and maintenance of health-care structures, under distinct arrangement structures" including such stand-alone facilities, nursing programs, or other hybrid models, according to Cruz and Marques. The three most popular PPP marketing strategies in healthcare, according to Abuzaineh et al., are:

1. infrastructure-based models—i.e., construction and/or refurbishing public healthcare infrastructure;
2. discrete Clinical Services models—i.e., integrating or extending clinical service delivery capacity;
3. integrated PPP models—i.e., bundled packages of both infrastructure and clinical services

Since the lack of epidemics is widely viewed as a global public benefit that is "not exclusive to a single geographic area or population, but spreads globally," To combat global health risks including such epidemics, federal bodies, non-governmental organizations (NGOs), nonprofit organizations, research institutions, pharmaceutical firms, and other private firms have regularly collaborated using these models. Since the expenses of global public health (e.g., drug/vaccine R&D, hospital/healthcare delivery, medical product procurement, etc.) are so high, this public-private partnership is important. As a result, private engagement aids in "closing the financial gap" while also "maybe improving the result standard thanks to better technological or science expertise." We are now seeing this partnership in real-time in the COVID-19 period (Baxter & Casady, 2020).

For weeks, months, or years, the virus's economic effects on PPPs would put a huge burden on project partners, consumers, the private business sector, and the public sector. Perhaps the most frustrating element is not learning. Failure of PPP programs should be avoided at all costs. It is important that the private sector recognizes that if concerns occur, they can contact their public-sector stakeholders and share project effects without fear of backlash if they are singled out for blame. It is also critical that rehabilitation strategies be aligned with national policy goals. Tactical recovery strategies would prioritize a win-win recovery approach that considers both public and private sector requirements. Steps to recognize gaps, assess the extent of project effects, track threats, incorporate constructive risk assessment, and identify voluntary and necessary recovery initiatives must be taken right away. This involves working with all partners to strengthen rehabilitation efforts. Meanwhile, genuinely sustainable and resilient PPPs should be promoted to help **minimize the risk of the coronavirus** on vulnerable populations and those already dealing with it. Failure of partners, both public and private, to unite around the rehabilitation of PPPs infected by the coronavirus is not a choice, since many people rely on these infrastructure and amenities to live economically sustainable lives (World Bank, 2020).

Lessons Learned From Pandemic

Sustainable PPPs necessitate the diligent development of effective governance processes, conflict-of-interest policies, and time spent learning about stakeholder views and constraints. There is a serious lack of examinations, personal protection devices, and breathing apparatus in the southern hemisphere in particular. This shows why people could fear private-sector involvement due to a lack of successful alliances prior to the pandemic. To more effectively solve global health challenges, Sy stated that an enabling climate composed of the government, the business sector, and numerous private stakeholders that is guided by modesty and resilience is required. With effective leadership and governance, a forum of global unity could begin to solve questions of equal access to goods and products. For successful pandemic planning and response, Diara stated that a single sector or agency cannot handle a global health problem by itself: the public sector, private sector, and local communities must all collaborate together within the context of the International Health Regulations and global health security (National Academies of Sciences, Engineering, and Medicine, 2020).

Seven disease outbreak preparedness and reaction lessons presented:

1.Schedule ahead of time, rather than waiting until the next crisis occurs;
2.Concentrate on reducing risk and contingency readiness for potential economic disturbances
3.Invest in cross-sectoral solutions
4.Ensure the long-term stability of health-care programs by making them more robust
5.Collaborate with organizations to close the gap between proposals and implementation
6.Prioritize cooperation to guarantee that a response is prompt, reliable, fair, and long-lasting
7.To create trust and encourage long-term commitment, invest in openness, governance, and accountability mechanisms (NASEM, 2020).

A Diverse Approach

At this crucial juncture, formal public-private collaborations are required to coordinate the activities of various actors**.** However, if concrete priorities are developed strongly, it would be possible to utilize the strengths of both the public and private sectors to overcome the existing weaknesses and threats we are experiencing. Unfortunately, we are informed on a regular basis of the complex nature of healthcare and the various problems that must be tackled urgently in order to enhance its resilience and long-term viability. This involves, for example, overloaded supply chains such as protective clothing, surgical instruments, etc., a lack of service ability like labs/testing, hospital beds, emergency vehicles etc., and a lack of healthcare professionals. Recent events have shown that the healthcare services of the majority of countries are not robust due to a lack of convergence. We face an extremely destructive breakdown in the face of the new virus's onslaught if the durability of facilities, resources, and healthcare systems is not resolved urgently by sustainability solutions. Agreements between the public and private sectors that resolve short-, mid-, and long-term issues are important. Future coronavirus pandemics, which many epidemiologists assume will become more widespread, will undoubtedly necessitate the development of long-term preventive strategies (Baxter & Casady, 2020).

PPP Strategy Components

Baxter & Casady (2020) states that short, medium, and long-term stages of intervention should be considered by implementers of a PPP-supported **recovery plan.** Short-term interventions (0–12 months) would be reactive and volatile by default, while medium-term initiatives (1–5 years) would require more proactive, formalized growth and adaptation plans. These enterprises will eventually extend to multinational settings in the long run (5+ years). Furthermore, “strong government leadership consensus for partnerships, a desirable policy habitat, and adequate operational capability are necessary variables for them to be implemented successfully. As a result, the longer the PPP’s desired dedication, the more formalized the public-private partnership must be to guarantee its long-term viability. Furthermore, these collaborations should take a **People First PPP** approach, which aligns long-term, people-centered healthcare policies with country-specific Sustainable Development Goals (SDGs).

Proposed healthcare PPP projects will require the cooperation of effective regulatory frameworks, demand reliability, and political and social will to accomplish their long-term targets after meeting urgent short-term demands for PPE, medical equipment, healthcare staff, and scalable surge capability.This will also necessitate good government management and operational capability to procure PPPs that optimize creativity, **cost effectiveness,** value for money, and value for citizens in a sustainable and open manner. Joint ventures will thus concentrate on developing healthcare-enabling conditions in centralized public healthcare systems, allowing the private sector to act as a backup to national healthcare providers (e.g., private hospitals being incentivized to seamlessly align with national systems in a time of crises). Joint ventures in integrated healthcare environments, on the other hand, will aim to increase **resource sharing** quality and fairness through networks with diverse health roles, funding processes, service management, human capital, and governance functions (Baxter & Casady, 2020).

Discussion of the Results from Literature Review

This chapter is classified and interpreted under 9 main design approaches taking into account different variations of flexibility, situations and guidelines. Those are Site planning, Technological Adaptability, Patient Centered, Flexibility Concept, Spatial Design Strategies, Functionality, Distribution, COVID-19,Digital Innovation in Healthcare and PPP Investment Model.

Site planning: The hospital complex’s architecture and development should take into account potential growth, whether by leaving it a vacant field to expand in the future, or by constructing but leaving unoccupied areas, or by designing the construction in such a way that horizontal and vertical future expansion of the building is possible.

Technological Adaptability: Hospital buildings contain many different technological equipment and these innovative equipment contain multi-functioning together with constantly developing technology. Since healthcare structures are expected to keep up with this developing technology, they should be designed with building elements such as movable partition walls and dry walls etc., that take adaptability criteria into consideration.

Standardization Concept: Healthcare structures need to adapt not only to the conditions of today, but also to future conditions, recommended design strategies such as international healthcare guidelines are used to incorporate or apply these principles in healthcare structures. The design of the different types of areas in the hospital within a defined standardization both reduces the confusion and the problems to occur and increases the quality of the spaces. At the same time, it makes it easy for the spaces to be transformed into each other when needed.

Design Strategies: In case of a possible growth or expansion in hospital structures, it is important that the horizontal and vertical service shafts or circulation elements are continuous without interruption. The floor heights and the carrier system must also be designed accordingly in order not to create any difficulties or obstacles.

Functionality: The most important indicators of the flexibility criterion in healthcare structures are that the spaces serve different functions at different times of the day without requiring any external intervention, they can easily respond to situations requiring excessive capacity, and that these spaces include easily adaptable furnitures and equipment.

Distribution: The distribution of rooms or units within the structure allows the user and equipment to move easily and comfortably. The fact that the spaces are large enough not only facilitates normal use but also facilitates adaptability in emergency situations such as pandemic. In such extraordinary situations, there is more patient flow and equipment usage than the capacity of healthcare facilities. In these cases, these structures should keep working without interruption.

Digital Innovation in Healthcare: Apart from physical environment and aspects, innovations in the healthcare industry, such as various wearables or smartphones, greatly control the spread of infection in extreme situations such as a pandemic. These innovations minimize the interaction between healthcare professionals and patients, reduce the risk of infection spread, and at the same time reduce the time and effort of healthcare professionals because of mobility. Especially in megastructure healthcare facilities with great potential of congestion and interaction by a large number of actors and components, the importance of such systems is taken to a higher level .

COVID-19: In addition to their normal operations, healthcare facilities should be prepared for all kinds of extraordinary situations. COVID-19 is an event that the whole world has been struggling recently and has upended the healthcare industry. In particular, designers, governments and operators have important responsibilities in terms of how to design and operate healthcare buildings according to changing needs since there is a lot of congestion on healthcare structures in a pandemic period. Taking lessons from this situation, healthcare facilities have to be designed for innovative, patient centered, easy to use.

PPP Investment Model: In the current period, the importance of the PPP investment model applied in the health sector has been understood to a great extent during the emerging pandemic. There has been an increased demand for the supply of all kinds of healthcare equipment, such as masks, medical gloves or vaccines, by private investor stakeholders. In addition, the necessity of ensuring the principles for increasing the flexibility and quality of the structure by international associations during both the design and implementation of the health structure should be a prerequisite for implementing the PPP investment model. Moreover, it is an investment model that helps optimize design decisions while stabilizing and reducing risk factors since several stakeholders from different fields take part in the process.

NEW KAROLINSKA UNIVERSITY HOSPITAL

Location
Stockholm, Sweden
Client
Stockholm County Council
Year
2010-2017
Collaborators
White Architects & Skanska Teknik/Ramböll
Area
276,000 square meter
Budget
$1,808,000,000

3.2 The Best Practices of PPP Model Applied to Healthcare Facilities in Europe

Sweden: Context and Cases

Role of PPP investment model

With a net budget of $3.0 billion (including $1.6 billion for construction), the New Karolinska Solna (NKS) Hospital initiative is known as one of the world's biggest public-private partnerships. The hospital is being designed by a consortium led by Skanska and Innisfree, a UK infrastructure investment company that has worked on a variety of British healthcare initiatives (Building, 2014). The Stockholm City Council (SCC) has signed a contract with Swedish Hospital Partners, a joint partnership between Skanska Infrastructure Development and the UK pension fund Innisfree, for the planning, building, funding, renovation, and service of the new hospital until 2040 (possibly even extending the contract until 2055). Swedish Hospital Partners, in exchange, contracted Skanska Healthcare to construct the hospital and Coor Service Management to operate the hospital (The Boston Consulting Group, 2017). Several major contract adjustments were done during the final talks between SCC and Skanska and Innisfree, substantially raising costs. The contract, as initially conceived, was broken down into over a hundred additional contracts over and above the main contract. These included, for example, work related to construction of the laboratory, offices for the administration, medical equipment and the telecommunication system (People's Health Movement, Medact, Third World Network, Health Poverty Action, Medico International & ALAMES, 2017).

The Stockholm City Council is responsible for health treatment and anything directly connected to it, such as healthcare products procurement. Skanska professionals from a number of countries (including the United Kingdom, the United States, Norway, and Poland) have contributed their BIM project expertise to the NKS project, and will certainly impact a reverse data transmission in the future, contributing their NKS skills to other Skanska ventures (The Boston Consulting Group, 2017).

Reduced building lifecycle expenses is a serious issue for the building sector overall. The rationale for using a PPP was that it was felt that the possibility of failures and higher prices would be lowered if these risks were moved to the "The PPP procedure offered an extremely comprehensive agreement laid down in very exact detail - such as with products - what was and wasn't suitable (Building, 2014). The hospital public-private partnership is operating under challenging conditions, along with a short timetable, strong public pressure, and the continuing presence of the old hospital, and it must be adaptable enough to meet potential healthcare developments The Boston Consulting Group, 2017).

In public-private partnerships, this practice of deliberately removing portions of the original arrangement and establishing new arrangements is a well-known ploy. Costs escalate with each new contract in a traditional PPP, and the process becomes less transparent. In the example of the Karolinska hospital, the negotiation council members and officials had very limited capacity to examine Skanska's calculations, making it difficult to discuss better terms. Members of the SCC began to understand that the proposal could not be financially feasible shortly after the contract was signed. After examining many cutting-edge technology hospitals in Europe, the committee found that the hospital's estimated expense was considerably higher than comparable projects in several other European countries while comparable projects in Denmark and Norway cost about 20,000–30,000 SEK (approximately US$ 2500–3500) per square meter. The cost at New Karolinska was calculated to be 46,000 SEK (US$ 5,000)(Ennart and Mellgren, 2016, p. 138–139). As a result of these issues, McKinsey was employed in 2012 to examine at the project's exorbitant costs. Surprisingly, McKinsey proposed deferring at least a quarter of expected improvements in other public hospitals to offset the Karolinska hospital's high public expenses. It will suggest that the immediate necessity of additional beds in these hospitals would be overlooked (Ennart & Mellgren, 2016 as cited in People's Health Movement et al., 2017).

General Architectural Background

The contemporary healthcare complex at the Karolinska University Hospital in Solna, Stockholm, is known as New karolinska Solna (NKS). The New Karolinska Solna will be a cutting-edge facility with the aim of gaining high-quality, highly advanced patient services, as well as academic training and testing on a wide scale. In 2016, the new Karolinska University Hospital accepted its first patients, and it was completely started to operation in the fall of 2017.

The most critical issues factor for the new University hospital is "patient always first," which is mirrored in the hospital's architecture and planning, and is focused around the patient's needs. The aim is to give the necessary treatment to the appropriate patient at the appropriate time. Single rooms, which will be common for all inpatients, will increase the protection, convenience, autonomy, and dignity of the patients. One of the most critical activities is to optimize coordination between patient care, healthcare study, scientific research, and teaching (at the Karolinska Institute) to strengthen healthcare development such that new research results can be applied easily in medical treatment (see Figure 3.13 & Figure 3.14).

NKS is being designed in compliance with the criteria for obtaining Gold certification in Sweden's Green Building "Miljöbyggnad" framework, which necessitates the use of sustainable solutions in the construction process. The built healthcare facilities will be one of the world's leading university hospitals, having been accredited by the US Green Building Council's Leadership in Energy and Environmental Architecture (LEED) criteria. The New Karolinska University Hospital is well-integrated into the city's new neighborhood. The healthcare facilities are a landmark and they are a vast facility with 9-11 stories and a total area of 320,000 square meters. The building's rectangular configuration is an evolution of the current neighborhood. There are five buildings in the new facility. The academic centres, the current Thorax building, and a modern technical building with internal parking are all situated in the north. Between the research district and the medical district, a green educational promenade will attach the hospital, the Karolinska Institute in the west, and the hospital park. Bridges that pass across the educational green promenade connect the healthcare and science activities (Nya Karolinska Solna, n.d.).

Figure 3.13: New Karolinska Hospital Masterplan
(Source: https://whitearkitekter.com/project/new-karolinska-solna/)

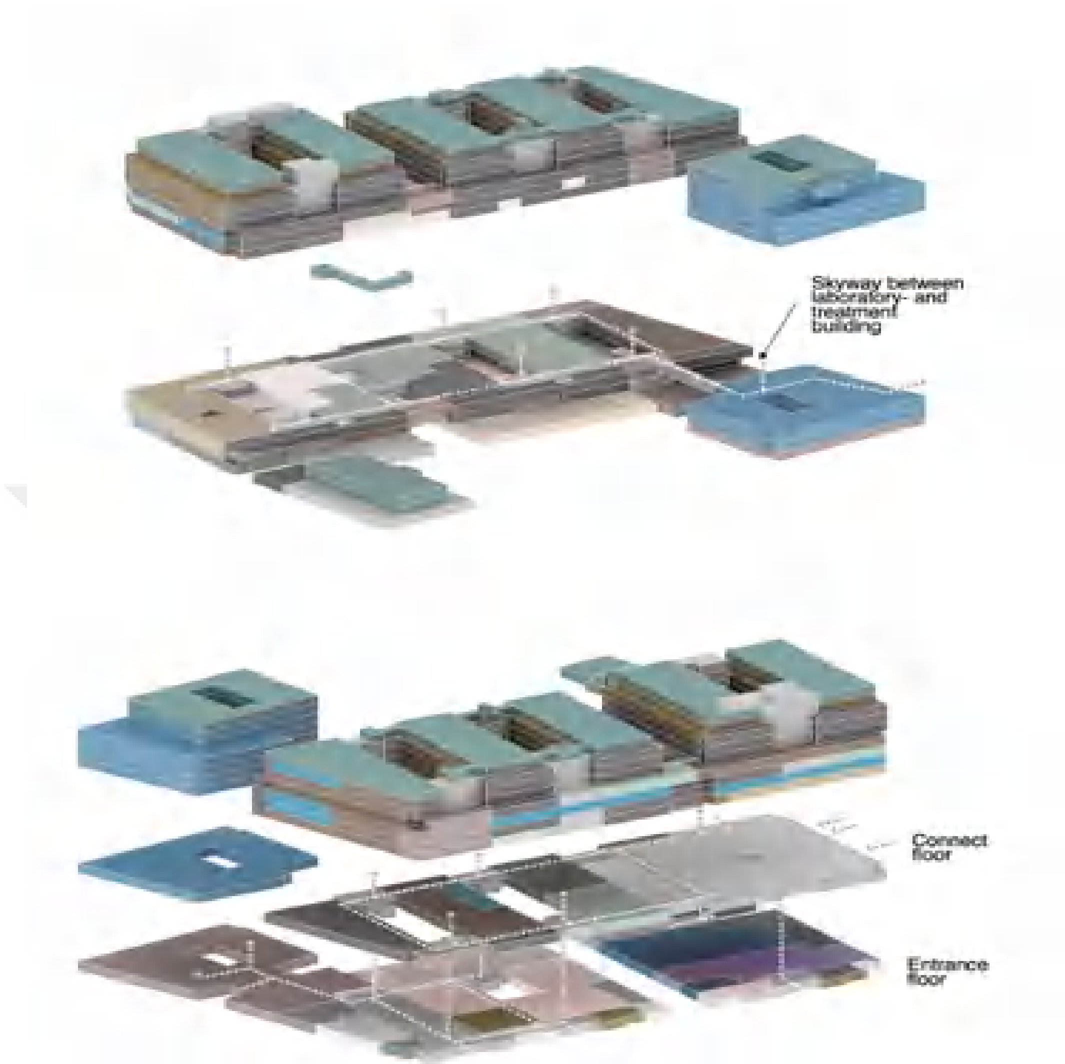


Figure 3.14: New Karolinska Hospital Functional Organization
(Source: https://docplayer.net/21464928-Nya-karolinska-solna.html, edited by author)

Short summary of capacity of NKS

- Around 600 inpatient rooms(400 care rooms, 75 rooms for intensive care, 50 rooms for intermediary care and 75 rooms for post-operative surgery)
- 100 rooms for day care
- 100 rooms in the patient hotel
- 36 fully equipped operating rooms, including three so called hybrid rooms and a number of intervention rooms
- 8 so-called radiation bunkers
- Sufficient space for advanced imaging and functional diagnostics
- Approximately 180 reception rooms

Hospital treatment is structured around particular concepts. To maximize patient flow, roles and events that have intersecting connections, such as surgery and intensive care, or radiology and ambulance, are placed next to each other. The community areas and meeting areas are built in such a way that several events can take place in the same space. The inpatient wards have 28 patient rooms since a ward is housed at the treatment center on each floor. Since support functions are near to the wards, personnel at these support functions provide the appropriate services for patients. Inpatient rooms are single-bed rooms with a reserved place for family members to stay.

Typological-spatial strategies for flexibility

Adaptability for future needs

The clinical configuration of several floors in the NKS buildings means that existing and future types of advanced patient treatment, research, and preparation can be provided without significant renovations. However, construction and planning come first, followed by equipment collection. All is taken into account, including weight, dimensions, heat generation, and vibrations. The NKS hospital is adaptable enough to allow for the interchange of medical product for a shorter life cycle than the building systems. As a result, the facade is planned to be able to be opened up in order to replace massive and heavy devices. One of the main principles in the architecture and planning of NKS is universality and stability, and the healthcare facilities and services are ready for future operations.

Modular design

The NKS hospital makes extensive use of prefabricated modules, which significantly simplifies building work and decreases the amount of transfers needed. Fabricating the modules in a safe manufacturing atmosphere also means that the finished product is of better quality than if they were installed on-site. The modules give you a lot of options when it comes to optimization. The hospital’s sanitary areas, for example, are fully prefabricated in a factory and shipped in enclosed containers that can be quickly lifted and placed.

The classification and configuration of the various functions are dependent on the role that exists in that district, taking into consideration several factors such as the space’s dimensions and place. In order to maximize the spaces devoted to each of these functions, the hospital planners developed a model/prototype for inpatient areas, outpatient areas, labs, surgical rooms, clinics, radiology, and radiotherapy. The functional units include multiple prototypes and multiple functional units form a floor (see Figure 3.15).

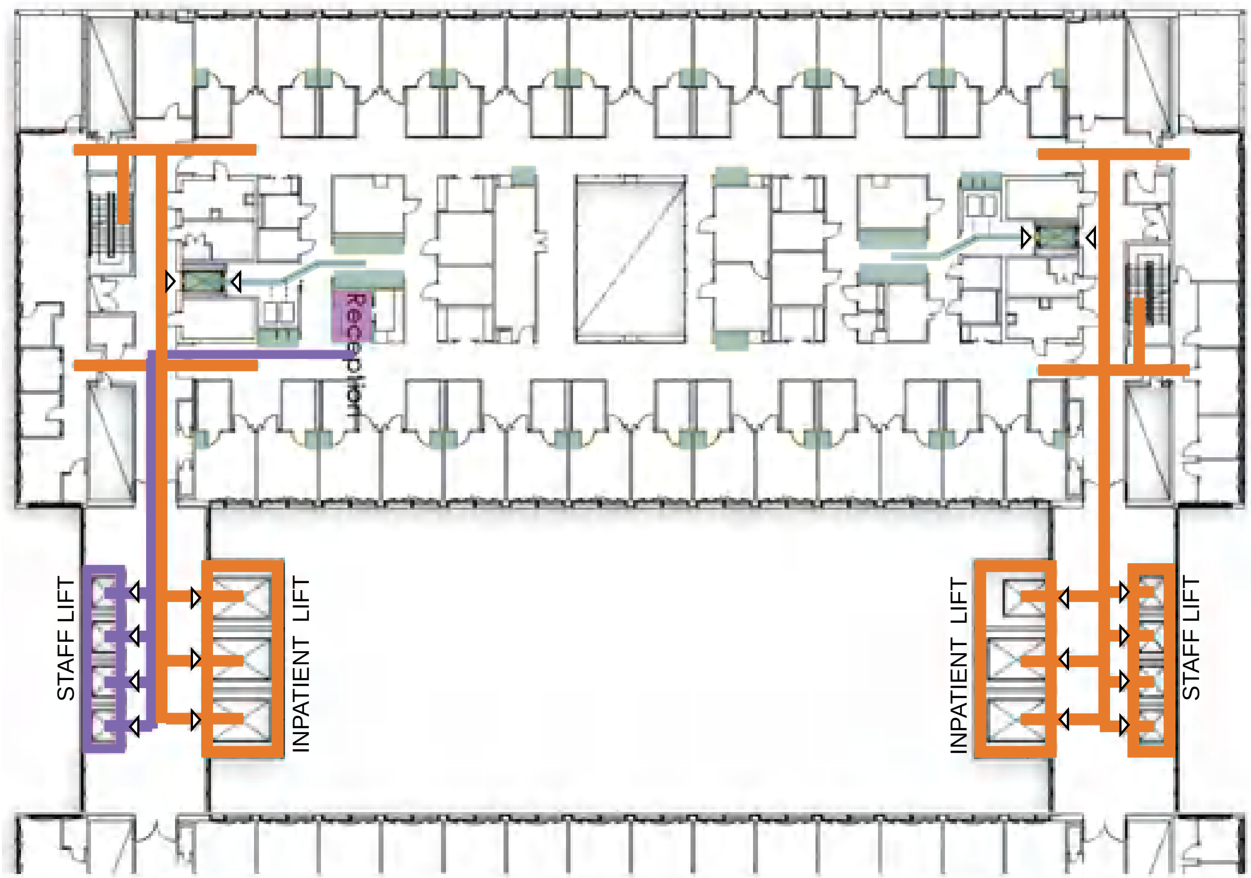


Figure 3.15: New Karolinska Hospital Ward Design
(Source: https://docplayer.net/21464928-Nya-karolinska-solna.html, edited by author)

Care facilities and capacity

In several aspects, the NKS' potential would be comparable to that of today's Karolinska University Hospital in Solna. In certain cases, capability would be better than it is now. This extends, for example, to critical care, specialized neonatal care, and intensive child care, as well as expanded ability for interventional radiological care and advanced surgical treatment, as well as access to advanced imaging and practical diagnostics and other advanced diagnostics.

The NKS will be able to handle much more seriously sick or disabled patients (highly advanced treatment) than is presently available due to the increased number of intensive care and intermediate care units. Meanwhile, the NKS would have less general care units than the Karolinska Hospital in Solna currently has. This will put further needs on the potential for post-acute treatment and recovery. In non-private hospital rooms with several beds, others are empty at certain hours, and men and women patients cannot be situated in the same space. Private hospital rooms in the NKS would allow for more capacity for receiving patients.

Functional Flexibility

All of the floors of the building have the same configuration. The room's dimension and form are determined by the generality principle. As a consequence, the room can handle a number of functions depending on the demand. A standardized floor height, the degree to which floors can handle heavy loads, and technological structures that are designed for expansion are all components related to generality. The NKS has a main kitchen with a lot of flexibility, so it's easy to turn to production kitchens.

Separation of User flow

A clinical design that separates the different flows was chosen, defining borders between outpatient/inpatient care, day/night care, adult/pediatric care and emergency /planned care. In the healthcare house, significant consideration has therefore been taken to ensure that strongly connected functions are situated next to one another. The acute one, for example, should be situated near emergency and ambulance services, as well as surgery and intensive care centers, as well as imaging and practical diagnostics (see Figure 3.16).

Figure 3.16: Patients Flow in Relation to Hospital Functions
(Source: https://docplayer.net/21464928-Nya-karolinska-solna.html, edited by author)

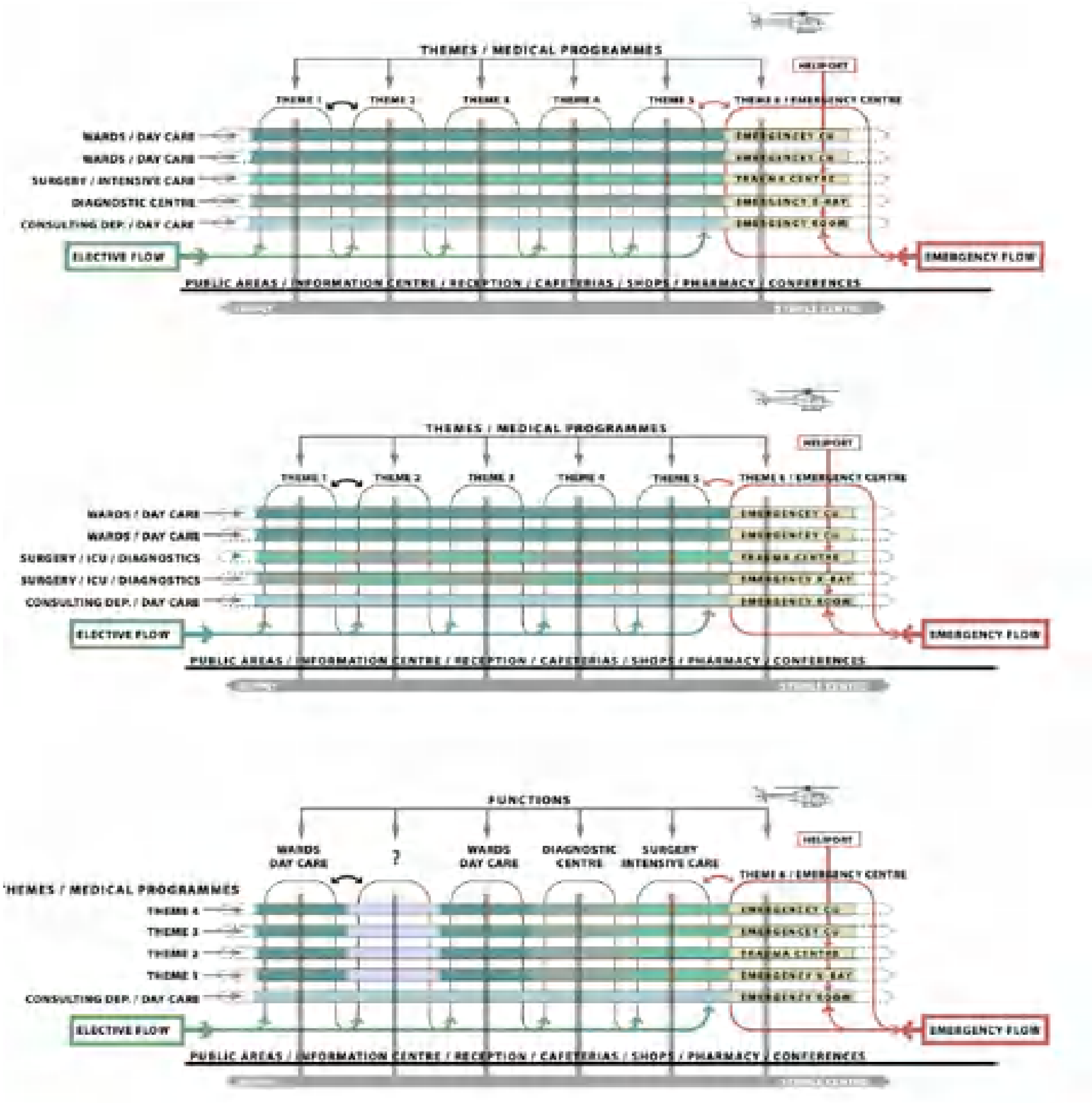


Figure 3.17: New Karolinska Hospital Flexibility Concept Proposals
(Source: Shang (2015), edited by author)

The New Karolinska Solna is one of the world's biggest and most ambitious hospital projects. The hospital was completed in 2017 and offers highly qualified specialist care and a world-class research environment. The objective was to enhance the integration between healthcare, research and education and ensure knowledge transfer between research and healthcare through joint use of resources and skills, which places great demand for how the buildings are planned and designed.

The New Karolinska Solna (NKS) will be a new and super modern University hospital with the mission to carry out highly specialized and specialized medical care as well as research and educational training on a significant scale and at highest quality. The new Karolinska University Hospital will open for the first patients in 2016 and will be completely ready during the fall of 2017. The most important key term for the new University hospital is patients first, which means that the entire planning of the hospital is based on what is best for the patient. The goal is to provide right care to the right patient at the right time. The patients' autonomy, safety, integrity and comfort are fundamental and can be enhanced with single rooms, which will be standard for all inpatients. Proximity, good logistics and less need to transport patients will significantly increase efficiency and safety. An important task is to strengthen collaboration between medical care, clinical research, basic research and training (at the Karolinska Institute) to better contribute to the development of medical care so that new findings from research can be more rapidly be put to use in medical care. The new Karolinska Solna is of utmost importance in the realization of the vision – which is shared by and the industry, academia and medical care - of making the Stockholm region the world's leading region in life sciences. Accordingly, a clinical design that separates the different flows was chosen, defining borders between outpatient/inpatient care, day/night care, adult/pediatric care and emergency /planned care. Great care has also been taken into consideration to assure that closely related functions are located near to each other in the healthcare building.

The new Karolinska Solna University Hospital is expected to be the first university hospital to achieve LEED Gold certification as well as the gold level of the Swedish certification system Miljöklassad Byggnad (environmentally classified building). Energy efficiency will play a major role in the new hospital and is expected to use half the power that the existing university hospital uses. Operated with minimal environmental impact, it is expected to be carbon neutral and utilize durable, recyclable materials based on renewable sources. Advanced lighting controls based on daylighting coming into the building will help save energy and a controlled ventilation system will also help improve indoor air quality. with 99.7% of energy from renewable sources with low CO_2 emissions, its environmental impact is halved, earning it LEED Gold and Miljöbyggnad Guld standard environmental certification – the first hospital to meet both Swedish and international standards.

Adaptability to COVID-19

Suppliers in healthcare have had no alternative but to adapt, and versatility has been critical in doing so. Operating rooms at the New Karolinska University Hospital in Solna have been converted into intensive care units for coronavirus cases (Cousins, 2020).

"Healthcare providers have had no option but to adapt and flexibility has been vital in achieving this. The new Karolinska University Hospital in Solna has had operating theatres turned into intensive care units for coronavirus patients. We designed 23 operating theatres. In Sweden, it has even become a standard now that we locate operating theatres along facades – instead of having the corridors along facades - to bring in the daylight to create a healing environment and attractive working environment for the staff," adds Charlotte Ruben from White Arkitekter."The project was supposed to be open for operating procedures in April, then the pandemic came. These 23 operating theatres were then instead transformed into intensive care units for three patients in each operating theatre. Equipment for surgery – the gases, the monitors and everything - they were taken out. And the equipment that came in was for respirators and intensive care" (DBR Healthcare, n.d.).

According to Cousins (2020), the Huddinge case study is interesting: in just ten days, 23 operating rooms were converted into 64 intensive care units, each with three patients and a light and healthy space. In the wake of the pandemic, this was spectacular activity.

Operating rooms were designed to receive daylight. This situation enabled them to be turned into intensive care units easily as the staff benefit from it psychologically and work long hours. A pleasant working environment is a must for such harsh working conditions during pandemic. Direct contact to outside also creates a decent air flow which is an important issue for especially intensive care units compared to standard patient wards. Information flow was another key point talking about organisational issues like the P22 Supply Chain that allows fast reaction time against any potential lameness (DBR Healthcare, n.d.).

Some architecture elements that proved effective during the highest weeks of the pandemic have been emphasized in our newly commissioned projects in Stockholm – Karolinska University Hospital in Solna and Huddinge Hospital. These qualities involve adaptability, versatility, and compassion, as well as a therapeutic and appealing experience for patients and workers that is long-lasting (Cousins, 2020).

AARHUS UNIVERSITY HOSPITAL

Location
Aarhus, Denmark
Client
Region Mid-Jutland
Year
2007-2020
Collaborators
C.F. Møller Architects, Cubo Architects & Alectia NIRAS A/S
Area
970,000 square meter
Budget
$954,140,000

Denmark: Context and Cases

Role of PPP investment model

A strategic partnership consisting of Pensionskassernes Administration A/S (PKA), Lrernes Pension Ejendomsaktieselskab, and KPC Herning A/S awarded the project competition for Denmark's biggest PPP project to date. Following that, KPC, as the turnkey contractor, signs a technical contract with Wicotec Kirkebjerg to build the New Psychiatric Center PPP project in Skejby, Denmark, north of Aarhus (Aarsleff, 2014). DKK1.3 billion (US$233.6 million) is expected to be spent in the project. For a period of 25 years, the project is made on a design, construct, finance, operation, and maintenance basis. KPC, as the turnkey contractor, has signed a deal for the technical contract with Aarsleff subsidiary Wicotec Kirkebjerg worth DKK282 million (US$50.7 million). The deal includes the entire technical construction of the 50,000-square-metre new building in Skejby, including power, plumbing, ventilation, building automation, and protection services (Infra PPP by IMC Worldwide, 2014).

General Architectural Background

The current Aarhus University Hospital in Skejby will be integrated with the New University Hospital in Aarhus to form a single hospital facility. The hospital will be the size of a Danish regional town, with a traditional town plan with an elevated, heavily built-up center (see Figure 3.18).

The hospital city's total size: 500,000 m²
New construction: 216,000 m², Conversion : 159,000 m² = 375,000 m²
Site: around 970,000 m²
Beds: 797
Dialysis places: 43
Hotel beds: 80

This provides a simple layout of three main elements: a two-storey baseline with care functions; wards rise on the baseline up to four floors; and, in the centre, the coming "Forum" central arrival zone, where public functions are situated at the foot of three multi-floor buildings. As a result, the hospital facility is built as a city, with a hierarchy of quarters, avenues, plazas, and squares as the base for a diverse and innovative green urban center, and it will work as a university hospital, regional hub, and basic hospital for the region's citizens (see Figure 3.19).

This is a building project for Denmark's first super-hospital, an contemporary facility that will be a groundbreaking initiative in the area of "healing architecture" in the healthcare industry, both in Denmark and globally. The idea of "Healing Architecture'' was able to affect each design choice in terms of the architectural composition of the hospital due to the effective use of the “Information and Evidence-Based Design” method. From the general configuration of single-bed wards to the volume of sunshine and its movement in all hospital rooms, to the landscape design and green areas surrounding the hospital facilities, there is a lot to consider. The DNU consultancy group has produced “The Healing Wheel of the Environment,” which acts as the project’s planning basis, based on EBD (see Figure 3.20 & 3.21).

The New University Hospital in Aarhus is known as a state of the art hospital concept in which people are the main focus for construction, which offers an atmosphere that helps patients’ recovery processes and provides strong guiding principles for future healthcare design.

The architecture of Aarhus University Hospital is patient centered with a significant concentration on human scale. The new healthcare center is built to not only promote patient movement inside the facility, but also to ensure that patients can support themselves and remain autonomous. To make it easy for patients and their families to navigate their way around, all aspects of logistics, construction, digital information systems, design, and art have been harmonized.

It was built with the flexibility to meet potential advances in medicine, technology, and working practices. The main priorities are wellness and healing, but science and training, as well as cultural and economic practices, all have an effect on and influence the new healthcare facility.
There is an ongoing conversation on between the New University Hospital in Aarhus, the upcoming buildings, and the local area. The complex’s architecture is simple and easy to comprehend, providing physical accessibility for all of its consumers.

Figure 3.18: Axonometric View of Aarhus University Complex
(Source: https://www.niras.com/projects/new-university-hospital-in-skejby/)

Figure 3.19: Aarhus University Hospital Functions
(Source: https://www.skyfish.com/p/cfmollerarchitects/1407226?predicate=label&direction=desc, edited by author)

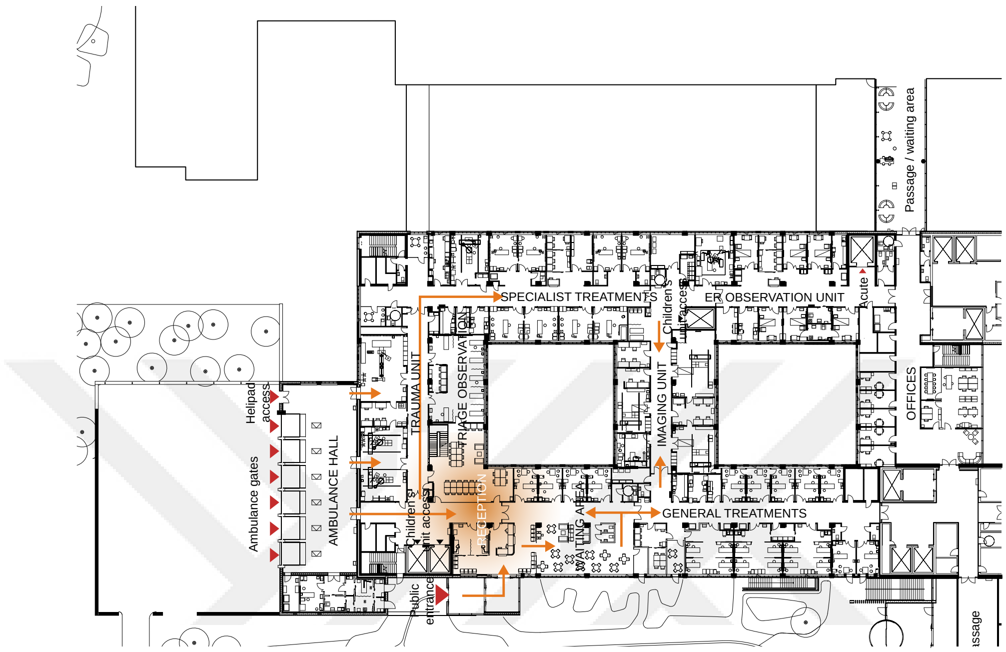


Figure 3.20: Aarhus University Hospital Ground Floor Plan

(Source: https://www.skyfish.com/p/cfmollerarchitects/1407226?predicate=label&direction=desc, edited by author)

Figure 3.21: Aarhus University Hospital Bed Ward Typical Floor

(Source: https://www.skyfish.com/p/cfmollerarchitects/1407226?predicate=label&direction=desc, edited by author)

Typological-spatial strategies for flexibility

Flexibility is a main key aspect within the construction of Aarhus University Hospital. The hospital will be developed with a flexible design that can be restructured, downsized, or extended in the future. The Aarhus University Hospital is the largest hospital construction site in Danish history and serves as the regional hospital for Central Denmark.

A flexible construction

Every third year, it is estimated that approximately ten percent of healthcare complexes around the world experience improvements and regenerations as a result of dramatic developments in healthcare knowledge and technology. Aarhus University Hospital, among other aspects, is designed as a "flexible construction" with a building style that incorporates the entire basic structure, both horizontally and vertically. Surgical wards, bed units, and recovery rooms are also typical examples of contemporary healthcare facilities. As a result, they are facing a major transition during the construction process, creating disruption and discomfort to patients and staff. It would be easier to handle modifications in the future at Aarhus University Hospital without having to shut down wards for an extended period of time. The work to integrate the five hospitals in Aarhus into one University Hospital in Aarhus was a major part of the overall effort.

Three primary elements promoting freedom and flexibility

The New University Hospital in Aarhus is composed of three key components, as previously mentioned. This fundamental structure has a number of benefits. The three components combine to form a highly adaptable structure that enables the foundation to be adjusted to the current facility and staggered hospital expansions to take place in compliance with political and economic conditions. The compact design of the hospital is therefore carefully balanced against decentralized factors that prefer local conditions and assist in breaking down the large scale.

BRISTOL SOUTHMEAD HOSPITAL

Location
Bristol,UK
Client
North Bristol NHS Trust
Year
2014 - 2018
Collaborators
Carillion/BDP
Area
114.000 m² square meter
Budget
£ 600,000,000

England: Context and Cases

Role of PPP investment model

The new Southmead Hospital, located in Southmead, North Bristol, is one of the country's biggest and most ambitious PPP healthcare projects, including the design, funding, maintenance, and management of an 832-bed, state-of-the-art complex (PFI, 2010). Carillion and Lloyds Bank's Hospital Company (Southmead) has a deal worth £600 million throughout 35 years and 4 months (including the building phase), which covers £430 million in construction services and £170 million in facility management and repair services. Both healthcare devices acquisition, purchasing, delivery, and implementation are included. The hospital is Lloyds Bank and Carillion›s first healthcare PPP initiative together, as well as their biggest single joint undertaking the two have a long tradition of working together in corporate banking. The contract includes "hard" facility administration services such as estate repair, pest control, grounds and garden care, helpdesk operations, and utilities. The trust will continue to be responsible for "soft" facility maintenance services such as catering, washing, and laundry. The building will be completed in two stages over a 64-month duration. The first of which involved the construction of the 102,000 sqm "Brunel" acute hospital building, which was completed in March 2014. The hospital has been fully operating since May 2014 and is now open for service. In 2016, the second phase, which included the destruction of the old hospital site and the construction of parking lots, a sterile services department, and landscaping, was nearly finished (Llyods Bank, n.d.).

When a partnership between Lloyds Banking Group and support services firm Carillion presented their proposal for the project in March 2007, budget did not seem to be a concern. The financial world had turned upside down by the time their venture was appointed preferred bidder for the project in March 2009, and there were concerns that it would be able to collect the necessary debt at a realistic rate. "It was the first time in our experience of PFI projects that we were actually quite concerned there could be a problem," said Lynn Oliver, transactions director at Carillion Private Finance (PFI, 2010).

General Architectural Background

The new hospital will integrate the North Bristol NHS Trust›s supply of specialist treatment to a 500,000-strong population on a single site, and is a key component of Bristol Health Services› overall plan to streamline acute services throughout the region, North Somerset, and South Gloucestershire. It would also assist in the development of North Bristol›s Southmead community.

The new Southmead Hospital will be a highlight of the city. It will be a single hospital with a central concourse in the shape of an atrium that extends the length of the building and divides wards from clinical/treatment areas. It will be constructed on the Trust's current 24.8 hectare site.

Outpatient facilities will be on the ground floor, with wards branching off the atrium in angled "fingers" to shape courtyards that will provide patients with sufficient light and exterior views while ensuring the requisite level of privacy (see Figure 3.22).

The building will occupy an area of nearly 115,000 square meters. The hospital will have 832 acute beds, with 75% of them being single rooms with en-suite bathrooms to allow patients more privacy and dignity, as well as 24 operating theatre suites. There will also be a dedicated accident and emergency department, as well as 2,700 parking spaces for workers, tourists, and patients, as well as expanded public transit connections.

Figure 3.22: Master Plan of Southmead Hospital
(Source: https://www.architecture.com/awards-and-competitions-landing-page/awards/riba-regional-awards/riba-south-west-award-winners/2018/brunel-building-southmead-hospital)

The usage of site floors to build an entry plaza at one end of the interior lane, meanwhile the Emergency Department is situated at the opposite end of the street, a floor level below, results in a quiet public domain and emergency access that is not blocked by other uses. The street is a lively space, with waiting areas, planting, courtyard views, cafés, and airport-inspired wayfinding – the acoustics have been deliberately built to provide a hum of background noise without being overpowering. Stairs that are easily visible and promote accessibility lead to hotel-style single rooms, each with a view and all of which are naturally ventilated.

The Brunel Building at Southmead Hospital is a brilliant solution to the North Bristol NHS Trust's brief to construct an extraordinarily sustainable healthcare facility that delivers long-term cultural, social, and financial benefits to patients, guests, employees, and the surrounding community The building received an Excellent BREEAM score, and its energy consumption per square meter is less than half that of the previous hospital, showing that sustainability was a top priority. The intention to place health and safety first for all consumers is apparent in the design.

Typological-spatial strategies for flexibility

Layers of flexibility are designed into the architecture to facilitate the effective and long-term delivery of healthcare. Additional wards or technical accommodation may be added without sacrificing travel time or adjacencies due to conscientious siting of key clinical services, while traditional rooms and soft zone concepts provide for continuing clinical flexibility throughout the project's lifetime. Patients' access to healthcare must be expressed in the architecture. Many services were provided virtually after the pandemic, and video conferencing has become the norm for outpatient and specialist appointments. This might necessitate constructing places of substantially fewer outpatient rooms, yet with flexibility in mind, such that any space may theoretically fulfill several objectives throughout its lifetime, such as refurbishing and reconfiguring current layouts to maximize diagnostic and care space.

Figure 3.23: Ground Floor View in Southmead Hospital
(Source:https://www.architecture.com/awards-and-competitions-landing-page/awards/riba-regional-awards/riba-south-west-award-winners/2018/brunel-building-southmead-hospital)

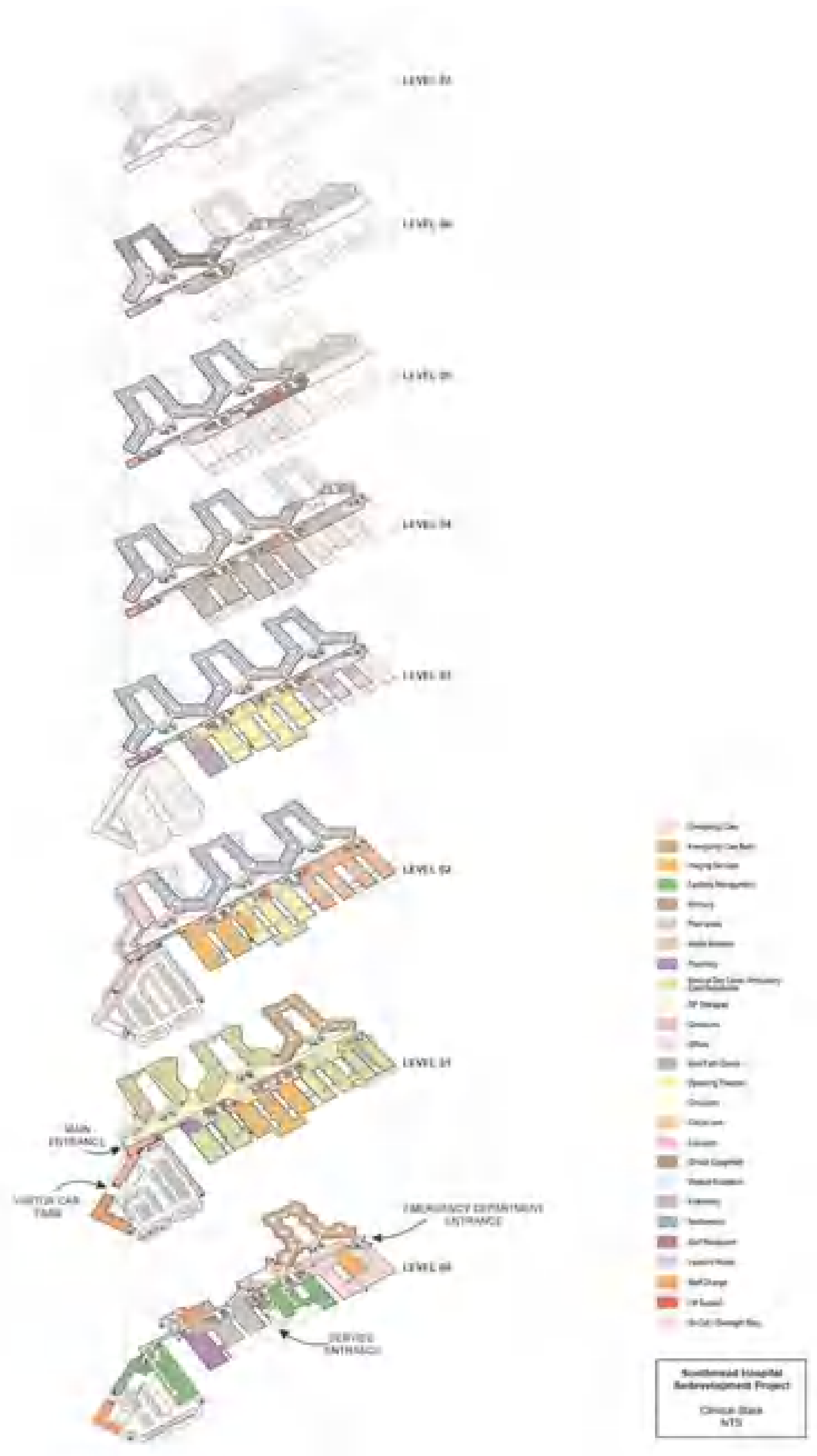


Figure 3.24: Distribution of Function in Southmead Hospital
(Source:https://www.architecture.com/awards-and-competitions-landing-page/awards/riba-regional-awards/riba-south-west-award-winners/2018/brunel-building-southmead-hospital)

Loose Fit

When BDP planned Southmead Hospital in North Bristol NHS Trust, for instance, rooms were loose fit with services provided to serve multiple activities and arranged in specific clusters. Scenario testing indicated that major items of device could be replaced with minimal reconfiguration giving operational flexibility throughout the life time span of the facility.

Modular design

Offsite building approaches were successful for the Nightingale hospitals built by BDP, and potential healthcare spaces could make use of modular and mobile facilities. To solve a very practical problem, a "kit of parts" approach, which culminated in a wonderfully designed solution was used. Prefabrication was extensively used to streamline construction; unified facades incorporating fixed glazing, louvred panels and reconstituted stone with local pennant rubble to plinths.

Designing new spaces flexibly

Any new hospital or clinical area should be built to be adaptable so that it can fulfill many functions throughout the course of its existence. When BDP designed Southmead Hospital in North Bristol NHS Trust (pictured above), rooms were loose fit with services provided to accommodate multiple functions and arranged in defined clusters. Scenario testing showed that major items of equipment could be replaced with minimal reconfiguration, giving operational flexibility over the life of the building (see Figure 3.25).

Figure 3.25: A Flexible Space in Southmead Hospital
(Source: https://www.hospitaltimes.co.uk/healthcare-design-in-a-post-covid-19-world)

Adaptability to COVID-19

Patients' access to healthcare must be reflected in the architecture. Many systems are controlled virtually after the pandemic, and video conferencing has become the standard for outpatient and specialist appointments. This might necessitate designing places of fewer outpatient rooms, yet with flexibility in mind, such that any space may theoretically serve many purposes throughout its lifetime, such as renovating and reorganizing current layouts to expand diagnostic and treatment area. Rooms were loosely fitted with facilities offered to handle several roles and grouped in specified clusters when BDP planned Southmead Hospital in North Bristol NHS Trust, for instance. Situation research revealed that large instruments could be removed with little to little rearrangement, allowing for organizational stability throughout the structure's lifespan. Acute hospitals will now have to offer treatment for Covid-19 patients before transitioning to normal operations. This means the emergency rooms and other hospital admission points would need to be redesigned carefully. One concept under consideration is to streamline patients in existing hospitals by expanding admission zones to become triage points where patients are led into specifically defined flows. Infected patients will be isolated from others in this manner, reducing the risk of contamination. A safe zone is one where you can be fairly assured that no one has been compromised. Covid-infected patients would be sent to a blue zone, while the patient's condition would be unknown in an amber zone. As a consequence, not only can health demands be met more effectively, but the general population would be assured that it is possible to use emergency care again (Welch, 2021).

Cameron (2021) asserts that, due to "extraordinary" demands on intensive care units (ICUs) in other areas of the world, Southmead Hospital is accepting seriously ill Covid patients from as far as Birmingham. According to a hospital chief, the ICU at the hospital in north Bristol is receiving about five Covid-positive patients from other territories each week, and that figure is expected to increase. Karen Brown, chief executive officer of North Bristol NHS Trust, said it has been a "challenge" to maintain stable staffing standards in the ICU and in the hospital since Southmead reached a high of more than 200 patients last month and had to suspend elective surgery and regular outpatient appointments to manage. Brown advised members of South Gloucestershire Council's health oversight committee on January 27 that ICU capability is being prepared on a state and national basis. To benefit London, Kent, and the Midlands, hospitals in the south are required to apply 'surge' proposals to NHS England and NHS Improvement. Southmead Hospital has expanded its ICU bed numbers from 46 to 55 and accepted ICU patients from "as far as Swindon, out to Yeovil and beyond", Brown said, adding: "We've had patients transferred to us from Kent and also Birmingham as well." The hospital has also drawn hundreds of non-ICU patients from the Bristol Royal Infirmary and Weston General Hospital, both with and without Covid-19. People who live in the local NHS district, on the other hand, need not be concerned that an ICU bed would not be available if they become ill, according to Brown. "We recognise our absolute requirements to our local population,” she added. “It’s a clinical decision on a daily basis about who we receive into the organisation from those regional places. “It’s part of our surge planning process… and we play our part in that to provide a local service for our local residents without question.” “We believe that we have been at our peak between the 19th of January and beyond, where we’ve now got over 200 patients who have been Covid-positive,” Brown said. She explained that the hospital schedules its capacity weekly and “fine tunes” it on a regular basis. According to the conference, admissions for flu and gastrointestinal ailments are down from previous years, in part due to social distancing, which limits spread of all contagious disorders, not just Covid-19.

Edwards (2020) states that another source of stress, given the scarcity of beds, is the hundreds of patients who are well enough to be discharged but are occupying much-needed beds. In the first week of November, health officials agreed to postpone certain non-urgent regular procedures and outpatient appointments, but sources said that if the number of Covid patients continues to increase, further cancellations are possible.Hundreds of Southmead nurses are on Covid or self-isolating. A doctor told the Cable: “There’s enormous staff absence. three weeks ago, when this was in its infancy, there were 370 staff isolating, either sick or in contact with someone who was. Now it must be way more than that. It’s only going up.”

Comparison of the Results from the Best Practices Analysis

Each 3 different hospitals from different parts of Europe were built under the PPP investment model with extremely huge expenses as City Hospitals which were constructed with the same investment model. Comparing these three hospitals’ total gross floor area with City Hospitals, it seems that the hospitals located in the EU are relatively small in scale. Those in Europe not only provide healthcare services, but also accommodate training and research activities so education and healthcare facilities are integrated into one complex. Regarding this issue, it is not the case in city hospitals. It is observed that the user circulation is largely separated from each other in examined state-of-the-art hospitals. This avoids the density and ambiguity in healthcare facilities. One of the common factors in design strategy is the increase of the number of single rooms. This leads to reducing the infection which is gained from hospitals and allows creation of a comfort zone and dignity as well as creating easily adaptable spaces to emergencies such as pandemic. Flexibility plays a major role in hospitals built with the PPP model in Europe. Hospitals with patient-oriented design can be adapted to future technological developments to the maximum extent. Besides, In addition, the understanding of ‹healing architecture› is one of the important features of these hospitals. Direct sunlight, being intertwined with green areas, and the view from the rooms have been part of the design. It is said to have an important effect on the healing process. Since hospitals are large facilities, the amount of energy they consume is much higher than other buildings. Therefore, there are healthcare facilities in Europe and Turkey which were awarded certificates like LEED related to green building systems. Related to the PPP model and its effect on architectural outcome, the role of Turkish Ministry of Health is quite big compared to cases in Europe. The MOH is a dominant stakeholder that directly affects the architecture of City Hospitals as they are being so similar in typology and functional program despiete varying locations because of the standards and regulations defined by the MOH. On the other hand, private actors in Europe are more participating and active in the building production process and the outcome. The architectural approaches or principles of the companies are more apparent and evident in those examples.

Most of the case studies from both Europe and Turkey experience ongoing extreme conditions regarding COVID-19. These healthcare facilities react and adapt themselves with specific precautions. However there is relatively a common ground talking about such interventions. For example, the number of intensive care units can be increased by transformation of the other bed wards. Secondly, separation of flows and zoning is a vital method to be applied. Lastly, with the help of technologies patient follow-up from distance is the current trend during pandemic. By doing that, these facilities try to reduce density of usage, increase capacity and decrease the spread of infections.

3.3 Case Studies Analysis

Introduction

This part focuses on examining and comprehending the difficulties and disadvantages that have formed the current design concept of city hospitals. It also seeks to figure out how flexible values are regarded and implemented in city hospitals. Case studies with a high degree of future proofing and flexibility standards that have recently been performed are chosen from various locations in Turkey to be studied and examined through a crucial perspective that focuses specifically on flexibility and future proofing as the primary issue.

The decision to select case studies were determined through research and critical analysis, and they were focused on both the application of flexibility and technology, particularly issues of infrastructure, structure system, and plant system, and how they are combined with architectural design and function organization.

Seven case studies from 29 city hospitals are chosen and evaluated in detail in respect of flexibility and future proofing implementation, architectural typology & spatial organization, and essentials such as location, customer, year of launch & completion collaborators and area to establish a detailed overview for each one of the case studies.

The seven selected case studies are as following (see Figure 3.26):

- Adana City Hospital
- Bursa City Hospital
- Elazig Fethi Sekin City Hospital
- Ankara Bilkent City Hospital
- Kayseri City Hospital
- Konya Karatay City Hospital
- Basaksehir Cam and Sakura City Hospital

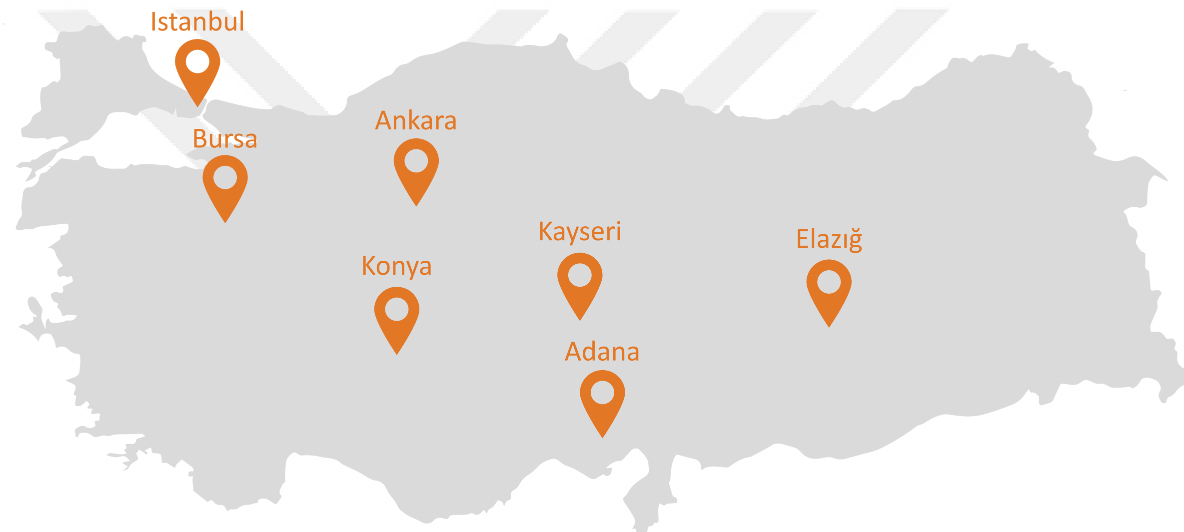


Figure 3.26: Locations of Seven Selected Case Studies

(Source: Author)

Assessment Tool for Case Studies

Each case study is assessed by an assessment method from “Elshazly & Ghazy: Optimized Flexibility Assessment Tool for Healthcare (OFAT), 2020” in terms of 9 Evaluation Criteria : shape, structure, facade, building plant, expandability, structural constraints,exchange of large equipments, technology and functionality with a grading system that presents for each parameter a score between 0 and 10 points (see Table 3.1).

This assessment tool’s performance is split into nine distinct groups, making it difficult to be unambiguous or transparent. To do so, it’s crucial to note that certain features are more important than others and have a larger effect on the project’s overall flexibility.

Diagrams to summarize the results of the final score of and how often each Evaluation Parameter is implemented are included during each case study. Finally, comparative graphs are used to summarize the findings of each case study independently as well as in relation to other case studies. The actual flexibility of the seven case studies was evaluated with the evaluation tool, showing whether or not they should be considered Flexible Buildings.

The potential outcomes for the OFAT approach are split into five separate ranges to help better explain and simplify the final outcome of the evaluation tool:

0-20 % : not flexible
21-40% : low potential for Flexible Building
41-60% : high potential for Flexible Building
61-80% : Flexible Building
81-100% : model of Flexible Building

	POINTS	OPTIONS	SCORE
SHAPE	10 9 8 7 6 4 2 0	100 % Compact 75 % Compact Vertical 50 % Compact Linear Articulated Horizontal, Detached Buildings	/ 10
STRUCTURE	4 2 +1 +1 +1 +1 +1 +1 +1	7m ≤ Span ≤ 8m Open floor plan Span > 8m Span < 7m Regular Grid Squared Grid Oversized elements Punch Through Concrete Slabs for Vertical Circulation Hollow Pillars for Technical Installations Ceiling Height ≥ 4m	/ 10
FACADE	6 4 2 0 0 +4	100 % Curtain Wall 75 % Curtain Walls 50 % Curtain Walls Ventilated Facade Traditional Masonry / Brick Wall Modular Panels	/ 10
BUILDING PLANT	2 1 0 +2 +1 +1 +1 +1 +2* +1* +1*	Distance in between Service Shafts: d ≤ 35m Distance in between Service Shafts: 35m < d ≤ 70m Distance in between Service Shafts: d > 70m Redundancy for Building Plant Distribution in Raised Floor and/or Exposed Installations if Required Plant Tower Technical Floor Service Shafts Area: Shafts Total Surface/Floor surface ≥ 0.01 Spread out Plant Infrastructure in False Ceiling* Condensed Plant Infrastructure (Varying Height of False Ceiling)* Technical Interstitial Floor*	/ 10
EXPANDABILITY	+4 +2 +1 +1 +1 +1	Internal: Already Euipped Spaces Internal: Shell Spaces Open Ended Corridor and/or Large Spaces on Building's End Soft Spaces: to be Retrofitted into Service Spaces if needed External: Volumes "Hanging" from the Facade Availability of Neighboring Plot	/ 10
STRUCTURAL CONSTRAINTS	6 4 2 0 +2 +1 +1	Only Fixed Vertical Elements (Circulation & Service Shafts) Fixed Elements of Building Plant: Up to 25% Fixed Elements of Building Plant: Up to 50% Fixed Elements of Building Plant: Up to 75% Drain Pipes: In Service Shafts or Running Next to Pillars Adjustability of Service Shafts Grouped Vertical Circulation Elements	/ 10
TECHNOLOGY	4 2 0 +1 +1 +1 +1 +2* +1*	Dry Assembly Technique Mixed Assembly Technique Wet Assembly Technique Internal Partitions: Modular Panels Internal Partitions: Panels Set up with Technical Installations Internal Partitions:Movable/Retractable Internal Partitions: Framed Construction Internal Partitions: Prefabricated Panels* Internal Partitions:Dry Walls Built In Situ*	/ 10
EXCHANGEABILITY OF LARGE EQUIPMENT	8 4 0 +1 +1	Only Needs Disassembly of Facade Panels Disassembly of Fcade Panels and of Internal Partitions Partial Demolitions Large Equip.: In Ground Floor/ Floor with Direct Contact to Outside Equipments Spaces with Redundancy	/ 10
FUNCTIONALITY	+4 +2 +1 +1 +1 +1	Generic/Universal Rooms Space Standardization Double Function Overflow Design Loose Fit Furniture/Equipment Flexibility	/ 10
TOP SCORE			**/ 90**

Table 3.1 : Optimized Flexibility Assessment Tool for Healthcare
(Source: Elshazly & Ghazy (2020))

The Common Ground

Many city hospitals in Turkey, particularly starting around the 2000s, began approaching an inability to keep pace with developments in the healthcare sector and technology. City hospitals, which were built previously, do not have the infrastructure to host developing health equipment as well. It is common for more than one patient to be treated in the same room. For such reasons, they have almost completed their lives. With the decisions taken in 2002, the Ministry of Health has decided to restructure these overdue hospitals and the health sector. In this context, it has developed the concept of "city hospital" where more than one department is gathered together and formed a new complex. They have several features which are valid almost every single one of them. In line with the 2010 minimum standards of the Ministry of Health, it is necessary to design an open area of at least 35% of the project area in new healthcare facility structures. In addition, green areas should constitute 25% of the total area of the project. These hospitals have both pros and cons. They have a much larger area compared to the public hospitals that were closed. This causes the carbon footprint to grow and the energy consumed to increase because they are active 24/7. Because of the size, it has also brought some social disadvantages such as the difficulty of wayfinding in the complex.

The structure of this health sector, as mentioned in other previous sections, has been organized by the Ministry of Health and City hospital projects have been implemented in many provinces. The hospitals built are basically divided into three groups in the previous chapters due to their typology.

These are as follows:

- Y-shaped towers on muffin
- Arms attached to the main core
- Mix type (arms attached to the main core and matchbox muffin)

A standard clinical module has been developed for almost all polyclinics in branch hospitals. It is based on a modular system consisting of two examination rooms and one doctor's room. Two doctors (4 examination rooms) will share the nurse and support services, while 4 doctors (8 examination rooms) will jointly use the interim waiting and reception place / registration functions. 8 doctors (16 examination rooms) use the same staff support and waiting areas. Polyclinic modules are designed to allow different uses. Modules that can be used as 4 doctor 8 examination rooms can also be transformed into 6 doctor 6 examination rooms (see Figure 3.29).

The interior design of the polyclinic modules has also been handled with a patient-oriented approach. All waiting areas are designed on the outer surface, allowing them to benefit from natural light. The chart shows the 12-room polyclinic module requirement list used in campus hospital designs (see Table 3.2).

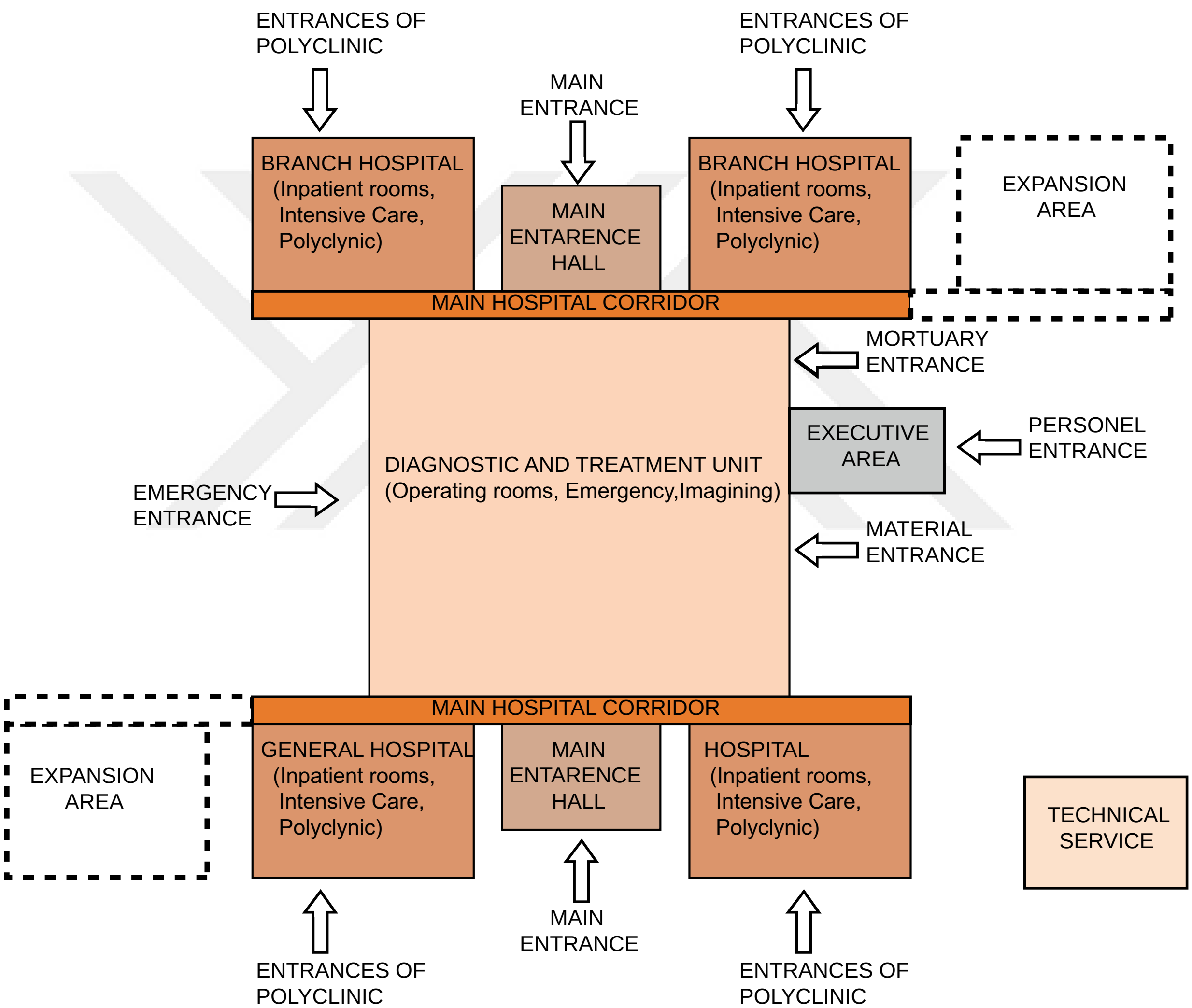
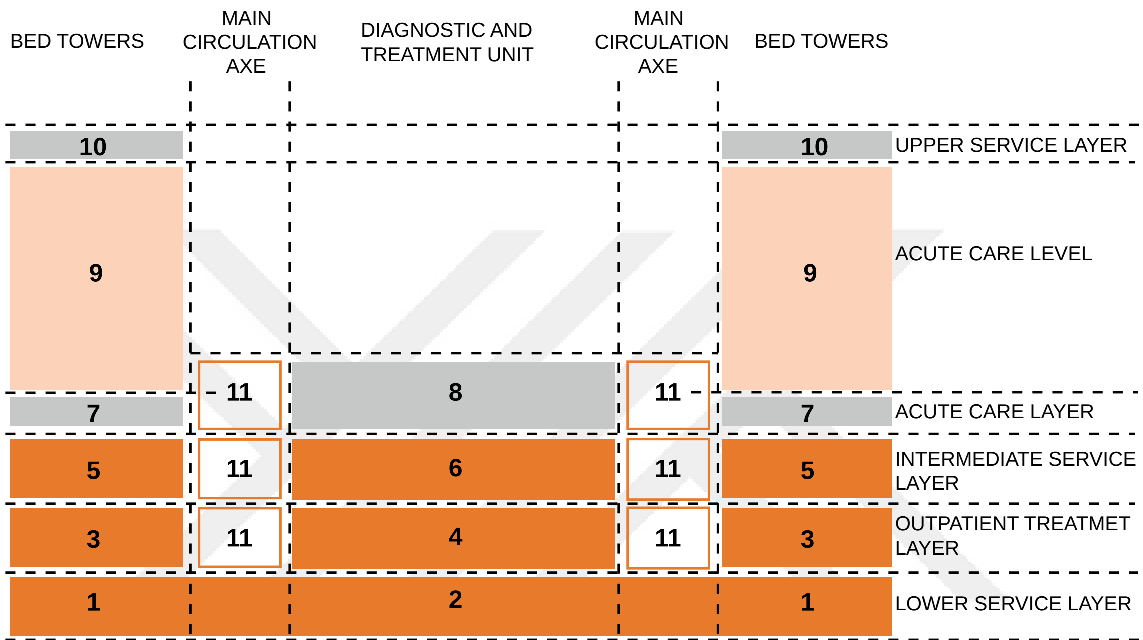


Figure 3.27: Main Hospital Mass Layout Scheme
(Source: Sönmez (2014), edited by author)



1.Car parking, personel fittings areas, mechanical installation
2.Car parking, personel fittings areas, mortuary, archive, storage, executive area, central pharmacy, central starilization, labs, material management, mechanical installation
3.Polyclynics and outpatient treatment areas, entarncae and reception of branch hospital, patient transport services
4.non-outpatient outpatient treatment units, diagnostic areas, emergency service, administration, main hospital, reception
5.Intensive care units
6.Operating rooms, daily operating room, endoscopy, KVC intensive care
7.Mechanical installation
8.Mechanical installation, central starilization, dining hall
9.Acute care units, LDRP, new born, etc.
10. Mechanicak installation, satellite dining hall
11. Main circulation axe

Figure 3.28: Main Hospital Mass Horizontal Stratification - Schematic Section Regarding Best Choice of Location for Departments
(Source: Sönmez (2014), edited by author)

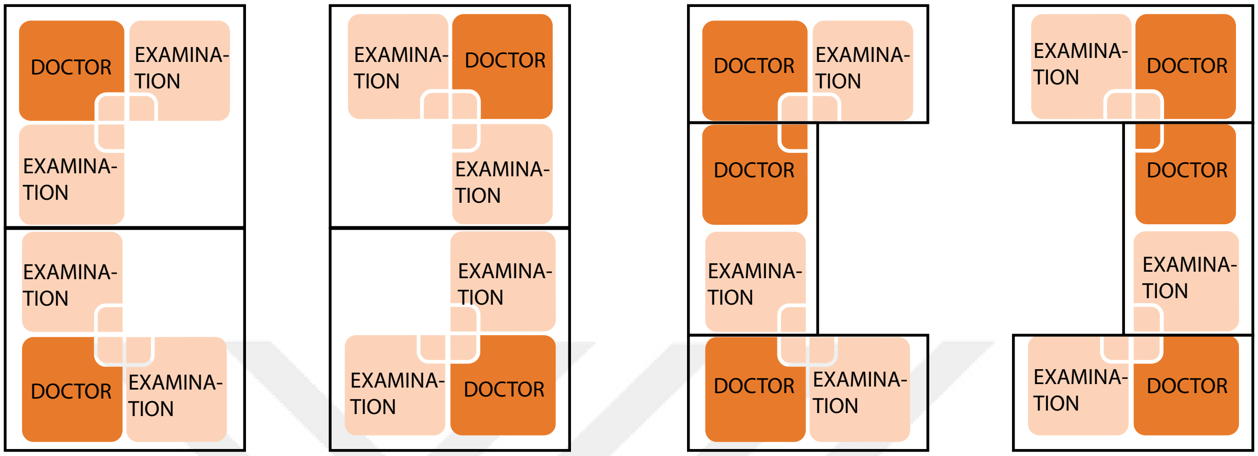


Figure 3.29: Flexibility in Polyclinic Modules
(Source: Sönmez (2014), edİted by author)

General 12 rooms unit			
	Number	Area	Total Area
Waiting area	2,0	50,0	100,0
Reception area	1,0	10,0	10,0
ARA BEKLEME	4,0	8,0	32,0
Doctor office	4,0	17,0	68,0
Examination room	8,0	17,0	136,0
Process room	2,0	16,0	32,0
Nurse station	2,0	9,0	18,0
Working area	1,0	4,5	4,5
Dirt hold area	1,0	6,0	6,0
Clean closet	1,0	6,0	6,0
Staff WC	2,0	5,0	10,0
Patient WC	3,0	7,0	21,0
Reserve area	1,0	50,0	50,0
Staff resting area	1,0	8,0	8,0

Table 3.2: 12 Room Polyclinic Module Requirements List
(Source: Sönmez (2014))

A single central emergency service is planned for the combined branch hospitals on campus. The emergency service, located on the ground floor of the main hospital core, can consist of 40-120 treatment rooms, depending on the size of the facility. In order for such a size to function smoothly, the distinction between public space and treatment areas must be made clearly.

City hospital projects consist of 3 basic areas: emergency service, entrance waiting-triage and treatment areas (see Figure 3.30). We can consider the triage area located between the entrance-waiting area and the treatment area as a barrier between the public space and the treatment area.

Considering the size of the emergency room, it is necessary to distinguish entrances from different points. In health campus projects, access to the emergency room is made from 3 different points. One entrance is provided for obstetrics and pediatric patients, one for adult outpatients and a separate entrance for ambulances.

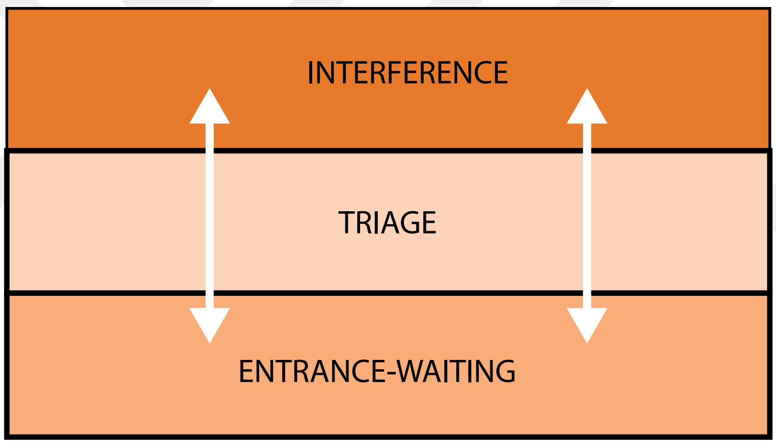


Figure 3.30: Emergency Room Public Space-Treatment Space Rating
(Source: Sönmez (2014), edİted by author)

Operating Rooms

There is a central preparation / recovery area serving all branch hospitals (see Figure 3.26). This area serves all operating rooms, intervention rooms, angio rooms, cardiac catheter rooms and some endoscopy rooms. Designed as the repetition of the same module, these areas provide staff flexibility and ease of managing patient flows at different times of the day. For example, a pre-operative space for morning angio patients can be used as a post-operative room for surgical patients in the afternoon. Depending on the modular system of the operating room, hardware storage areas are also shaped flexibly. The largest of these is located in the operating room module and allows them to be used in the future without building new spaces.

The operation areas are planned in arena type. Operating rooms, which can vary in number according to need, are placed around the clean corridor, and a sterile core with limited access is located in the middle.

Each unit has its own sterilization unit directly on the first basement floor and these areas are connected by separated clean and dirty elevators.
Lockers, rest areas and administrative offices are located next to the operating rooms and provide easy and direct access by the staff.

The department is organized into four main areas:

- A public area for waiting and admission
- A preparation / sobering area and associated support spaces for patient care.
- A field of initiative with support areas
- A staff support area that also includes administrative functions.

In the campus planning, pedestrian and vehicle circulation are separated as much as possible and a more comfortable user environment has been created. At the same time, the emergency entrance and exit are separated from the main entrances, opening the way for rapid transportation and intervention.

One of the most important features of these health facilities is that it is a health complex where almost all health services (obstetrics, pediatrics, oncology, cardiovascular, FTR, etc.) are brought together.

Adana City Hospital

Bursa City Hospital

Elazığ Fethi Sekin City Hospital

Y-shaped Towers on Muffin: Adana-Bursa-Elazig City Hospitals

Essentials

City Hospital	Population	Operation Date	Contractor	Gross Floor Area m²	Bed Capacity	Intensive Care Unit	Operation Room
Adana	2.22 million	September 2017	Rönesans	550.000	1550	274	61
Bursa	3.05 million	July 2019	Rönesans	465.000	1355	217	49
Elazığ Fethi Sekin	579.980	August 2018	Rönesans	360.000	1038	160	39

Table 3.3: Main Features of Adana, Bursa and Elazığ Fethi Sekin City Hospitals
(Source: Author)

It is a Y-shaped typology that includes Y-shaped towers designed together with the main mass including Adana, Bursa, Elazig Fethi Sekin City Hospitals. These hospitals contain many common points apart from their similarities in terms of shape. Therefore, these three hospitals will be examined under the same heading.

Rönesans Holding is the firm that won the tender for Adana, Bursa and Elazig Fethi Sekin city hospitals with a total surface area of 360,000-550,000 square meters and built between 2017 and 2020. Except for Bursa City Hospital, two other hospitals are located in the developing (semi-developed) area of the city. Bursa, on the other hand, was designed in an undeveloped, rural area. This situation has created major problems with accessibility. According to the information obtained from various news and read sources, the public complains about the frequency and time table of public transportations to these hospitals, except Adana City Hospital.

As in Elazig Fethi Sekin City Hospital, expansion areas have been left on the campus in order to meet the demands that may increase in the future (see Figure 3.31).

The building settlement was formed by the Y-shaped branch hospital towers of the diagnosis and treatment units, which the Turkish Ministry of Health called the core. In the design, emphasis has been placed on the prevalence and accessibility of common areas. In the main core, social areas such as eating and drinking areas, markets, clothing stores, ATMs, pharmacies and parks where many needs of the users can be met are located on the ground floor. General approach of campus designs differs in Elazığ as PMR is not designed to be a seperate building but rather integrated in the main hospital. Also, a dental hospital is a plus in this campus.

City hospitals have a lot of energy consumption capacity due to their size. Therefore, various approaches have been determined to minimize energy consumption. Within the framework of this understanding, trigeneration buildings were built that generate some of the energy of the complex itself. Within the green building concept, Adana, Bursa and Elazig City Hospitals have been awarded “Leed Gold” certificate. Besides, Adana City Hospital was awarded the best PPP project in Europe that year.

These hospitals are hospitals that can keep up with the developing technology as latest technological systems are used. Especially since Turkey is in the primary seismic zone there are seismic isolators in all three hospitals. This allows the hospital to continue to serve by minimizing the disruptions that may occur as a result of a possible earthquake. Adana City Hospital was the biggest building with seismic isolators when constructed with 1512 İsolators.

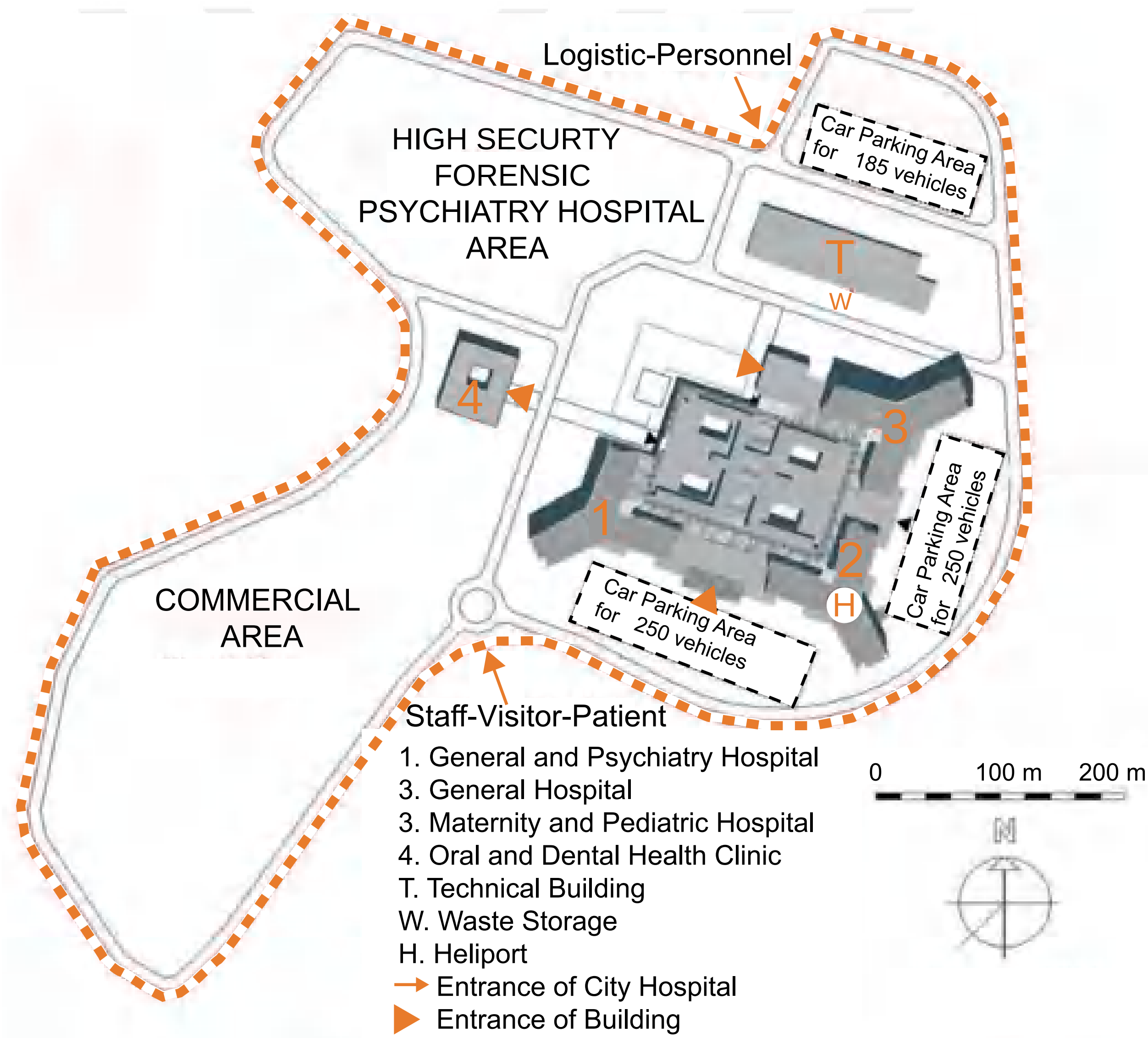


Figure 3.31: Elazığ Fethi Sekin City Hospital Master Plan
(Source: ELZ Sağlık Yatırım A.Ş. (2017), edited by author)

Architectural Typology and Spatial Organizations

By the Ministry of Health, the mass for diagnostic and treatment units called core is planned in the center, while the towers are in the Y-shape and around the core block (see Figure 3.31 & 3.32). In this scheme, diagnosis and treatment units such as emergency, operating room, imaging (radiology and nuclear medicine, etc.), endoscopy are located in the core block . Generally, these blocks are planned up to 2-3 floors for medical use . The ground floor of the branch hospital towers are generally planned as outpatient clinics wherease intensive care units and operating rooms are located in the core. Plus, inpatient rooms on the upper floors of the tower (see Figure 3.33 & 3.34).

Figure 3.32: Adana City Hospital with Y-shaped Towers on Muffin
(Source: https://www.yazgandesign.com/adana-integrated-health-campus)

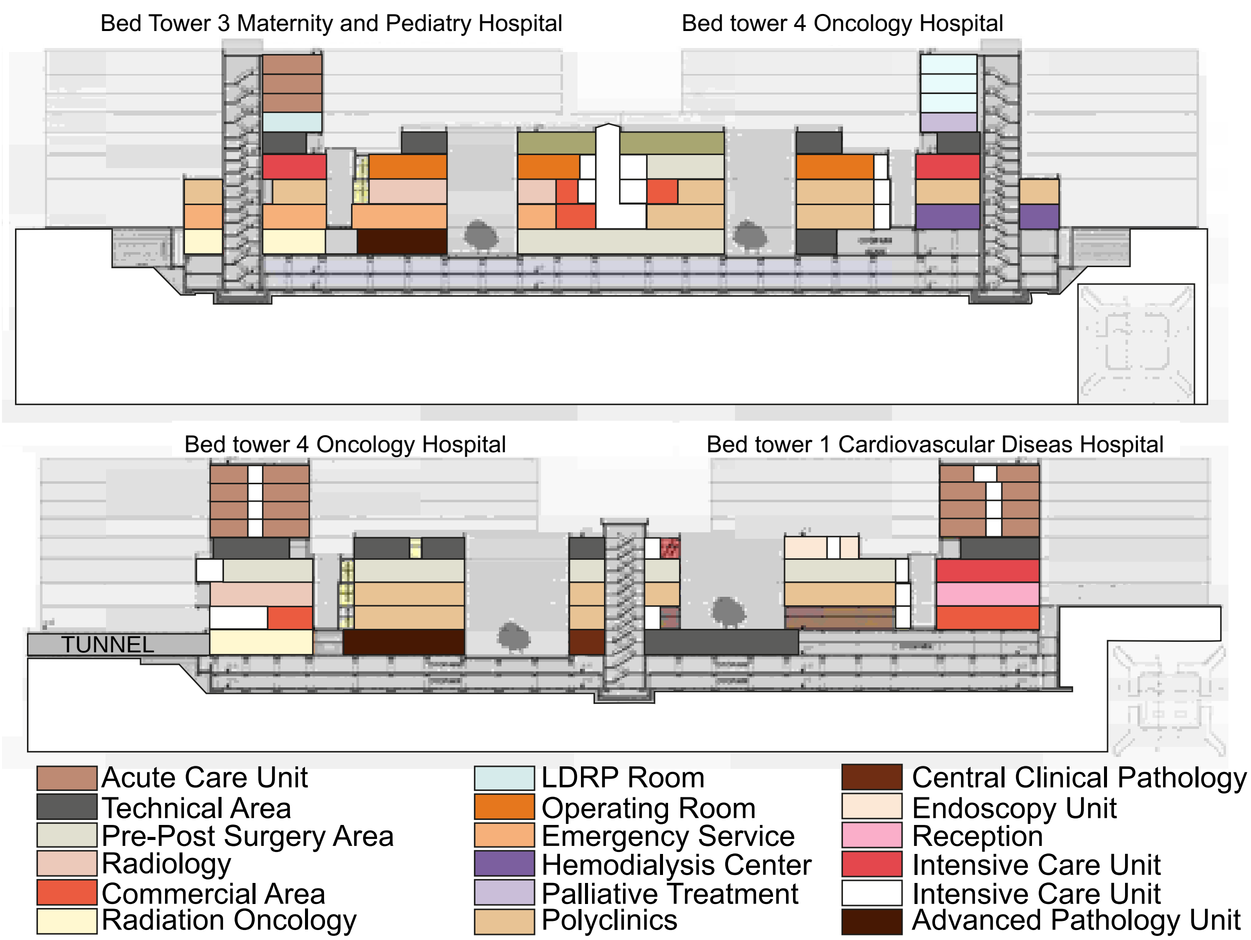


Figure 3.33: Bursa City Hospital Sections
(Source: BRS Sağlık Yatırım A.Ş. (2016), edited by author)

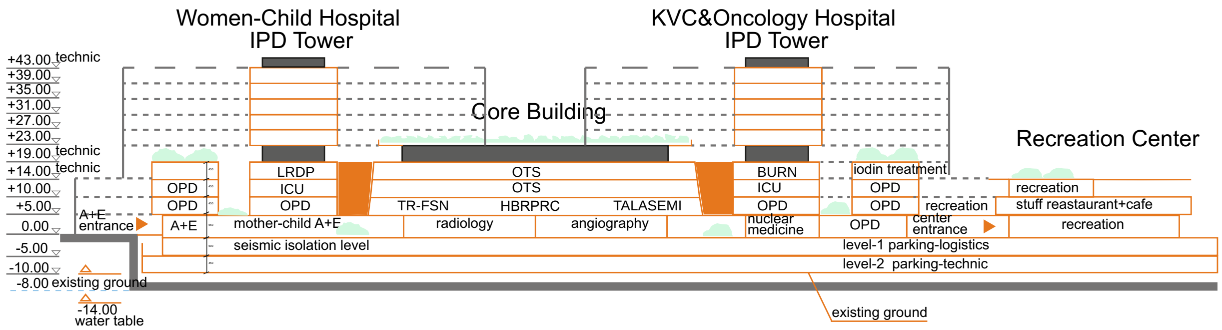


Figure 3.34: Adana CİtyHospital Section
(Source: Adana PPP Sağlık Yatırım A.Ş. (2014), edited by author)

As seen in Elazığ City Hospital; the inpatient departments, nurse stations are not gathered in a center and consist of homogenized units to be seen by the patients that aim to stabilize the service quality and establish a continuous observation and healthy coordination system (see Figure 3.35).

At the same time, the admissions and support units on the ground floors serve diagnosis, treatment units and polyclinics. Likewise the new solutions around Europe, it is aimed that the patients make maximum use of sunlight and the patient rooms are positioned to receive as much daylight as possible. With mentioned space organizations, the relationship of the three main units with each other has been tried to be strengthened.

Figure 3.35: Elazığ Fethi Sekin City Hospital Nursing Station
(Source: http://www.ronesansisletmehizmetleri.com/tr/36502/Elazig-Fethi-Sekin-Sehir-Hastanesi)

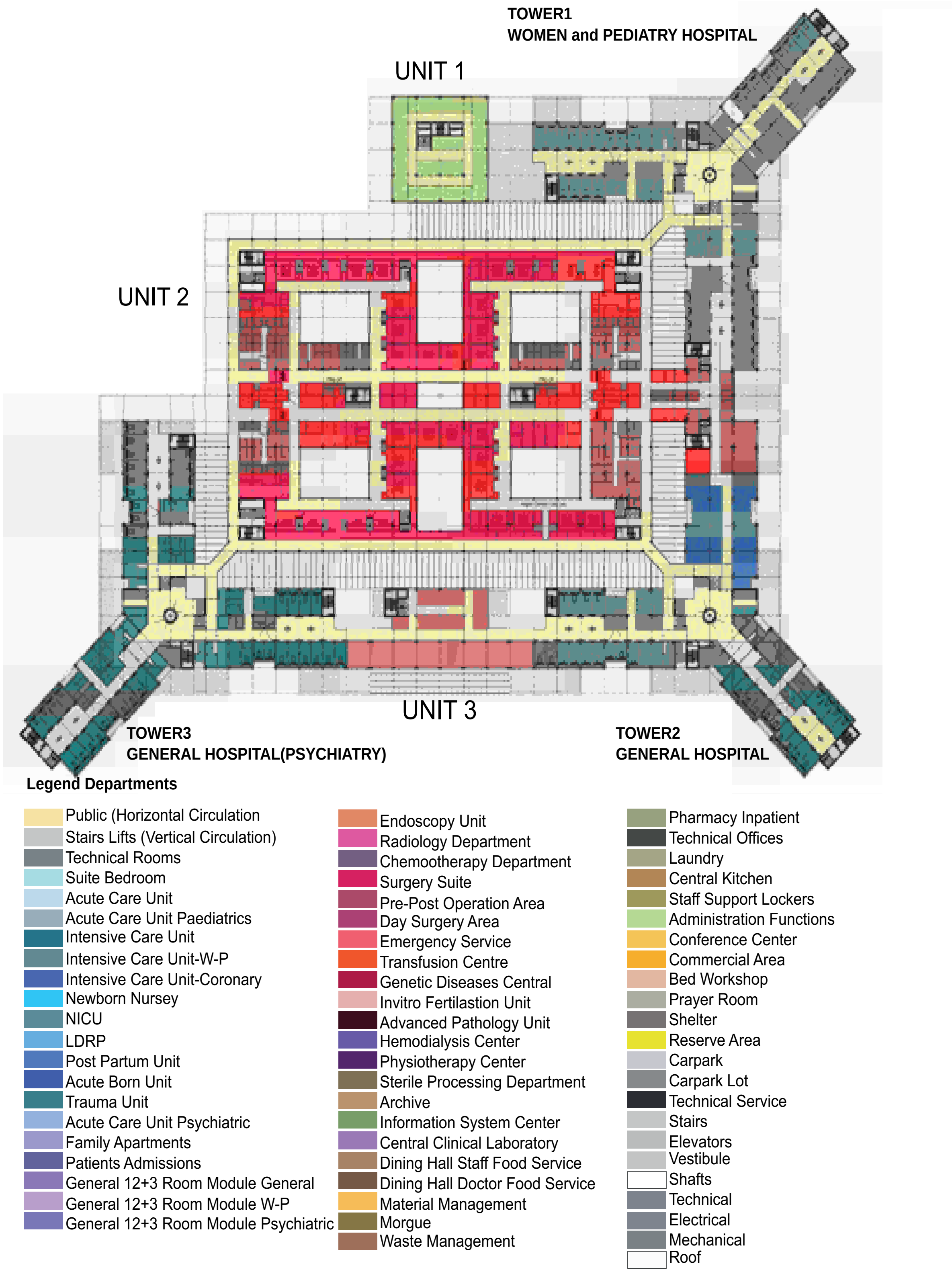


Figure 3.36: Elazığ City Hospital Ground Floor Plan
(Source: ELZ Sağlık Yatırım A.Ş. (2017), edited by author)

UNIT1
Administration: NF(rp) 650 m²
NF(cd) 650 m²
NF(rp) 100 m²
NF(cd) 119 m²

GFA 1.183 m²

UNIT2
Surgery Suite: NF(rp) 3.916 m²
NF(cd) 4.194 m²

Sterile Good Corridor NF(rp) 909,5 m²

Pre-Post Operation Area: NF(rp) 2.026 m²
NF(cd) 1.991 m²

GFA 13.525,5 m²

UNIT3
Endoscopy: NF(rp) 859,5 m²
NF(cs) 859,3 m²

GFA 1.334 m²

TOWER 1 WOMEN and PEDIATRY HOSPITAL

3* 13 Bed Intensive Care Unit (W&P) : NF(rp) 2.307,6 m²(3x769,2m²)
NF(cd) 2.317 m²

GFA 4.363 m²

TOWER 2 GENERAL HOSPITAL

1* 13 Bed Intensive Care Unit (G) : NF(rp) 769,2 m²
NF(cd) 826,9 m²

1* 13 Bed Trauma Unit: NF(rp) 760,8 m²
NF(cd) 745 m²

1* 13 Bed Intensive Care Unit (G) : Coronary NF(rp) 237,5 m²
NF(cd) 651 m²

GFA 3.965 m²

TOWER 3 GENERAL HOSPITAL(PSYCHIATRY)

3* 13 Bed Intensive Care Unit (G) : NF(rp) 2.307,6 m²(3x769,2m²)
NF(cd) 2.317 m²

GFA 4.363 m²

Figure 3.37: Elazığ City Hospital Ground Floor Plan Legend
(Source: ELZ Sağlık Yatırım A.Ş. (2017), edited by author)

In all three city hospitals, a human flow starting from a central area and towards decentralized specialized areas is one of the main principles.It is possible to read a circulation hierarchy both the interior of the hospitals and the campus. A semi-permeable, continuous promenade is designed along with commercial areas in between diagnostic treatment and branch hospital units in Elazig City Hospital. One of the devices that separates Elazig City Hospital from the other two hospitals is this promenade. (see Figure 3.38). In addition, vertical circulation in the core is provided by the escalators in the center, as well as the elevators and stairs located around the floor (see Figure 3.39). There are also galleries in this area where visual communication is strengthened (see Figure 3.40).

Figure 3.38: Promenad of Elazig Integrated Health Campus
(Source: ELZ Sağlık Yatırım A.Ş. (2017), edited by author)

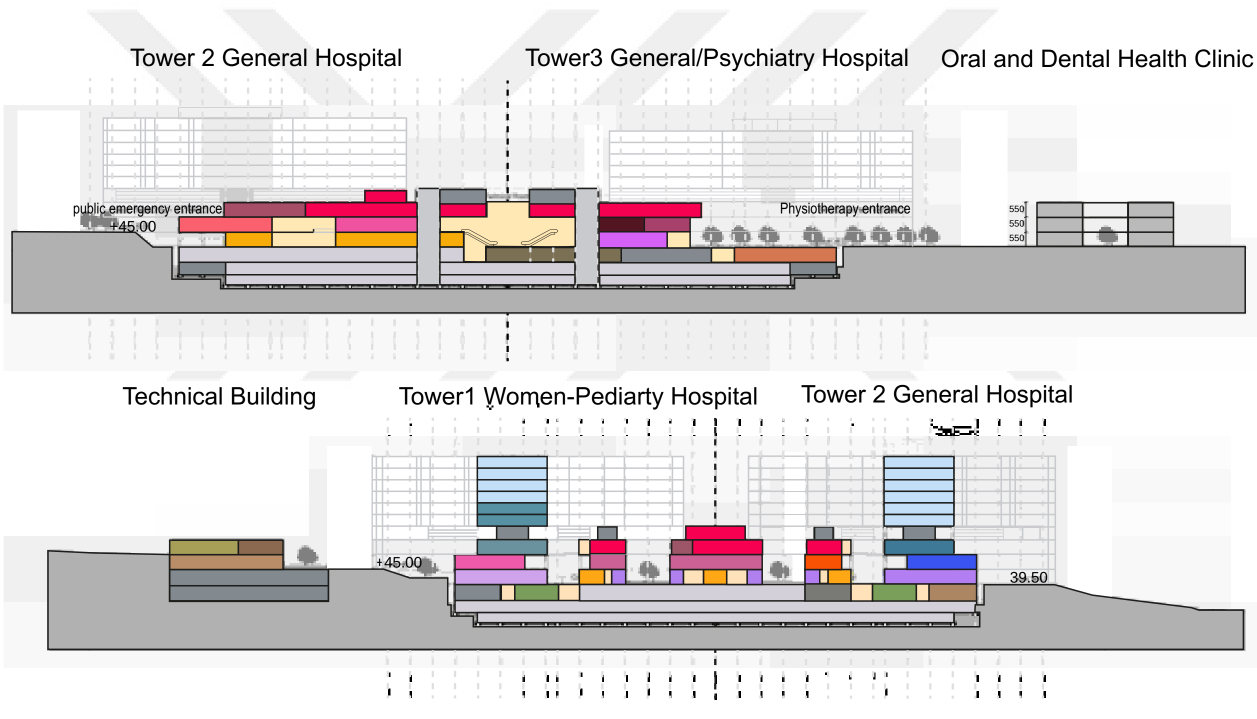


Figure 3.39: Elazığ City Hospital Sections
(Source: ELZ Sağlık Yatırım A.Ş. (2017), edited by author)

Figure 3.40: Bursa City Hospital Interior
(Source: https://www.yazgandesign.com/bursa-integrated-health-campus)

Flexibility Concept in the Architecture

The patient admission offices on the ground floors are the first places where patients encounter indoor space. However, in these huge masses where many functions exist together, wayfinding is a clear and relevant issue based on interviews and questionnaires with patients. Regarding this problem, mobile applications that provide navigation services inside and outside the hospital have been developed. Courtyards have been created in Adana city hospital to strengthen the relationship of people with the outdoors and to ensure that they benefit from sunlight to the maximum. Rich social areas have been created by landscaping in these courtyards (see Figure 3.41).

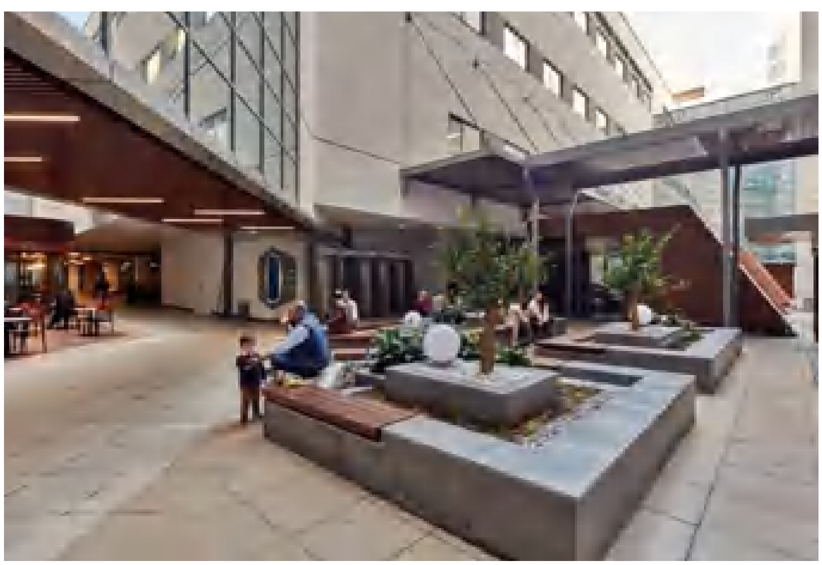


Figure 3.41: Adana City Hospital Outdoor
(Source: https://www.yazgandesign.com/adana-integrated-health-campus)

Modular design

As in Adana City Hospital, core masses generally have a modular grid system and are formed at 8.50m axis range. The reason for this is that city hospitals are obliged to have a certain amount of basement parking space, which is stipulated by the ministry. Because this structure system is designed to fit three vehicles in each axle range as a design preference. In addition, these distances have enabled larger spaces such as imaging and operating rooms to be placed in accordance with the standards without being divided by structural elements. In addition, the 3.00m patient corridor required by the Ministry of Health (FGI is 2.40m) and two rooms of 20-24 m² are suitable to fit all in this axis arrangement (Turkey's Healthcare Building 2010 Minimum Design Standards Guideline).

The situation is a little different for inpatient services or intensive care. Despite the fact that the width of the two patient bedrooms fits into the 8.50m span, the axes on the other side are designed as 6-7m in order to optimize the room depths according to the standards. Because a patient's room needs to receive daylight. On the other hand, functions in the core mass require less sunlight (in some cases courtyards can be seen), while polyclinic and inpatient services require thinner masses. In other words, due to the axle spans and functional reasons, plan schemes differ greatly in the core and towers (see Figure 3.42 & 3.43).

One of the important elements that distinguish new hospitals from old hospitals is the facade systems. These hospitals are structures with technical equipment that enables natural ventilation as well as HVAC systems. In three city hospitals, curtain wall systems that can easily respond to the developing and changing health sector and needs by providing easy assembly and disassembly are preferred. This provides great future advantages in terms of flexibility and adaptability (see Figure 3.44). Addition to this, in the example of Bursa, it is seen that colors and materials that will make the patients feel in a warm environment were chosen which affects patient health and psychology directly (see Figure 3.45).

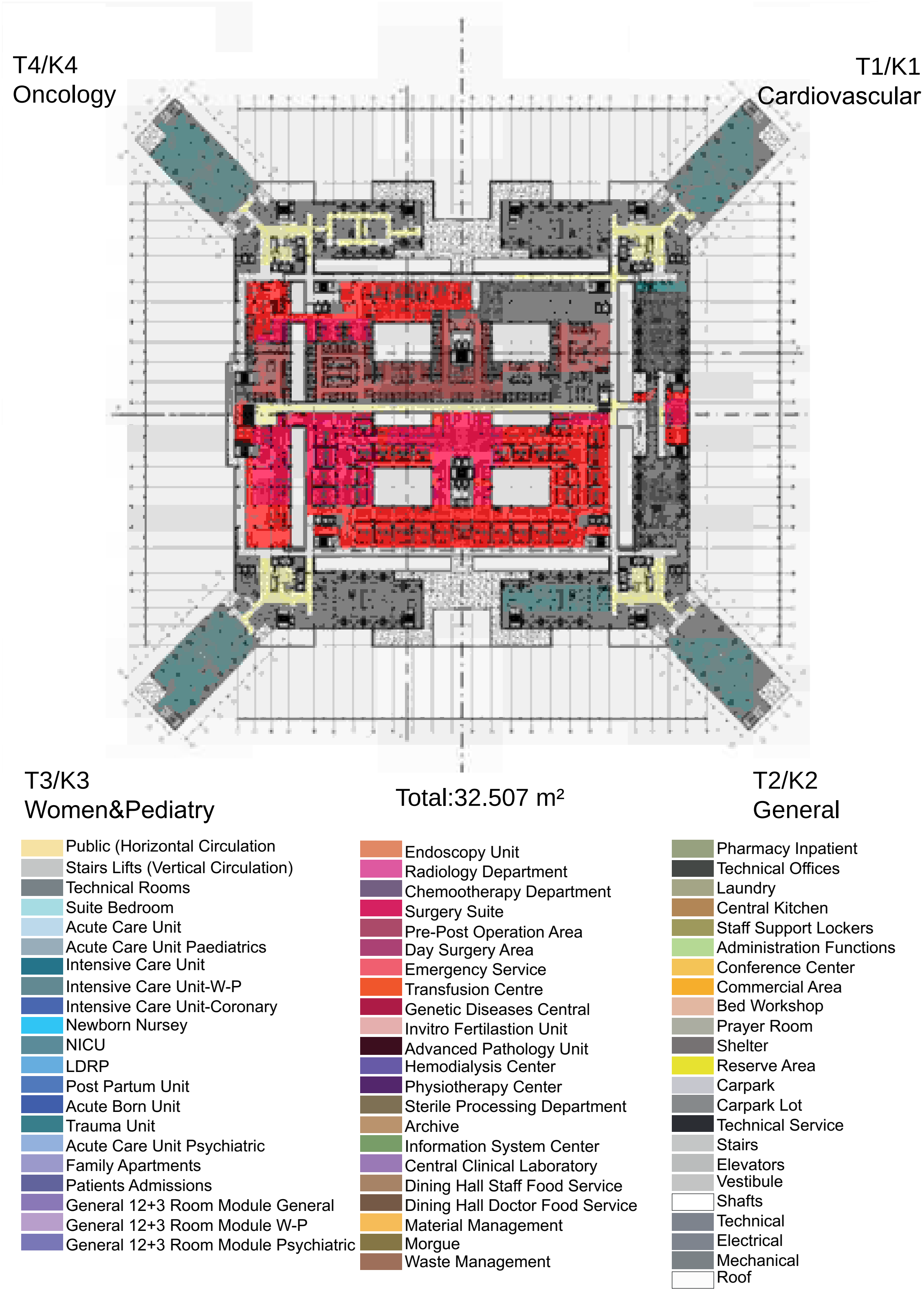


Figure 3.42: Bursa City Hospital Ground Floor Plan
(Source: BRS Sağlık Yatırım A.Ş. (2016), edited by author)

T1/K1

16 Bed Intensive Care Unit : Coronary	NF(rp) GFA	769,2 m² 2344,5 m²
13 Bed Intensive Care Unit : Coronary	NF(rp) GFA	620,4 m² 1004,5 m²

T2/K2

16 Bed Intensive Care Unit : General-1	NF(rp) GFA	681,1 m² 1217,5 m²
16 Bed Intensive Care Unit : General-2	NF(rp) GFA	664,1 m² 1127,0 m²
13 Bed Intensive Care Unit : General	NF(rp) GFA	609,4 m² 1004,5 m²

T3/K3

16 Bed Intensive Care Unit : Women-Pediatry1	NF(rp) GFA	720,3 m² 1260,5 m²
16 Bed Intensive Care Unit : Women-Pediatry2	NF(rp) GFA	714,3 m² 1165,5 m²

T4/K4

16 Bed Intensive Care Unit : Oncology1	NF(rp) GFA	720,3 m² 1260,5 m²
16 Bed Intensive Care Unit : Oncology1	NF(rp) GFA	714,3 m² 1165,5 m²

CORE

Pre-Post Operating Area :	NF(rp) GFA	2409,2 m² 4129,3 m²
16 Operating Rooms :	NF(rp) GFA	4518,5m² 9197,3m²
16 Bed Cardio-Intensive Care Unit:	NF(rp) GFA	425,0 m² 850,4 m²

Figure 3.43: Bursa City Hospital Ground Floor Plan Legend
(Source: BRS Sağlık Yatırım A.Ş. (2016), edited by author)

Figure 3.44: Bursa City Hospital Modular Facade Design
(Soorce: https://www.yazgandesign.com/bursa-integrated-health-campus?pgid=k1darsw3-2d59810b-3173-4659-8a8a-ca9582d83198)

Figure 3.45: Bursa City Hospital
(Source: https://www.yazgandesign.com/bursa-integrated-health-campus)

Change by management

Single rooms are designed to be transformed into intensive care units under necessary conditions. In addition, these rooms, which are planned above normal standards, have a mechanical system that can be turned into double rooms when necessary.

Open ended plan system

As in the case in Adana, patient rooms on both sides are located around a single corridor. While the staff rooms are designed in the central area where it connects the two branch hospitals. As a result, both sides are used as corridors. At the same time, the bed towers were designed as open-ended corridors in order to provide the hospital with the opportunity to grow due to the possible future increase in demand and need.

Flexible site strategies

Again, taking into account a possible growth situation in the context of flexibility, the masterplan has left areas of expansion for the future, as seen in Elazig City Hospital (see Figure 3.31).

Future adaptability

Due to the fact that city hospitals have more than one electronic and mechanical system together, the circulation of these systems in the building is provided by the suspended ceiling system in the horizontal and the service shafts in the vertical. Since specialized or normal areas with various mechanical and technological equipment in hospitals are planned close to these shafts, they are easy to adapt in any growth situation. Considering that the rooms are spacious and the curtain wall system has sufficient adaptable technical equipment, it allows the equipment that is likely to be changed and renewed in the future to be easily installed.

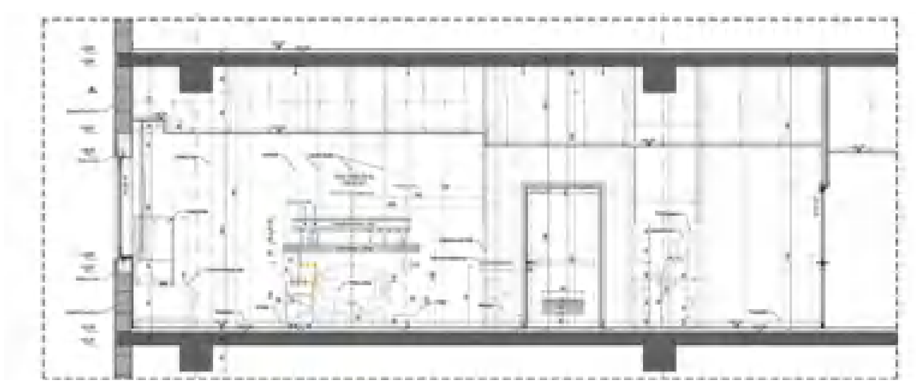


Figure 3.46 : Adana City Hospital Patient Room Section
(Source: https://www.yazgandesign.com/adana-integrated-health-campus)

Adaptability to COVID-19

These hospitals faced the COVID-19 epidemic that surrounded the world in a short period of one or two years after they were put into service. Except for Konya City Hospital, since it started its service in 2020, other three city hospitals were defined as pandemic hospitals and served a large number of patients at the same time. PCR (Polymerase Chain Reaction) Laboratory, known as "Coronavirus Diagnosis Laboratory" and having an important role in the diagnosis of COVID-19 disease, has been put into service in Elazig Fethi Sekin City Hospital. The Provincial Health Director Prof.Dr. Cahit POLAT stated that "Our Fetih Sekin City Hospital with our Directorate has played an active role in the pandemic process as in all other fields. Our laboratory has been put into service in order to get faster results in our hospital, which is the center of our region within the scope of combating coronavirus. Samples taken from people who apply to our hospital and are suspected of having COVID-19 are concluded in the laboratory on the same day, and the treatment of patients is started without wasting time. We get fast results with high capacity by using the latest technology diagnostic methods in the laboratory, which serves on a 24/7 basis."

The surgical instruments used in the operating rooms are sterilized with great care and diligence, and all textile products, from bed sheets to doctor's gowns and operating room covers, are sterilized by a "chip tracking system". 597 physicians and 2 thousand 55 assistant health personnel take charge ("Adana Şehir Hastanesi Covid-19 hastalarına umut oluyor", 2020). Fillation is a method of tracking who is infected with the virus and who has infected a case with a COVID-19 positive. In other words, it is the method of detecting the transmission and spread chain of the virus in every positive case. Since the first case on March 11, the virus has been traced around the contact area of each new patient. With the tracing method, everyone who had contact with the disease in the last 4 days was reached, the necessary tests were performed, and positive cases were quarantined and treated . In this context, 600 thousand fillation studies have been carried out so far. Contact persons were contacted and asked to isolate themselves first, and their locations were evaluated and tested. Trainings were provided in order to prevent contamination potentials. In this way, 99% of those who come into contact with positive cases within a period of 20 hours are reached. Thanks to fillation studies, cases are detected early and the risk of transmitting the disease to others is minimized and early detection of patients ensures early initiation of the treatment process and increases the rate of recovery (TGA, n.d.). In the report submitted by the TTB to the Ministry of Health, it was unfortunately seen that the prominent problems continued during the pandemic period, and that new challenges were added. Due to the large indoor area per bed in city hospitals, physicians and healthcare professionals have to spend a lot of effort both during daily working hours and during shifts due to the increased distance they have to provide services within the hospital. Some colleagues report that they have to take more than twenty thousand steps during their seizures. It is obvious how much trouble these difficulties created during the pandemic period (Türk Tabipler Birliği, 2019).

	POINTS	OPTIONS	ADANA CITY HOSPITAL	BURSA CITY HOSPITAL	ELAZIG CITY HOSPITAL
SHAPE	10 9 8 7 6 4 2 0	100 % Compact 75 % Compact Vertical 50 % Compact Linear Articulated Horizontal, Detached Buildings	2 / 10	2 / 10	2 / 10
STRUCTURE	4 2 +1 +1 +1 +1 +1 +1 +1	7m ≤ Span ≤ 8m Open floor plan Span > 8m Span < 7m Regular Grid Squared Grid Oversized Elements Punch Through Concrete Slabs for Vertical Circulation Hollow Pillars for Technical Installations Ceiling Height ≥ 4m	5 / 10	7 / 8	4 / 8
FACADE	6 4 2 0 0 +4	100 % Curtain Wall 75 % Curtain Walls 50 % Curtain Walls Ventilated Facade Traditional Masonry / Brick Wall Modular Panels	10 / 10	10 / 10	10 / 10
BUILDING PLANT	2 1 0 +2 +1 +1 +1 +1 +2* +1* +1*	Distance in between Service Shafts: d ≤ 35m Distance in between Service Shafts: 35m < d ≤ 70m Distance in between Service Shafts: d > 70m Redundancy for Building Plant Distribution in Raised Floor and/or Exposed Installations if Required Plant Tower Technical Floor Service Shafts Area: Shafts Total Surface/Floor surface ≥ 0.01 Spread out Plant Infrastructure in False Ceiling* Condensed Plant Infrastructure (Varying Height of False Ceiling)* Technical Interstitial Floor*	7 / 10	7 / 8	7 / 8
EXPANDABILITY	+4 +2 +1 +1 +1 +1	Internal: Already Equipped Spaces Internal: Shell Spaces Open Ended Corridor and/or Large Spaces on Building's End Soft Spaces: to be Retrofitted into Service Spaces if needed External: Volumes "Hanging" from the Facade Availability of Neighboring Plot	7 / 10	6 / 10	7 / 10
STRUCTURAL CONSTRAINTS	6 4 2 0 +2 +1 +1	Only Fixed Vertical Elements (Circulation & Service Shafts) Fixed Elements of Building Plant: Up to 25% Fixed Elements of Building Plant: Up to 50% Fixed Elements of Building Plant: Up to 75% Drain Pipes: In Service Shafts or Running Next to Pillars Adjustability of Service Shafts Grouped Vertical Circulation Elements	9 / 10	9 / 10	9 / 10
TECHNOLOGY	4 2 0 +1 +1 +1 +1 +2* +1*	Dry Assembly Technique Mixed Assembly Technique Wet Assembly Technique Internal Partitions: Modular Panels Internal Partitions: Panels Set up with Technical Installations Internal Partitions:Movable/Retractable Internal Partitions: Framed Construction Internal Partitions: Prefabricated Panels* Internal Partitions:Dry Walls Built In Situ*	5 / 10	5 / 9	5 / 9
EXCHANGEABILITY OF LARGE EQUIPMENT	8 4 0 +1 +1	Only needs disassembly of facade panels Disassembly of facade panels and of internal partitions Partial demolitions Large Equip.: In Ground Floor/ Floor with Direct Contact to Outside Equipments Spaces with Redundancy	4 / 10	5 / 10	5 / 10
FUNCTIONALITY	+4 +2 +1 +1 +1 +1	Generic/Universal Rooms Space Standardization Double Function Overflow Design Loose Fit Furniture/Equipment Flexibility	10 / 10	10 / 10	10 / 10
TOP SCORE			**59 / 90**	**62 / 85**	**59 / 85**

Table 3.4: Assessment of Adana, Bursa Elazig Fethi Sekin City Hospitals (Source: Author)

Adana City Hospital Assessment

Figure 3.47: Adana City Hospital Optimized Assessment Score & Classification
(Source: Author)

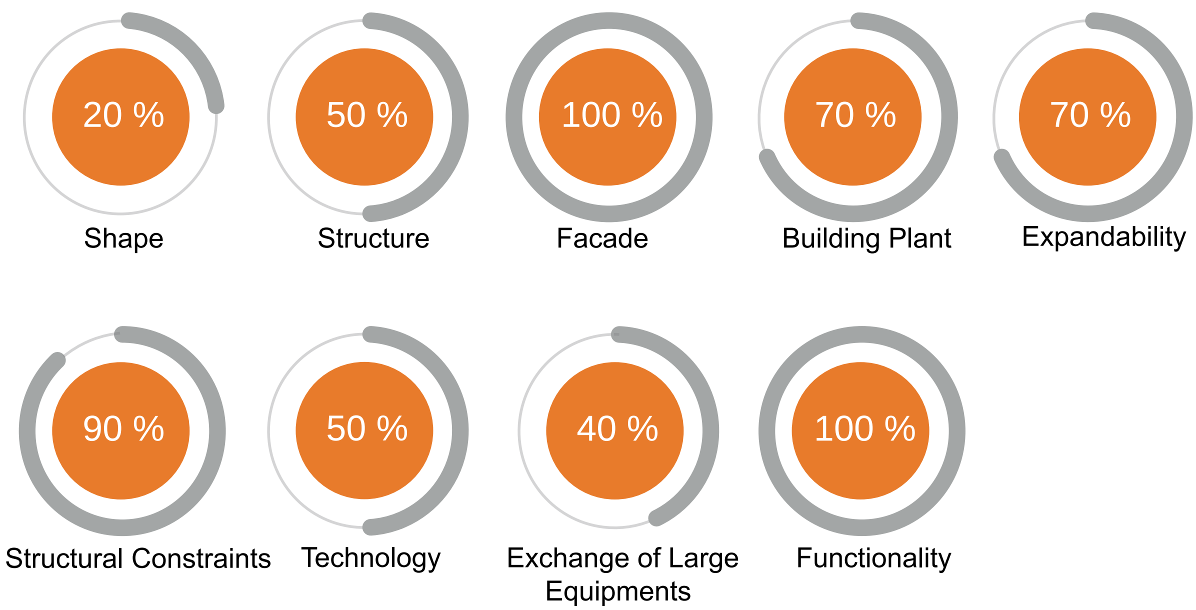


Figure 3.48: Adana City Hospital Optimized Evaluation Parameters Score
(Source: Author)

Bursa City Hospital Assessment

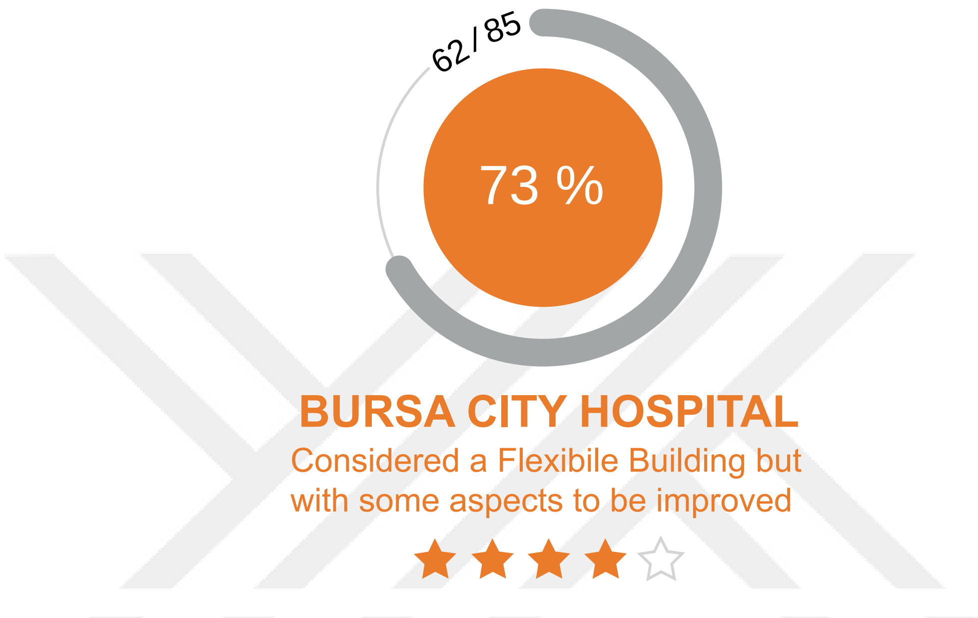


Figure 3.49: Bursa City Hospital Optimized Assessment Score & Classification
(Source: Author)

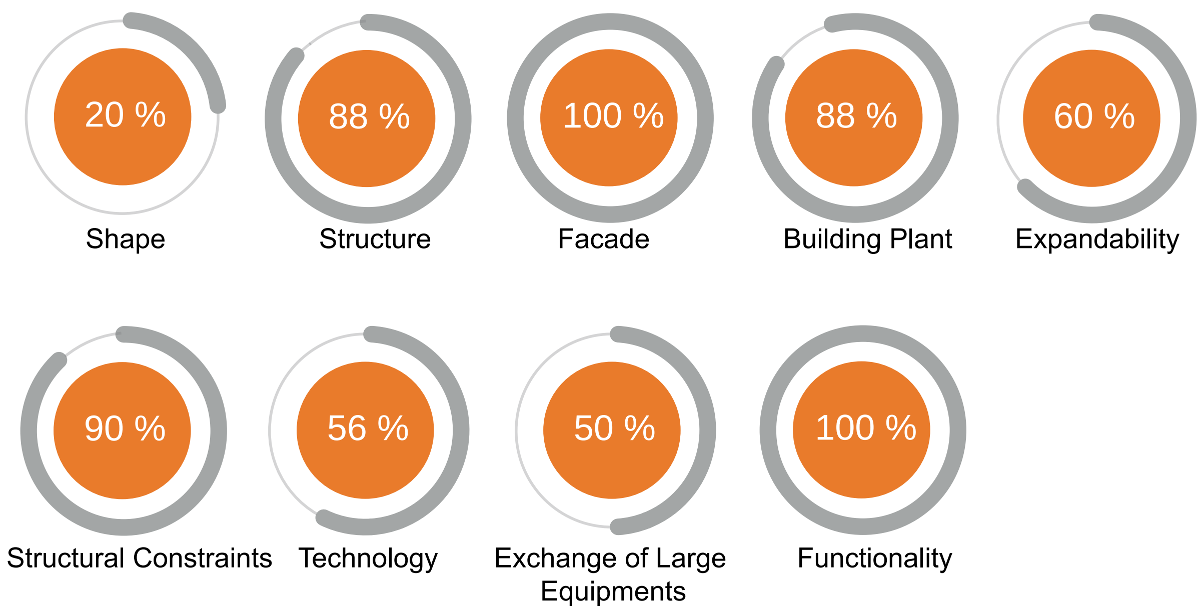


Figure 3.50: Bursa City Hospital Optimized Evaluation Parameters Score
(Source: Author)

Elazığ Fethi Sekin City Hospital Assessment

Figure 3.51: Elazığ Fethi Sekin City Hospital Optimized Assessment Score & Classification
(Source: Author)

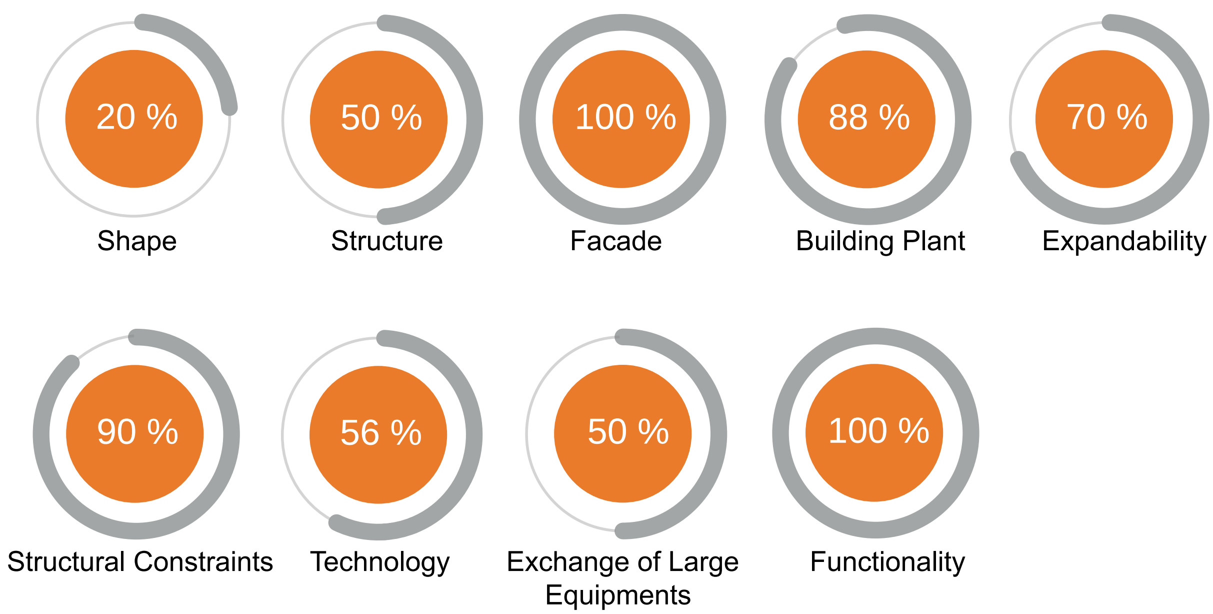


Figure 3.52: Elazığ Fethi Sekin City Hospital Optimized Evaluation Parameters Score
(Source: Author)

Ankara Bilkent City Hospital

Kayseri City Hospital

Konya City Hospital

Arms attached to the Main Core: Ankara-Konya-Kayseri City Hospitals

Essentials

City Hospital	Population	Operation Date	Contractor	Gross Floor Area m²	Bed Capacity	Intensive Care Unit	Operation Room
Ankara Bilkent	5.50 million	February 2019	CCN	1.312.000	3711	506	131
Kayseri	1.39 million	August 2019	YDA	466.379	1607	253	43
Konya Karatay	2.20 million	October 2020	YDA	421.566	1250	240	49

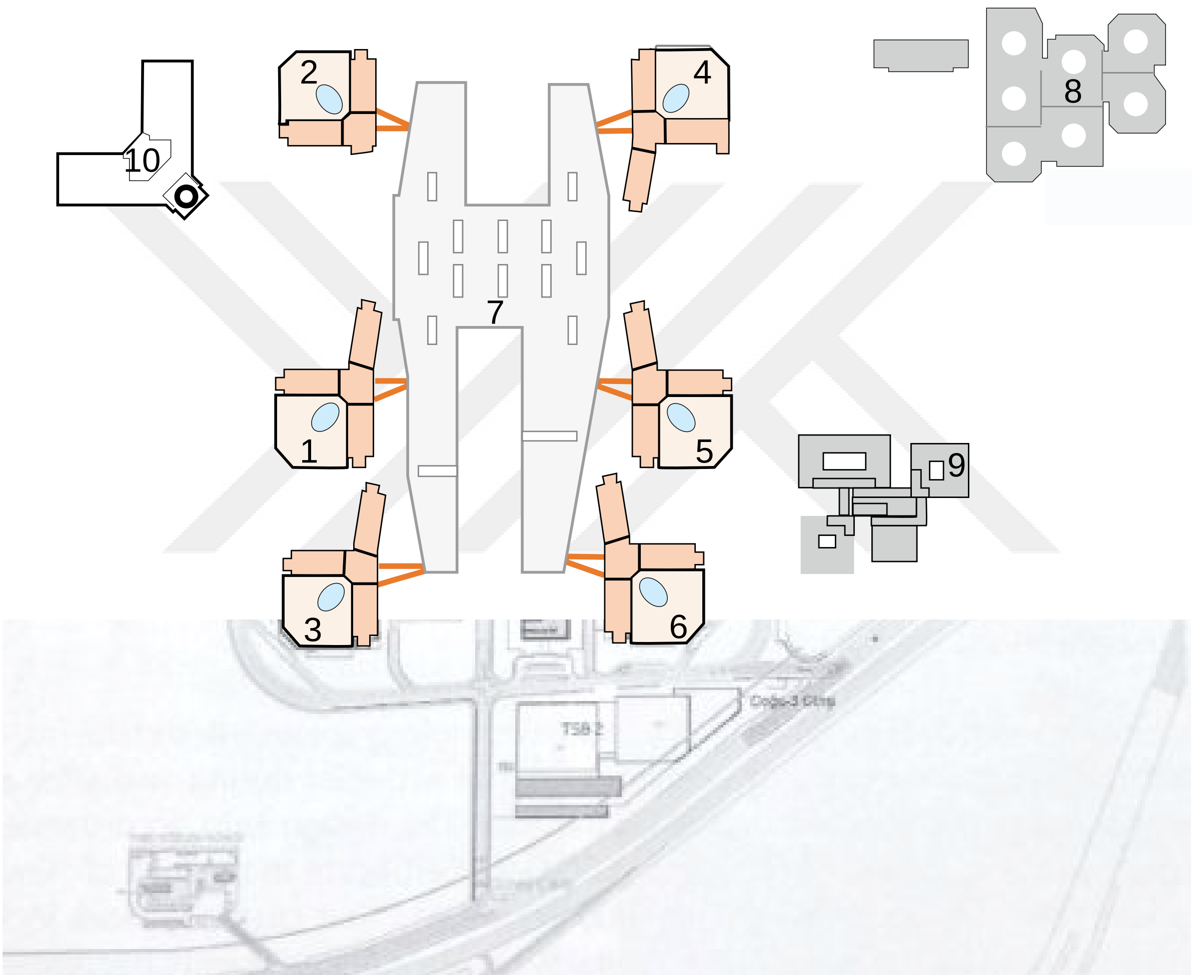
Table 3.5: Main Features of Ankara Bilkent, Kayseri and Konya Karatay City Hospitals
(Source: Author)

Ankara Bilkent City Hospital, Kayseri City Hospital and Konya Karatay City Hospital can be categorized as arms attached to the main core. The most distinctive feature of this typology from “Y-shaped towers on muffin” is that branch hospital towers are connected to the main core, which are the treatment diagnostic units, by bridges or transition spaces.

The construction of Ankara and Kayseri city hospitals was completed in 2019, and Konya City Hospital started operating in October 2020. The contractor firm of Kayseri and Konya city hospitals is YDA Group and their total construction areas are approximately 440,000 (420,000-460,000) square meters due to the proximity of the city populations in which they are located. The contractor firm of Ankara Bilkent City Hospital is CCN Group and is the largest city hospital built so far , with a construction area of approximately 1,300,000 square meters. Additionally, this hospital includes some departments of the Ministry of Health. When comparing these new hospitals in Turkey, with up to 3700 bed capacity, with the ones in Europe; they seem to be quite big and complicated healthcare facilities. Additionally, Ankara Bilkent City Hospital

They all are located in the developing (semi-urban) parts of their city. In the campus planning, pedestrian and vehicle circulation are separated as much as possible and a more comfortable user environment has been created.

As in the city hospitals mentioned before, these three hospitals have a wide variety of departments (general hospital, pediatric hospital, obstetrics, oncology, cardiology, PRM, psychology). While the main mass serves as diagnosis and treatment, branch hospitals reached with the help of bridges host polyclinics. In the case of Kayseri City Hospital, the main hospital in the campus contains the services of cardiology, neurology, internal diseases, cardiovascular surgery, endocrinology and metabolism, dermatology, infectious diseases, ENT, plastic surgery, pediatric surgery, ophthalmology, orthopedics, general surgery, thoracic surgery, neurosurgery, urology, gastrology, hematology, oncology, chest diseases, and psychiatry. Konya Karatay City Hospital additionally, includes a dental hospital in the campus. The facilities have heliports and patients that are brought to the hospital by helicopters can directly be taken to operation rooms or intensive care rooms by the rooftop. The claim of the Ministry of Health is that patients can experience private hospital service at state hospitals under international standards.



(1) General Hospital
(2) KVC Hospital
(3) Neurology Hospital
(4) Child Hospital
(5) Women Maternity Hospital
(6) Oncology Hospital
(7) Main Hospital
(8) High Security Forensic Psychiatry Hospital
(9) Phisical Therapy and Rehabilitation Center
(10) Ministry of Health

Figure 3.53: Ankara Bilkent City Hospital Master Plan

(Source: http://www.turkbiyokimyadernegi.org.tr/upload/48/Dosyalar/tmp/201959174414.pdf, edited by author)

These 3 hospitals, which have a larger area compared to “Y-shaped towers on muffin” hospitals, have not yet received LEED certification. However, Kayseri City Hospital was awarded the 2017 Sign of the City Awards, Best Healthcare Building.

Architectural Typology and Spatial Organizations

As in the “Y-shaped towers on muffin” typology, all departments are gathered together in these three hospitals. These different departments are connected to the main mass with the help of a transition space (bridge or passage corridor). Since the diagnostic treatment mass has a large surface area, units such as operating room, imaging, endoscopy, which do not need daylight, are gathered here. The inpatient sections are planned to receive daylight in the surrounding towers of the diagnostic treatment mass. On the ground floors, admissions and support units serve inpatient and outpatient units (see Figure 3.54 & Figure 3.55). In Ankara Bilkent City Hospital there are towers with L-type plan schemes attached to a linear mass.

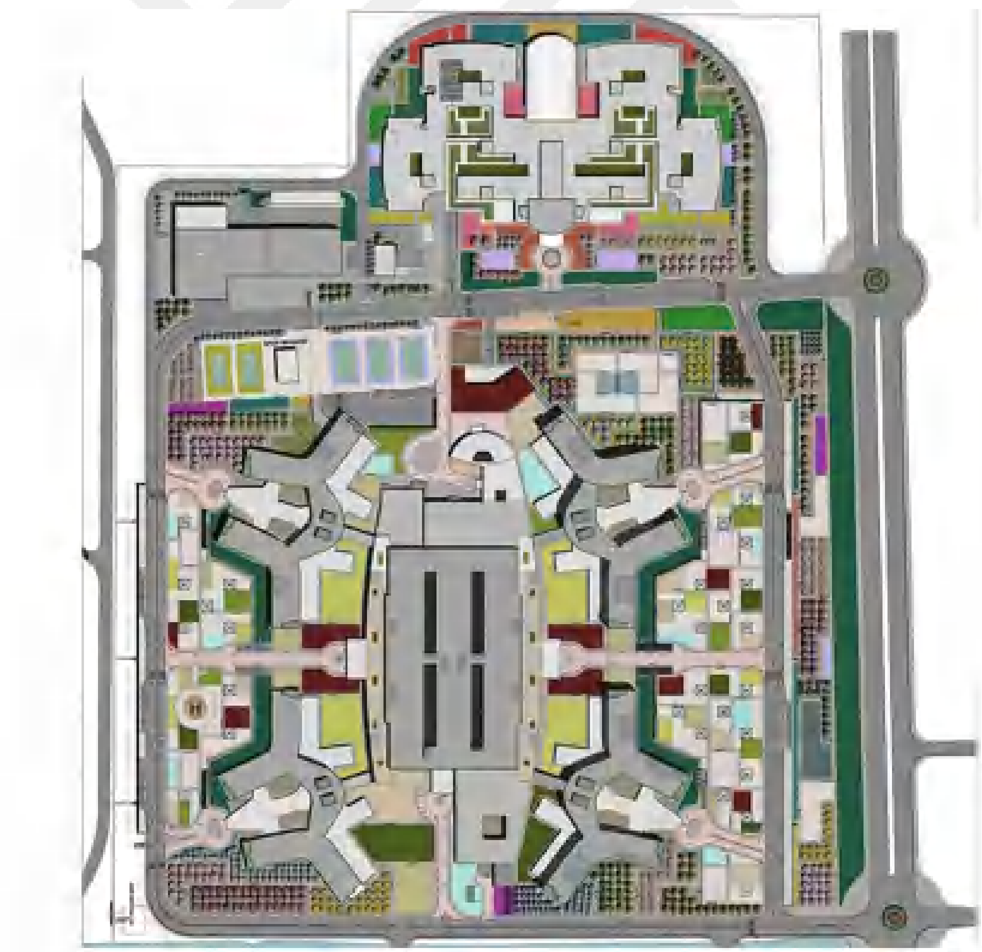


Figure 3.54: Kayseri City Hospital Master Plan
(Source: https://www.yazgandesign.com/kayseri-integrated-health-campus)

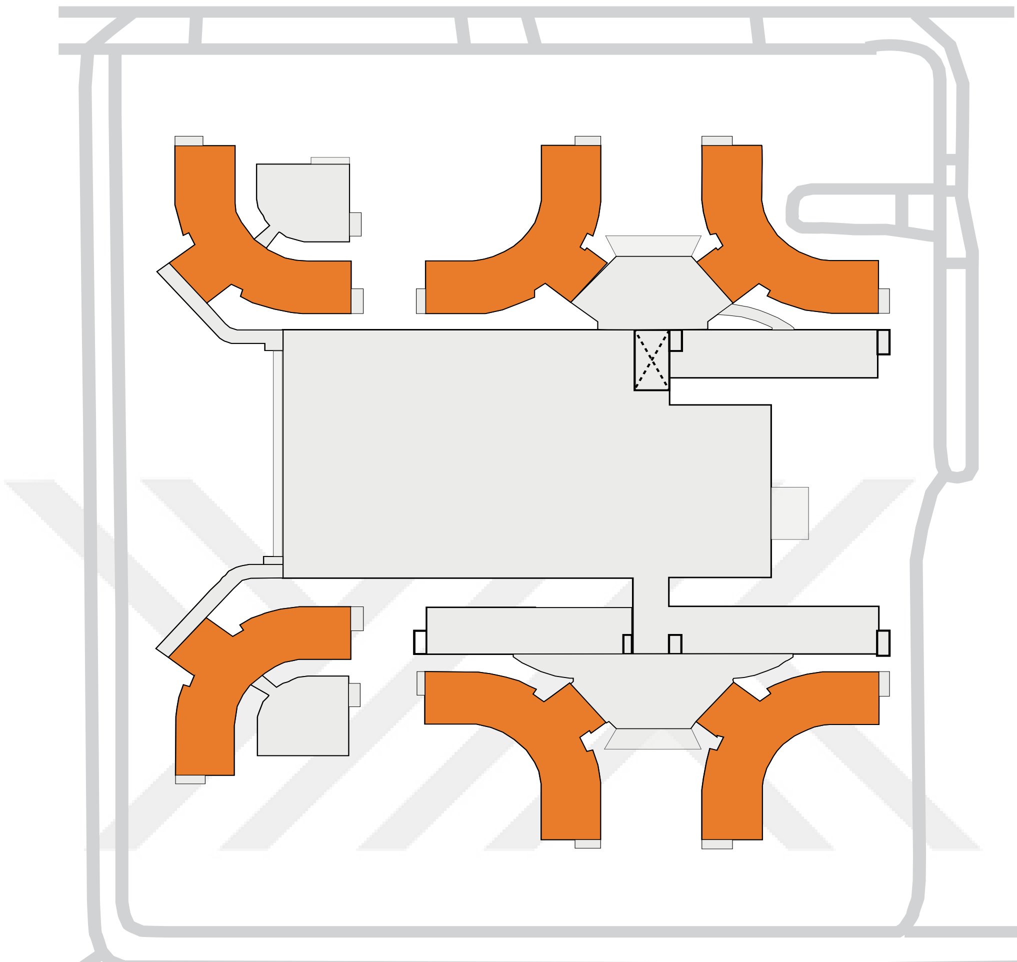


Figure 3.55: Konya Karatay City Hospital Master Plan
(Source: https://play.google.com/store/apps/details?id=tr.gov.saglik.konyasehirhastanesi&hl=tr&gl=US, edited by author)

City hospitals are quite large in mass, while Ankara is extra large compared to the others. This situation causes problems in terms of space organization and human scale. This space organization includes a human circulation scheme that starts from a central area in all three city hospitals and towards non-centralized specialized areas.

It is observed that the pedestrian roads and vehicle roads inside the complex are also separated from each other. Inside the hospital, there is a large separation of personnel, patients, dirty-clean materials in both vertical and horizontal planes. In addition, vertical circulation is provided by the escalators in the main mass, as well as the cores where the elevators and stairs are located. There are also galleries in this area where visual communication is strengthened (see Figure 3.56 & 3.57). There are orientation and wayfinding problems in Ankara due to the mass size whereas Kayseri is rich in instructions and guides. These elements are both located on the floor and wall make it easier for the users to find their way (see Figure 3.58, 3.59 & 3.60).

Figure 3.56: Kayseri City Hospital Entrance
(Source: https://www.yazgandesign.com/kayseri-integrated-health-campus)

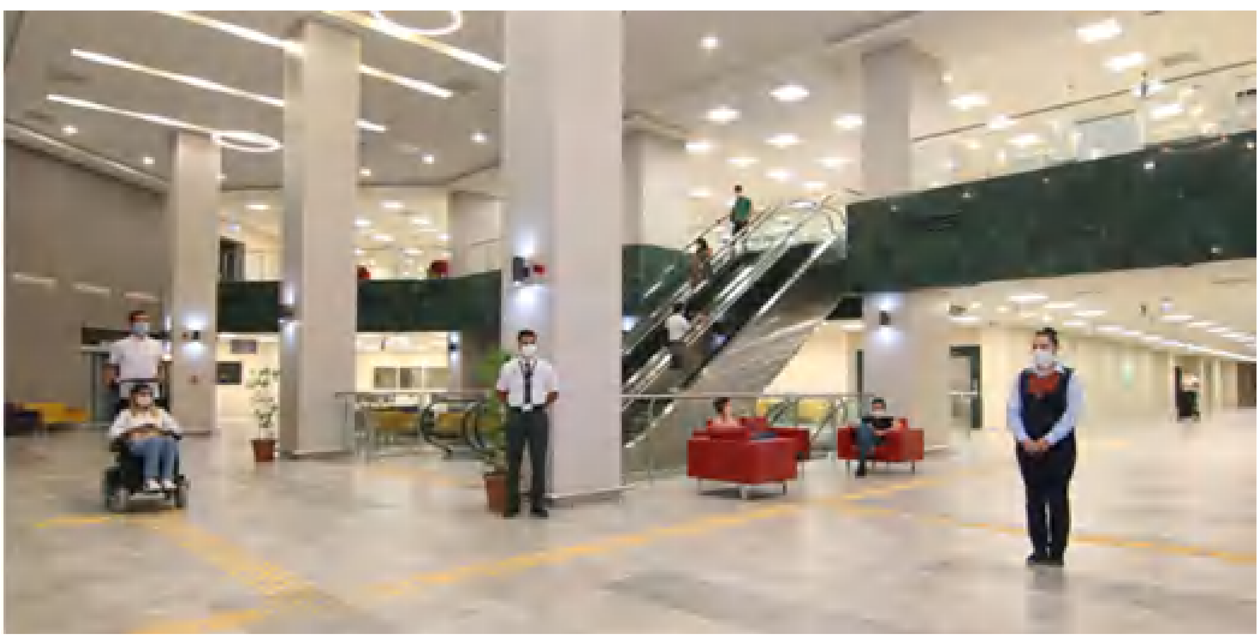


Figure 3.57: Konya Karatay City Hospital
(Source: http://ydasaglik.com.tr/projelerimiz/konya-karatay-sehir-hastanesi/)

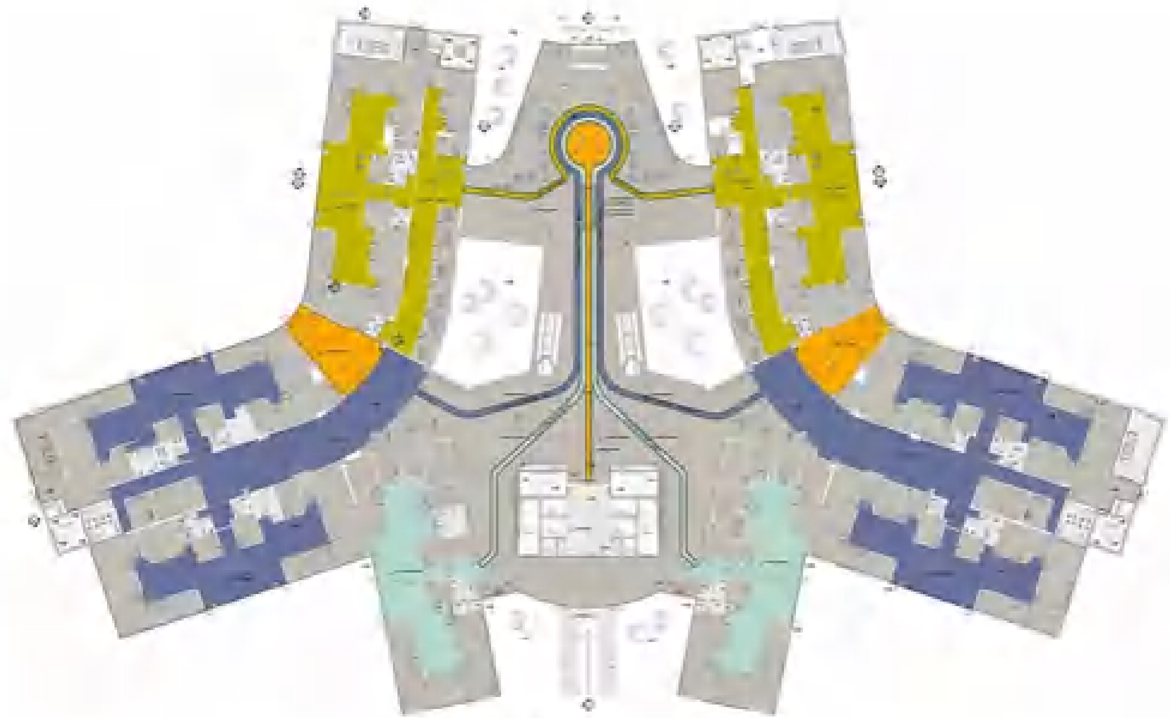


Figure 3.58: Kayseri City Hospital Floor Plan
(Source: https://www.yazgandesign.com/kayseri-integrated-health-campus)

Figure 3.59: Kayseri City Hospital Interior

(Source: https://www.yazgandesign.com/kayseri-integrated-health-campus)

Figure 3.60: :Kayseri City Hospital Section
(Source: https://www.yazgandesign.com/kayseri-integrated-health-campus)

As in the example of the Kayseri city hospital, the nurse stations in branches are not concentrated in a single point and are spread along the corridors surrounding the rooms in order to ensure maximum observation and communication of the inpatients. There is one nurse for four rooms. In intensive care units, a central nurse station is designed for every 12 patient rooms. In addition, there is a nurse work desk in between for every two intensive care rooms. Visual contact with the patient is provided through the windows facing the patient room in front of these desks (see Figure 3.61).

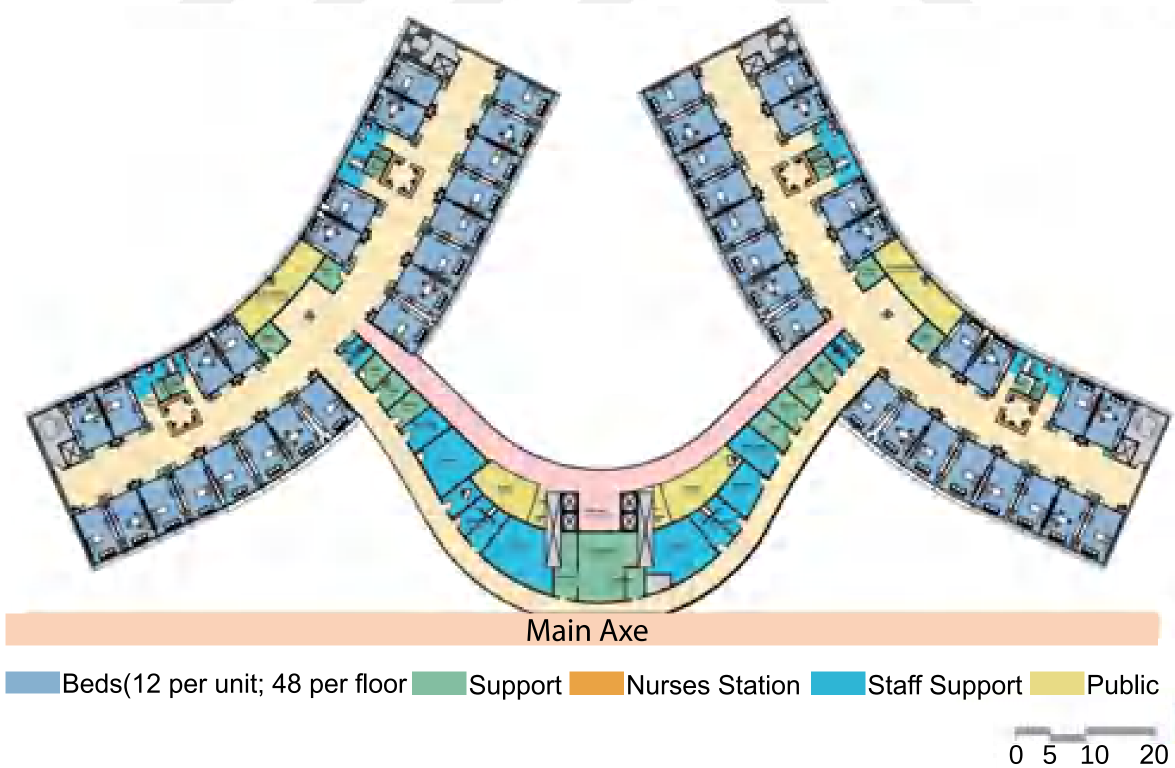


Figure 3.61: Kayseri Integrated Health Campus Intensive Care Unit Floor Plan
(Source: Sönmez (2014), edited by author)

Flexibility Concept in the Architecture

Comfort and capacity in inpatient wards

One of the most striking points in the design of Integrated Health Campuses is the patient rooms. Designed with a patient-oriented design logic, these rooms are remarkable in terms of the innovative approaches they offer in the interior and the size of the space. In the case of Kayseri, single patient bedrooms have a total area of 33 m² with 27 m² patient area, 5 m² toilet-shower area. Double patient bedrooms have 35 m² patient area, 5 m² toilet-shower area and net 35 m² area (see Figure 3.62 & Figure 3.63). The first reason why the patient bedrooms are made so large is to ensure that the relatives of the patients can stay in a comfortable environment without disrupting the treatment. The second reason is the effort to create more space for flexibility. It is known that the wider the hospital spaces, the more compatible they are with future medical developments.

Figure 3.62: Kayseri City Hospital Single Patient Room

(Source:https://www.yazgandesign.com/kayseri-integrated-health-campus)

Figure 3.63: Kayseri City Hospital Double Patient Room
(Source: https://www.yazgandesign.com/kayseri-integrated-health-campus)

In city hospitals, the infrastructure is planned to place an extra bed by placing extra bedside equipment in patient bedrooms. In this way, while providing treatment in a spacious and comfortable place during normal times, the hospital bed capacity can be doubled with the added beds in possible extraordinary situations. Behind the reason for the claim of city hospitals to provide treatment services in the comfort of a hotel lies the design of patient rooms A design approach has been adopted that will make the patient forget that they are in the hospital. The bedside furniture of the patient was extended to the ceiling, ensuring that the patient was under a safe roof. Bedside plumbing connections of the patient are hidden within the furniture. Colors that do not strain the eyes as much as possible have been chosen in the room. A cozy space was created by using wood or wood-like materials in the furniture in the room. The furniture is raised from the ground and cleaning is made easy. The companion sofa is designed to be wide and openable. A spacious and bright space was tried to be created by using curtain wall systems on all patient rooms, and it was aimed for the patient to see the view.

Modular Design

In acute care units, there is a ratio of one to two between the number of single rooms and double rooms. In other words, there is one double room per single room. Several patient care modules can come together in the same tower floor. There are elevators and support units at the intersection points of these modules (see Figure 3.64, 3.65 & 3.66).

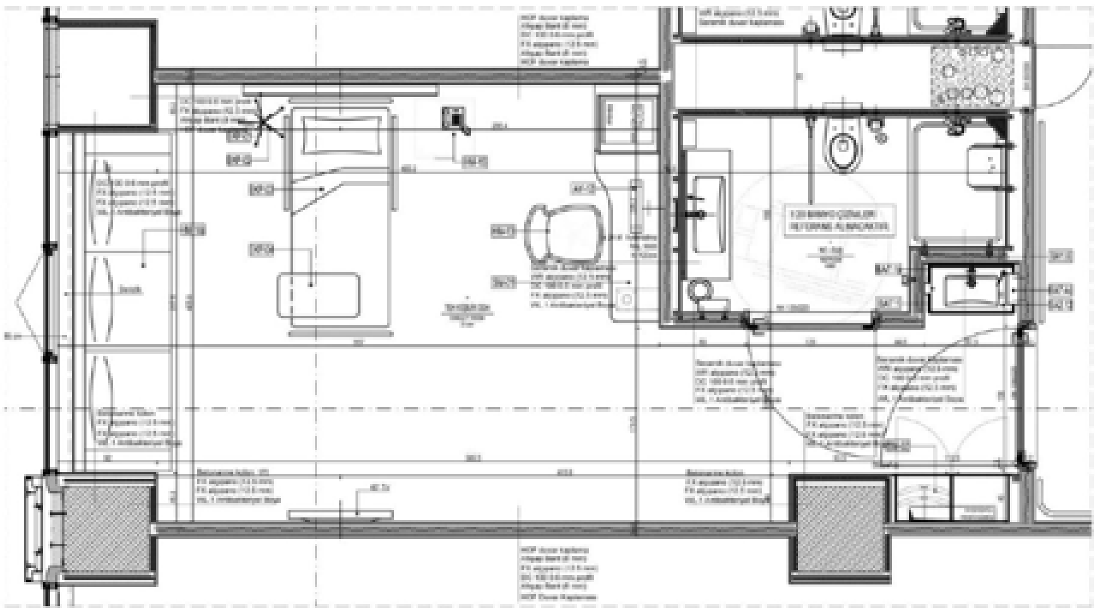


Figure 3.64: Ankara Bilkent City Hospital, Single Bedroom
(Source: Özkan (2018))

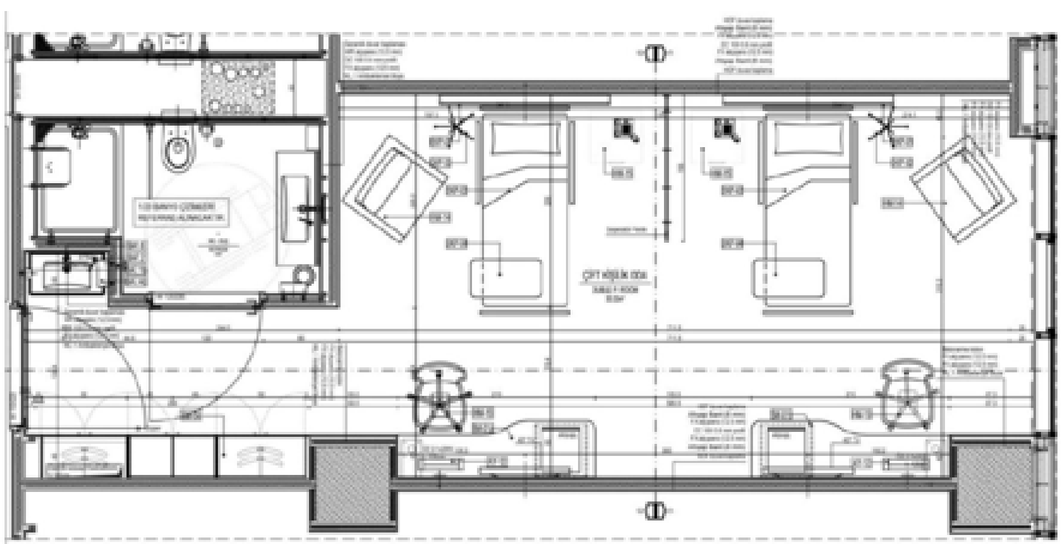


Figure 3.65: Ankara Bilkent City Hospital, Double Bedroom
(Source: Özkan (2018))

Figure 3.66: Ankara Bilkent City Hospital Inpatient Rooms
(Source: Özkan (2018))

A standard clinical module has been developed for all polyclinics in all branch hospitals. It is based on a modular system consisting of two examination rooms and one doctor's room. Two doctors (4 examination rooms) will share the nurse and support services, while 4 doctors (8 examination rooms) will jointly use the interim waiting and reception place/registration functions. 8 doctors (16 examination rooms) use the same staff support and general waiting areas. Each of the four modules has two rooms that can be used as private clinical rooms (intervention, ECG, EMG, etc.). One of them is considered as a sampling room. In this way, there is no need for outpatient clinic patients to go to the laboratory.Polyclinic modules are designed to allow different uses. The modules that can be used as 4 doctor 8 examination rooms can also be transformed into 6 doctor 6 examination rooms (see Figure 3.67).

Overflow design

There is a central preparation/recovery area serving all branch hospitals. This area serves all operating rooms, intervention rooms, angio rooms, cardiac catheter rooms and some endoscopy rooms. Designed as the repetition of the same module, these areas provide staff flexibility and ease of managing patient flows at different times of the day. For example, a pre-operative space for morning angio patients can be used as a post-operative room for surgical patients in the afternoon.

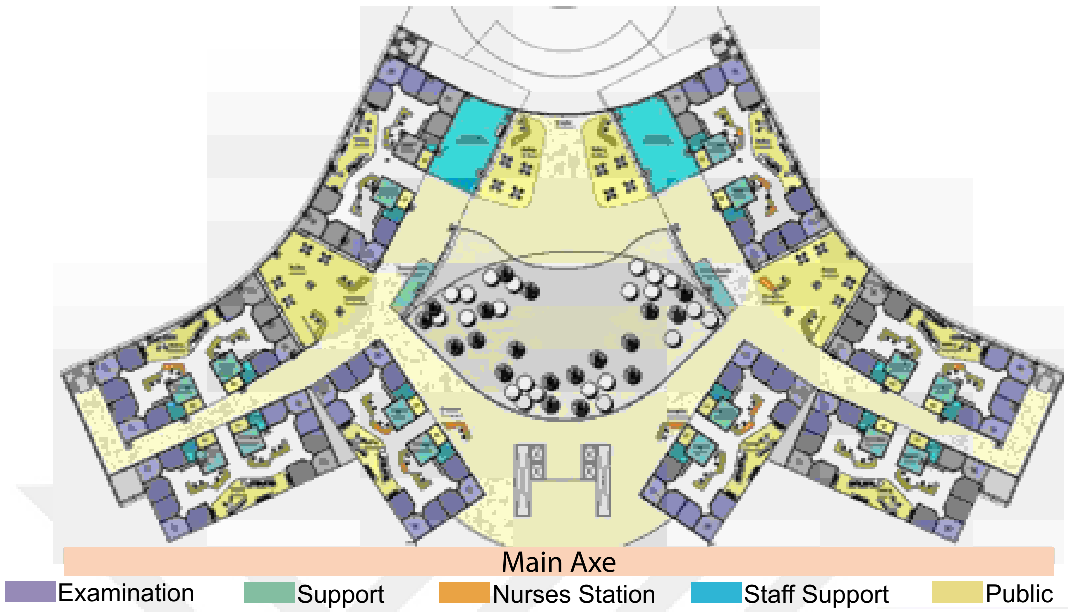


Figure 3.67: Kayseri City Hospital Polyclinic Floor Plan
(Source: Sönmez (2014), edited by author)

Figure 3.68: Kayseri City Hospital Operating Rooms Plan
(Source: Sönmez, 2014)

Future adaptability

Depending on the modular system of the operating room, hardware storage areas are also shaped flexibly. The largest of these is located in the operating room module and allows them to be used in the future without building new spaces. The practice of doctors washing their hands and then entering the operating room from the clean work area is not a globally universal model. Hand washing sinks are also located in the opposite corridor in order to adapt if the models change (see Figure 3.69).

Figure 3.69: Kayseri City Hospital Operating Room Plan
(Source: Sönmez (2014), edited by author)

Modular Facade System

While the facades of Kayseri and Konya City Hospitals are designed as curtain walls almost %100 percent, it differs for Ankara Bilkent City Hospital. Because although branch hospitals have curtain walls in this complex, it is not the case for most part of the diagnostic and treatment mass. Despite this situation, these facade systems, which are easy to install and remove, partially available in some parts are to provide convenience in terms of equipment installation when necessary. This feature is necessary for adaptation to technological equipment and treatment methods (see Figure 3.70).

Open ended plan system

In Konya Karatay City Hospital, patient rooms on both sides are located around a single corridor which curves along the tower. These corridors in bed towers are designed to be open-ended in order to create flexibility to grow in case of possible future increase (see Figure 3.71).

Figure 3.70: Kayseri City Hospital Modular Facade System
(Source: https://www.yazgandesign.com/kayseri-integrated-health-campus)

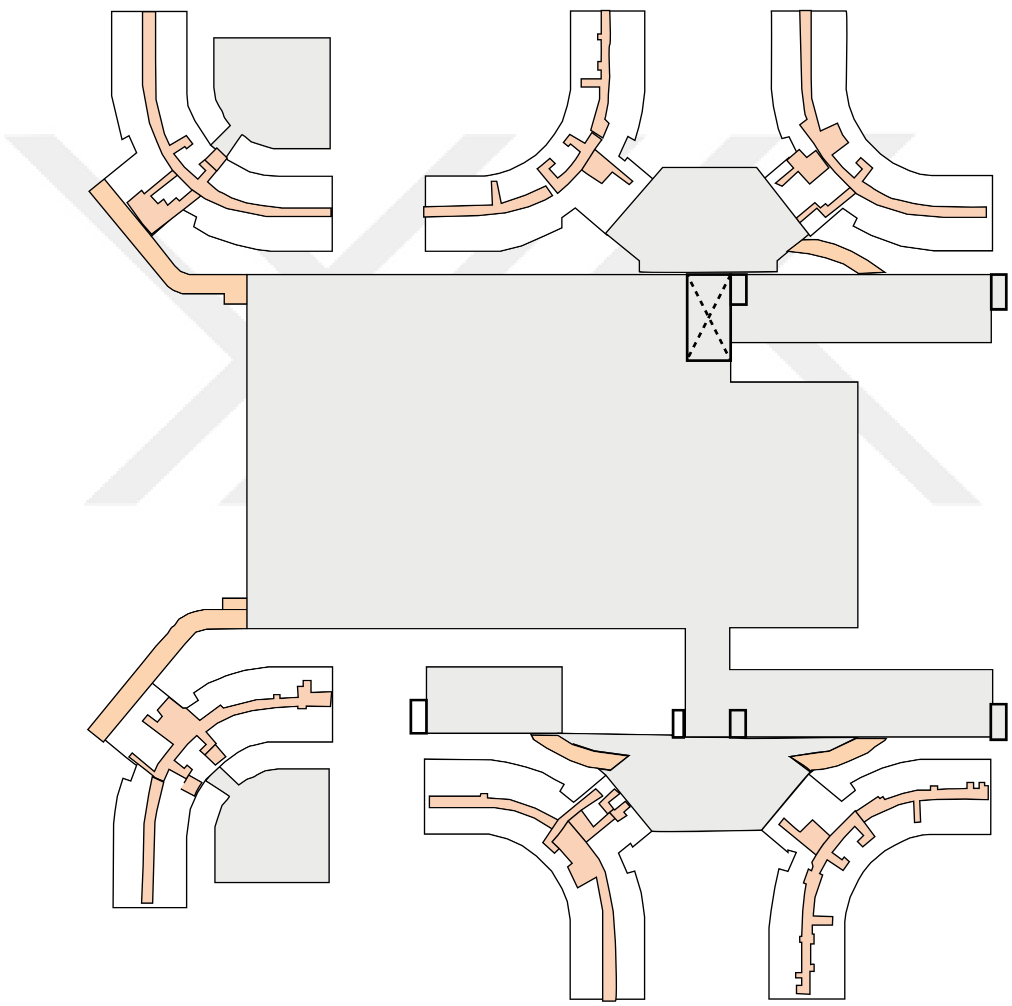


Figure 3.71: Konya Karatay City Hospital 6th Floor Plan
(Source: https://play.google.com/store/apps/details?id=tr.gov.saglik.konyasehirhastanesi&hl=tr&gl=US, edited by author)

Adaptability to COVID-19

Branch hospitals of Kayseri City Hospital played an important role during covid-19 as they allow separation of contaminated and non-contaminated parts. It is easier to control over spread of disease. For example, the psychiatric hospital serves for the COVID-19 test, while the cardiovascular hospital has been defined as the area of vaccination. In this way, the risk of spreading the infection is minimized (see Figure 3.72).

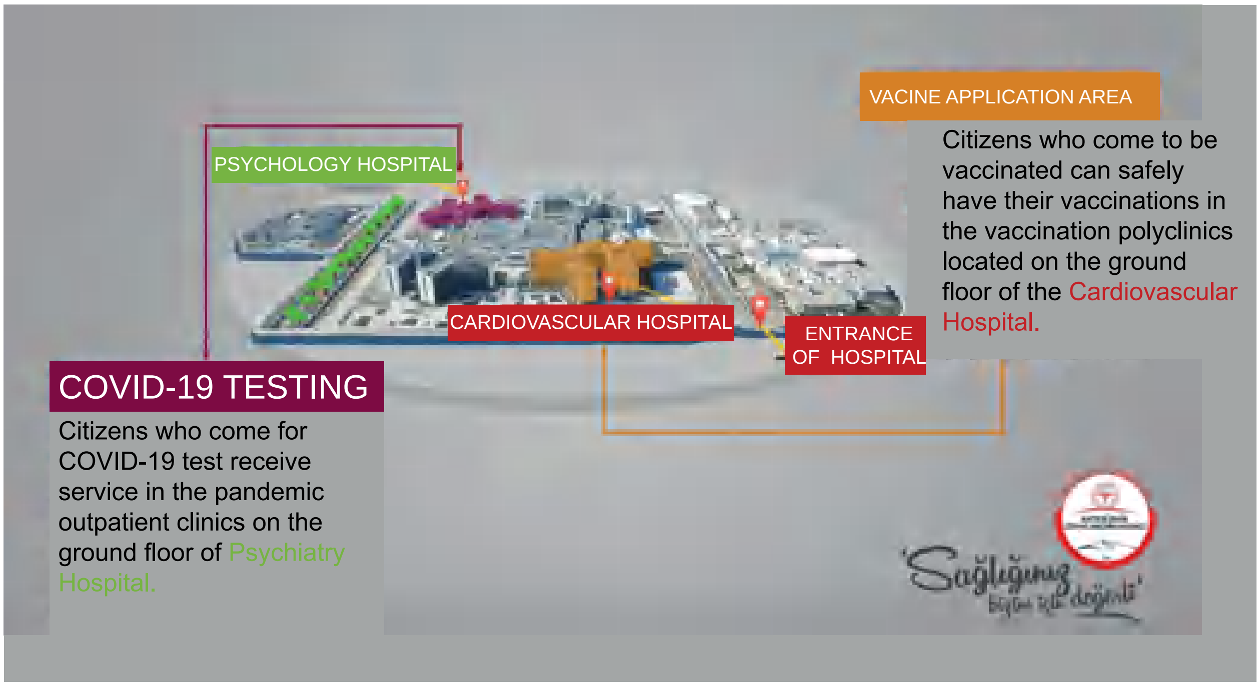


Figure 3.72: Pandemic Polyclinic and Vaccine Application Areas
(Source: https://kayserisehir.saglik.gov.tr/TR,521881/pandemi-pol-ve-asi-uygulama-alanlari.html, edited by author)

In the Covid-19 Follow-up Polyclinic established in Ankara City Hospital, Covid-19 patients who were taken into intensive care and intubated are regularly checked by the relevant branch physicians after their treatment. Ankara City Hospital Administrative and Training Supervisor Chest Diseases Specialist Prof. Dr. Aysegul Karalezli states that "An area of the Cardiovascular Hospital, including the Chest Diseases Clinic, was transformed into a Kovid Follow-up Polyclinic. Here, patients are evaluated within the scope of post-treatment follow-up with the departments of chest diseases, internal medicine, physical therapy and rehabilitation, neurology, cardiology and psychiatry if necessary." The physician, who follows the patients with intensive care or severe lung involvement in their clinics, records the patient in the Covid Follow-up Polyclinic before the patient is discharged. After this stage, an appointment is arranged for the patient. In this direction, after the patients are discharged, the necessary examinations are made and examined by the relevant branch physicians. Patient follow-up is carried out remotely (Karaaslan Sert, 2021).

While the hospital treated 7 thousand 425 Covid-19 patients in a 4-month period and was sent home, 99 of our patients died. Our Coordinator Chief Physician Op. Dr. Aziz Ahmet Surel said, “In general, we have a death rate that can be said to be below the world average.” In our hospital, where about 300 of our patients are still being treated; A total of 99 people died. Hospital mortality was 1.33 percent. Our Ankara City Hospital Coordinator Chief Physician Op. Dr. Aziz Ahmet Surel stated that they have treated 7 thousand 425 patients and discharged them since March 11, when the first case was seen. All provinces with city hospitals, we see that these provinces are always at the forefront in the fight against the pandemic. The existence of our Ankara City Hospital and its technological and physical structure made it the main base of our hospital in combating the pandemic in Ankara. In Ankara, more than 70 percent of our patients hospitalized in the intensive care unit and 40 percent of our inpatients were treated by the city hospital on the occasion of Covid-19. When there is a need above this, we are in a position to meet it, “he said (T.C. Sağlık Bakanlığı Ankara Şehir Hastanesi, 2020).

	POINTS	OPTIONS	ANKARA CITY HOSPITAL	KAYSERI CITY HOSPITAL	KONYA CITY HOSPITAL
SHAPE	10 9 8 7 6 4 2 0	100 % Compact 75 % Compact Vertical 50 % Compact Linear Articulated Horizontal, Detached Buildings	6 / 10	6 / 10	6 / 10
STRUCTURE	4 2 +1 +1 +1 +1 +1 +1 +1	7m ≤ Span ≤ 8m Open floor plan Span > 8m Span < 7m Regular Grid Squared Grid Oversized Elements Punch Through Concrete Slabs for Vertical Circulation Hollow Pillars for Technical Installations Ceiling Height ≥ 4m	7 / 8	4 / 8	6 / 8
FACADE	6 4 2 0 0 +4	100 % Curtain Wall 75 % Curtain Walls 50 % Curtain Walls Ventilated Facade Traditional Masonry / Brick Wall Modular Panels	8 / 10	8 / 10	10 / 10
BUILDING PLANT	2 1 0 +2 +1 +1 +1 +1 +2* +1* +1*	Distance in between Service Shafts: d ≤ 35m Distance in between Service Shafts: 35m < d ≤ 70m Distance in between Service Shafts: d > 70m Redundancy for Building Plant Distribution in Raised Floor and/or Exposed Installations if Required Plant Tower Technical Floor Service Shafts Area: Shafts Total Surface/Floor surface ≥ 0.01 Spread out Plant Infrastructure in False Ceiling* Condensed Plant Infrastructure (Varying Height of False Ceiling)* Technical Interstitial Floor*	5 / 7	5 / 8	6 / 8
EXPANDABILITY	+4 +2 +1 +1 +1 +1	Internal: Already Equipped Spaces Internal: Shell Spaces Open Ended Corridor and/or Large Spaces on Building's End Soft Spaces: to be Retrofitted into Service Spaces if needed External: Volumes "Hanging" from the Facade Availability of Neighboring Plot	5 / 10	8 / 10	7 / 10
STRUCTURAL CONSTRAINTS	6 4 2 0 +2 +1 +1	Only Fixed Vertical Elements (Circulation & Service Shafts) Fixed Elements of Building Plant: Up to 25% Fixed Elements of Building Plant: Up to 50% Fixed Elements of Building Plant: Up to 75% Drain Pipes: In Service Shafts or Running Next to Pillars Adjustability of Service Shafts Grouped Vertical Circulation Elements	9 / 10	9 / 10	9 / 10
TECHNOLOGY	4 2 0 +1 +1 +1 +1 +2* +1*	Dry Assembly Technique Mixed Assembly Technique Wet Assembly Technique Internal Partitions: Modular Panels Internal Partitions: Panels Set up with Technical Installations Internal Partitions:Movable/Retractable Internal Partitions: Framed Construction Internal Partitions: Prefabricated Panels* Internal Partitions:Dry Walls Built In Situ*	4 / 9	5 / 9	5 / 9
EXCHANGEABILITY OF LARGE EQUIPMENT	8 4 0 +1 +1	Only Needs Disassembly of Facade Panels Disassembly of Facade panels and of Internal Partitions Partial Demolitions Large Equip.: In Ground Floor/ Floor with Direct Contact to Outside Equipments Spaces with Redundancy	5 / 10	4 / 10	4 / 10
FUNCTIONALITY	+4 +2 +1 +1 +1 +1	Generic/Universal Rooms Space Standardization Double Function Overflow Design Loose Fit Furniture/Equipment Flexibility	10 / 10	10 / 10	10 / 10
TOP SCORE			**59 / 84**	**59 / 85**	**63 / 85**

Table 3.6: Assessment of Ankara Bilkent, Kayseri, Konya Karatay City Hospitals (Source: Author)

Ankara Bilkent City Hospital Assessment

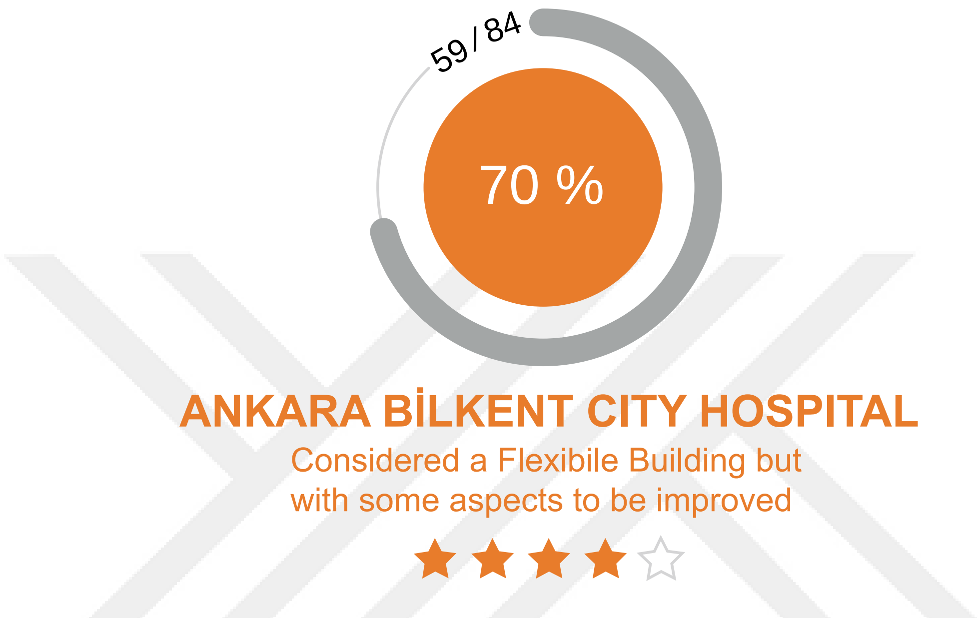


Figure 3.73: Ankara Bilkent City Hospital Optimized Assessment Score & Classification
(Source: Author)

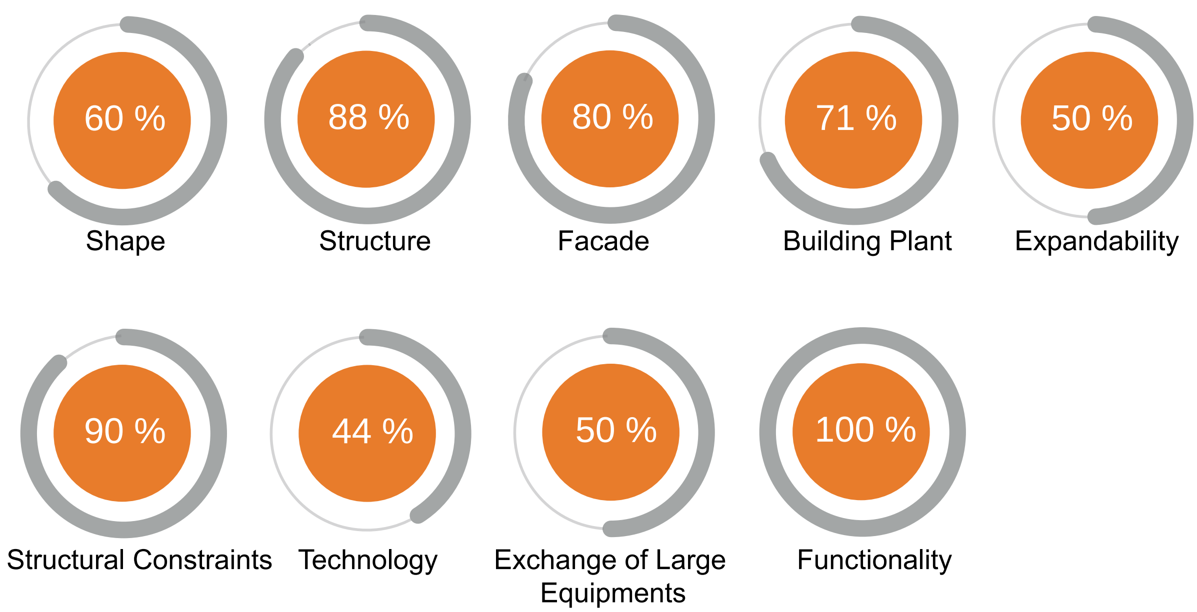


Figure 3.74: Ankara Bilkent City Hospital Optimized Evaluation Parameters Score
(Source: Author)

Kayseri City Hospital Assessment

Figure 3.75: Kayseri City Hospital Optimized Assessment Score & Classification
(Source: Author)

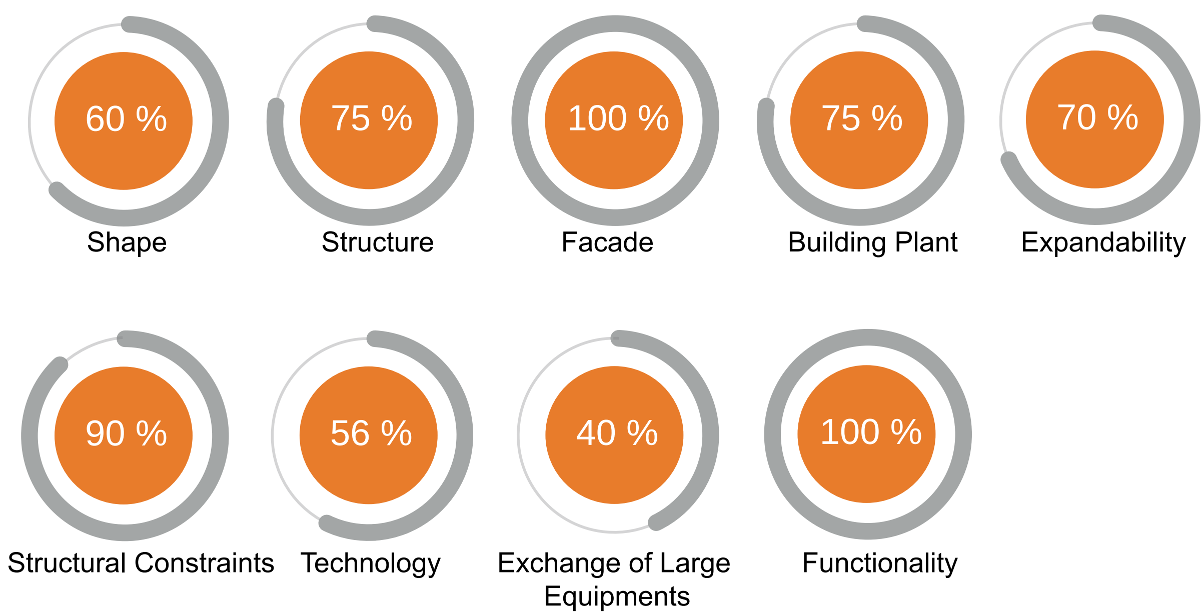


Figure 3.76: Kayseri City Hospital Optimized Evaluation Parameters Score
(Source: Author)

Konya Karatay City Hospital Assessment

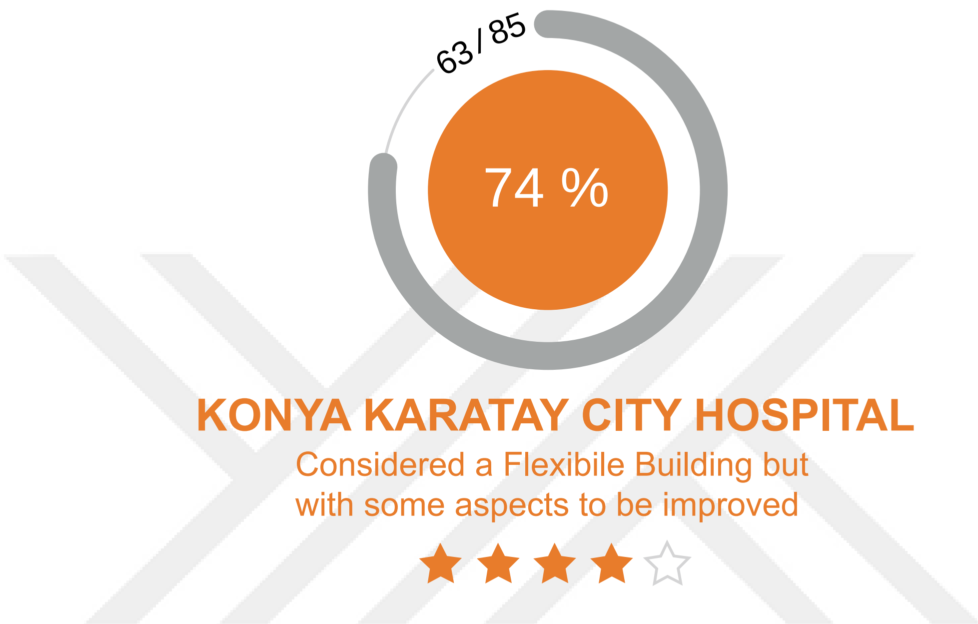


Figure 3.77: Konya Karatay City Hospital Optimized Assessment Score & Classification
(Source: Author)

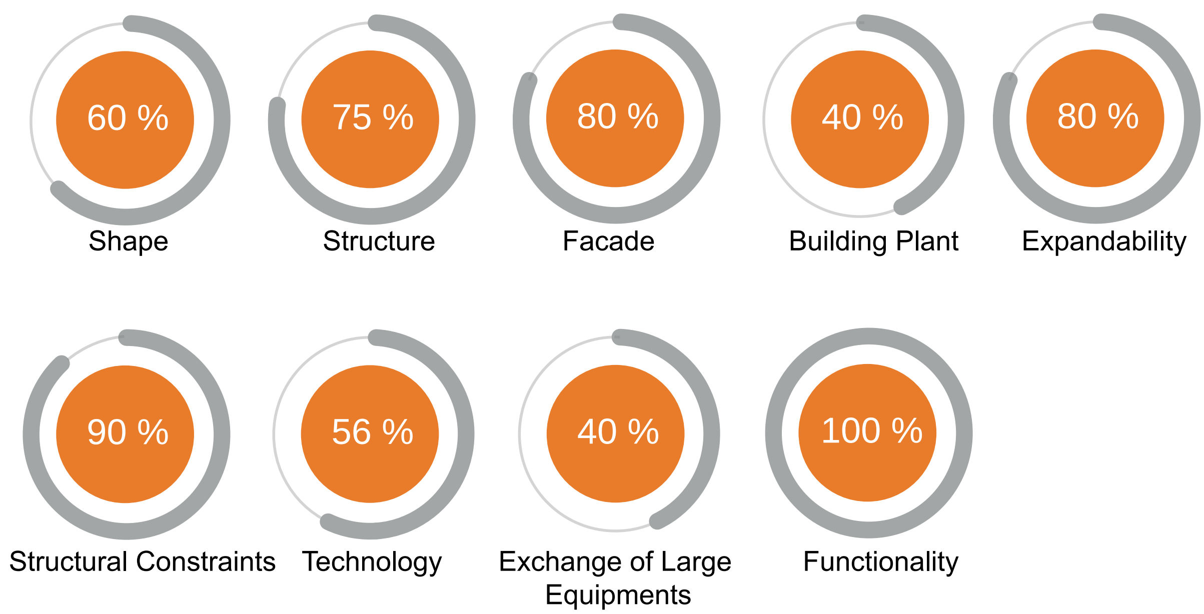


Figure 3.78: Konya Karatay City Hospital Optimized Evaluation Parameters Score
(Source: Author)

Basaksehir Cam and Sakura City Hospital

Matchbox on Muffin: Basaksehir Cam and Sakura City Hospital

Essentials

City Hospital	Population	Operation Date	Contractor	Gross Floor Area m²	Bed Capacity	Intensive Care Unit	Operation Room
Istanbul Başakşehir Çam and Sakura	15.52 million	April 2020	Rönesans	1.015.714	2682	456	90

Table 3.7: Main Features of Istanbul Başakşehir *Çam* and Sakura City Hospitals (Source: Author)

Başakşehir Cam and Sakura City Hospital is categorized as “matchbox on muffin” typology. Diagnostic treatment mass constitutes the main core and branch hospitals rise above this core vertically. Unlike other hospitals, vertical circulation systems are directly connected with the diagnosis and treatment mass. Opening in 2020 Basaksehir is among the largest city hospitals with 2682 bed capacity and 1,000,000 square meters of surface area. It is located in a semi-urban (developing) area. The land is quite inclined with a 55 m elevation difference. Since the continuity of circulation is very important in hospital design, this level difference has brought some problems. With 725 polyclinic rooms, 90 operating theaters, 3 of which are hybrid, the hospital has a daily capacity of 35 thousand outpatients and 500 specific operations. The hospital, which will serve in a total of 107 branches for children and adults, offers advanced diagnosis and treatment opportunities with the most advanced medical devices and equipment. The “Xoft Intraoperative Radiotherapy” (IORT) system, which can be applied to the patient during the surgery while under anesthesia, is also used in this hospital for the first time (see Figure 3.79).

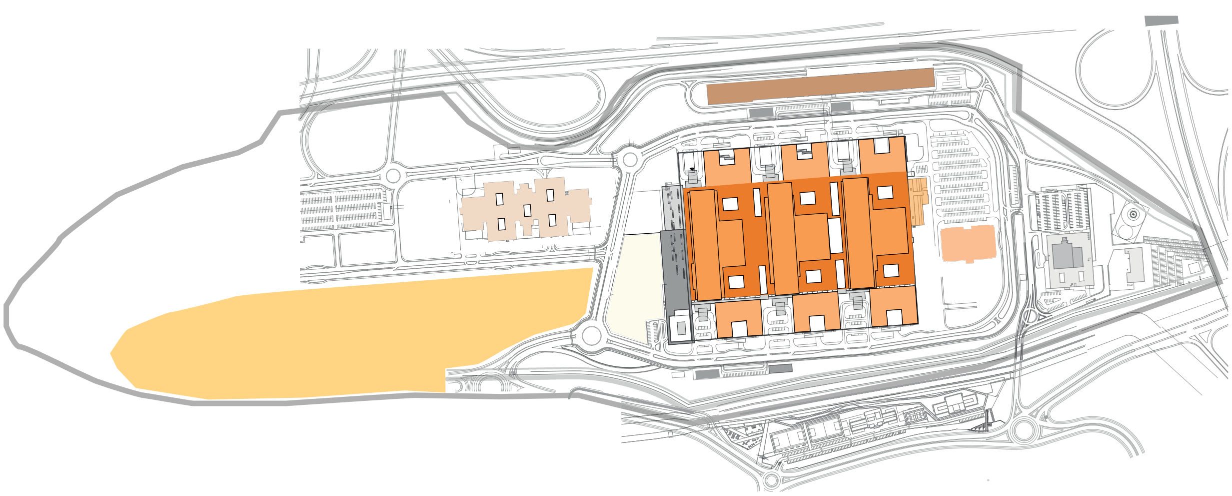


Figure 3.79: Basaksehir Cam and Sakura City Hospital Masterplan
(Source: https://www.hayalgucu.com/project/detail/ikitelli-2700-yatakli-entegre-saglik-kampusu-208, edited by author)

Public transportation is an important problem due to the fact that the hospital is not in a central area. Taking Istanbul's population into consideration, bus service frequency is not sufficient to meet the demand.

The general branch hospitals such as gynecology, pediatrics, oncology, cardiology and neurology also rises above the diagnosis and treatment mass. As in other city hospitals, physical therapy and rehabilitation and psychology departments are located as separate masses within the campus. In design, emphasis has been placed on the prevalence and accessibility of common use areas. In the main core, social areas such as eating and drinking areas, markets, clothing stores, ATMs, pharmacies and parks where many needs of the users can be met are located on the ground floor. Courtyards were created to enable the diagnostic treatment mass to benefit from daylight and these were enriched with various landscaping arrangements. In order to meet the demands that are likely to increase in the future, an expansion area was left in the southern part of the campus (see Figure 3.80).

Figure 3.80: Basaksehir Cam and Sakura City Hospital Courtyard
(Source: https://www.naturalpeyzaj.com.tr/ronesansikitelli)

Başakşehir city hospital has a great potential of energy consumption considering its size. Therefore, various approaches have been determined to minimize energy consumption such as having Trigeneration buildings in the campus that generate some of the energy of the complex. This hospital has been awarded the “Gold Leed’’ certificate with its green building concept.

Başakşehir City Hospital is a hospital that can keep up with the developing technology in which the latest technological systems and equipments are used. There are 2068 seismic isolators in the hospital building since Istanbul is in the primary earthquake zone. This allows the hospital to continue to serve by minimizing the disruptions that may occur as a result of a possible earthquake.

Architectural Typology and Spatial Organizations

Başakşehir City Hospital, which has the matchbox on muffin typology, includes a design approach where the slope of the land is in the east-west direction and the settlement is in the north-south direction. It has a spatial setup where branch hospitals rise over a main mass and, as previously mentioned, accommodates different departments together. Outpatient clinic units are designed as units attached to the diagnostic treatment mass.

Due to the massive setup specific to the project, Başakşehir hospital bed towers were not designed as corridors in the middle and bedrooms on both sides like the usual inpatient services, but as rooms on one side of the corridor. There are cores and service areas between two department corridors. Therefore, it differs greatly from other city hospital towers by being almost twice the width of a standard bed tower.

Figure 3.81: Basaksehir Cam and Sakura City Hospital Polyclinics and Bed Masses
(Source: https://www.yazgandesign.com/ikitelli-city-hospital)

There are 2-3 storey polyclinic blocks connected to the core. Since there is no bed service on the upper floors, the axle spacing is 8.50m and has a plan scheme similar to the core mass. This axis spacing is an optimum span for seismic isolator application, as well as being easily adaptable to functional requirements and interior spaces. Although the columns are large in this structure layout, a more economical result is achieved by optimizing the number of insulators more. If there is a gap distance greater than this, the carrier sections are no longer feasible this time (see Figure 3.81).

The patient admission and support units on the ground floors serve diagnosis, treatment and polyclinics. A flow of people has been constructed, starting from a central area and towards non-centralized specialized areas. Patients who come to any branch hospital can enter from the closest point by parking in the open car park in front of the branch hospital tower or in the areas inside. There is direct access from the closed parking area reserved for the personnel to the parts of the hospital where special areas such as dressing rooms and storage rooms are located. In addition, vertical circulation is provided by the escalators in the main mass, as well as the cores where the elevators and stairs are located. There are also galleries in this area where visual communication is strengthened (see Figure 3.82).

Figure 3.82: Basaksehir Cam and Sakura City Hospital Galeries and Escalators
(Source: https://www.yazgandesign.com/ikitelli-city-hospital)

The patient-reception areas on the ground floors are the first places where patients encounter indoor spaces. However, there is a wayfinding problem in these huge masses where many functions exist together. Some interviews and questionnaires with patients reveal this clearly. Based on this problem, mobile applications that provide navigation services inside and outside the hospital have been developed. Talking about circulation, the one between the diagnosis-treatment mass in the center and branch hospital towers is provided by the main circulation axis. Even though it is difficult for patients to find their way, the once in polyclinic areas, inpatient services, vertical connections and within the diagnostic treatment mass are designed in a patient-oriented manner and at the same time adhering to the user-staff hierarchy.

Flexibility Concept in the Architecture

Modular design

The core mass has a modular grid system and is formed with an axis range of 8.50m. The reason for this is that city hospitals are obliged by the ministry to have a certain amount of basement parking space (see Figure 3.83).Because this structure system is designed to fit three vehicles in each axle range as a design preference. In addition, these distances have enabled larger spaces such as imaging and operating rooms to be placed in accordance with the standards without being divided by structural elements. In addition, the 3.00m patient corridor required by Turkey’s Healthcare Building 2010 Minimum Design Standards Guideline (FGI is 2.40m) and two rooms of 20-24 m² are suitable to fit all in this axis arrangement. Some of the internal partition walls were desing in a modular way to be able to be adjustable in case of a need.

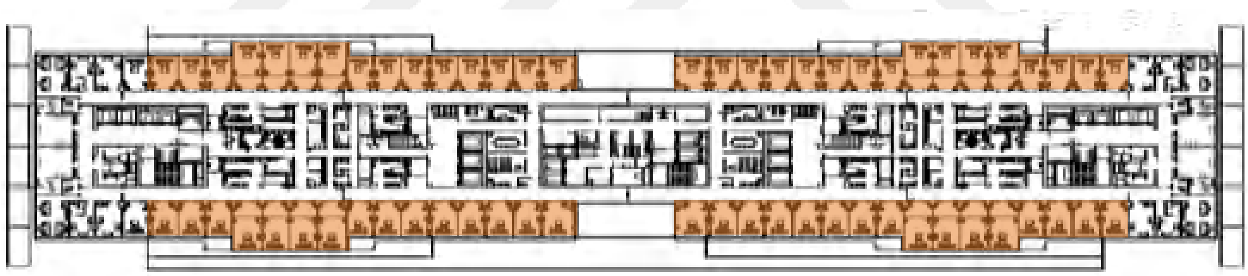


Figure 3.83: Basaksehir Cam and Sakura City Hospital Intensive Care Unit Floor Plan
(Source: Nevrim (2020), edited by author)

Curtain wall systems that can easily respond to the developing and changing health sector needs and plus, provide ease of assembly and disassembly of equipment were preferred. This flexibility and adaptability provides great advantages for the future. Compared to other city hospitals, the main facades of the diagnosis and treatment unit of Basakşehir City Hospital and the facades facing the courtyard are designed as curtain walls (see Figure 3.85). In addition, appropriate transparent partition panels were used in the interiors to keep up with future technological developments, to reduce costs in the long term and to increase visual permeability (see Figure 3.86).

Figure 3.84: Basaksehir Cam and Sakura City Hospital Outpatient Units
(Source: https://www.yazgandesign.com/ikitelli-city-hospital)

Figure 3.85: Basaksehir Cam and Sakura City Hospital Curtain Walls of Courtyard
(Sourc: https://www.naturalpeyzaj.com.tr/ikitellihaber?lightbox=dataItem-kfpfbhle)

Figure 3.86: Basaksehir Cam and Sakura City Hospital Internal Partitions
(Images Source: https://www.yazgandesign.com/ikitelli-city-hospital)

Flexibility strategies

Single rooms are designed to be transformed into intensive care units under necessary conditions. In addition, these units, which are planned above normal standards, can be turned into rooms for 2 people when necessary (see Figure 3.87 & Figure 3.88). In addition, considering a possible growth situation, expansion areas are left in the context of adaptability for the future in the masterplan. Başakşehir is a hospital with the largest intensive care unit capacity on a single campus in Europe, its first leg started operating as a pandemic hospital in 2020. This is an ongoing situation of how it adapts to an unexpected situation like a pandemic.

Figure 3.87: Basaksehir Cam and Sakura City Hospital double patient room
(Source:https://sygm.saglik.gov.tr/TR-33995/istanbul--basaksehir-cam-ve-sakura-sehir-hastanesi.html)

Figure 3.88: Basaksehir Cam and Sakura City Hospital Single Patient Room
(Source:https://sygm.saglik.gov.tr/TR-33995/istanbul--basaksehir-cam-ve-sakura-sehir-hastanesi.html)

Future adaptability

Due to the fact that city hospitals have more than one electronic and mechanical system together, the circulation of these systems in the building is provided by the suspended ceiling system in the horizontal and the service shafts in the vertical direction. Since specialized or normal areas with various mechanical and technological equipment in hospitals are planned close to these shafts, they are easy to adapt in any growth situation. Considering that the rooms are spacious and the curtain wall system has sufficient adaptable technical features, it allows the equipments that is likely to be changed and renewed in the future to be easily installed (see Figure 3.89).

Figure 3.89: Basaksehir Cam and Sakura City Hospital Out Patient Rooms
(Source:https://www.yazgandesign.com/ikitelli-city-hospital)

Adaptability to COVID-19

Minister Koca said “In terms of intensive care capacity, I would like to say that there is a hospital with the most intensive care beds in Europe in a single block. Also, as in all our city hospitals, our Başakşehir City Hospital has an intensive care infrastructure with all its beds, namely 2.686 beds, and all of them can be used as intensive current when necessary.” 155 of 450 intensive care beds have been served, Koca said that 155 ventilators have been placed in each intensive care room and put into operation. Emphasizing that every intensive care room is under negative pressure, Koca said “Each of them consists of single rooms, rooms with dialysis infrastructure. Our 450 intensive care beds also have a ventilator for each bed. In other words, 456 ventilators will have been found. In 155 intensive care units we are currently opening, 155 ventilators have been installed.” During this epidemic period, especially the most problematic in the world were ventilators used in intensive care and intensive care units, which we call respiratory devices.Here, I would like to emphasize the ventilators that were developed by a prototype firm under the leadership of our Ministry of Health, followed by Baykar, the intense support of our Ministry of Industry, and produced by ASELSAN and Arçelik during this period. In other words, our domestic and national ventilator has been produced and ready to use as of today” (Bozdoan, Kara & Çat, 2020).

	POINTS	OPTIONS	ISTANBUL BASAKSEHIR CITY HOSPITAL
SHAPE	10 9 8 7 6 4 2 0	100 % Compact 75 % Compact Vertical 50 % Compact Linear Articulated Horizontal, Detached Buildings	2 / 10
STRUCTURE	4 2 +1 +1 +1 +1 +1 +1 +1	7m ≤ Span ≤ 8m Open floor plan Span > 8m Span < 7m Regular Grid Squared Grid Oversized elements Punch Through Concrete Slabs for Vertical Circulation Hollow Pillars for Technical Installations Ceiling Height ≥ 4m	5 / 10
FACADE	6 4 2 0 0 +4	100 % Curtain Wall 75 % Curtain Walls 50 % Curtain Walls Ventilated Facade Traditional Masonry / Brick Wall Modular Panels	10 / 10
BUILDING PLANT	2 1 0 +2 +1 +1 +1 +1 +2* +1* +1*	Distance in between Service Shafts: d ≤ 35m Distance in between Service Shafts: 35m < d ≤ 70m Distance in between Service Shafts: d > 70m Redundancy for Building Plant Distribution in Raised Floor and/or Exposed Installations if Required Plant Tower Technical Floor Service Shafts Area: Shafts Total Surface/Floor surface ≥ 0.01 Spread out Plant Infrastructure in False Ceiling* Condensed Plant Infrastructure (Varying Height of False Ceiling)* Technical Interstitial Floor*	7 / 10
EXPANDABILITY	+4 +2 +1 +1 +1 +1	Internal: Already Equipped Spaces Internal: Shell Spaces Open Ended Corridor and/or Large Spaces on Building's End Soft Spaces: to be Retrofitted into Service Spaces if needed External: Volumes "Hanging" from the Facade Availability of Neighboring Plot	8 / 10
STRUCTURAL CONSTRAINTS	6 4 2 0 +2 +1 +1	Only Fixed Vertical Elements (Circulation & Service Shafts) Fixed Elements of Building Plant: Up to 25% Fixed Elements of Building Plant: Up to 50% Fixed Elements of Building Plant: Up to 75% Drain Pipes: In Service Shafts or Running Next to Pillars Adjustability of Service Shafts Grouped Vertical Circulation Elements	9 / 10
TECHNOLOGY	4 2 0 +1 +1 +1 +1 +2* +1*	Dry Assembly Technique Mixed Assembly Technique Wet Assembly Technique Internal Partitions: Modular Panels Internal Partitions: Panels Set up with Technical Installations Internal Partitions:Movable/Retractable Internal Partitions: Framed Construction Internal Partitions: Prefabricated Panels* Internal Partitions:Dry Walls Built In Situ*	5 / 10
EXCHANGEABILITY OF LARGE EQUIPMENT	8 4 0 +1 +1	Only Needs Disassembly of Facade Panels Disassembly of Facade Panels and of Internal Partitions Partial Femolitions Large Equip.: In Ground Floor/ Floor with Direct Contact to Outside Equipments Spaces with Redundancy	4 / 10
FUNCTIONALITY	+4 +2 +1 +1 +1 +1	Generic/Universal Rooms Space Standardization Double Function Overflow Design Loose Fit Furniture/Equipment Flexibility	10 / 10
TOP SCORE			**60 / 90**

Table 3.8: Assessment of Istanbul Basaksehir Cam and Sakura City Hospital (Source: Author)

Başakşehir Çam and Sakura City Hospital Assessment

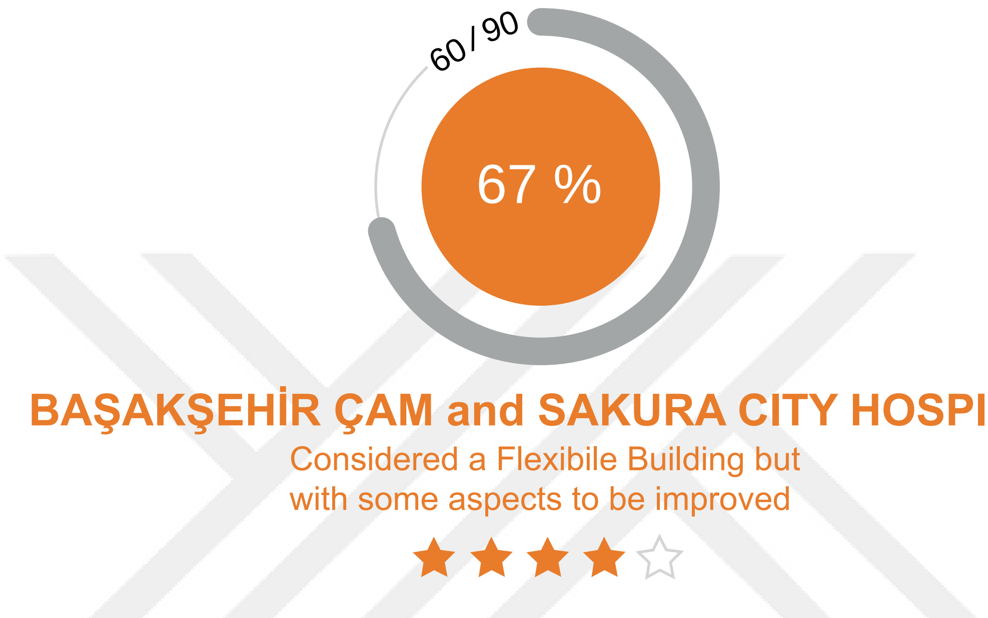


Figure 3.90: Başakşehir Çam and Sakura City Hospital Optimized Assessment Score & Classification

(Source: Author)

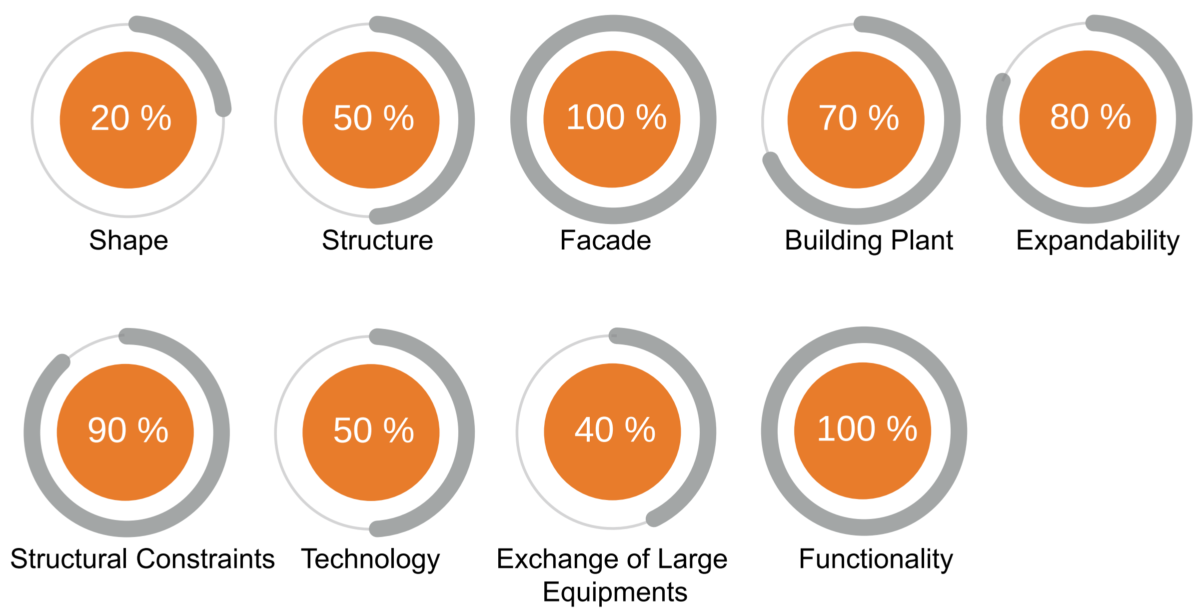


Figure 3.91: Başakşehir Çam and Sakura City Hospital Optimized Evaluation Parameters Score

(Source: Author)

Comparisons and Results

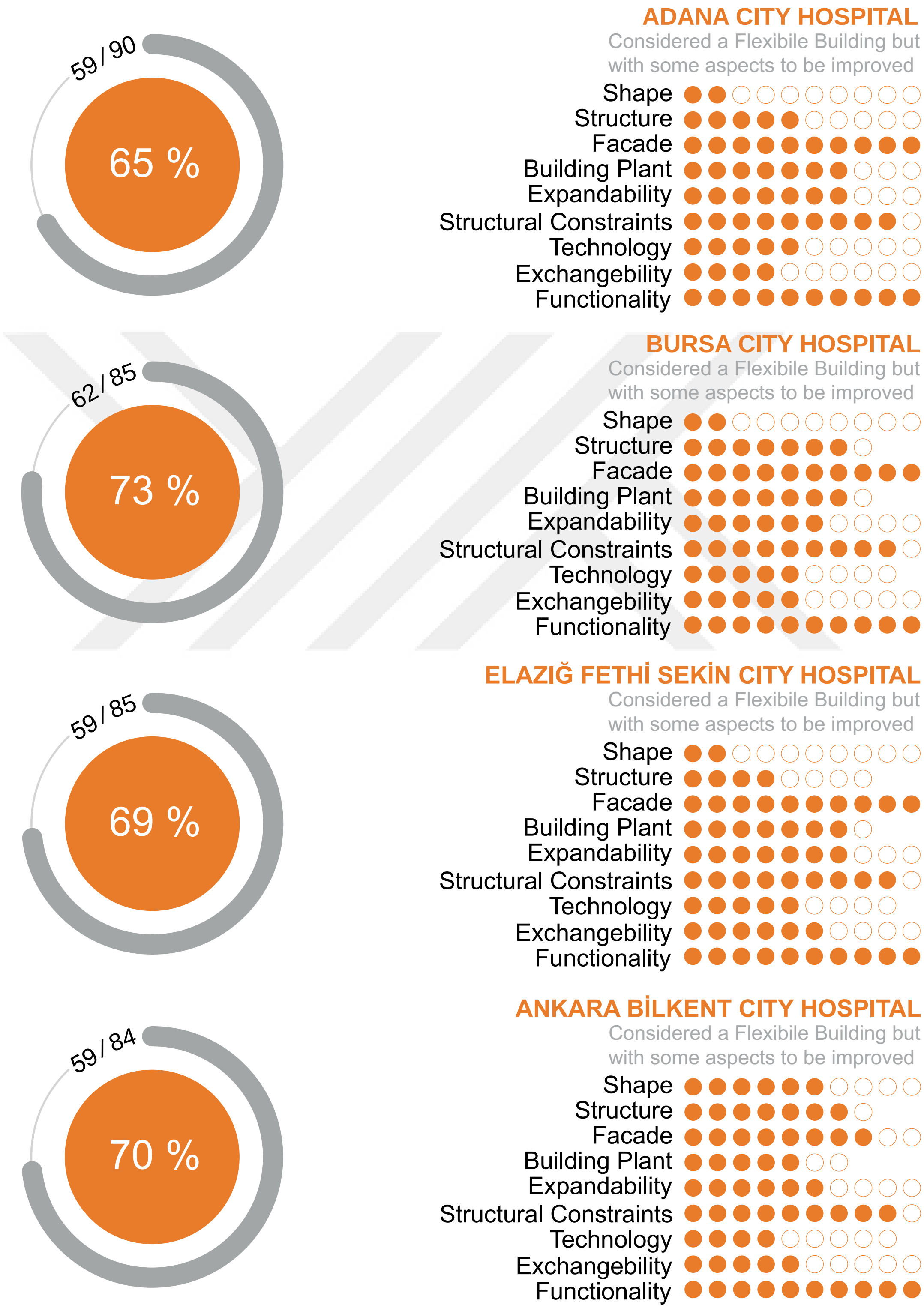


Figure 3.92: Flexible Building : Assessment, Evaluation Parameters Scores & Classifications of Selected Case Studies (Source: Author)

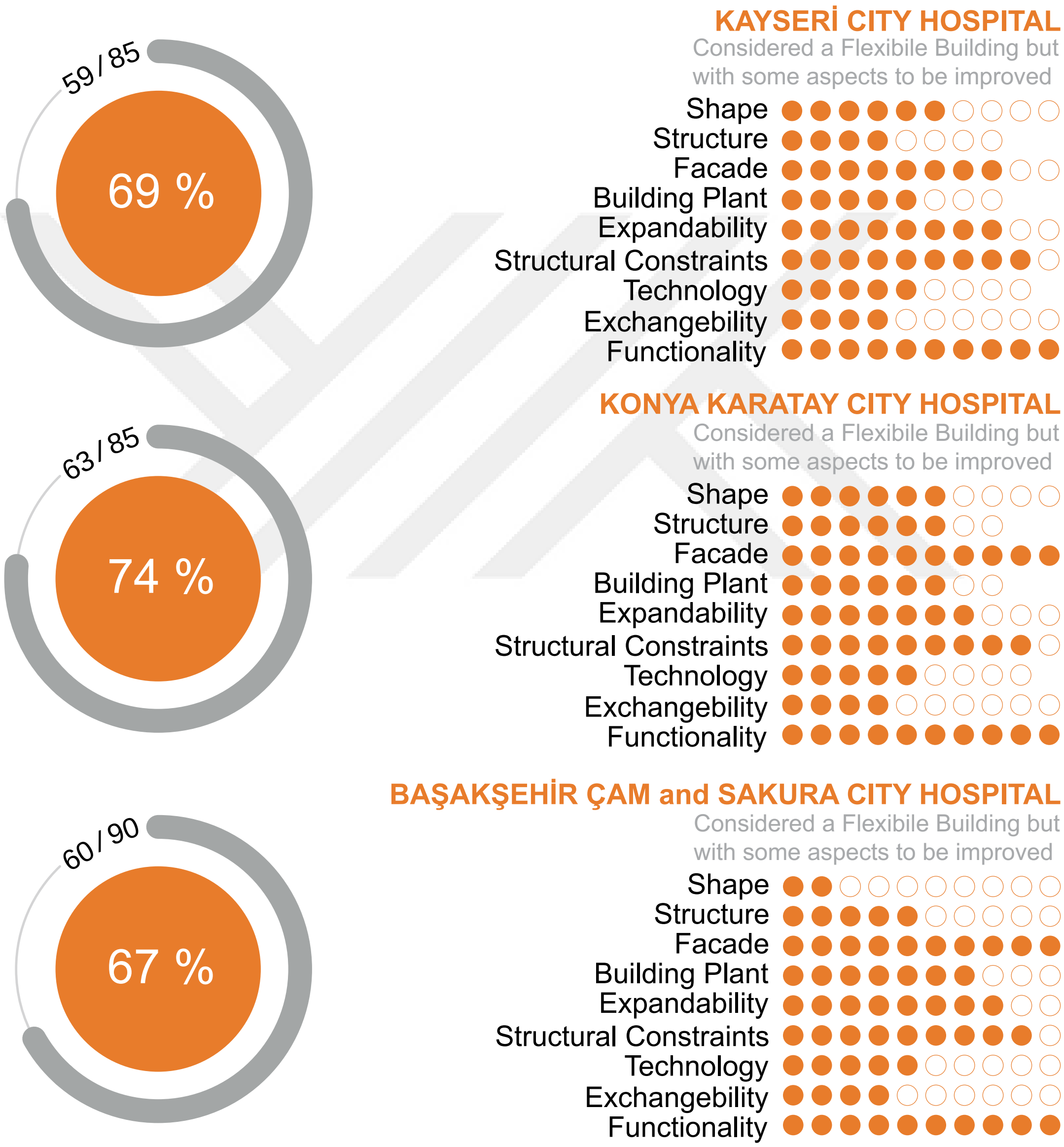


Figure 3.93: Flexible Building : Assessment, Evaluation Parameters Scores & Classifications of Selected Case Studies (Source: Author)

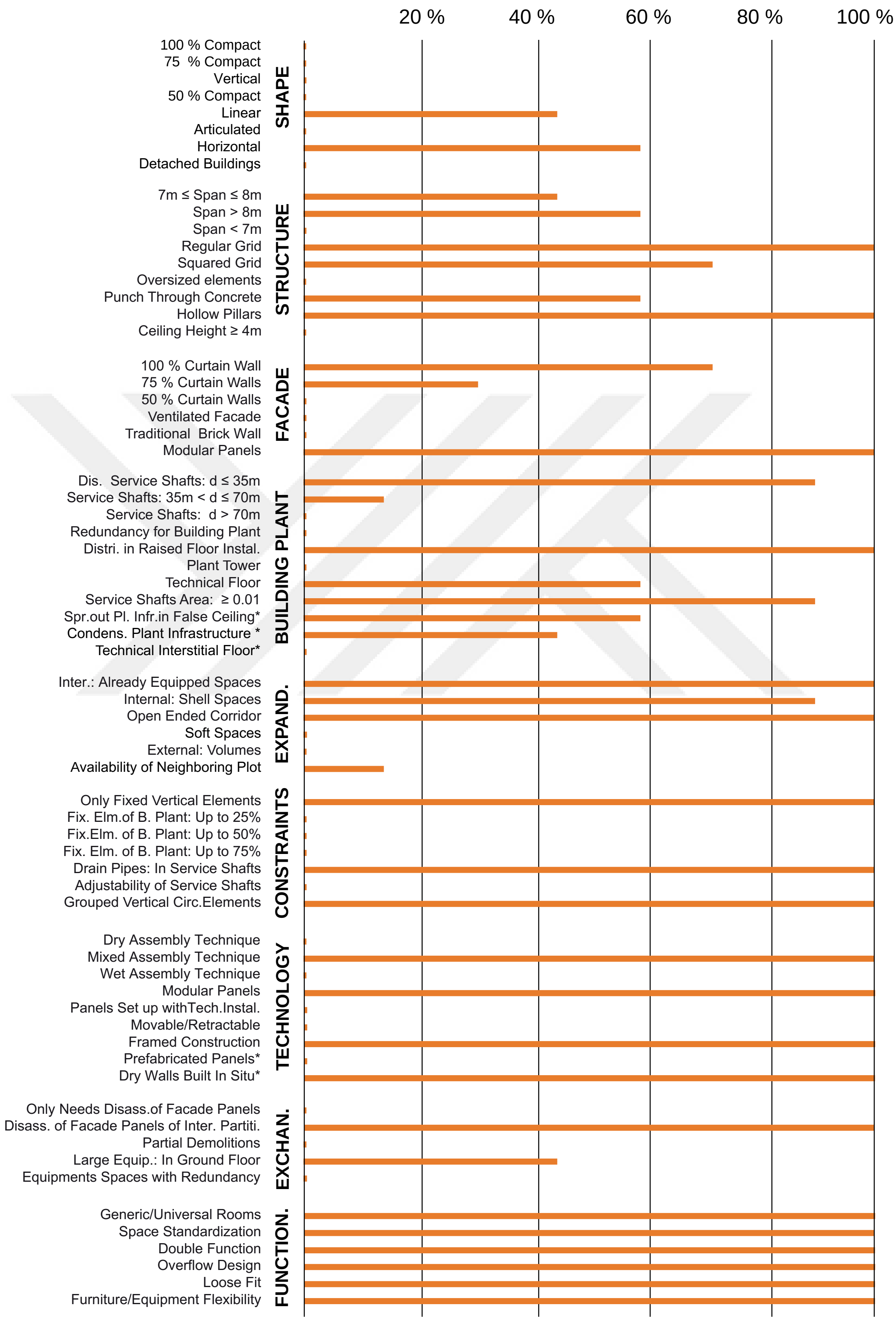


Figure 3.93: Histogram with Percentage of Application of Evaluation Parameters
(Source: Author)

One of the shortcomings faced in the course of analyzing and assessing the various case studies is the lack of knowledge about certain sub-points in the evaluation criteria of some situations. As a result, the scores of those missed sub-points were subtracted from the overall score of the " Optimized Flexibility Assessment Tool" in order to eliminate their effect on the final result and prevent any possible misinterpretation.This allows for a more precise appraisal by establishing an impartial distinction between the case studies.

The final findings of the seven case studies (see Figure 3.91 & 3.92) reveal the following:

- The assessment for absolute score of Optimized Flexibility Assessment Tool
- To what degree are any of the assessment criteria satisfied, and are there any points deducted due to a lack of data?
- In which range/category out of the five different percentages that shows whether or not they could be considered Flexible Buildings, the hospitals included,

Figure 3.93 indicates the percentage of the evaluation criteria that are used.

None of the case studies received a ranking higher than 80% or lower than 61% based on the interpretation and assessment.

All of the chosen healthcare facilities received points ranging from 61% to 80%, indicating that they are Flexible Buildings with certain features that could be enhanced for all manner and purposes, namely:

- Adana City Hospital, Adana, TR
- Bursa City Hospital, Bursa , TR
- Elazig Fethi Sekin City Hospital, Elazig, TR
- Kayseri City Hospital, Kayseri, TR
- Konya Karatay City Hospital, Konya, TR
- Ankara Bilkent City Hospital, Ankara, TR
- Istanbul Basaksehir Cam and Sakura City Hospital, Istanbul, TR

2 different types of **Shapes** which are Horizontal and Linear were determined. Four of them are horizontal (Adana City Hospital, Bursa City Hospital, Elazig Fethi Sekin City Hospital, Istanbul Basaksehir Cam and Sakura City Hospital) and three of them are defined as Linear (Konya Karatay City Hospital, Ankara Bilkent City Hospital and Kayseri City Hospital) since they consist of separate masses linked only via bridges.

For **Structure** analysis parameter, Ankara Bilkent City Hospital and Bursa City Hospital performanced high level compared to others. They both have 7.5m x 7.5m modular, regular and squared grid structure layout. There are hollow pillars for technical installations. On the other hand, even though Konya Karatay City Hospital has the same span, its structure layout is not squared. The rest is identified with a span of 8.5m x 8.5m because of seismic isolators to be applied in an optimal way.

Except for Ankara Bilkent City Hospital and Kayseri City Hospital, they all scored maximum because of %100 curtain wall system. The reason for not having a totally curtain wall is that the main core of these structures have a different type of **Facade**. Nevertheless, all of the city Hospitals got four points from modular panels parameter since the majority of the facade system is curtain wall.

All of the city hospitals contain service shafts which are smaller than 35m whereas in Kayseri City Hospital there are service shafts which are in between 35m and 70m so it gets a lower score in **Building Plant** flexibility. Different from majority of the cases, Basaksehir Cam and Sakura City Hospital and Adana City Hospital includes Technical Interstitial Floor. Even though it is possible to detect different types of false ceiling in one complex, spread out plant infrastructure in false ceiling parameter is prefered when scoring.

Başakşehir Cam and Sakura City Hospital and Kayseri City Hospital showed the best performance in **Expandability.** The main distinctive feature of the Basaksehir Cam and Sakura city Hospital and Bursa City Hospital is availability of neighboring plot in case of increase in capacity of the facilities for the future. Besides, only Kayseri City Hospital has Soft Spaces in the areas where clinics come together to be Retrofitted into Service Spaces if needed,

Since all City Hospitals are subjected to the same national or international legislations and regulations defined by the MOH, they end up in a very similar technical infrastructure regarding **Structural Constraints**. For this reason, all of the case studies scored nine points as they have only fixed vertical elements, drain pipes and grouped circulation elements.

Because of the same reason stated above, the same point was assigned to all six hospitals for **Technology** parameter as assembly techniques that are used in the construction phases of these structures are identical. Only Ankara Bilkent City hospital has a lower scoring that the others with lack of modular internal partitions.

Although all hospitals got points from disassembly of facade panels and of internal partitions; Bursa City Hospital, Elazig Fethi Sekin City Hospital and Ankara Bilkent City Hospital have higher scores than the rest four hospitals due to involving large equip.: in ground floor/ floor with direct contact to outside indicator of **Exchange of Large Equipment**.

Because of the same reason stated above, the same and highest score of 10 was assigned to all city hospitals for **Functionality** aspects as they provide all six indicators designated under this parameter.

A comparative bar chart (see Figure 3.89) is built based on the comparative and empirical context applicable to the case studies and outcomes obtained from Optimized Flexibility Assessment Tool to demonstrate which are the most implemented techniques (sub points) in the Evaluation Parameters within the chosen city hospitals.

Because of the reason that all City Hospitals are bound by the same national or international laws and regulations indicated by the Ministry of Health, they have a very similar technological infrastructure. This results in the same or very similar final scores for some of the parameters which are Structural Constraints, Technology, Exchange of Large Equipment, Functionality. Another reason for this result is caused by the scale of these healthcare facilities since it creates difficulties for the assessment as it is hard to analyse and evaluate huge complexes like city hospitals. On the other hand, they differ from each other regarding architectural features in relation with Shape and Structure parameters.

3.4 Structured Interviews: Validation of the Results Expert Opinions

Survey: Flexibility in Healthcare Design in Turkey

Thank you for taking part in this survey.
It is being conducted as a partial fulfillment of Master of Science Thesis in Architecture and Urban Design in Politecnico di Milano, investigating the issue of Flexibility in Healthcare Design with PPP(public-private partnership) investment model.

The thesis aims to identify space and distributional flexibility in Healthcare Design. The purpose of this survey is to understand how these principles are applied and tackled by the most leading architecture firms in healthcare design in Turkey.

This survey is intended for educational purposes only, and not for any commercial purposes.

01 General Information

1. What is the percentage of healthcare design projects among all?

- o 0 – 20%
- o 21 – 40%
- o 41 – 60%
- o 61 – 80%
- o 81 – 100%

2. On a scale from 1 to 10 (1= Low, 10= High), How important are "Flexibility Principles" in healthcare design projects?

- o 1
- o 2
- o 3
- o 4
- o 5
- o 6
- o 7
- o 8
- o 9
- o 10

Figure 3.95: Flexibility in Healthcare Survey/Structured Interview, Page 01 (Source: Author)

02 Definition

3. In which part of the healthcare design project do you take "Flexibility principles" into consideration? (Select one or multiple)

- Equipments
- Buildings Elements
- Project Management
- Future Usage
- Other, Specify____

4. Which level of Flexibility when applied has more impact on future proofing of the hospital? (Select one or multiple)

- Hospital Complex (Combination of all buildings and external spaces)
- Hospital Building (An individual single-block building)
- Functional Unit (Combination of grouped rooms)
- Individual Room

5. On a scale from 1 to 10 (1= Low, 10= High), How much flexibility principles get affected by the scale of the project?

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

Figure 3.96: Flexibility in Healthcare Survey/Structured Interview, Page 02 (Source: Author)

03 Based on Constructed Projects

6. **What is the percentage of planned flexibility principles that are realized and applied in the construction phase?**

- 0 – 20%
- 21 – 40%
- 41 – 60%
- 61 – 80%
- 81 – 100%

7. **What "Aspects of Flexibility" in new hospital design have you taken into consideration? (Select one or multiple)**

- Structural Grid
- Buildings Elements
- Position of Vertical Circulation System
- Position of Electrical Mechanical Service
- Interstitial Space
- Open Building Concept

8. **From the following 4 attributes of "Distributional Flexibility", Which is most important?**

- Access and Paths
- Hospitalization Blocks (plan layout)
- Space Flexibility and adaptability
- Departments (functionality and connections)

9. **From the following 7 features of "Functional Flexibility", What are the most important?**

- Multiple Division and Zoning Opportunities
- Peer Lines of Sight
- Patients Visibility
- Proximity to Support
- Resilience to enable the moving, relocating and interchanging of Units
- Ease of Movement between Units and Departments
- Multiple Administration Control and Service Expansion Options

Figure 3.97: Flexibility in Healthcare Survey/Structured Interview, Page 03 (Source: Author)

10. ‘’Flexibility” is more relevant in:

- Design and Planning
- Construction Techniques and Methods
- Future Adaptability
- Other specify____

11. What are the main limitation factors for flexibility principles to be applied in the hospital design process? (Select one or multiple)

- Investment model
- Cost
- Users
- Guidelines and regulations
- Duration
- Client
- Other specify____

04 Other Consideration

12. What is the most difficult thing to control in mega projects like city hospitals regarding flexibility?

- Mass Orientation
- Structure
- Space Orientation
- Department Connections
- Circulations and Paths
- Campus Flow (roads and vehicles etc.)
- Other specify____

Figure 3.98: Flexibility in Healthcare Survey/Structured Interview, Page 04 (Source: Author)

13. On a scale from 1 to 10 (1= Low, 10= High), How much is the effect of the investment model in healthcare design projects?

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

14. On a scale from 1 to 10 (1= Low, 10= High), How much is the effect of the client in healthcare design projects?

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

15. Apart from the above mentioned questions, what other visionary aspects/ principles of flexibility in healthcare design would you apply?

16. What are the possible tensions between private actor and client in the design process?

17. How does the PPP investment model affect hospital design projects?

Figure 3.99: Flexibility in Healthcare Survey/Structured Interview, Page 04 (Source: Author)

Results & Comparison of Semi-structured Interviews

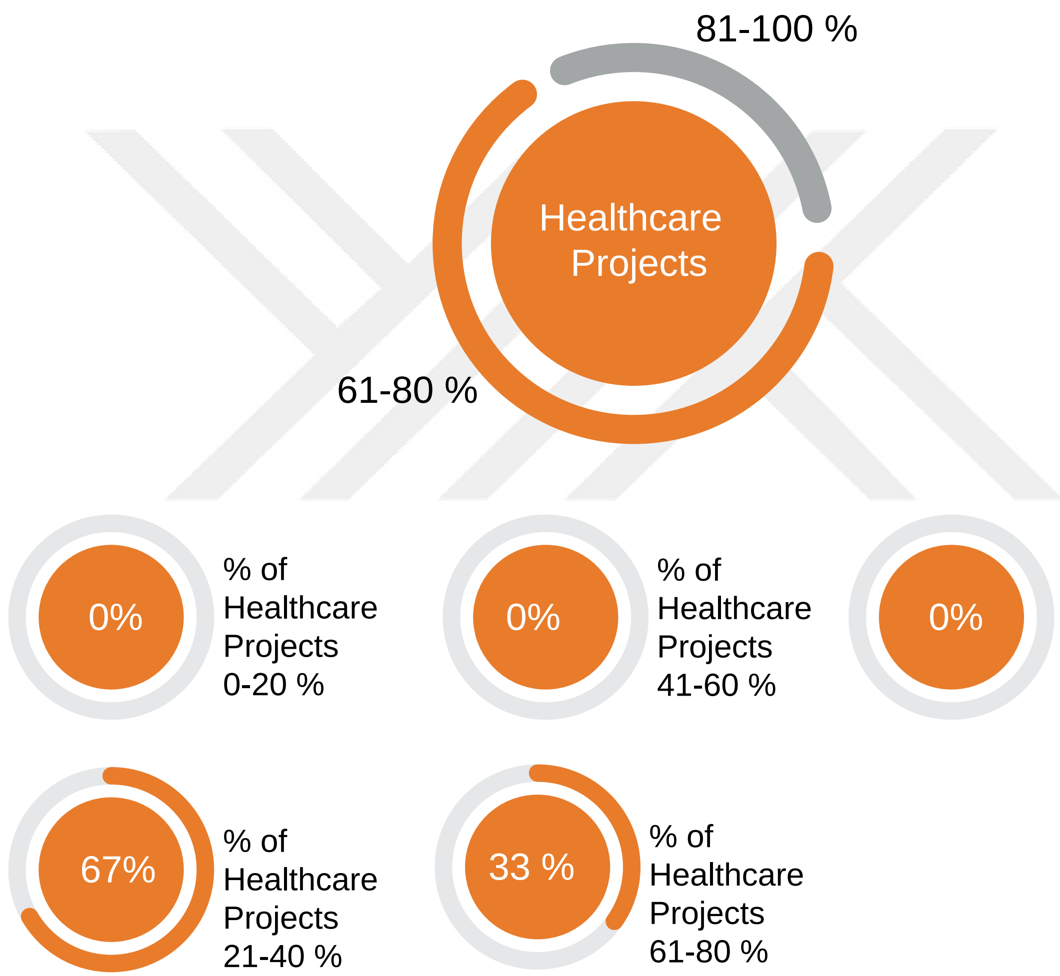


Figure 3.100: Percentage of Healthcare Design Projects in the Firms
(Source: Author/Structured Interviews)

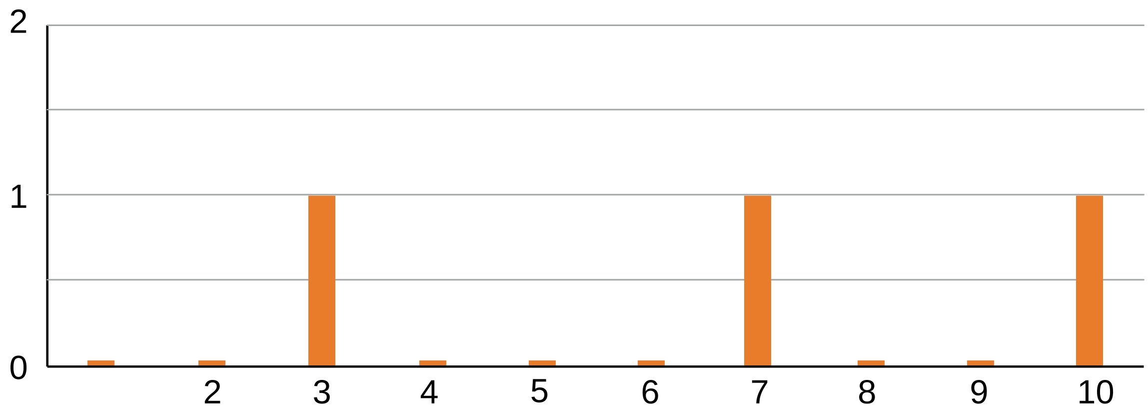


Figure 3.101: Level of Application of “Flexibility Principles” in Healthcare Projects
(Source: Author/Structured Interviews)

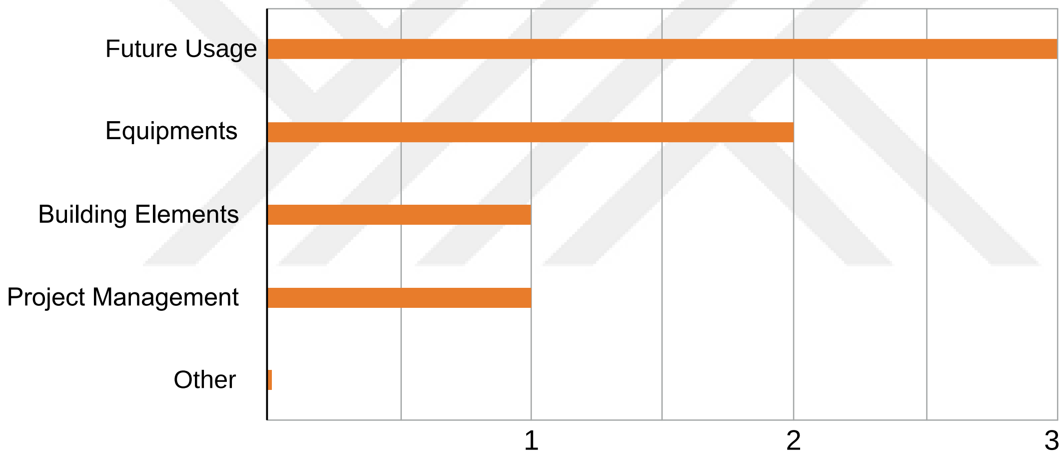


Figure 3.102: Type of “Flexibility Principles ” that are Taken into Account in Healthcare Design
(Source: Author/Structured Interviews)

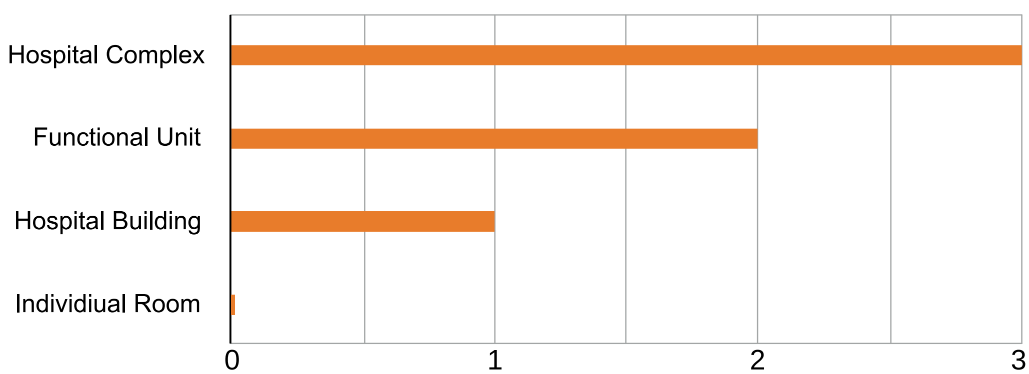


Figure 3.103: Level *of* “Flexibility Principles ” that are more Impact on Future Proofing of the Hospital
(Source: Author/Structured Interviews)

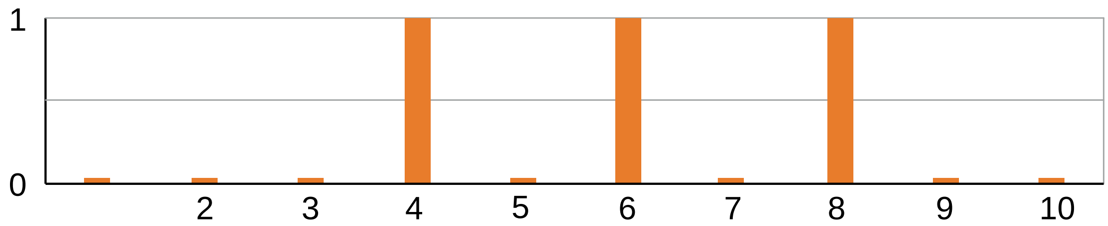


Figure 3.104: ‘’Flexibility Principles’’ *affected* by the Scale of the Project Healthcare Design
(Source: Author/Structured Interviews)

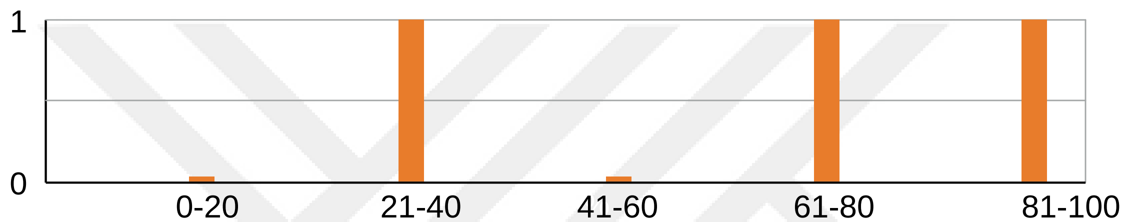


Figure 3.105: Level of the Flexibility Principles in Construction Phase
(Source: Author/Structured Interviews)

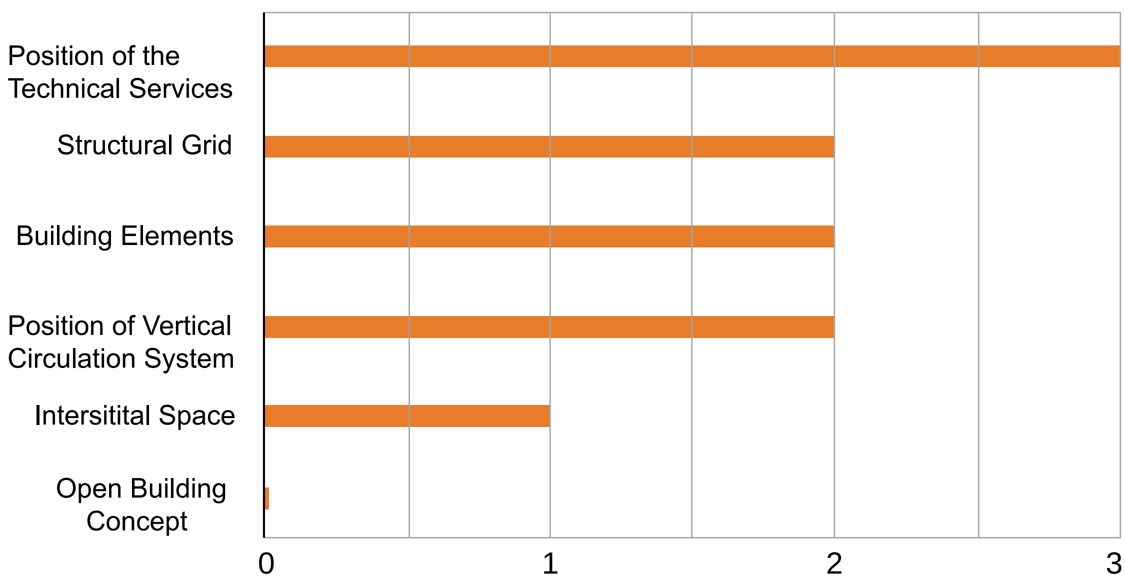


Figure 3.106: “Aspects of Flexibility” that are that are Considered in New Hospital Design
(Source: Author/Structured Interviews)

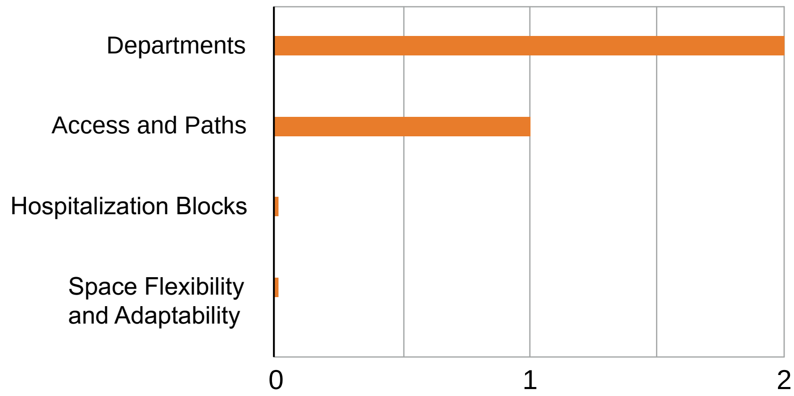


Figure 3.107: Importance of the “Distributional Flexibility” in Hospital Design
(Source: Author/Structured Interviews)

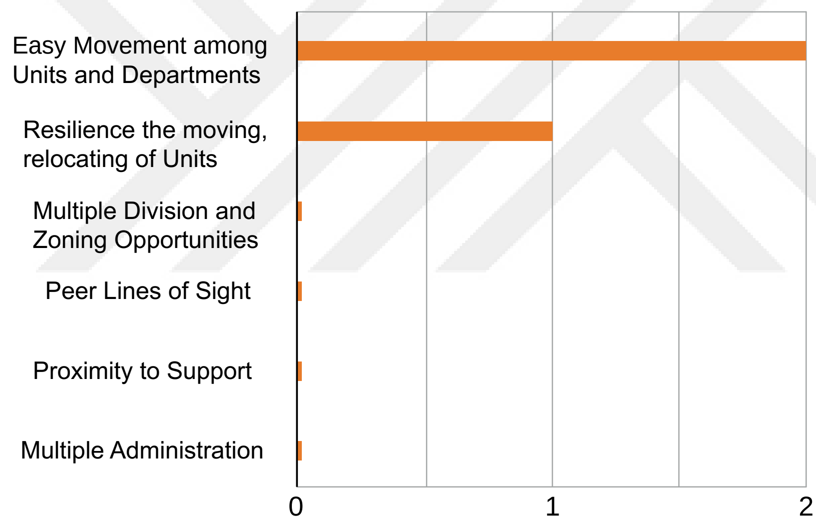


Figure 3.108: Level of Importance of ““Functional Flexibility” ” that are Taken into Account in Healthcare Design
(Source: Author/Structured Interviews)

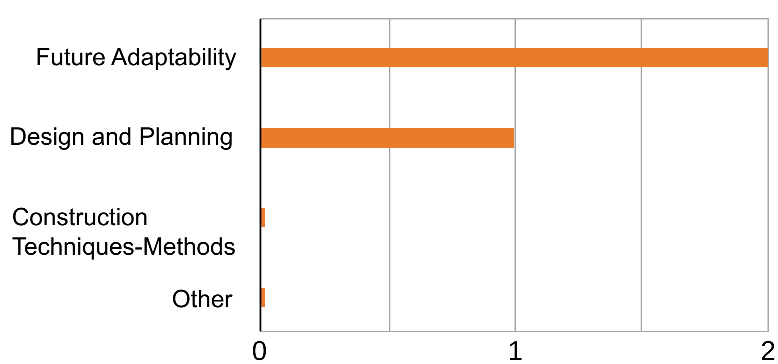


Figure 3.109: Type of Element ‘’Flexibility’’ is more relevant in Healthcare Design
(Source: Author/Structured Interviews)

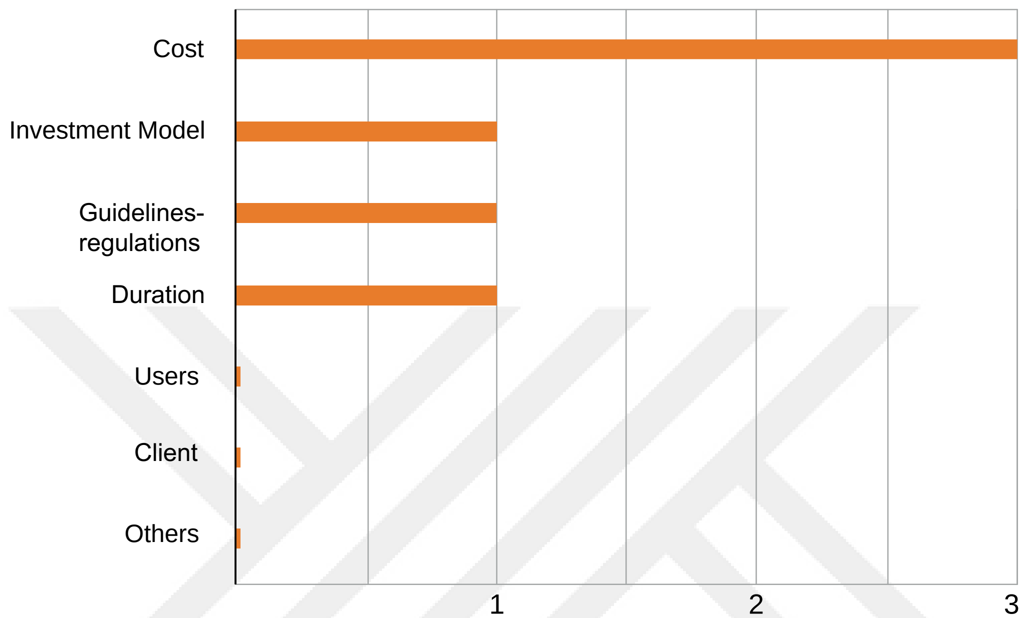


Figure 3.110: Main Limitation Factors for ''Flexibility Principles'' to be applied in the Healthcare Design Process
(Source: Author/Structured Interviews)

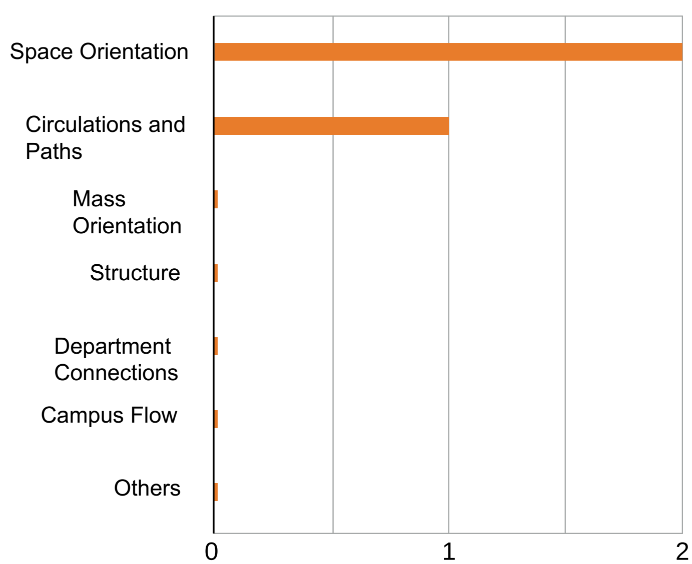


Figure 3.111: The most Difficult Thing to Control in Mega Projects regarding Flexibility
(Source: Author/Structured Interviews)

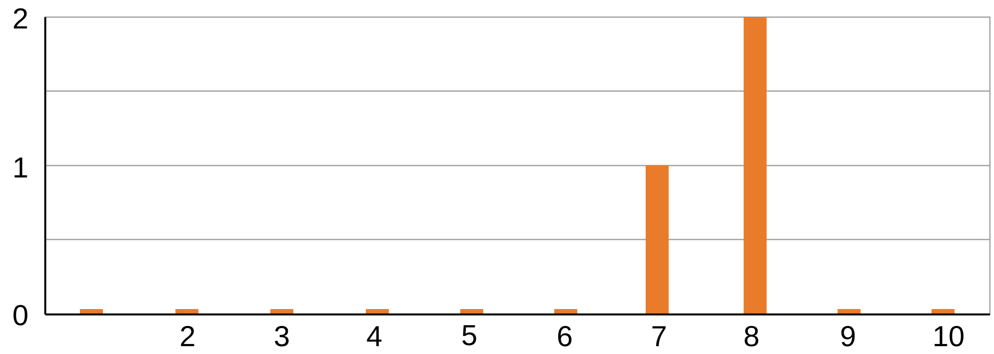


Figure 3.112: The Effect of the Investment Model in Healthcare Design Projects (Source: Author/Structured Interviews)

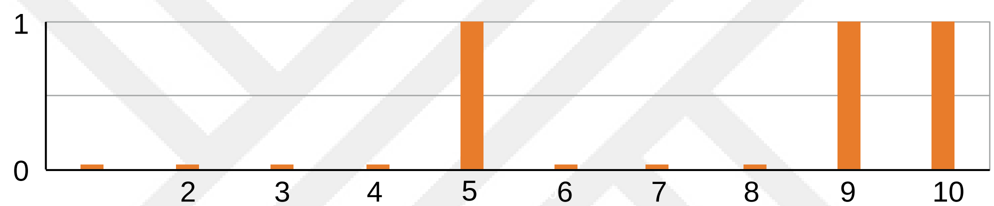


Figure 3.113: The Effect of the Client in Healthcare Design Projects (Source: Author/Structured Interviews)

Interviews Further Recommendations

Apart from the above mentioned questions, what other visionary aspects/principles of flexibility in healthcare design would you apply?

1. Hayalgucu Design

‘’Technological flexibility. The diagnostic and treatment methods are developed with technology. The technological development needs flexible medical and electrical supplies. The installed power principles, low voltage and mechanical elements(ventilation, medical gas etc.) should be designed in accordance with the possible future expansion of technology.’’

What are the possible tensions between private actor and client in the design process?

1. Hayalgucu Design

‘’Even if the private actor and client(MoH) are partners, because the contractor will be managing the hospital and wants to make profit, some conflicts are inevitable. When the client requested more medical functions or updating the construction according to updated codes (Some codes have updated during the construction periods) the contractor resisted. The client doesn’t want to change the construction area of the contract. Because the PPP hospitals were tendered as a design and built project, the construction and design are done simultaneously. The project revisions affect the installations at site. On the other hand the contractor makes a profit also from construction works (not only from the operational period). So the contractor would like to protect the planned budget of construction.’’

2. Unnamed

‘’Single mindedness of healthcare professionals’’

How does the PPP investment model affect hospital design projects?

1. Hayalgucu Design

‘’The PPP projects have been built and managed with international investment. The International investors stipulate to complying with international standards and regulations. The Ministry of Health updated the national codes and standards in accordance with international standards (not in full compliance) in 2012. The new hospitals have been designed with new standards. On the other hand the international fund has been provided to build new and modern healthcare facilities.’’

2. Unnamed

''Negatively. It hinders community involvement.''

Final Considerations

The aim of the structured interview is to learn how flexibility concepts are considered during the design and planning of healthcare facilities, and then implemented, by communicating a series of designed multiple choice, scaling, and open questions with Turkey's leading and most successful firms in the healthcare design sector.

The structured interviews are divided into four parts, each of which explores a different subject. The responses to questions are often close-ended, but open-ended questions are often used at the conclusion of the formal interviews to encourage firms to clarify and provide longer replies that explicitly show their perspectives on flexibility of healthcare design and PPP investment model. The formal interviews are published entirely in English. Interviews can also be completed online using the Forms App survey administration application, which can be found at the following links: The **final outcome of the four parts of the structured interviews** (see Figures 3.95 to 3.104) reveal how many companies chose each component, which represents the degree to which this component was chosen and applied especially in healthcare facilities like city hospitals, and the role of the investment model in this design process.

According to the conducted interviews, two companies have a **percentage of healthcare projects** of 21-40%, while only one has a percentage of 61-80%. This demonstrates that one company is primarily focused on this type of work (healthcare design).

One company chose 10, the other choses 7 and the last company selected 3 (on a scale of 1 to 10 (1=low, 10=high) for the **degree of flexibility principles applied**. This indicates that two of the companies see flexibility as a critical component in designing whereas the other one does not.

Two companies chose 10 and one chose 8 on a scale of 1 to 10 (1=low, 10=high) for the degree to which versatility standards were applied in healthcare programs. This demonstrates that all three companies regard design versatility as a critical component that cannot be overlooked.

For **the parts in healthcare design projects in which flexibility principles are used**, all 3 companies selected Future Usage as 2 companies chose Equipments. This reflects that future usage is the most crucial part to be considered in the healthcare design process.

In terms of **the degree of flexibility that has the greatest effect on the hospital's future proofing**, all 3 companies chose the hospital complex and 2 of them selected hospital building, while one company chose a functional unit. Hospital complexes have the most effect for hospital's future proofing.

Regarding **the level of the effect by the scale of the project on flexibility principles**, the companies gave a score of 8, 6 and 4 respectively. It shows that there is an effect regarding the scale of the structure worth to be taken into consideration.

One firm stated that **the percentage of planned flexibility principles which are realized in the construction phase** is 81-100 %. The other 2 companies have 21-40 % and 61-80 % for the same case. The percentages seem to differ from firm to firm regarding changing healthcare projects and conditions.

In terms of **the aspects of flexibility that have been considered in new hospital design**, positions of electrical mechanical service were chosen by all 3 companies, structural grid and building elements were the second option which were selected by the same 2 companies. Position of the vertical circulation system is also chosen by 2 companies. This indicates the importance of technical service elements regarding flexibility.

Regarding **4 attributes of distributional flexibility in healthcare design**, departments is the most important criteria prefered by 2 companies, on the other hand 1 firm selected access and paths option. Distribution of the departments in the healthcare design projects are considered to have more impact on flexibility compared with others among participant firms.

Out of the 7 options of **functional flexibility** (multiple division and zoning opportunities, peers line of sight, patient visibility, proximity to support, resilience to enable the moving, relocating and interchanging of units, ease of movement between units and departments, multiple administration control and service expansions options), ease of movement between units and departments were preferred by 2 firms. Resilience to enable the moving, relocating and interchanging of units was selected by one company. Mobility inside of the healthcare facilities are essential for not only designers but also users to avoid waste of time and to improve efficiency of the personnel according to the answers.

In terms of more **relevance of flexibility attribute**, 2 companies believed that future adaptability is the more relevant issue for flexibility of hospitals. On the other side, design and planning is the most related option for flexibility according to one company. Construction techniques and methods were neglected by 3 companies in terms of flexibility. This shows that architectural spatialization is considered more related with flexibility compared to implementation techniques.

In terms of the **limitation factors for flexibility principles**, all 3 companies selected cost as the most important parameter. This analysed as the key point in feasibility of these principles when it comes to practice.

For **the most difficult thing to control in mega projects like city hospitals**, 2 companies selected space orientation, 1 company chose the circulation and paths out of 6 attributes. Those selected 2 attributes are considered that they have a relation to each other and designed together to provide integrity in such big structure design.

Regarding the degree of the **effect of the investment model**, 2 companies gave a score of 8 and one gave 7 out of 10. This strongly indicates the investment model factor in healthcare design projects.

In terms of the **effect of the client in healthcare design projects**, 2 companies thought that client has the highest effect on healthcare design, but one company gave a score of 5 out of 10. Those results show that clients have a crucial impact designing a healthcare facility, the project is planned regarding their demands.

The suggestions to **other visionary aspects or principles of flexibility in healthcare design** stated as technical infrastructure in regard to give possibility for future adaptation and expansion for constantly changing technological equipment and tools.

The possible tensions between stakeholders in the design process is the problem of design and planning changes regarding demand in more functions or updated building codes by the client (MOH) taking place during the construction phase. This creates another issue for feasibility of flexibility principles.

On one hand, since international investors and partners take part in PPP projects' management and building process, the client (MOH) updated the national codes and standards in accordance with international standards as an obligation in order not to interrupt the process. It results in a positive effect for regulations and legislation. On the other hand, it hinders community involvement because the tender is made with invited companies.

TOOL DEVELOPMENT & TEST

CRITICAL ANALYISIS, OPTIMIZATION, AND COMPARISON

04

04 EMPIRICAL PHASE: ASSESSMENT TOOL DEVELOPMENT & TEST

4.1 Introduction

This section would explore the **“Optimized Flexibility Assessment Tool”** in order to comprehend the identification of the test and review criteria. Furthermore, gaining a thorough understanding of **the measurement and ranking techniques** used by each **parameter**.

A critical overview is developed by reviewing the meanings and details of each analysis parameter, as well as the allocated score, to illustrate the advantages and shortcomings of each parameter in order to create an optimal assessment tool with the least amount of subjective assessment possible.

Proposed changes to be performed out on each parameter are clarified based on the crucial analysis of the assessment criteria, and a specific description for each one is created with the allocated score based on its importance in terms of flexibility for the healthcare facility.
Finally, **a newly developed assessment method** based on the current updated, integrated, and deleted parameters is created, along with a manual for appraisal criteria and a glossary of meanings for more precise use.This serves as a kind of control mechanism for designers to improve their designs, and it can also be used on existing structures to determine how well they meet the requirements and principles of flexibility.

4.2 Analysis and Critical Review of the Existing Assessment Tool (OFAT)

General Analysis of OFAT

Elshazly and Ghazy (2020), after analyzing “Assessment Tool for Open Building Flexibility, which is improved by Zanchi E. (2015), based on selected 7 case studies which are as follows:

•Hospital Südspidol, Esch sur Alzette, Luxembourg
•Massachusetts General Hospital (Lunder Building), Boston, MA, U.S
•Machala Fluid Hospital, Machala, Ecuador
•The Sammy Ofer Heart Building, Tel Aviv
•New Karolinska Hospital, Stockholm, Sweden
•Aarhus University Hospital, Aarhus, Denmark
•New Martini Hospital,Groningen, Netherlands

Optimized Flexibility Assessment Tool is the method developed by Elshazly and Ghazy (2020) under the guidance of this method.The approach is further optimized by identifying standard research parameters that make for a clearer understanding of each hospital's characteristics in terms of the **Flexible Building** principles.As a result, **three macro fields** (project, flexibility & construction technology) and a total of **fifteen parameters** (building form, structure system, facade, building plant, interstitial floor, shafts distribution, site adaptability, expandability, internal organization, equipments, assembling, exchangeability of large equipments, modular facade panels, modularity & reuse of internal partitions and functionality).

The first macro category is associated with the project's key dimensional and qualitative features, which relate in general to the building's primary or foundation structure framework, with the exception of the plant selection parameters, which have a significant impact on the evaluation of the other parameters. As a result, these parameters apply to all of the building's most resilient components, those that will be least affected by modifications and will remain so in the future, regardless of how the other elements change.

The second macro field contains the analysis parameters that have been defined to evaluate the building's flexibility under service at various time thresholds, both with a constant and variable surface.

The third macro field is concerned with criteria relating to the materials and construction methods used, which would ensure that the ideals of Flexible Building and flexibility in general are adhered to.

PROGRESSIVE	CUMULATIVE	ALTERNATIVE
SCORE	SCORE	SCORE
10		6
8	+5	4
6	+3	2
4	+2	+2*
2		+1*
0		

Figure 4.1: All Three Assessment Tool Evaluation Methods

(Source: Elshazly & Ghazy (2020), edited by author)

Based on the experience and considerations applied to the research criteria of the case studies, an evaluation method has been created to ascertain the degree of satisfaction with the Flexible Building specifications, which can be used by all current health systems and those currently in the design stages.

In the second example, the assessment method will assist designers in assessing a project during the design and planning process in order to find areas where flexibility can be enhanced.
The assessment criteria are comprised of the nine elements listed below:

•Shape
•Structure
•Facade
•Building Plant
•Expandability
•Restrictions
•Technology
•Exchangeability of Large Equipment
•Functionality

Each of them is measured separately and given a score ranging from 0 to 10 on a scale of 1 to 10. As a result, for each of the indicators, a score will be allocated that expresses the degree of conformity with the Flexible Building's flexibility characteristics for that relevant aspect of the project.

Evaluation/Scoring methods

For each indicator, a set of options is listed, each of which is given a separate score based on the analysis matrix's considerations. There are two point attribution schemes that can be used separately or simultaneously. **The first method** is progressive evaluation, which is used after the measurement matrix has allowed the recognition of various solutions and the evaluation of how well they respond to the indicator, resulting in a ranking. **The second form of assessment** is cumulative, and it is related to the established "accessory" solutions, whose usage ensures a higher degree of versatility. A "+" symbol will be placed in front of the score allocated to these choices. Alternative options can be provided by the **third evaluation method,** which cannot exist at the same time. As a result, these strategies can only earn points as a substitute for another choice. In this case, a score of +n* may be assigned to the project.

Critical Review of Evaluation Parameter & Proposed Modifications

1. Shape Parameter

	POINTS	OPTIONS	SCORE
SHAPE	10 9 8 7 6 4 2 0	100 % Compact 75 % Compact Vertical 50 % Compact Linear Articulated Horizontal Detached Buildings	/ 10

Table 4.1: OFAT Shape Evaluation Parameter
(Source: Elshazly & Ghazy (2020))

Description

The compact form, according to Elshazly & Ghazy (2020), is the best for satisfying the demands for flexibility, convenience, and economic viability. As a result, **a single compact building** receives the highest possible value of (+10). **A partially compact building**'s score is determined by the "compactness percentages" of the volume, or how much of the overall mass can be considered compact (for example, a structure with two masses, one compact and one not).

If the building is **75 % compact**, the score is high (+9), vertical building is equivalent to (+8) points with the most significant building plant part located in the shafts and a relatively clear floor network. When **the compactness percentage falls 50%**, the score given is average (+7).If the construction is **linear**, the (+6) applies so the benefits and drawbacks on the structure and building plant are equivalent.

If the building's form is especially **articulated**, however, the score decreases even more (+4) The plant network would undoubtedly be more complex and costly if the building is substantially **horizontal**. As a result, the grade is exceptionally poor (+2). If, on the other hand, the hospital is viewed as **detached**, the score is smaller (zero).

Shape parameter critical review

The key criterion for determining the utility of building shape/morphology in this segment of the assessment tool is focused on achieving flexibility, comfort, and cost effectiveness however, as discussed in literature, emergency issues like pandemic are neglected. It is important because it directly affects flexibility parameters with new methods and strategies derived during COVID-19 process. Plus, It is very difficult to evaluate these huge structures with an overall perception because each volume would eventually involve its own plant and technical installations, they would be treated as a single individual, but not as a single compact structure.

There is considerable uncertainty in how the designers or users of the assessment tool view those research parameters (100% Compact, 75% Compact, 50% Compact) since the ratios given are not quite definitive and explanatory for megastructures. As a result, it is ambiguous which classification mega healthcare facility belongs to thus, each of the research criteria should be precisely defined to ensure optimum accuracy of outcomes. Additionally, compactness is a questionable issue with regard to flexibility in pandemic. Is it still the best solution in terms of the shape?

Masses Linked with Bridges is noted as an extra option. However, facilities include separate masses which are connected to each other by linking elements such as bridges to reduce and control the spread of infection in emergency situations such as a pandemic. Also, pandemic showed that Masses Linked with Bridges are suitable to adapt possible extensions. Additionally, since the entrances and exits of these independent masses are different from each other, some of them can be turned into a pandemic hospital, while the other part can continue their normal operation without any interruption. Therefore, this criterion, which was added as a note by Elshazly & Ghazy (2020), should be re-evaluated for more accurate results.

Since positioning on the horizontal plane is important in pandemic conditions, it has been understood that vertical structuring is not very suitable for emergency conditions. Also, it does not provide easily accessible open spaces.

Although it is mentioned that the Linear building gets a score (+6), there is a confusion between Horizontal and Linear since the definition and the given ratio does not truly meet geometric notion, hence it needs to be redefined.

Because the horizontal indicator was found to be very complicated and expensive, the lowest score of +2 was given. However, it is observed that megastructures are so huge in scale so horizontality is an inevitable result because they are either located outside of the city or already to the optimum height that they cannot exceed any further regarding regulation etc. With horizontal approach, there is a homogeneous distribution of core units (diagnostic and treatment, operating etc.). The operation of the hospital on the horizontal plane, on the other hand, allows the interrelated units to work more easily on the same plane in case where the hospital is exposed to many users.

A. Shape Parameter Proposed Modifications

In order to optimize the Shape parameter assessment, some modifications are applied as following:

- 3 different compactness levels (100% Compact, 75% Compact and 50% Compact) merged into one. As a result, the given score is (+6).
- Arms Attached to the Main Core is no longer an extra option but a sub-parameter with a score of (+10).
- The score of Vertical is reduced from (+8) to (+4).
- Linear and Horizontal merged into one sub-parameter since they have a similar orientation. Thus, (+8) score is assigned.
- The score of Detached buildings is increases from (0) to (+2) due to the ability to control over contaminated and non-contaminated parts of healthcare complexes.

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows:

Note: assuming that the generic building mass is a perfect cube of XYZ, as X “length”, Y “width” & Z “height”.

1.Horizontal or Linear

In this case the building is designed in either horizontal or linear direction as the length (X) or the width (Y) exceeds double the height (Z) of the mass. Thus, (+10) score is assigned as the common units of hospital are gathered on the same plane with homogenous distribution.

2.Arms Attached to the Main Core

The complex in this case is made up of separate masses yet only linked with bridges or auxiliary elements. Scoring (+8) since the control of an emergency situation would definitely be easier to control and adapt with additional fragmentations.

3.Compact

In this case, only one single mass with Z dimension, provided that X & Y, exceed 1.2 Y & 1.2 Y. Hence, (+6) score is given due to reasonable flexibility & cost efficiency.

5.Vertical

In this case, the height (Z) of the building mass should at least exceed double the length of the longest base edge (X or Y). Scoring (+4) as the building plant components are vertically stacked and placed in the shafts but mechanical floors are needed that are costly and complex.

4.Detached

In this case, the complex consists of completely separate and regular masses without any internal links. Scoring (+2) due to lack of flow continuity and the need for individual plants for each building. However it may provide a safe environment for emerging conditions like pandemic.

6.Articulated

In this case, the masses are irregular and intersecting with different morphologies and heights. Scoring (0) as the non-uniformity of the masses, leads to complexity of structure, irregular modulation, cost and time increase and complicates the patients/staff flow by creating high risk of infection.

Note: Since megastructures are located in huge campuses, in some cases there are High Security Forensic Psychiatry Hospital as well. It is thought that hospital should be planned separately from other units in terms of security. In this case, while evaluating the detached buildings criterion, if the mentioned hospital is exceptional like psychiatric hospital, this situation should be ignored.

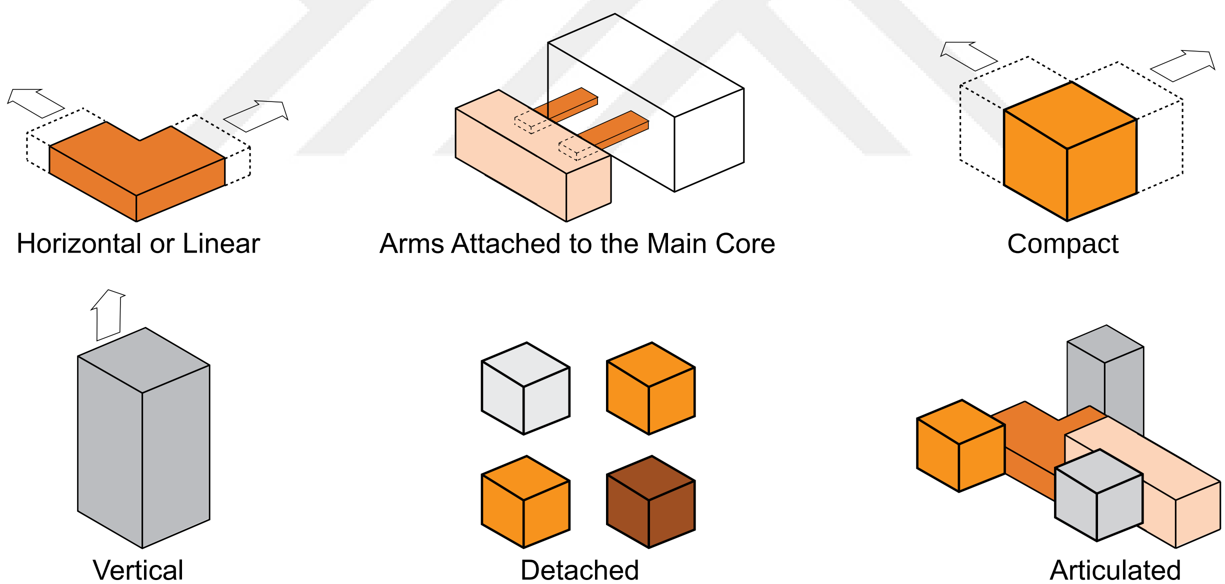


Figure 4.2: Shape Evaluation Parameter Morphological Variations
(Source: Author)

B. Shape Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
SHAPE	Horizontal or Linear	10	No
	Arms Attached to the Main Core	8	No
	Compact	6	No
	Vertical	4	No
	Detached	2	No
	Articulated	0	No
	Shape Total Assigned Score		No / 10

Table 4.2: Shape Parameter Megastructure Flexibility Assessment
(Source: Author)

2. Structure Parameter

	POINTS	OPTIONS	SCORE
STRUCTURE	4	7m ≤ Span ≤ 8m Open floor plan	/ 10
	2	Span > 8m	
	+1	Span < 7m	
	+1	Regular Grid	
	+1	Squared Grid	
	+1	Oversized Elements	
	+1	Punch Through Concrete Slabs for Vertical Circulation	
	+1	Hollow Pillars for Technical Installations	
	+1	Ceiling Height ≥ 4m	

Table 4.3: OFAT Structure Evaluation Parameter
(Source: Elshazly & Ghazy (2020))

Description

The structural modulation with a span between 7m and 8m is clearly and scientifically the most appropriate. In this case it has been given the highest possible score (+4). The open floor plan, which helps you to arrange the spaces easily and without constraints, receives the same score (+4). **A span of more than 8m** is also recommended, but in some situations, making the full use of the areas can be problematic precisely since this areas are so wide. As a result, the graded grade is average (+2). Rather, the lowest score (+1) is applied to spans less than 7m, since they are mostly too short to handle certain operations. Extra points, one for each alternative, can be applied depending on the flexibility features of the structure. By using **a regular module**, one point is assigned to the rating, and another if the result is a squared **module**. Another point to be assigned is whether the **structural elements** (pillars and beams) are **oversized** in comparison to the standards, allowing them to tolerate any load rise (useful for instance for new weighty healthcare instruments). If the slab has a **removable section** for new plant pipes or vertical links, a point must be allocated. Where all **hollow pillars for technical installations** to manage plant pipes are available, the same idea is implemented. Furthermore, if the **ceiling height** is greater than 4m, the score can be increased by one point.

Structure parameter critical review

This category of the evaluation scheme is used to evaluate the facility's stability and adaptability in terms of its ability to handle new loads such as heavy hospital instruments or vertical potential extension and ability to have enough space for new installations.
The structural spans evaluation criterion is clearly described and divided into three groups, each with a separate ranking, as follows: (Span 7m, Span > 8m, & 7m Span 8m), which corresponds to the literature, healthcare design guidelines, and chosen case studies. However, there is an ambiguity with Span < 7m since lower limit is not defined.

To prevent uncertainty in Regular and Squared evaluation criterion there is a need of certain amount of tolerance for megastructures as they often include more than one building and not every case have the same typology or structural layout.

As for the oversized components, they are considered an asset in healthcare architecture because they allow for potential advances in medical instruments, vertical extension of the building if desired, and the capacity to handle future advancements in hospital instruments. Plus, in emergencies like pandemic, structure should overcome extra demand and usage. (1+) is given in terms of vertical growth, there is no concrete proportion of oversizing; instead, it would rely on each particular case and the project location's building heights regulations. Also, the name of the indicator does not meet the description given because it is not the size that gives strength to the structure in every case. Therefore it lacks a more defined title.

According to the literature and healthcare architecture standards, "Ceiling Height 4m" achieves a (+1) score because it has a huge effect on the flexibility of the healthcare facilities, allowing for potential convertibility in case of new mechanical installations. Besides, high ceilings avoid spread out infections due to the huge volume of spaces. However, it creates confusion, especially since it is not specified which floor should be higher than 4 m. There is a generalization of ceiling heights though every function or unit (inpatient, diagnostic and treatment etc.) require different ceiling heights.

A. Structure Parameter Proposed Modifications

In order to optimize the Structure parameter assessment, some modifications are applied as following:

- A new indicator which is Span < 6m added. Plus, Span < 7m is modified into 6m ≤ Span < 7m. Their scores are (0) and (1) respectively.
- Ceiling Height parameter is splitted into 2 groups which are Ceiling Height: Inpatient Rooms ≥ 4 m and Ceiling Height: Ground Floor ≥ 5 m. (+1) score is assigned for each.
- Hollow Pillars for Technical Installation is deducted since It is relatively a small issue for megastructures and related to building plant parameter more than structural capability.

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows:

1. Structural Spans

The 4 different structural spans are to be measured from the axis/center of the pillars. Scoring (+4) in the case of 7m ≤ Span ≤ 8m Open floor plan, (+2) for Span > 8m, (+1) for Span < 7m and (0) for Span < 6m. This is according to their spatial/functional efficiency respectively

2. Regular Grid

A fixed grid modulation of the surface, (+1) score is assigned, bearing in mind there is a tolerance of 20%.

3. Squared Grid

A grid modulation with a squarish outline that is arrayed in. In this case, a (+1) score is given, keeping in mind the resistance of 20%.

4. Redundancy in Structural Capacity

Increasing the structural elements' capacity to withstand additional loads in the event of a heavy demand condition, such as a pandemic. In this case, a (+1) score is given because the infrastructure is sufficient for vertical expansion as well.

5. Punch Through Concrete Slabs for Vertical Circulation

It's a squarish space in the concrete slab with no support that allows vertical circulation elements, shafts, technical installations, and other things to be installed. In this case, a score of (+1) is given.

6. Ceiling Height

Ceiling Height parameter is divided 2 different categories which are Ceiling Height: Inpatient Rooms ≥ 4m score of (+1) is assigned in this case, as it is an instrumental element when it comes to maximizing possibility to future flexibility, for instance converting patient rooms into operation room. Ceiling Height: Ground Floor ≥ 5m is (+1) score.

B. Structure Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
STRUCTURE	7m ≤ Span ≤ 8m Open floor plan	4	No
	Span > 8m	2	No
	Span < 7m	1	No
	Span < 6m	0	No
	Regular Grid	+1	No
	Squared Grid	+1	No
	Redundancy in Structural Capacity	+1	No
	Punch Through Concrete Slabs for Vertical Circulation	+1	No
	Ceiling Height : Inpatient Rooms ≥ 4m	+1	No
	Ceiling Height : Ground Floor ≥ 5m	+1	No
		Structure Total Assigned Score	No / 10

Table 4.4: Structure Parameter Megastructure Flexibility Assessment (Source: Author)

3. Facade Parameter

	POINTS	OPTIONS	SCORE
FACADE	6 4 2 0 0 +4	100 % Curtain Wall 75 % Curtain Walls 50 % Curtain Walls Ventilated Facade Traditional Masonry / Brick Wall Modular Panels	/ 10

Table 4.5: OFAT Facade Evaluation Parameter
(Source: Elshazly & Ghazy (2020))

Description

Facade is a vital element of building construction as it can be used like a short-cut to the rooms by skipping all circulation units.

The 100 percent **curtain wall facade** is the most appropriate style of facade from this point of view, and thus receives the top rating (+6). In this situation, the exterior is completely separate from the structure of the building. The ranking is (+4) if the exterior is made up of a 75% **curtain wall**. The score given is (+2) when the **curtain wall percentage decreases by 50%.**

Although the **ventilated facade** is frequently suggested because of its benefits, it earns 0 points for flexibility because an alteration aimed at changing the internal surface of the facade will negatively affect the proper functioning of natural ventilation.

A classical **masonry** exterior is also given 0 points for any alteration entails at least partial demolition. Since this will be inconvenient and disrupt the hospital's and plant's current operations.

Another significant consideration is whether the facade is mainly composed of **modular panels** that are conveniently reversible and adjustable, which receives a high score (+4).

Facade parameter critical review

The key criteria for assessing the utility of a building facade in this category of the evaluation tool are based on flexibility, architectural expression and functional factors being ignored. However, the skin of the hospital is so vital especially with megastructures as the surface area which is exposed to exterior and sunlight is too much. Therefore a more careful and complicated analysis is needed. Although facade options given in the parameter are varying, there are other types of facades or hybrid systems which are neglected.

100 % Curtain Wall, 75 % Curtain Wall and 50 % Curtain Wall are 3 categories of curtain wall system. However, such classification is a little overdetailed and unnecessary for megastructures. Therefore, the categories should be redefined.

Modular Panels have a (+4) grade since they are used as a significant strategy for heavy equipment exchangeability and future extension, but they have a similar role with Curtain Wall. In other words, the Curtain Wall and Modular Panel cannot be considered separately. As a result, the rating is significantly unbalanced.

A. Facade Parameter Proposed Modifications

In order to optimize the Facade parameter assessment, some modifications are applied as following:

- Curtain Wall analysis parameter is redefined into 2 different classifications as 100% Curtain Wall and 70 % Curtain Wall. Also, 50 % curtain wall is deducted from the facade parameter to simplify. The scores are (+6) and (+4) respectively.
- A new assessment parameter "Prefabricated Facade" is added which allows easy assembly in the site and cost efficiency. The score (+2) is assigned.
- "Solar Shading Panels" parameter is added as it increases the life of the materials and equipment. Also, it helps to provide thermal comfort with cost effectiveness, (+2) score is assigned.
- Modular formation is an inevitable consequence for easy assembly and construction of curtain wall system and large-scale structures. Therefore the score is reduces from (+4) to (+2).

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows:

1. Curtain Wall

The 2 different curtain wall categories are classified according to glazing to solid percentage. Scoring (+6) in the case of 100% Curtain Wall, (+4) for 70% Curtain Wall. This is according to their independence from the building structure

2. Ventilated Facade or Traditional Masonry/Brick Wall

Ventilated Facade system that allows the formation of an air chamber between the external wall of the building and the cladding. A score of (zero) is assigned in this case, for Ventilated Facade and Traditional Masonry/Brick wall due to the significant limitations occur in case of facade modification/maintenance affecting the functionality of the building due to the significant limitations as demolition is essential in case intervention, that interrupts the on going functions of the facility

3. Modular Panels

Modulated glazing or cladding panels that can be easily assembled or disassembled. In this case, (+2) score is assigned, due to its advantage to exchangeability and expandability

4. Prefabricated

Prefabricated components are joined or combined on-site to create this sort of facade. These facades' components are mass-produced in highly automated factories. The key benefits of this type of facade include speed and ease of installation, removal, as well as lower cost than other systems. The score is (+2).

5. Solar Shading Panels

Solar Shading Panels extends the life span of skin materials and indoor equipment. It is also effective in creating thermal comfort for patients with low cost and energy. Thus, (+2) score is given.

Note: In some cases, specific functions necessitates to have solid facades, such as (technical floor, interstitial floor, auditorium, etc.). These solid portions are to be neglected from the calculation the percentage of the Curtain Wall in the building.

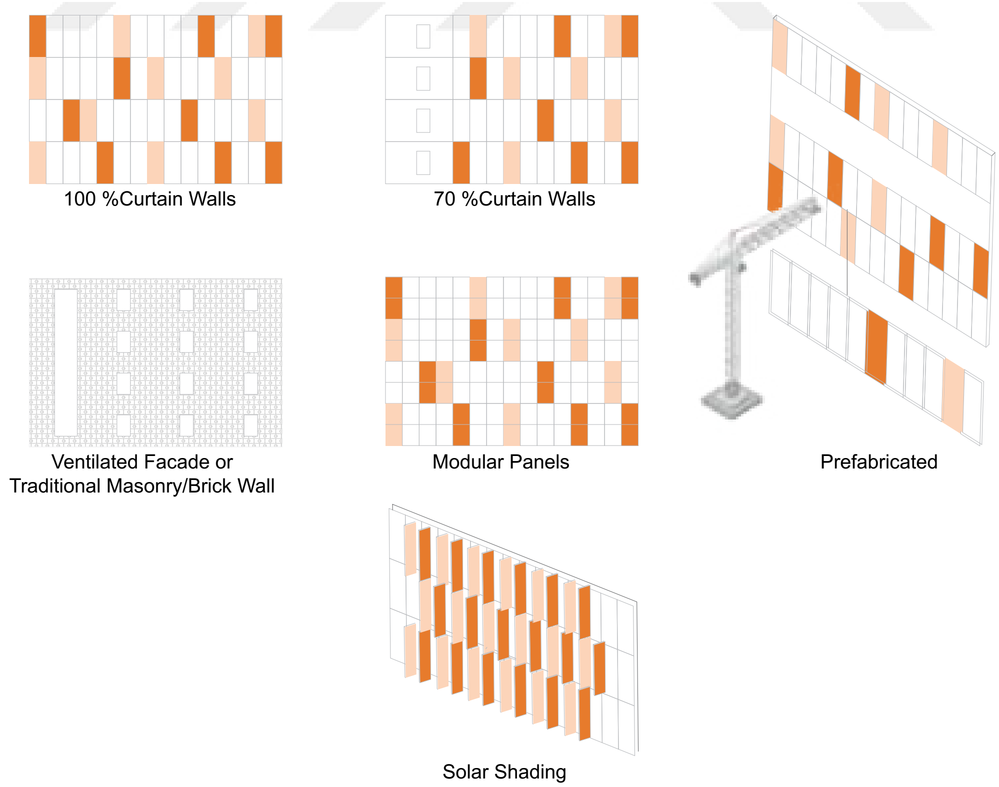


Figure 4.3: Facade Evaluation Parameter Morphological Variations
(Source: Author)

B. Facade Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
FACADE	100 % Curtain Wall	6	No
	70 % Curtain Walls	4	No
	Prefabricated Facade	2	No
	Ventilated Facade or Traditional Masonry/Brick Wall	0	No
	Modular Panels	+2	No
	Solar Shading Panels	+2	No
		Facade Total Assigned Score	No / 10

Table 4.6: Facade Parameter Megastructure Flexibility Assessment
(Source: Author)

4. Building Plant Parameter

	POINTS	OPTIONS	SCORE
BUILDING PLANT	2 1 0 +2 +1 +1 +1 +1 +2* +1* +1*	Distance in between Service Shafts: d ≤ 35m Distance in between Service Shafts: 35m < d ≤ 70m Distance in between Service Shafts: d >70m Redundancy for Building Plant Distribution in Raised Floor and/or Exposed Installationsif Required Plant Tower Technical Floor Service Shafts Area: Shafts Total Surface/Floor surface ≥ 0.01 Spread out Plant Infrastructure in False Ceiling* Condensed Plant Infrastructure (Varying Height of False Ceiling)* Technical Interstitial Floor*	/ 10

Table 4.7: OFAT Building Plant Evaluation Parameter
(Source: Elshazly & Ghazy (2020))

Description

It is argued in the parameter that decisions about plant distribution and component capability must allow for the need to respond to future hospital needs. Some of the suggested solutions are mutually incompatible. This is a case of inter-plane transmission that is pervasive, localized, and technical.

The technological interstitial-floor receives a low score (+1) because, considering its benefits, its high costs prevent it from being very practical. **The condensed plant infrastructure** receives an equal ranking (+1). (varying height of false ceiling). The technical reconfiguration in this situation will include modifications on the false ceiling as well as the structures installed above it. **The spread out plant infrastructure in false ceiling**, with the same level in all spaces, receives a high score (+2). As a result, reconfiguring the areas will not be challenging. This method causes the bathrooms to be separated from the pipe column.

If needed (+1) in areas with special requirements, such as labs, in case of distribution in **raised floor and/or exposed installations.**

A service plant with a vertically clustered service network that divides horizontally for the storeys is known as **a plant tower.** As a consequence, a (+1) is assigned.

Technical Floor, since it allows for free transfer between roles of different physical configuration and technical/structural criteria (for example, bed tower and organizational block). As a result, a (+1) score is given.

According to the literature and design standards, **redundancy for building plant** allows for potential modifications and improvements to the structure. It has been given a (+2) rating.

The dimension and location of the service shafts are also very significant. Organizing them at **a maximum length (d) of 35m** receives a high score (+2) since it makes for easy service network delivery on the floor.

Since the system becomes more flexible and branched, positioning them at greater distances, **between 35m and 70m**, results in a lower score (+1). **Distances higher than 70 meters** receive a 0 rating.

The minimum size of 15m2, slightly overweight to provide room for potential uses, and the optimum distance of 30-35m is assumed for the **service shafts area** (A). Each 15m2 shaft will compete for a 1225m2 field. The value is measured to be (A) ideal= 0.012, and it is compared to the measured with the information of the hospital under investigation, using the formula: A= Total area of rooms on one floor / Total area of one floor, if the ratio is higher than 0,01, the score is (+1).

Building Plant parameter critical review

Capacity, distribution, and the potential to respond to possible changes or extension are the key requirements for describing the performance of the building plant in this section.

The Plant Distribution analysis parameter is specifically defined and categorized into three groups, each with a unique score: (Spread out plant infrastructure in false ceiling, Condensed plant infrastructure and , and Interstitial Floor). However Interstitial Floor differs from the other alternative styles. In some examples of contemporary hospitals, there is infrastructure in false ceiling and interstitial floor together. This leads to a need for further consideration about the categorization.

(+2) score is assigned for Building Plant Redundancy as it allows for additional alterations and changes to the structure. However it is more important than ever regarding literature review with especially emerging issues like pandemic. Therefore the scoring should be revised.

The Service Shafts criteria is no longer an indicator for flexibility since analyzed case studies showed that all of the examples provide such feature.

A. Building Plant Parameter Proposed

In order to optimize the Building Plant parameter assessment, some modifications are applied as following:

- Interstitial Floor is set as an alternative indicator since it has a different approach than Distribution of Plant in Ceiling. In some cases these two sub-parameters can be seen together.
- The score of Building Plant Redundancy is increased from (+2) to (+3) since it is a fundamental and vital issue to be taken into consideration.
- The ratio of Service shafts is deducted from the parameter since it is not a valid difference maker as a flexibility issue anymore.
- Plant Tower and Technical Floor are set as two alternatives to be chosen relying on studied examples of hospitals and literature, those are two different techniques that serve similar aims.

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows:

1. Distance between Service Shafts

The three distinct distances between shafts are defined based on the reliability of their utility network integration. Scoring (+2) in the case of $d \leq 35m$, (+1) for $35m < d \leq 70m$, and (zero) for $d > 70m$ respectively

2. Redundancy for Building Plant

Building Plant to be built with extra areas in order to be adaptable and usable over time, and planned and installed in such a manner that potential alterations and additions can be accommodated. In this case, (+1) score is assigned

3. Distr. in Raised Floor and/or Exposed Installations if Required

Raised Floor is a structurally elevated floor that provides a continuous space under the floor surface that can be used to route all mechanical structures. It comes in handy in labs and workplaces. Although Exposed Installations When Required is a technique that enhances the functional versatility of space by making technological outputs noticeable and available, particularly in patient rooms. In the availability of one or both of them, a score of (+1) is assigned.

4. Plant Tower

A service plant with a vertically compacted network infrastructure that branches horizontally for floor. Hence, (+1) score is assigned

5. Technical Floor

It is a story devoted to holding the technical machinery of the floors above it in vertical/compact structures, stressing the functional structure of the building by separating it into separate blocks. In this case, a score of (+1) is given.

6. Distribution of Plant in Ceiling

The 2 different distribution techniques in ceiling. Scoring (+2) for Spread out plant infrastructure in false ceiling, (+1) Condensed plant infrastructure. The first allows maximum convertibility, the second limits flexibility.

7. Interstitial Floor

Interstitial Floor is not a cost efficient solution but still provides flexibility to some extent. Therefore, (+1) score is assigned.

B. Building Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
BUILDING PLANT	Distance in between Service Shafts: d ≤ 35m	2	No
	Distance in between Service Shafts: 35m < d ≤ 70m	1	No
	Distance in between Service Shafts: d >70m	0	No
	Redundancy for Building Plant	+3	No
	Distribution in Raised Floor and/or Exposed Installations if Required	+1	No
	Plant Tower*	+1*	No
	Technical Floor*	+1*	No
	Spread out Plant Infrastructure in False Ceiling*	+2*	No
	Condensed Plant Infrastructure (Varying Height of False Ceiling)*	+1*	No
	Technical Interstitial Floor	+1	No
Building Plant Total Assigned Score			No / 10

Table 4.8: Building Plant Parameter Megastructure Flexibility Assessment (Source: Author)

5. Expandability Parameter

	POINTS	OPTIONS	SCORE
EXPANDABILITY	+4 +2 +1 +1 +1 +1	Internal: Already Equipped Spaces Internal: Shell Spaces Open Ended Corridor and/or Large Spaces on Building's End Soft Spaces: to be Retrofitted into Service Spaces if needed External: Volumes "Hanging" from the Facade Availability of Neighboring Plot	/ 10

Table 4.9: OFAT Expandability Evaluation Parameter
(Source: Elshazly & Ghazy (2020))

Description

It is stated that the ability to adapt to potential space requirements without needing to construct physical additions, it is preferable to develop temporary "shell" spaces or secondary functions inside the structure, which can be reused as desired.

Internal: Already Equipped Spaces with the multiple plant networks receive the best score (+4). All that will be required is the construction of sufficient internal partitions and the furnishing of the structure, permitting them to be used as required.

Internal: Shell Spaces receive a lower (+2) rating because they need broader and more complex measures, such as the installation of plant networks, the removal of flooring or panels, or the development of false ceilings. While more realistic than conventional methods, the scheduling and expenses of these interventions are higher than those of the first solution.

An open-ended corridor and/or large spaces on the building's end are used as an evaluation criterion since they facilitate lateral extension without eliminating the areas at the building's ends and affecting current operations. As a result, a (+1) score is given.

Another analysis criterion is **soft spaces**, which can be retrofitted into service spaces if desired, maximizing the building's flexibility to adapt to future requirements. In this case, a score of (+1) is given.

Another evaluation factor is **Neighboring Plot Availability**, which ensures the probability of spatial extension. In this situation, a point of (+1) is given.

External: Volumes "Hanging" from the Facade receives the least value (+1) for solutions that maximize the overall area of the structure. The project anticipates the recognition of these components, accounting for them in the calculations for the scaling of the structural support, which would be oversized as a result. Even if the intervention does not require structure, it is unquestionably more intrusive than the other two options since these masses must be created from scratch. As a result, they take up more time and spend more money.

Expandability parameter critical review

The presence of additional spaces to absorb and certain factors that encourage the volume itself to grow inside the current system are the key requirements for determining the possibility of extending the healthcare services in this part of the assessment tool.

Internal: Already Equipped Spaces with the multiple plant networks receive the best score (+4). This parameter has improved while taking into account pandemic conditions which need high technology like oxygen and negative pressure equipment etc. All that is necessary is the installation of adequate internal partitions and the furnishing of the structure so that they can be used as needed. (+3) Score is assigned to it.

Internal: Shell Space evaluation parameter omıts some spaces which are useful to be used during emergency conditions like pandemic. Therefore, it's content is extended taking into account already defined and big enough areas to serve a high amount of patients in case extraordinary situations. Hence a score of (+2) is assigned.

Soft Spaces would be a useful buffer zone regarding division of ward spaces in order to prevent spread of infection besides the role of potential backup service facilities.

Availability of Neighboring Plot analysis parameter is not only important for the expansion of the existing structure but also it allows installation of temporary structures which have ease assembly techniques and prevent losing time in case of pandemic or natural disaster in order to meet patients over capacity.

A. Expandability Parameter Proposed Modifications

In order to optimize the Expandability parameter assessment, some modifications are applied as following:

- A new analysis parameter "Removable Partitions" is added, as it enables rooms or spaces to enlarge in case of need or emergency. In this case a score of (+1) is assigned.
- In order to create more comprehensive and useful sub-parameters, pandemic conditions were taken into consideration and revised accordingly depending on literature review and case studies.
- The score of Already Equipped Spaces reduced from (+4) to (+3) since the number of varying alternatives of indicators were increased.

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows:

1. Already Equipped Spaces with Advanced System

Spaces planned and built with high technology service systems such as suction, oxygen, negative pressure etc. to be used when needed. (+3) Score is assigned to it.

2. Internal: Shell Spaces

Areas which are already constructed and served daily operation in mega-structured facilities such as gyms, car parks, congress centers or unused areas that need more time and invasive technical operations, such as the installation of plant networks to be used when needed. They can be converted into bed-wards areas in emergency conditions. Hence a score of (+2) is assigned.

3. Open-Ended Corridor and/or Large Spaces on Building's End

Extra adjacent areas that lie within the property borders along with an open-ended corridor that facilitates horizontal expansion if needed in the future. This maximizes operational flexibility as merging expansion with already existing functions. Hence, a score of (+1) is assigned.

4. Soft Spaces: to be Transformed into Service Spaces and Buffer Zones if needed

Extra space where backup facilities can be accommodated in case of need or disaster or damage. Providing soft spaces next to technical services is preferred as it may be retrofitted into service spaces to meet the future services needs with no interruption to the ongoing healthcare facility functions. For instance, these areas may provide buffer zones between wards and divide contaminated and non-contaminated spaces in case of pandemic. In this case, (+1) score is assigned

5. External: Volumes "Hanging" from the Façade

The facility's structure equations involve extruded volumes from the facade, but it would not involve additional supporting structure in the event of extension. In this case, a score of (+1) is given.

6. Availability of Neighboring Plot

Extra neighboring spaces within the property boundaries that allow for potential horizontal expansion if desired. This not maximizes operational flexibility as merging expansion with already existing functions but also provides areas for pop-up temporary structures in case of pandemic. Hence, a score of (+1) is assigned

7. Removable Partitions

It makes it easier to move partitions to enlarge or fit in spaces in case of need or emergency. Removable partition that allows rapid and relatively simple installation, while providing flexibility for easy adaptation to any constructions type. In some embodiments, the modular panel assembly involves panels which are prefabricated with panel connectors. In this case (+1) score is assigned.

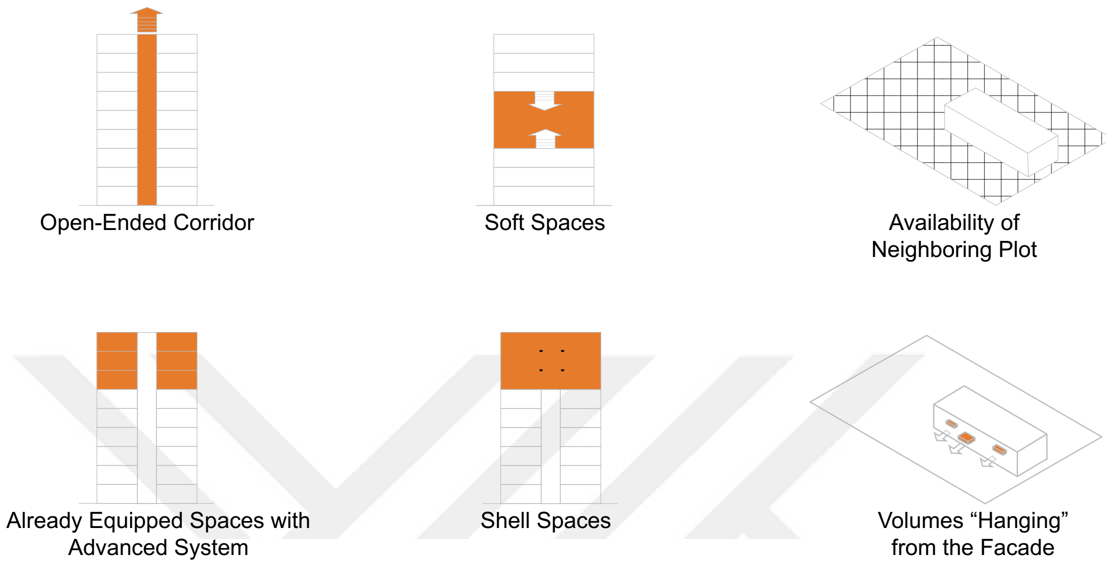


Figure 4.4: Expandability Evaluation Parameter Possible Solutions

(Source: Author)

B. Expandability Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
EXPANDABILITY	Already Equipped Spaces with Advanced System	+3	No
	Internal: Shell Spaces	+2	No
	Open Ended Corridor and/or Large Spaces on Building’s End	+1	No
	Soft Spaces: to be Transformed into Service Spaces and Buffer Zones If Needed	+1	No
	External: Volumes “Hanging” from the Facade	+1	No
	Availability of Neighboring Plot	+1	No
	Removable Partitions	+1	No
		Expandability Total Assigned Score	No / 10

Table 4.10: Expandability Parameter Megastructure Flexibility Assessment

(Source: Author)

6. Structural Constraints Parameter

	POINTS	OPTIONS	SCORE
STRUCTURAL CONSTRAINTS	6 4 2 0 +2 +1 +1	Only Fixed Vertical Elements (Circulation & Service Shafts) Fixed Elements of Building Plant: Up to 25% Fixed Elements of Building Plant: Up to 50% Fixed Elements of Building Plant: Up to 75% Drain Pipes: In Service Shafts or Running Next to Pillars Adjustability of Service Shafts Grouped Vertical Circulation Elements	/ 10

Table 4.11: OFAT Structural Constrains Evaluation Parameter
(Source: Elshazly & Ghazy (2020))

Description

The ranking would be the best (+6) if there are only fixed elements in all levels, which are **fixed vertical elements** (connections and service shaft), so this ensures the greatest degree of consistency in spatial planning. If the **fixed elements of Building Plant: up to 25%**, the rating will be marginally lower (+4) and will decline as the number of constant components in the floor plan rises; if the value is **at most 50%**, the result will be average (+2). The ranking would be decreased if the number rises to a limit of **75%**, the score is (0).

Extra points may be assigned to this score where there are features in the project that allow for the elimination of a restriction, such as **drain pipes in service shafts or running next to pillars**. As a result, two different options have been established.

Rather than being built in designated drainage ducts, **drain pipes** are installed in service shafts or sleeves along concrete pillars. Since drainage pipes are called moving items in bed ward floors, replacing them with pillars or utility shafts will greatly minimize the vertical restrictions in the floor plan. As a consequence, a (+1) is assigned.

Adjustability of Service Shafts areas in response to changes in mechanical and healthcare needs. Modular architecture can be used to do this. Because of their adjustability, the structure's ability to react to changes in structural and medical needs is maximized. A score of (+1) is given in this scenario.

Grouped Vertical Circulation Elements, grouping the vertical core circulation components together to keep the remainder of the floor space free and continuous. Vertical secondary system networks (such as electrical risers and low current) can be classified with circulation centers. A score of (+1) is given in this situation.

Structural Constraints parameter critical review

The percentage of the fixed vertical elements in the construction plant that occur in some or all structure levels is the key criterion for determining the structural constraints that limit potential modifications of the healthcare facility in this part of the assessment tool.

The structural constraints assessment criterion is well described and divided into four parts: (Only fixed vertical elements (circulation and operation shafs), fixed elements of building plant: up to 25%, up to 50%, up to 75%,) scoring (+6), (+4), (+2), and (zero). As the lower percentage of fixed elements in the building plant, the more guaranteed level of space flexibility, thus having minimal fixed elements is recommended. It is a well balanced classification system for building plant as it also provides a high adjustability of spaces during pandemic regarding reviewed literature.

Drain pipes in service shafts and drain pipes running next to columns are called moving features in the bed wards levels, receiving a score of (+2). However it is so common in recently built hospitals. Because of that, there is a need for reduction in the score to meet the true value of the parameter. Grouped Vertical Circulation Elements, grouping the vertical core circulation components together to keep the remainder of the floor space free and continuous. A score of (+1) is given in this situation. However, in some cases there might be other types of vertical circulation such as escalators. This makes the parameter questionable since it lacks quantitative definition.

A. Structural Constraints Parameter Proposed Modifications

In order to optimize the Restrictions parameter assessment, some modifications are applied as following:

- The score of Drain Pipes: In Service Shafts or Running Next Pillars reduces from (+2) to (+1) as a result of reclassification of the parameter.
- Another new analysis parameter Flat Land: slope < 5% is added since natural restrictions should be taken into consideration in structural layout. (+1) score is given.
- The score of Drain Pipes: In Service Shafts or Running Next Pillars reduces from (+2) to (+1) as a result of reclassification of the parameter.

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows

1.Fixed Elements

The four separate ratios of fixed elements are determined by the area of the building plant's fixed elements in proportion to the overall area of the building plant.Scoring (+6) in the case of Only fixed vertical elements (connections and service shaft), (+4) for Fixed (vertical and horizontal) Elements of Building Plant: Up to 25%, (+2) for Fixed Elements(vertical and horizontal) of Building Plant: Up to 50% and (zero) for Fixed (vertical and horizontal) Elements of Building Plant: Up to 75%

2.Placement of Drain Pipes

Rather than being installed in designated drainage ducts, drain pipes are installed in service shafts or sleeves along concrete pillars.Hence, a score of (+1) is assigned

3.Adjustability of Service Shafts

Changing the areas of service shafts in response to changes in technological and medical criteria. Modular structure can be used to do this. A score of (+1) is given in this case.

4.Grouped Vertical Circulation Elements: More than 80%

Clustering the vertical core circulation elements together, so that the rest of the floor space is contiguous and open. Grouped Vertical Circulation Elements: More than 80% is assigned (+1) score.

5. Flat Land: slope < 5%

Slope of the project site directly affects the foundation structure of the building, as a result distribution of the related functions inside of the building are located in different levels as it affects functionality and flexibility. (+1) score is assigned in this case.

Note: There are various types of service shafts: mechanical, electrical and other medical special ones such as (firefighting, drainage/plumbing, HVAC, power, low current, medical gases, linen chute, garbage chute, PTS chute “horizontal and vertical”, natural gas)

B. Restrictions Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
RESTRICTIONS	Only Fixed Vertical Elements (Circulation & Service Shafts)	6	No
	Fixed Elements of Building Plant: Up to 25%	4	No
	Fixed Elements of Building Plant: Up to 50%	2	No
	Fixed Elements of Building Plant: Up to 75%	0	No
	Placement of Drain Pipes	+1	No
	Adjustability of Service Shafts	+1	No
	Grouped Vertical Circulation Elements: More than 80%	+1	No
	Flat Land: slope < 5%	+1	No
		Restrictions Total Assigned Score	No / 10

Table 4.12: Restrictions Parameter Megastructure Flexibility Assessment
(Source: Author)

7. Technology Parameter

	POINTS	OPTIONS	SCORE
TECHNOLOGY	4 2 0 +1 +1 +1 +1 +2* +1*	Dry Assembly Technique Mixed Assembly Technique Wet Assembly Technique Internal Partitions: Modular Panels Internal Partitions: Panels Set up with Technical Installations Internal Partitions:Movable/Retractable Internal Partitions: Framed Construction Internal Partitions: Prefabricated Panels* Internal Partitions:Dry Walls Built In Situ*	/ 10

Table 4.13: OFAT Technology Evaluation Parameter
(Source: Elshazly & Ghazy (2020))

Description

According to Zanchi E. (2015), the first indicator to consider is that of assembly technique, since it is able to determine the flexibility with which it is possible to intervene to the building.

The technique that achieves the maximum score (+4) is certainly **dry assembly**, since it ensures time performance, less discomfort, and less interference when conducting intervention. Instead, **a mixed assembly technique** that includes both dry and wet assembly achieves an intermediate (+2) score.**The wet assembly**, on the other hand, receives a zero because any modifications to the internal partitions will result in loud and dirty destruction, which are obviously unsuitable for healthcare operations.

Extra points can be added if the panels used for the **internal partitions** are modular and therefore readily re-claimable in the overall structure (+1) and if they are **panels set up with technical installations inside them**, making assembly operations even easier and quicker therefore (+1) is assigned.

Extra points would be given for recognizing the difference between prefabricated panels and on-site dry walls. The score awarded to **prefabricated panels** is higher (+2), since the construction of internal partitions is limited to purely assembly work. The other, less favorable choice is to **build dry walls on site**, which receive a lower score (+1). This is the situation, for instance, with plasterboard walls, which necessitate activities that may be inconvenient for patients, staff, and health care providers.

Areas can be changed simply by moving objects, thanks to the **movable/retractable** function.By varying the degree of contact between adjacent spaces, they allow a variety of versatile ways to use space. A score of (+1) is given in this scenario.

Framed Construction provides partition walls to be modified in case of repair or necessity of alteration. Therefore, a score of (+1) is given.

Technology parameter critical review

The installation and construction methods of the interior walls/partitions are the key criterion for determining the flexibility of construction technologies in this segment of the assessment tool.
The Assembly Techniques analysis criterion is well developed and divided into three groups based on the construction method used: (+4), (+2), and (zero) for Dry assembly technique, Mixed assembly technique, and Wet assembly technique, respectively. Since the Dry assembly technique simplifies the entire operation, whereas the Wet assembly technique receives no points due to the distractions and discomforts it creates.

Although Internal Partitions: Dry Walls Built in Situ provides different technical style, it has a similar purpose with Dry Assembly Technique. Additionally, Dry Walls Built in Situ is not a special and unique technique which offers flexibility anymore in contemporary healthcare construction.

Other construction elements like slaps, roofs etc. are omitted as its focus point is on internal partitions. Prefabrication of the healthcare structure itself brings a great flexibility potential with fast and handy use of dry assembly techniques in case of a need in demand, improvement of equipment and maintenance(re-assembling) of materials.

A. Technology Parameter Proposed Modifications

In order to optimize the Technology parameter assessment, some modifications are applied as following:

- A new analysis parameter “Prefabricated Building Elements (Framework, Roof, Slab)” is added since it ensures that spaces can be modified simply by moving elements. They allow various flexible ways for the usage of space and capacity with low cost intervention. Plus, it makes it easier for intervention and installation of equipment. In this case a score of (+1) is assigned for each.
- Another new analysis parameter “Innovative Temporary Structures” is added because it guarantees fast and easy intervention in case of emergencies like pandemic. These are light temporary structures that provide additional capacity outside of the facility as it also

enables to control possible infection growth. In this case a score of (+1) is assigned for each.

- Internal Partitions: Dry Walls Built in Situ is withdrawn from the parameter because it is not today's issue regarding contemporary examples. Plus, it has a common ground with indicator Dry Assembly Technique.

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows:

1. Assembly Techniques

Due to the methodology used, the three different types of Assembly are defined. In Dry Assembly technique internal dry partition walls are formed by modules assembled with mechanical fixing techniques that do not involve combining substances with wet material. The Mixed Assembly, on the other hand, is a combination of the two methods. Dry assembly receives a score of (+4), mixed assembly receives a score of (+2), and wet assembly receives a score of zero.

2. Internal Partitions: Modular Panels

Technique that provides for fast and simple installation while still allowing for easy adaptation to any form of system. Panels that are prefabricated with connectors are seen in some forms of the modular panel setup. A plus one (+1) is given.

3. Internal Partitions: Panels Set Up with Technical Installations

Distinct prefabricated, self-supporting components are built with channels to fit technological systems to build internal non load-bearing partitions. A score of (+1) is given.

4. Internal Partitions: Framed Construction

Internal Partitions are built in a framed modular form that enables partition walls to be easily changed and re-assembled. A score of (+1) is given in this scenario.

5. Internal Partitions: Prefabricated Panels

Internal partitions with easy to install and take down connections, as well as minimal technical configurations and uniform networks. This form only necessitates installation. As a result, a (+1) score has been allocated.

6. Prefabricated Building Elements (Framework, Roof, Slab)

It is similar to Prefabricated Panel in internal partitions but in vertical and horizontal direction with less mechanical installations and cost efficiency. The spaces can be adjusted by element alterations. Plus, it allows vertical expansions and installations of equipment in the future if needed. The score is assigned (+1).

7. Innovative Temporary Structures

For unexpected situations like pandemic that the capacity of the healthcare facility does not meet demand, temporary structures such as containers, inflatable systems, tent structures, modules, partition panels etc. would be used. These solutions bring advantage in flexibility with easy assembly techniques and cost efficiency. In this case (+1) score is given.

B. Building Elements Parameter Mega Structure Flexibility Assessment Tool

BUILDING ELEMENTS	Mixed Assembly Technique	2	No
	Wet Assembly Technique	0	No
	Internal Partitions: Modular Panels	+1	No
	Internal Partitions: Panels Set up with Technical Installations	+1	No
	Internal Partitions: Framed Construction	+1	No
	Internal Partitions: Prefabricated Panels	+1	No
	Prefabricated Building Elements (Framework, Roof, Slab)	+1	No
	Innovative Temporary Structures	+1	No
		Building Elements Total Assigned	No / 10

Table 4.14: Building Elements Parameter Megastructure Flexibility Assessment
(Source: Author)

8. Exchangability of Large Equipments Parameter

	POINTS	OPTIONS	SCORE
EXCHANGEABILITY OF LARGE EQUIPMENT	8 4 0 +1 +1	Only Needs Disassembly of Facade Panels Disassembly of Facade Panels and of Internal Partitions Partial Demolitions Large Equip.: In Ground Floor/ Floor with Direct Contact to Outside Equipments Spaces with Redundancy	/ 10

Table 4.15: OFAT Exchangeability of Large Equipment Evaluation Parameter
(Source: Elshazly & Ghazy (2020))

Description

It is identified and discussed that The ability to quickly upgrade big and heavy machinery is an important parameter to consider when determining flexibility. If the building meets challenges during the process, it can be a delicate and expensive installation.

The intervention that should be performed to facilitate the relocation of these instruments has been classified into three categories of complexity. Since the diagnostic units are situated around the structure's external perimeter and the facade is made up of removable panels, the first level comprises entirely of **facade panel disassembly**. This makes the intervention smoother, which is why this choice gets the highest score (+8). The second stage imposes further limitations, as certain **internal partitions must be removed** in addition to the facade panels in order to allow equipment transfer between corridors. This gives a medium (+4) rating. The third degree of intervention difficulty, in which demolitions are needed, even if only partially, is given a zero score.

Since it is difficult to predict the physical space needed for the new **equipment, storage spaces** can be built with additional areas to be adaptable to meet advances in medical equipment. As a consequence, a (+1) is assigned.

Exchangeability of Large Equipment parameter critical review

This part of the assessment tool's key criteria for determining whether or not massive equipment should be exchanged in the future due to technical and medical advances is the need to complete the procedure with limited interference, no demolition, and in a reasonable amount of time.

The Complexity of Exchangeability of Large Equipments evaluation criterion is well described and divided into three groups based on the type of the intervention: (Only requires disassembly of facade panels, Disassembly of facade panels and internal partitions, and Partial demolitions) scoring (+8), (+4), and (zero) respectively. Just requiring disassembly of facade panels simplifies the whole procedure and causes minor disruption to existing operations, while disassembly of facade panels enhances the process's complexity due to the discomfort of disassembly. Because of the high level of noise and dusty atmosphere, the third group received no points. However, it is a common phenomenon that disassembly of facade and internal partitions while exchanging of the large equipment for megastructures since masses get thicker and larger with big scale buildings and it becomes harder to penetrate through inside.

Despite the fact that (+2) is allocated to large equipment on the ground floor or floor with direct contact to the outside, yet it misses the case of having the equipment located in a floor that is too large in width and not easily reachable to the inner parts. Also, future proofing plans for equipment spaces should be considered, since they should be constructed for flexibility in order to accommodate equipment that will need additional space.

"Large Equip.: In Ground Floor/ Floor with Direct Contact to Outside" and "Only needs disassembly of facade panels" are two overlapping indicators even though they consider different parameters. For the reason that even though equipment is located on the ground floor, it is not possible to move them if there are not required facade elements. Plus, it is not a common thing to see large equipment only on the ground floor of megastructures regarding their scale.

Although there are a variety of options considering exchangeability of large equipment, possibility of installation from the top of the structures is neglected. It would be an important issue for large and fat masses where you cannot reach inner parts.

A. Exchangeability of Large Equipments Parameter Proposed Modification

In order to optimize the Exchangeability of Large Equipment parameter assessment, some modifications are applied as following:

- The score for Disassembly of Facade Panels and Internal Partitions is increased from (+4) to (+6) as an inevitable result for megastructures.
- "Large Equip.: In Ground Floor/ Floor with Direct Contact to Outside" and "Only needs disassembly of facade panels" are aiming for the same purpose. Therefore they can be merged into one analysis parameter.
- A new analysis parameter called "Disassembly of Roof or Slab Panels" is added. In this case (+1) score is assigned

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows:

1.Complexity of Exchangeability

The three different types of the Complexity of Exchangeability of Large Equipments are defined depending on the form of building interference. Only needs disassembly of facade panels receives a score of (+8), Disassembly of facade panels and internal partitions receives a score of (+6), and Partial demolitions receives a score of (zero).

2.Equipments Spaces with Redundancy

Equipment rooms can be built with additional capacity to allow for further advances in medical technology, since it is difficult to predict the physical space available for the most up-to-date equipment. As a result, a (+1) is given.

3.Disassembly of Roof or Slab Panels

Scoring (+1) in the case of Disassembly of Roof or Slab Panels in case the mass is too large that inner space has no direct contact to outside or equipment is located at the top for placing or removing large equipment from the building.

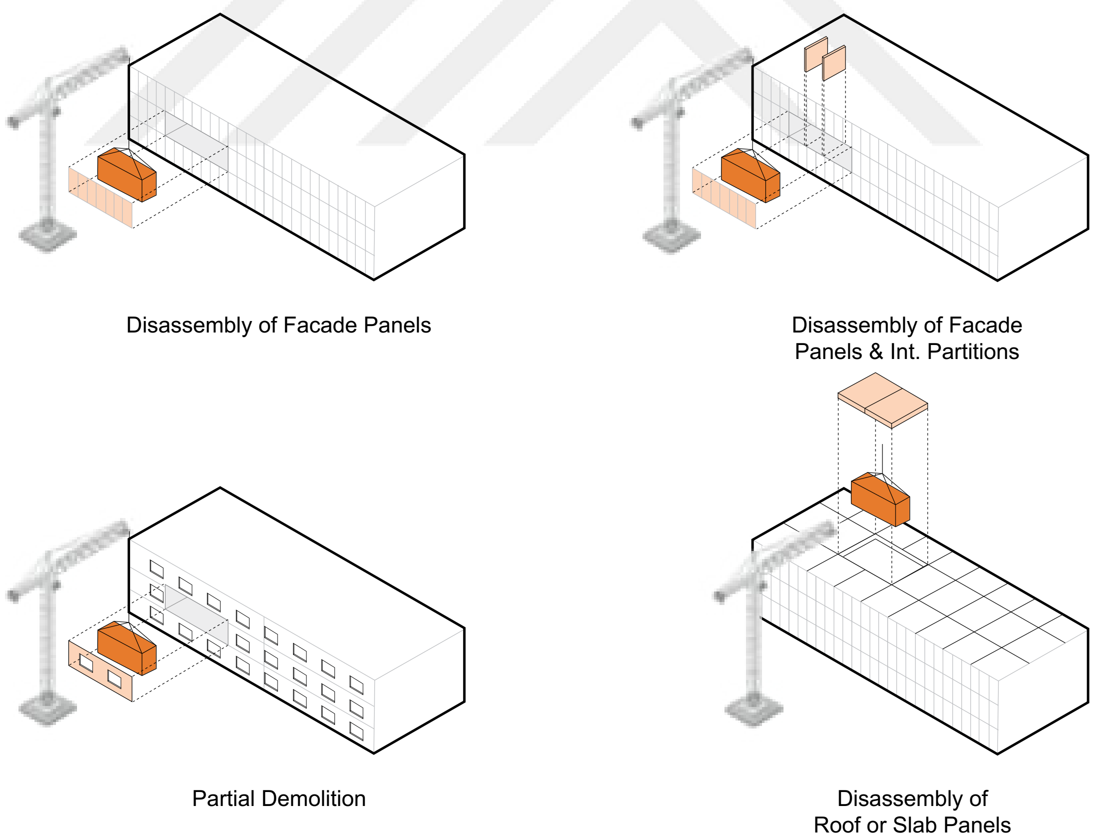


Figure 4.5: Exchangeability of Large Equipments Evaluation Parameter Possible Scenarios
(Source: Author)

B. Exchangability Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
EXCHANG. OF LARGE EQUIPMENTS	Only Needs Disassembly of Facade Panels	8	No
	Disassembly of Facade Panels and of Internal Partitions	6	No
	Partial Demolitions	0	No
	Equipments Spaces with Redundancy	+1	No
	Disassembly of Roof or Slab Panels	+1	No
	Exchange of Large Equipments Total Assigned Score		No / 10

Table 4.16: Exchangeability of Large Equipments Parameter Megastructure Flexibility Assessment (Source: Author)

9. Functionality Parameter

	POINTS	OPTIONS	SCORE
FUNCTIONALITY	+4 +2 +1 +1 +1 +1	Generic/Universal Rooms Space Standardization Double Function Overflow Design Loose Fit Furniture/Equipment Flexibility	/ 10

Table 4.17: OFAT Shape Evaluation Parameter
(Source: Elshazly & Ghazy (2020))

Description

Since it recognizes adaptability, flexibility, resilience, convertibility, and expandability as instrumental aspects that must eventually be addressed, functionality is an important concept for the building, both from a capacity and future proofing perspective.

Generic/Universal Rooms receive the highest score (+4) because they help to avoid excessive variance of related elements where the shift in configuration can be accommodated in a single uniform template.

The existence of **Space Standardization** earns a lower score of (+2), which is related to description, specification, efficiency, and error control due to repetitive usage, as well as the capacity to respond to possible transformations and requirements of the facility's users.
Double Function receives a (+1) since it provides for improvements in operating mode by sharing space.

Since it maximizes the space's capacity to handle various functions without crossing time schedules, **Overflow Design** received a score of (+1). It is extremely useful in the event of an emergency.

Although it is given a score of (+1) for **Loose Fit** since it is a principle in which areas properly respond to today's organizational strategy while still having the intrinsic flexibility to react to a variety of alternatives.

Fulfilling either one or both of these criteria wins a (+1) in **Furniture/Equipment Flexibility** because they enable mobility through various areas for feature flexibility.

Functionality parameter critical review

essment tool main criterion for defining the possibility of functionality in order to adapt future alterations in utilization.

The analysis parameter of Functionality is classified in two main categories which are modular spaces(generic/universal room and space standardization) scoring (+4) and (+2) respectively, and serving different type of use (Double Function, overflow design, loose fit and furniture/equipment flexibility) with scoring (+1) for both four of them.

Template areas with a modular framework that offers a standardized solution that is expense, service, staffing, and construct effective while restricting the number of customized spaces. On the other hand, studied examples of contemporary healthcare facilities and conducted interviews showed that Generic/universal rooms as a design approach is not quite feasible and profitable as results in overdesign and high cost.

Since hospitals hold many functions together, it is very important in terms of flexibility that the spaces adapt to different functions in the future or adapt to the conditions of the day they are in. Double function, overflow design and loose fit indicators allow us to analyze the structure in a functional manner.

The volume of room spaces is another dimension to be considered with emerging pandemic issues as it creates extra areas in order to decrease a possible risk of infection while increasing the number of beds inside. Extra spaces are so vital for not only functional and capacity-wise of healthcare structure but also to provide psychological support areas for healthcare workers who are under stress.

A. Functionality Analysis Parameter Proposed Modifications

- Another new analysis parameter "Progressive Shutdown" is added since it optimizes sources with demand as it prevents unnecessary energy consumption and creates concentrated coordination. In this case (+1) score is given.
- Another new analysis parameter "Redundancy in Room Space" is added as it gives flexibility capability in case of emergency situations like natural disasters or pandemic. (+1) score is assigned in this case.
- As a result of adding 3 new analysis parameters and causing overdesign problem and high cost, the scoring of Generic/Universal Rooms is reduced from (+4) to (+2). Besides, the score of Space standardization is reduced from (+2) to (+1).

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows:

1. Generic/Universal Rooms

Prototype spaces with a modular grid that offers a standardized solution that is effective in expense, service, staffing, and build-ability while restricting the number of specialized spaces. If the need appears, this would allow for a shift in usage between units. It acknowledges the specifications of all suitable uses and accommodates them all. As a result, a (+2) is allocated.

2. Space Standardization

Many characteristics are independently defined in measured spaces. Standardized rooms have features such as standardized room size, modular units, equivalent room patterns, ergonomic credentials, modular detailing, and standard modules that can handle different tasks depending on the situation. A score of (+1) is given in this scenario.

3. Double Function

This term extends to plans that allow for operational improvements as a result of management rather than actual construction adjustments. Two Inpatient Units, for example, can be built back to back such that a variety of spaces can be shared. It provides a difference in scale without causing the unit to be extended or physical adjustments to be made. A score of (+1) is given in this situation.

4. Overflow Design

Functions that are intended to act as a substitute for other functions that are subject to demand fluctuations. Day and ambulatory treatment areas, for example, should be adapted for overnight use in emergencies such as those caused by natural disasters or pandemic. As a result, a (+1) is given

5. Loose Fit

Models that can not only respond appropriately to today's organizational strategy, but also have the inherent flexibility to react to a number of different scenarios. For instance, in case of a pandemic since healthcare workers are under pressure and in need of relaxation, some of the existing areas would be turned into recharge rooms. Easy, well-proportioned, regular-shaped rooms with easy access to clear circulation networks should be provided. A score of (+1) is given in this situation.

6. Furniture/Equipment Flexibility

Using furniture that can be modified and relocated to provide for room personalization and adjustment, such as modular furniture components to allow for space customization. And/or the use of modular facilities to allow for moving into various areas for operation versatility. Wherever feasible, use portable equipment; when fixed equipment is needed, prepare for other roles in the space to optimize use. (+1) score is assigned.

7. Redundancy in Room Space

Planning spaces which do not only fulfill today's needs but also have a potential to overcome situations like increase in demand, natural disasters and pandemic etc. For instance, a single patient room can be transformed into a double patient room with help of already available technical installations. Additionally, it helps to decrease the risk for possible infection spread. Therefore (+2) score is assigned.

8. Progressive Shutdown

If such parts are not in operation, a Progressive Shutdown strategy can be implemented. Energy, maintenance, and personnel expenses will all be minimized as a result. It also concentrates personnel around patients, enhancing coordination and protection. Therefore (+1) score is given.

B. Functionality Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
FUNCTIONALITY	Generic/Universal Rooms	+2	No
	Space Standardization	+1	No
	Double Function	+1	No
	Overflow Design	+1	No
	Loose Fit	+1	No
	Furniture/Equipment Flexibility	+1	No
	Redundancy in Room Space	+2	No
	Progressive Shutdown	+1	No
		Functionality Total Assigned Score	No / 10

Table 4.18: Functionality Parameter Megastructure Flexibility Assessment (Source: Author)

4.3 Development of Mega Structure Flexibility Assessment Tool [MeSFAT]

Added Evaluation Parameters

After examining the current evaluation parameters of the assessment tool "Optimized Flexibility Assessment Tool" and establishing a key outline, it was discovered that all of the established evaluation parameters are primarily concerned with the physical aspects of the healthcare facility, with minor attention paid to secondary and more intangible issues like investment model and technology; and extraordinary situations like pandemic. Besides there are neglected topics like typology regarding physical aspects. Although existing parameters have concerns about physical issues they do not take the scale of a healthcare facility into consideration where megastructures become one of the current trends in the healthcare sector.

Flexibility concepts relevant to mentioned topics that play a critical role in ensuring future proofing of the architecture are defined and derived based on the performed analysis in literature, healthcare, contemporary healthcare facilities and conducted interviews. As a result, new assessment parameters called "Typology", "Technology & Digital Innovation" and "PPP Investment Model" have been added to provide a more detailed and optimized evaluation for the healthcare structures.

10. Typology

Description

Typology is not only a vital issue for healthcare design, to create a healing environment and future proof design but also it provides required practices to reduce infection in pandemic, since it considers adaptability, flexibility, profitability, convertibility & expandability as schematic identity that should inevitably be well designed.

The highest score (+4) is assigned when having **Innovative Distribution in Departments**, it allows quality atmosphere for recreation and easy adaptability in different time of operation, **Classical Distribution in Departments**, that is less appropriate for future convertibility because of clustered distribution and decreased motivation of users. For this reason, a lower score of (+2) is assigned to it.

A Corridor and Rooms in One of the Two sides limits accessibility inside of the building with high users displacement, **Central Corridor and Rooms at the Two Sides** maximize mobility in two-direction, **Double Corridor** offers innovative solutions for circulations and service spaces with high flexibility. The assigned scores are (+1),(+2) and (+3) respectively. **Radial Disposition of the Rooms and Central Control Zone**, is an advanced typology with more centralization and less risk factor and highest capability of adaptation and flexibility. The score is (+4).

Division of **Separation of Corridors and Accesses** prevents density in the circulation, to allow easy use with high flexibility distribution. (+1) score is given for both of two. Horizontal arrangements are so common in contemporary examples of healthcare facilities relying on literature review that prefered to differentiate hospital architecture typology. In an emergency, this setting ensures that areas of the building can be arranged without disrupting the general flow and route configuration with separation of units. Besides these analysis parameters limit cross-contamination due to division of paths and possible routes.

Distribution of Emergency Department and Infectious Wards at the Same Floor decreases transition time between those two units, leads quick interventions and improves the healthcare workers' motivations in pandemic situations with this horizontal distribution.
(+1) score is assigned.

A. Typology Analysis Parameter

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows:

1. Innovative Distribution in Departments
If open spaces or quality recreation areas are distributed through the inside of the hospital's blocks, and similar functions are not placed as a cluster but rather intertwined so it allows future adjustability and creates a quality environment for the users. A score of (+3) is given.

2. Classical Distribution in Departments
Certain functions such as offices, nurse stations are located in certain points in the departments. This variation may include recreation areas however they are not reasonably positioned therefore not appropriate for adaptation or future use. A score of (+1) is given.

3. A Corridor and Rooms in One of the Two Sides;
A layout that is served on only one-hand with limited accessibility to rooms and functionality. In the same way it increases users displacement and reduces flexibility. A score of (+1) is given.

4. Central Corridor and Rooms at the Two Sides;
A layout that is served on two-hand with better accessibility to rooms and functionality. At the same time, relatively less users displacement and improved flexibility capability. A score of (+2) is given.

5. Double Corridor

A layout in which service spaces are located in the middle and rooms on both sides with decent accessibility to rooms and functionality. At the same time, small users displacement and strong flexibility capability. A score of (+3) is given.

6. Radial Disposition of the Rooms and Central Control Zone;

A layout in which service spaces are located in the center and rooms and other spaces are all around with great accessibility to rooms and functionality. In the same way, very limited users displacement and excellent flexibility capability decreased risk factor. A score of (+4) is given.

7. Separation of Corridors: d ≥ 2,5 m

Paths (corridor for medical staff, public one and patients with suspected or known infections by other users) are separated accurately from each other, and all of them have to be equal or bigger than 2,5 m to allow circulation in two directions and mobility of the stretchers. This type of approach also provides a decent ability to keep possible infection under control with creating alternative routes for patients with infection. A score of (+1) is given.

8. Separation of the Accesses:

If different entrances such as the emergency area, inpatient/outpatient or service entrances etc. are separated both in the structure and the campus. In case of pandemic, this helps to clearly separate and host patients with suspected infection while keeping and managing daily operation at the same time. A score of (+1) is given.

9. Distribution of Emergency Department and Infectious Wards with Direct Connection

The close connection between the emergency units and the contaminated areas entails a quick connection and flow for patient and healthcare workers. As a result, both spaces are designed to be directly connected, facilitating horizontal links with shortest distance. A score of (+1) is given.

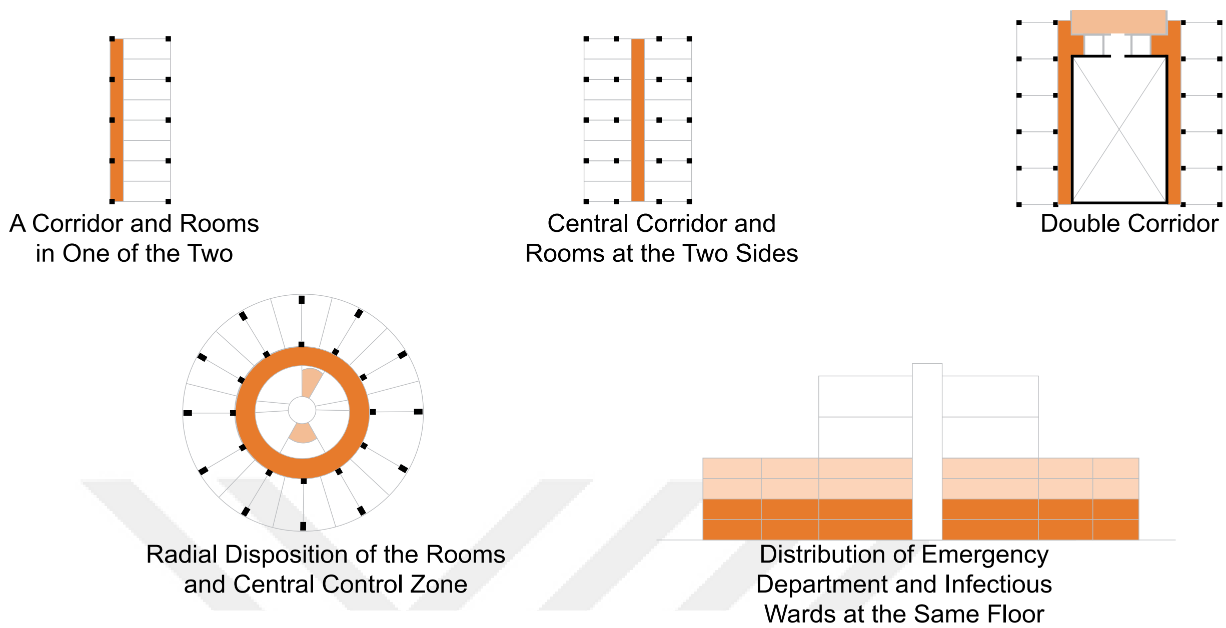


Figure 4.6: Typology Evaluation Parameter Possible Solutions
(Source: Author)

B. Typology Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
TYPOLOGY	Innovative Distribution in Departments*	+3*	No
	Classical Distribution in Departments*	+1*	No
	A Corridor and Rooms in One of the Two Sides	1	No
	Central Corridor and Rooms at the Two Sides	2	No
	Double Corridor	3	No
	Radial Disposition of the Rooms and Central Control Zone	4	No
	Separation of Corridors: d ≥ 2,5 m	+1	No
	Separation of the Accesses	+1	No
	Distribution of Emergency Department and Infectious Wards with Direct Connection	+1	No
		Typology Total Assigned Score	No / 10

Table 4.19: Typology Parameter Megastructure Flexibility Assessment
(Source: Author)

11. Technology & Digital Innovation

Description

Patients' recovery and care systems can be supported by emerging digital technology, both in the hospital and through the regional healthcare network. These issues are essential and vital in the operation phase of healthcare facilities especially with megastructures because of increasing number of department and unit components which results in creating difficulties for managing and distribution flow. Advanced technological systems allow uninterrupted operation during the pandemic or natural disasters with high flexibility and adaptability. For instance, innovations in healthcare strategies avoid spreading infections not only between patients but also healthcare workers during daily operations and emergency conditions, and decrease the pressure on healthcare workers which have to provide treatment to high amount patients at the same time. It improves hospital management and balances different units of healthcare facilities regionally or locally regarding intensity.

Innovative HVAC System and Negative Pressure Rooms is about circulation of air among the different parts of the hospital due to flexible mechanical systems and filters that increase the inside air quality and remove the polluted air immediately. It is more useful in pandemic time. Therefore, (+3) score is assigned for each.

Choosing **Innovative & Movable Materials** in the design phase of the healthcare facilities prevents bacterial growths on the surfaces, which ensures the adaptability and resilience of the rooms, as they are easy to clean, upgrade, and/or uninstall. Hence, (+2) score is given.

A score (+2) is assigned when having **Monitoring & Digital Storage** since it makes easier operation of the facility and provides a more quality environment inside of the hospitals with control of intensity.

A. Technology & Digital Innovation Analysis Parameter

To prevent uncertainty, a more definite and explanatory for each research parameter is given, which are as follows:

1. Innovative HVAC System

Adaptable ventilation systems play a vital role in ensuring effective treatment in the event of an emergency, such as an infectious disease, but their service must be able to respond to a range of healthcare needs in all circumstances, especially in situations like pandemic where air may be a source of infection diffusion. A score of (+3) is given.

2. Negative Pressure Rooms

Negative room pressure is a method for avoiding cross-contamination between rooms in hospitals and surgical centers. Each space has a negative pressure in comparison to the exterior hallway, allowing air circulation from the corridor into the room and out of the hospital due to the use of HEPA filters. A score of (+3) is given.

3. Innovative & Movable Materials

Alternatives used in emergency situations, such as washable cloth fabrics, must be examined and considered carefully. Their use could be expanded to include various sanitary spaces for social distance and they could be disinfected, replaced or removed in the event of a need, ensuring the spaces' adaptability and resilience. A score of (+2) is given.

4. Monitoring & Digital Storage

Continuous monitoring of health status and vital parameters through IT systems such as wearable devices or smartphones which ensure improved hospitalization management, reduced spending time for healthcare facilities. As well as, it reduces paper-based health and documentation usage which results in reuse of storages and archive rooms by assigning functions. Eventually, increase in capacity or space is easily achieved. A score of (+2) is given.

A. Tech./Digital Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
TECHN. & DIGITAL INNOV.	Innovative HVAC System	+3	No
	Negative Pressure Rooms	+3	No
	Innovative & Movable Materials	+2	No
	Monitoring & Digital Storage	+2	No
	Technology and Digital InnovationTotal Assigned Score		No / 10

Table 4.20: Technology and Digital Innovation Parameter Megastructure Flexibility Assessment (Source: Author)

12. PPP Investment Model

Description

It is a system that aims to reduce risk factors in all manners by distribution workload and responsibilities while bringing flexibility and adaptability behaviour during the building production process. The PPP Investment Model is not only a monetary aspect but also delivers treatment in the most innovative way. It is especially important for private sector stakeholders of the PPP investment method, which is in demand in this period, to create healthcare data systems that collect information on how the pandemic spreads and lessons learned for future events. Many national healthcare networks around the world have been devastated by the coronavirus (COVID-19) pandemic. Governments are gradually reaching out to the private sector to establish viable public-private partnerships in order to address their emergency needs and alleviate growing problems.

Concept and Construction Project Difference: c < %15 gets (4) score whereas The score (+2) is assigned when applying **Concept and Construction Project Difference: %15 < c < %30,** there can be seen mostly great differences between concept and construction projects to meet state's demands in all phases of the project. These various alterations cause increase in expenses and efforts therefore flexibility of the facility are affected negatively. (+2) score is given.

Designers or private stakeholders must take into account international legislations and guidelines during the design stage of the healthcare projects in case there is an **Inclusion of International Associations** which results in a patient centered design approach with respect to flexibility issues. The score is (+2).

Alternative Project Sites enables flexible design decisions and principles to be applied in advance regarding urban and architectural scale. Besides, it reduces work-load of contractors since field selection is made by the joint decision of two stakeholders which are private and public. Hence, (+2) score is assigned.

A. PPP Investment Model Analysis Parameters

1. Concept and Construction Project Difference: c < %15

An acceptable and limeted change in design and construction phase is vital in regard to stabilizing and realizing flexible design principles and cost efficiency. A score of (+4) is given.

2. Concept and Construction Project Difference: %15 < c < %30

Too much change in design and construction phase has a negative impact on stabilizing and realizing flexible design principles and cost efficiency. A score of (+2) is given.

3. Alternative Project Sites

Since it includes governmental partnership there are more than one options for site location. This helps to reduce risks and difficulties for contractors before the design phase. A score of (+3) is given.

4. Inclusion of International Associations

If International associations are included in a partnership economically as they supply funds, designers must pay attention to related international regulations and standards. This automatically increases design quality of healthcare facilities with healthy and adaptable environments in regard to flexibility principles. A score of (+3) is given.

A. PPP Investment Parameter Mega Structure Flexibility Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
PPP INVETSMENT MODEL	Concept and Construction Project Difference: < 15 %	4	No
	Concept and Construction Project Difference: 15 % < c < 30 %	2	No
	Alternatives Project Sites	+3	No
	Inclusion of International Associations	+3	No
	PPP Investment Model Total Assigned Score		No / 10

Table 4.21: PPP Investment Model Parameter Megastructure Flexibility Assessment
(Source: Author)

Operations Performed on the Evaluation Parameters

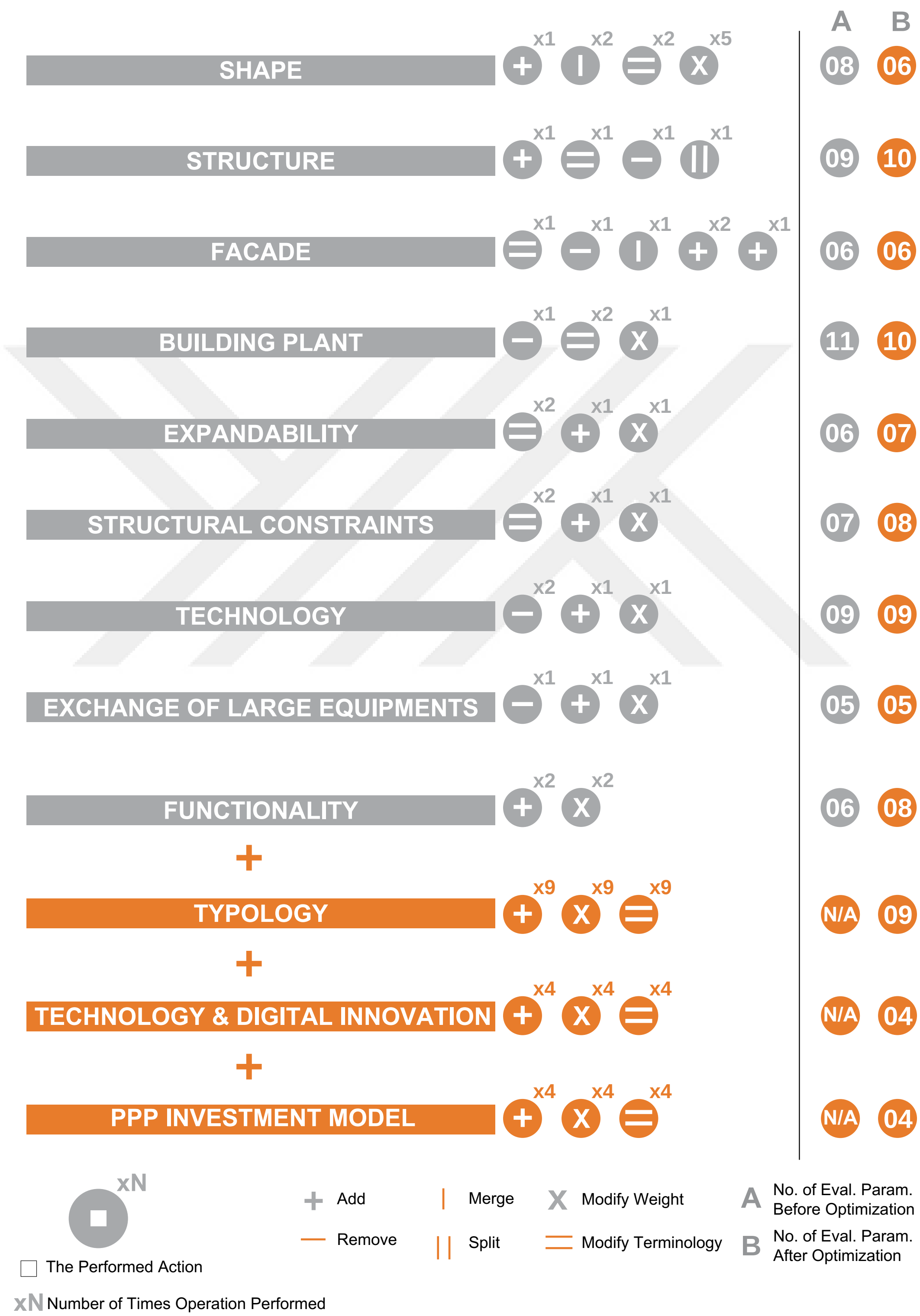


Figure 4.7: Operations Performed on the Evaluation Parameters
(Source: Author)

MeSFAT
Mega Structure Flexibility Assessment Tool for Hospital Planners

This Assessment Tool was created with the aim of determining the degree to which the key fundamentals of the Flexibility principle for megastructures have been met. The scale makes it difficult to address questions of flexibility and adaptability in a systematic way. As a result, it was created to assess flexibility of healthcare facilities during the planning and design process, serving as a kind of control mechanism for designers to improve their projects. Also, it can be used on existing structures to determine how well they meet the requirements, principles of flexibility, and, as a result, what needs to be changed if necessary.

The Evaluation Method consists of 12 evaluation factors each of which is subdivided into specific research parameters, each of which is assigned a score ranging from 0 to 10. These parameters are optimized, redeveloped and redefined based on current literature, conducted case studies and interviews. As a result, each measurement criterion will be given a score that represents the degree to which flexibility criteria are applied. Five score categories are defined using this weighing system, which lead to five different degrees of accordance with the Flexibility criterion. As a result, assessing the building's flexibility. A description of all measurement and interpretation criteria is included with the assessment tool.

Assessment Tool

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
SHAPE	Horizontal or Linear	10	No
	Arms Attached to the Main Core	8	No
	Compact	6	No
	Vertical	4	No
	Detached	2	No
	Articulated	0	No
		Shape Total Assigned Score	No / 10

Table 4.22: MeSFAT Shape Parameter
(Source: Author)

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
STRUCTURE	7m ≤ Span ≤ 8m Open floor plan	4	No
	Span > 8m	2	No
	Span < 7m	1	No
	Span < 6m	0	No
	Regular Grid	+1	No
	Squared Grid	+1	No
	Redundancy in Structural Capacity	+1	No
	Punch Through Concrete Slabs for Vertical Circulation	+1	No
	Ceiling Height : Inpatient Rooms ≥ 4m	+1	No
	Ceiling Height : Ground Floor ≥ 5m	+1	No
	Structure Total Assigned Score		No / 10

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
FACADE	100 % Curtain Wall	6	No
	70 % Curtain Walls	4	No
	Prefabricated Facade	2	No
	Ventilated Facade or Traditional Masonry/Brick Wall	0	No
	Modular Panels	+2	No
	Solar Shading Panels	+2	No
	Facade Total Assigned Score		No / 10

Table 4.23: MeSFAT Structure & Facade Parameters
(Source: Author)

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
BUILDING PLANT	Distance in between Service Shafts: d ≤ 35m	2	No
	Distance in between Service Shafts: 35m < d ≤ 70m	1	No
	Distance in between Service Shafts: d >70m	0	No
	Redundancy for Building Plant	+3	No
	Distribution in Raised Floor and/or Exposed Installations if Required	+1	No
	Plant Tower*	+1*	No
	Technical Floor*	+1*	No
	Spread out Plant Infrastructure in False Ceiling*	+2*	No
	Condensed Plant Infrastructure (Varying Height of False Ceiling)*	+1*	No
	Technical Interstitial Floor	+1	No
	Building Plant Total Assigned Score		No / 10

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
EXPANDABILITY	Already Equipped Spaces with Advanced System	+3	No
	Internal: Shell Spaces	+2	No
	Open Ended Corridor and/or Large Spaces on Building's End	+1	No
	Soft Spaces: to be Transformed into Service Spaces and Buffer Zones If Needed	+1	No
	External: Volumes "Hanging" from the Facade	+1	No
	Availability of Neighboring Plot	+1	No
	Removable Partitions	+1	No
	Expandability Total Assigned Score		No / 10

Table 4.24: MeSFAT Building Plant & Expandability Parameters (Source: Author)

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
RESTRICTIONS	Only Fixed Vertical Elements (Circulation & Service Shafts)	6	No
	Fixed Elements of Building Plant: Up to 25%	4	No
	Fixed Elements of Building Plant: Up to 50%	2	No
	Fixed Elements of Building Plant: Up to 75%	0	No
	Placement of Drain Pipes	+1	No
	Adjustability of Service Shafts	+1	No
	Grouped Vertical Circulation Elements: More than 80%	+1	No
	Flat Land: slope < 5%	+1	No
	Restrictions Total Assigned Score		No / 10

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
BUILDING ELEMENTS	Dry Assembly Technique	4	No
	Mixed Assembly Technique	2	No
	Wet Assembly Technique	0	No
	Internal Partitions: Modular Panels	+1	No
	Internal Partitions: Panels Set up with Technical Installations	+1	No
	Internal Partitions: Framed Construction	+1	No
	Internal Partitions: Prefabricated Panels	+1	No
	Prefabricated Building Elements (Framework, Roof, Slab)	+1	No
	Innovative Temporary Structures	+1	No
	Building Elements Total Assigned		No / 10

Table 4.25: MeSFAT Restrictions & Building Elements Parameters
(Source: Author)

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
EXCHANG. OF LARGE EQUIPMENTS	Only Needs Disassembly of Facade Panels	8	No
	Disassembly of Facade Panels and of Internal Partitions	6	No
	Partial Demolitions	0	No
	Equipments Spaces with Redundancy	+1	No
	Disassembly of Roof or Slab Panels	+1	No
	Exchange of Large Equipments Total Assigned Score		No / 10

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
FUNCTIONALITY	Generic/Universal Rooms	+2	No
	Space Standardization	+1	No
	Double Function	+1	No
	Overflow Design	+1	No
	Loose Fit	+1	No
	Furniture/Equipment Flexibility	+1	No
	Redundancy in Room Space	+2	No
	Progressive Shutdown	+1	No
	Functionality Total Assigned Score		No / 10

Table 4.26: MeSFAT Exchangeability of Large Equipments & Functionality Parameters
(Source: Author)

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
TYPOLOGY	Innovative Distribution in Departments*	+3*	No
	Classical Distribution in Departments*	+1*	No
	A Corridor and Rooms in One of the Two Sides	1	No
	Central Corridor and Rooms at the Two Sides	2	No
	Double Corridor	3	No
	Radial Disposition of the Rooms and Central Control Zone	4	No
	Separation of Corridors: d ≥ 2,5 m	+1	No
	Separation of the Accesses	+1	No
	Distribution of Emergency Department and Infectious Wards with Direct Connection	+1	No
	Typology Total Assigned Score		No / 10

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
TECHN. & DIGITAL INNOV.	Innovative HVAC System	+3	No
	Negative Pressure Rooms	+3	No
	Innovative & Movable Materials	+2	No
	Monitoring & Digital Storage	+2	No
	Technology and Digital InnovationTotal Assigned Score		No / 10

Evaluation Parameter	Analysis Parameter	Score	Assigned Score
PPP INVETSMENT MODEL	Concept and Construction Project Difference: < 15 %	4	No
	Concept and Construction Project Difference: 15 % < c < 30 %	2	No
	Alternatives Project Sites	+3	No
	Inclusion of International Associations	+3	No
	PPP Investment Model Total Assigned Score		No / 10

Table 4.27: MeSFAT Typpology, Technology Digital Innovation & PPP Investment Model Parameters

(Source: Author)

Assessment Criteria & Glossary

The newly optimized tool evaluates flexibility, which is a wider term that includes the Flexible Megastructures concept, after refining the initial evaluation tool.

The measurement tool's final result is divided into five main ranges:

- 0 to 20%: definitely not a Flexible Megastructures
- 21% to 40%: following some principles, but it cannot be considered a Flexible Megastructures
- 41% to 60%: following several principles of the Flexible Megastructures approach
- 61% to 80%: it can be considered a Flexible Megastructures but with some aspects to be improved
- 81% to 100%: model of Flexible Megastructures

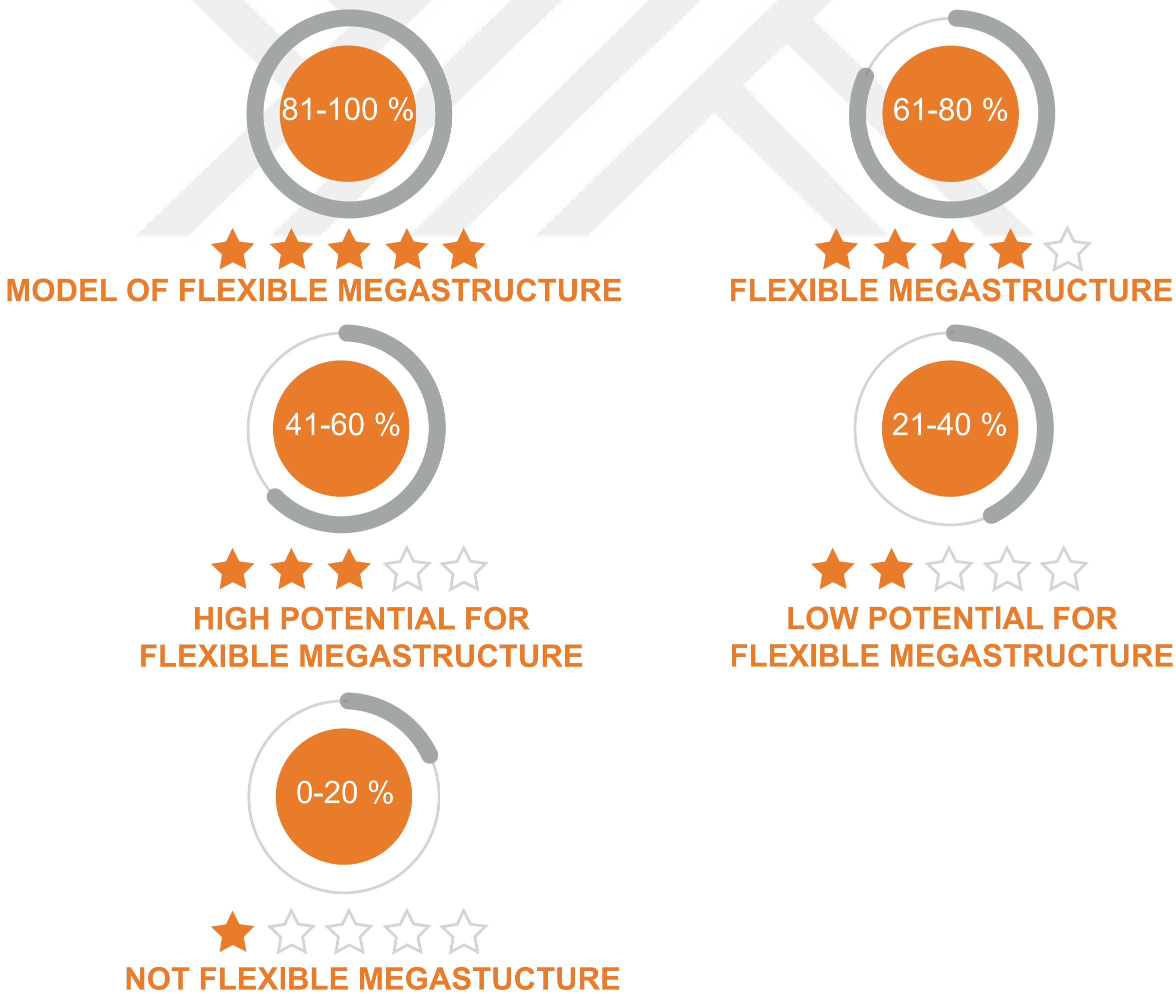


Figure 4.8: Final Assessment Ranges & Classifications
(Source: Author)

01. Shape Parameter

Assuming that the generic building mass is a perfect cube of XYZ, as X “length”, Y “width” & Z “height”.

1.Horizontal or Linear: In this case the building is designed in either horizontal or linear direction as the length (X) or the width (Y) exceeds double the height (Z) of the mass. The common units of hospital are gathered on the same plane with homogenous distribution.

2.Masses linked with Bridges: The complex in this case is made up of separate masses yet only linked with bridges or auxiliary elements.

3.Compact: In this case, only one single mass with Z dimension, provided that X & Y, exceed 1.2 Y & 1.2 Y.

5.Vertical: In this case, the height (Z) of the building mass should at least exceed double the length of the longest base edge (X or Y).

4.Detached: In this case, the complex consists of completely separate and regular masses without any internal links.

6.Articulated: In this case, the masses are irregular and intersecting with different morphologies and heights.

Note: Since megastructures are located in huge campuses, in some cases there are High Security Forensic Psychiatry Hospital as well. It is thought that hospital should be planned separately from other units in terms of security. In this case, while evaluating the detached buildings criterion, if the mentioned hospital is exceptional like psychiatric hospital, this situation should be ignored.

02. Structural Parameter

1.Structural Spans: The 4 different structural spans are to be measured from the axis/center of the pillars.

2.Regular Grid: A fixed grid modulation of the surface, bearing in mind there is a tolerance of 20%.

3.Squared Grid: A grid modulation with a squarish outline that is arrayed in, keeping in mind the resistance of 20%.

4.Redundancy in Structural Capacity: Increasing the structural elements' capacity to withstand additional loads in the event of a heavy demand condition, such as a pandemic. The infrastructure is sufficient for vertical expansion as well.

5.Punch Through Concrete Slabs for Vertical Circulation: It's a squarish space in the concrete slab with no support that allows vertical circulation elements, shafts, technical installations, and other things to be installed.

6.Ceiling Height: Ceiling Height parameter is divided 2 different categories which are Ceiling Height: Inpatient Rooms ≥ 4m and Ceiling Height: Ground Floor ≥ 5m. As it is an instrumental element when it comes to maximizing possibility to future flexibility, for instance converting patient rooms into operation room.

03. Facade Parameter

1.Curtain Wall: The 2 different curtain wall categories are classified according to glazing to solid percentage.

2.Ventilated Facade or Traditional Masonry/Brick Wall: Ventilated Facade system that allows the formation of an air chamber between the external wall of the building and the cladding. Ventilated Facade and Traditional Masonry/Brick wall due to the significant limitations occur in case of facade modification/maintenance affecting the functionality of the building due to the significant limitations as demolition is essential in case intervention, that interrupts the on going functions of the facility

3.Modular Panels: Modulated glazing or cladding panels that can be easily assembled or disassembled due to its advantage to exchangeability and expandability

4.Prefabricated: Prefabricated components are joined or combined on-site to create this sort of facade. These facades' components are mass-produced in highly automated factories. The key benefits of this type of facade include speed and ease of installation, removal, as well as lower cost than other systems.

5. Solar Shading Panels: Solar Shading Panels extends the life span of skin materials and indoor equipment. It is also effective in creating thermal comfort for patients with low cost and energy.

Note: In some cases, specific functions necessitates to have solid facades, such as (technical floor, interstitial floor, auditorium, etc.). These solid portions are to be neglected from the calculation the percentage of the Curtain Wall in the building.

04. Building Plant Parameter

1.Distance between Service Shafts: The three distinct distances between shafts are defined based on the reliability of their utility network integration.

2.Redundancy for Building Plant: Building Plant to be built with extra areas in order to be adaptable and usable over time, and planned and installed in such a manner that potential alterations and additions can be accommodated

3.Distr. in Raised Floor and/or Exposed Installations if Required: Raised Floor is a structurally elevated floor that provides a continuous space under the floor surface that can be used to route all mechanical structures. It comes in handy in labs and workplaces. Although Exposed Installations When Required is a technique that enhances the functional versatility of space by making technological outputs noticeable and available, particularly in patient rooms.

4.Plant Tower: A service plant with a vertically compacted network infrastructure that branches horizontally for floor.

5.Technical Floor: It is a story devoted to holding the technical machinery of the floors above it in vertical/compact structures, stressing the functional structure of the building by separating it into separate blocks.

6.Distribution of Plant in Ceiling: The 2 different distribution techniques in ceiling.

7.Interstitial Floor: Interstitial Floor is not a cost efficient solution but still provides flexibility to some extent.

05. Expandability Parameter

1. Already Equipped Spaces with Advanced System: Spaces planned and built with high technology service systems such as suction, oxygen, negative pressure etc. to be used when needed.

2. Internal: Shell Spaces: Areas which are already constructed and served daily operation in mega-structured facilities such as gyms, car parks, congress centers or unused areas that need more time and invasive technical operations, such as the installation of plant networks to be used when needed. They can be converted into bed-wards areas in emergency conditions.

3. Open-Ended Corridor and/or Large Spaces on Building's End: Extra adjacent areas that lie within the property borders along with an open-ended corridor that facilitates horizontal expansion if needed in the future.

4. Soft Spaces: to be Transformed into Service Spaces and Buffer Zones if needed: Extra space where backup facilities can be accommodated in case of need or disaster or damage. Providing soft spaces next to technical services is preferred as it may be retrofitted into service spaces to meet the future services needs with no interruption to the ongoing healthcare facility functions. For instance, these areas may provide buffer zones between wards and divide contaminated and non-contaminated spaces in case of pandemic.

5. External: Volumes "Hanging" from the Facade: The facility's structure equations involve extruded volumes from the facade, but it would not involve additional supporting structure in the event of extension.

6. Availability of Neighboring Plot: Extra neighboring spaces within the property boundaries that allow for potential horizontal expansion if desired. This not maximizes operational flexibility as merging expansion with already existing functions but also provides areas for pop-up temporary structures in case of pandemic.

7. Removable Partitions: It makes it easier to move partitions to enlarge or fit in spaces in case of need or emergency. Removable partition that allows rapid and relatively simple installation, while providing flexibility for easy adaptation to any constructions type. In some embodiments, the modular panel assembly involves panels which are prefabricated with panel connectors.

06. Restrictions Parameter

1. Fixed Elements: The four separate ratios of fixed elements are determined by the area of the building plant's fixed elements in proportion to the overall area of the building plant.

2.Placement of Drain Pipes: Rather than being installed in designated drainage ducts, drain pipes are installed in service shafts or sleeves along concrete pillars.

3.Adjustability of Service Shafts: Changing the areas of service shafts in response to changes in technological and medical criteria. Modular structure can be used to do this.

4.Grouped Vertical Circulation Elements: More than 80%: Clustering the vertical core circulation elements together, so that the rest of the floor space is contiguous and open.

5. Flat Land: slope < 5%: Slope of the project site directly affects the foundation structure of the building, as a result distribution of the related functions inside of the building are located in different levels as it affects functionality and flexibility.

Note: There are various types of service shafts: mechanical, electrical and other medical special ones such as (firefighting, drainage/plumbing, HVAC, power, low current, medical gases, linen chute, garbage chute, PTS chute “horizontal and vertical”, natural gas)

A. Building Elements Parameter

1.Assembly Techniques: Due to the methodology used, the three different types of Assembly are defined. In Dry Assembly technique internal dry partition walls are formed by modules assembled with mechanical fixing techniques that do not involve combining substances with wet material. The Mixed Assembly, on the other hand, is a combination of the two methods.

2.Internal Partitions: Modular Panels: Technique that provides for fast and simple installation while still allowing for easy adaptation to any form of system. Panels that are prefabricated with connectors are seen in some forms of the modular panel setup.

3.Internal Partitions: Panels Set Up with Technical Installations: Distinct prefabricated, self-supporting components are built with channels to fit technological systems to build internal non load-bearing partitions.

4.Internal Partitions: Framed Construction: Internal Partitions are built in a framed modular form that enables partition walls to be easily changed and re-assembled.

5.Internal Partitions: Prefabricated Panels : Internal partitions with easy to install and take down connections, as well as minimal technical configurations and uniform networks. This form only necessitates installation.

6.Prefabricated Building Elements (Framework, Roof, Slab): It is similar to Prefabricated Panel in internal partitions but in vertical and horizontal direction with less mechanical installations and cost efficiency. The spaces can be adjusted by element alterations. Plus, it allows vertical expansions and installations of equipment in the future if needed.

7.Innovative Temporary Structures: For unexpected situations like pandemic that the capacity of the healthcare facility does not meet demand, temporary structures such as containers, inflatable systems, tent structures, modules, partition panels etc. would be used. These solutions bring advantage in flexibility with easy assembly techniques and cost efficiency.

08. Exchangeability of Large Equipments Parameter

1.Complexity of Exchangeability: The three different types of the Complexity of Exchangeability of Large Equipment are defined depending on the form of building interference.

2.Equipments Spaces with Redundancy: Equipment rooms can be built with additional capacity to allow for further advances in medical technology, since it is difficult to predict the physical space available for the most up-to-date equipment.

3.Disassembly of Roof or Slab Panels: Disassembly of Roof or Slab Panels in case the mass is too large that inner space has no direct contact to outside or equipment is located at the top for placing or removing large equipment from the building.

09. Functionality

1.Generic/Universal Rooms: Prototype spaces with a modular grid that offers a standardized solution that is effective in expense, service, staffing, and build-ability while restricting the number of specialized spaces. If the need appears, this would allow for a shift in usage between units. It acknowledges the specifications of all suitable uses and accommodates them all.

2.Space Standardization: Many characteristics are independently defined in measured spaces. Standardized rooms have features such as standardized room size, modular units, equivalent room patterns, ergonomic credentials, modular detailing, and standard modules that can handle different tasks depending on the situation.

3.Double Function: This term extends to plans that allow for operational improvements as a result of management rather than actual construction adjustments. Two Inpatient Units, for example, can be built back to back such that a variety of spaces can be shared. It provides a difference in scale without causing the unit to be extended or physical adjustments to be made.

4.Overflow Design: Functions that are intended to act as a substitute for other functions that are subject to demand fluctuations. Day and ambulatory treatment areas, for example, should be adapted for overnight use in emergencies such as those caused by natural disasters or pandemic.

5.Loose Fit: Models that can not only respond appropriately to today’s organizational strategy, but also have the inherent flexibility to react to a number of different scenarios. For instance, in case of a pandemic since healthcare workers are under pressure and in need of relaxation, some of the existing areas would be turned into recharge rooms. Easy, well-proportioned, regular-shaped rooms with easy access to clear circulation networks should be provided.

6.Furniture/Equipment Flexibility: Using furniture that can be modified and relocated to provide for room personalization and adjustment, such as modular furniture components to allow for space customization. And/or the use of modular facilities to allow for moving into various areas for operation versatility. Wherever feasible, use portable equipment; when fixed equipment is needed, prepare for other roles in the space to optimize use.

7.Redundancy in Room Space: Planning spaces which do not only fulfill today's needs but also have a potential to overcome situations like increase in demand, natural disasters and pandemic etc. For instance, a single patient room can be transformed into a double patient room with help of already available technical installations. Additionally, it helps to decrease the risk for possible infection spread.

8.Progressive Shutdown: If such parts are not in operation, a Progressive Shutdown strategy can be implemented. Energy, maintenance, and personnel expenses will all be minimized as a result. It also concentrates personnel around patients, enhancing coordination and protection.

10. Typology

1.Innovative Distribution in Departments: If open spaces or quality recreation areas are distributed through the inside of the hospital's blocks, and similar functions are not placed as a cluster but rather intertwined so it allows future adjustability and creates a quality environment for the users.

2.Classical Distribution in Departments: Certain functions such as offices, nurse stations are located in certain points in the departments. This variation may include recreation areas however they are not reasonably positioned therefore not appropriate for adaptation or future use.

3. A Corridor and Rooms in One of the Two Sides: A layout that is served on only one-hand with limited accessibility to rooms and functionality. In the same way it increases users displacement and reduces flexibility.

4.Central Corridor and Rooms at the Two Sides: A layout that is served on two-hand with better accessibility to rooms and functionality. At the same time, relatively less users displacement and improved flexibility capability.

5.Double Corridor: A layout in which service spaces are located in the middle and rooms on both sides with decent accessibility to rooms and functionality. At the same time, small users displacement and strong flexibility capability

6.Radial Disposition of the Rooms and Central Control Zone: A layout in which service spaces are located in the center and rooms and other spaces are all around with great accessibility to rooms and functionality. In the same way, very limited users displacement and excellent flexibility capability decreased risk factor.

7.Separation of Corridors: d ≥ 2,5 m: Paths (corridor for medical staff, public one and patients with suspected or known infections by other users) are separated accurately from each other, and all of them have to be equal or bigger than 2,5 m to allow circulation in two directions and mobility of the stretchers. This type of approach also provides a decent ability to keep possible infection under control with creating alternative routes for patients with infection.

8.Separation of the Accesses: If different entrances such as the emergency area, inpatient/ outpatient or service entrances etc. are separated both in the structure and the campus. In case of pandemic, this helps to clearly separate and host patients with suspected infection while keeping and managing daily operation at the same time.

9.Distribution of Emergency Department and Infectious Wards with Direct Connection: The close link between the emergency units and the contaminated areas entails a quick connection and flow for patient and healthcare workers. As a result, both spaces are designed to be directly connected, facilitating horizontal links with shortest distance.

11. Digital Innovation & Technolog

1.Innovative HVAC System and Negative Pressure Rooms: Adaptable ventilation systems play a vital role in ensuring effective treatment in the event of an emergency, such as an infectious disease, but their service must be able to respond to a range of healthcare needs in all circumstances, especially in situations like pandemic where air may be a source of infection diffusion. Negative room pressure is a method for avoiding cross-contamination between rooms in hospitals and surgical centers. Each space has a negative pressure in comparison to the exterior hallway, allowing air circulation from the corridor into the room and out of the hospital due to the use of HEPA filters.

2. Negative Pressure Rooms

Negative room pressure is a method for avoiding cross-contamination between rooms in hospitals and surgical centers. Each space has a negative pressure in comparison to the exterior hallway, allowing air circulation from the corridor into the room and out of the hospital due to the use of HEPA filters.

3. Innovative & Movable Materials

Alternatives used in emergency situations, such as washable cloth fabrics, must be examined and considered carefully. Their use could be expanded to include various sanitary spaces for social distance and they could be disinfected, replaced or removed in the event of a need, ensuring the spaces' adaptability and resilience.

4. Monitoring & Digital Storage

Continuous monitoring of health status and vital parameters through IT systems such as wearable devices or smartphones which ensure improved hospitalization management, reduced spending time for healthcare facilities. As well as, it reduces paper-based health and documentation usage which results in reuse of storages and archive rooms by assigning functions. Eventually, increase in capacity or space is easily achieved.

12. PPP Investment Model

1. Concept and Construction Project Difference: c < %15

An acceptable and limeted change in design and construction phase is vital in regard to stabilizing and realizing flexible design principles and cost efficiency.

2. Concept and Construction Project Difference: %15 < c < %30

Too much change in design and construction phase has a negative impact on stabilizing and realizing flexible design principles and cost efficiency.

3.Alternative Project Sites: Since it includes governmental partnership there are more than one options for site location. This helps to reduce risks and difficulties for contractors before the design phase.

4.Inclusion of International Associations: If International associations are included in a partnership economically as they supply funds, designers must pay attention to related international regulations and standards. This automatically increases design quality of healthcare facilities with healthy and adaptable environments in regard to flexibility principles.

Application of Mega Structure Assessment Tool & Results Comparison

Following the creation of a mega structure flexibility assessment tool, it is put to the test with two healthcare facilities chosen from the previously studied and assessed case studies: (Istanbul Basaksehir Cam and Sakura City Hospital & Kayseri City Hospital). This is to test the mega structure flexibility assessment tool’s viability by comparing the scores of and assessment criterion with both the initial and developed versions of the tool.

Computed results from the mega structure flexibility assessment tool are produced for each of the two case studies, along with a crucial comparison with the optimized assessment tool’s result. Diagrams to outline the results of the total score from the developed assessment tool, as well as the extent to which and Evaluation Criterion is used. Also, to define the structure based on its appraisal ranking, whether it is a flexible megastructure or not, and if so, to what degree.

The method is again hindered by the lack of knowledge about certain sub-points in assessment criteria in the chosen three case studies. As a result, the weights of those missed sub-points were subtracted from the overall score to remove their effect on the final result to prevent a misleading calculation.This allows for a more precise evaluation by creating an impartial distinction between the case studies.

Case study 01: Istanbul Basaksehir Cam and Sakura City Hospital

The mega structure flexibility assessment tool was used on the healthcare building, and the overall given score was 83/120 | 69 %, classifying it as a Flexible Megastructure with certain features that could be more developed.

The particular scores for each Evaluation Parameter are as following:

•Shape: 10/10 | 100%
•Structure: 4/10 | 40%
•Facade: 8/10 | 80%
•Building Plant: 7/10 | 70%
•Expandability:8/10 | 80%
•Restrictions: 8/10 | 80%
•Building Elements: 4/10 | 40%
•Exchange of Large Equipments: 6/10 | 60%
•Functionality: 9/10 | 90%
•Typology: 8/10 | 80%
•Technology & Digital Innovation: score: 8/10 | 80%
•PPP Investment Model: 3/10 | 30%

The final results, the overall allocated score, the degree to which each of the test criteria is achieved, and the facility rating are represented in Figures 4.9 & 4.10.

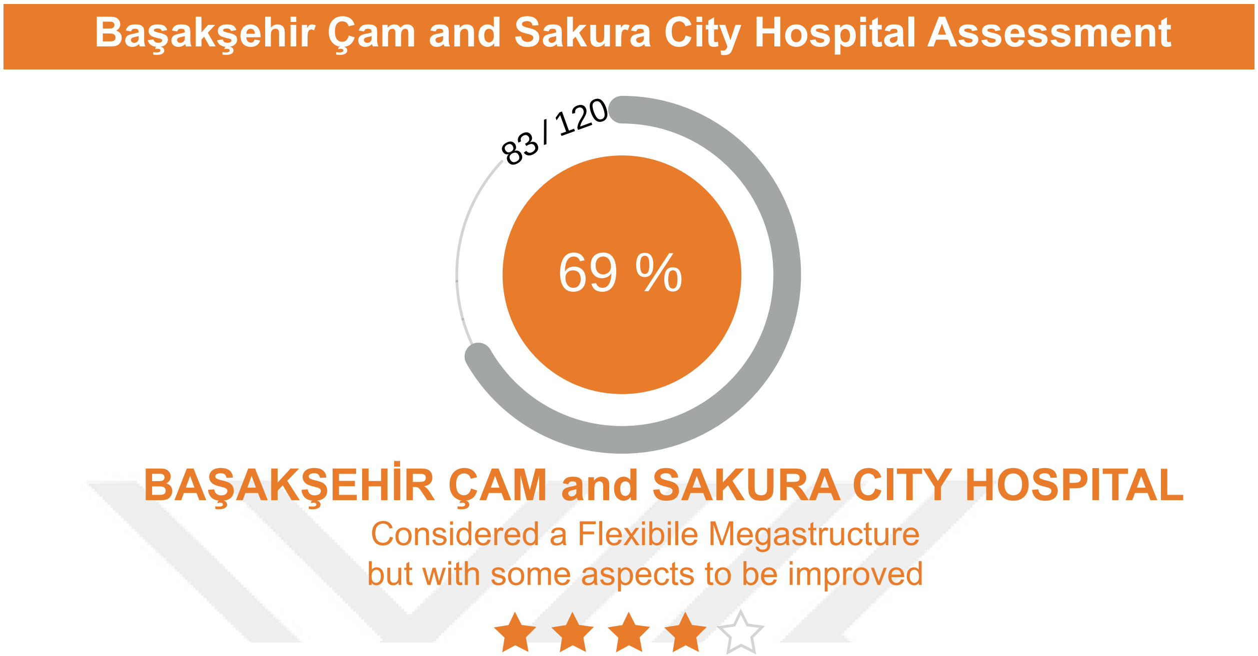


Figure 4.9: Başakşehir Çam and Sakura City Hospital Flexibility Megastructure Assessment Score & Classification

(Source: Author)

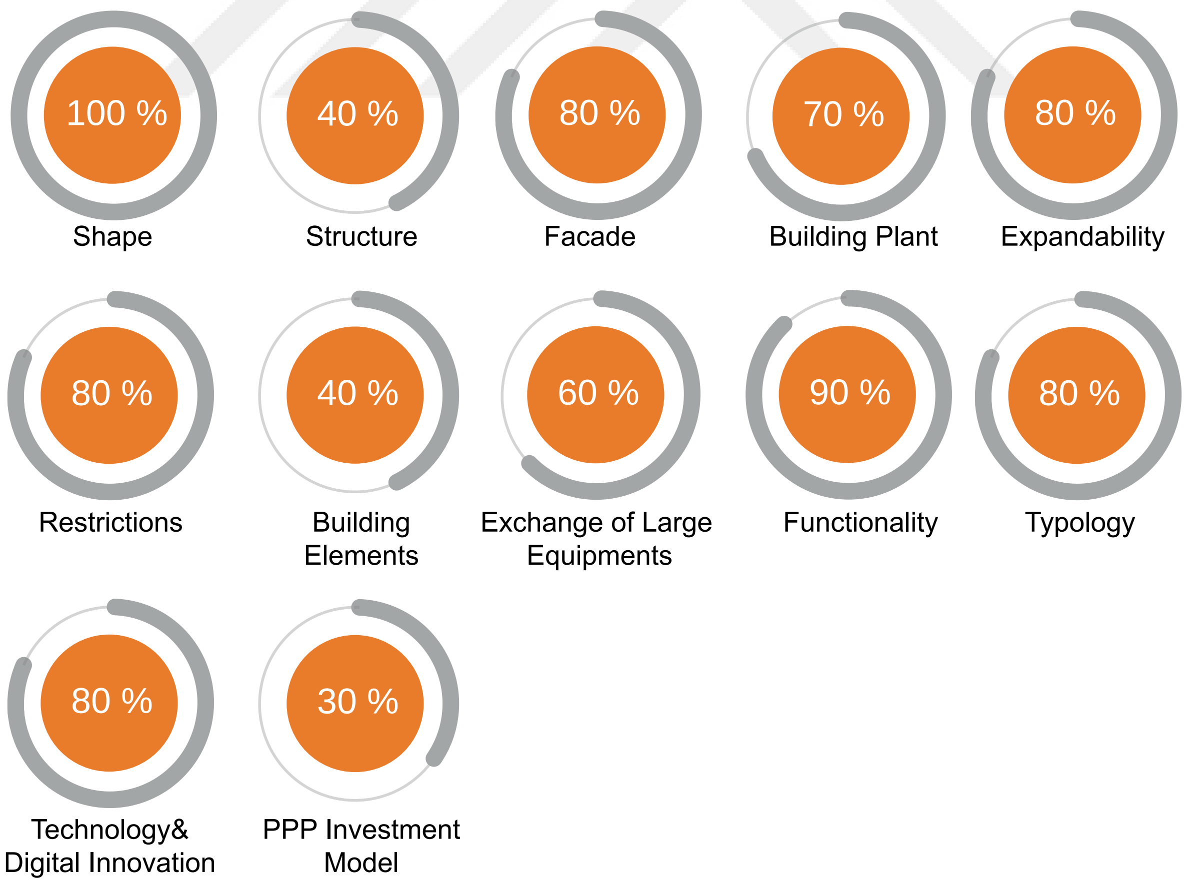


Figure 4.10: Başakşehir Çam and Sakura City Hospital Megastructure Flexibility Assessment Parameters Score

(Source: Author)

According to the final scores, the overall given score from the initial evaluation method is 67 % while the developed one is 70 %. However, comparing the total allocated scores is invalid because the developed one has an entire assessment criterion “Typology,” Technology & Digital Innovations, and PPP Investment Model incorporated to it, changing the total score from 90 to 120. Furthermore, there have been important improvements in the analysis criteria and their ratings (adding, removing, merging, splitting & modifying weights).

As for the **Shape** parameter, a big difference in the assigned scores is made due to merging horizontal and linear analysis parameters, assigned new score and modified terminology, consequently scores have changed to match the new modifications. Since, Scoring in total 10/10 instead of 2/10.

In the **Structure** parameter, it is assigned a score of 4/10 instead of 5/10, as hollow pillars for technical installations analysis parameter is removed from structure parameter so (+1) score is deducted overall result.

The total assigned score to **Facade** is reduced from 10/10 to 8/10. As in the optimized assessment tool, the score of the modular panels parameter reduced because of the new adding prefabricated facade parameter and solar shading.

As for the **Building Plant** parameter, it is assigned a score of 6/10 instead of 7/10. One point is decreased since the ratio of service shafts analysis parameter has been removed from the developed one.

The total assigned score to **Expandability** remains the same at 8/10. However internal already equipped spaces analysis parameter’s score have changed to be (+3) instead of (+4) and its name was modified. On the other hand, 1 new analysis parameter is added and assigned a score of (+1), this is Removable Partitions. Therefore, the overall assigned score is not changed.

In the **Restriction** parameter, its assigned score is slightly changed from 9/10 to 8/10. The score that is assigned for Drain Pipe parameters are reduced from (+2) to (+1) since Flat Land:slope< 5% a new analysis parameter is added with (+1) score.

As for **Building Elements** parameter’s total score reduced from 5/10 to 4/10 because Internal Partitions: Dry Walls Built in Situ analysis parameter is eliminated. On the other hand, a new Prefabricated Slab or Roof: %50 parameter is added.

In **Exchangeability** of Large Equipments parameters total score changed from 4/10 to 6/10. The score assigned to the Disassembly of Facade Panels and Internal Partions increase from (+4) to (+6).

A total assigned score to **Functionality** parameter slightly drops from 10/10 to 9/10. Generic/ Universal Rooms analysis parameter score have changed to be (+2) instead of (+4) and Space Standardization analysis parameter score reduced from (+2) to (+1). On the other hand, two new analysis parameters, Redundancy in Room Space, Progressive Shutdown, are added with (+2) and (+1) score respectively.

A total score of 8/10 is assigned to the newly added evaluation parameter **“Typology”**, as it fulfilled the analysis parameters of (Innovative Distribution in Departments,Classical Distribution in Departments, A Corridor and Rooms in One of the Two sides,Central Corridor and Rooms at the Two Sides,Double Corridor,Radial Disposition of the Rooms and Central Control Zone, Separation of Corridors: d ≥ 2,5 m, Separation of the Accesses and Distribution of Emergency Department and Infectious Wards with Direct Connection). An overall score of 8/10 is given to another recently added criteria ‘**’Technology & Digital Innovation’’** which includes 4 analysis parameters (Innovative HVAC System, Negative Pressure Rooms, Innovative & Movable Materials & Monitoring & Digital Storage). Eventually, it gains a 3/10 score from new inserted parameter **‘’PPP Investment Model’’** as it involves Concept and Construction Project Difference: c < %15 and %15 < c < %30, Alternative Project Sites & Inclusion of International Association.

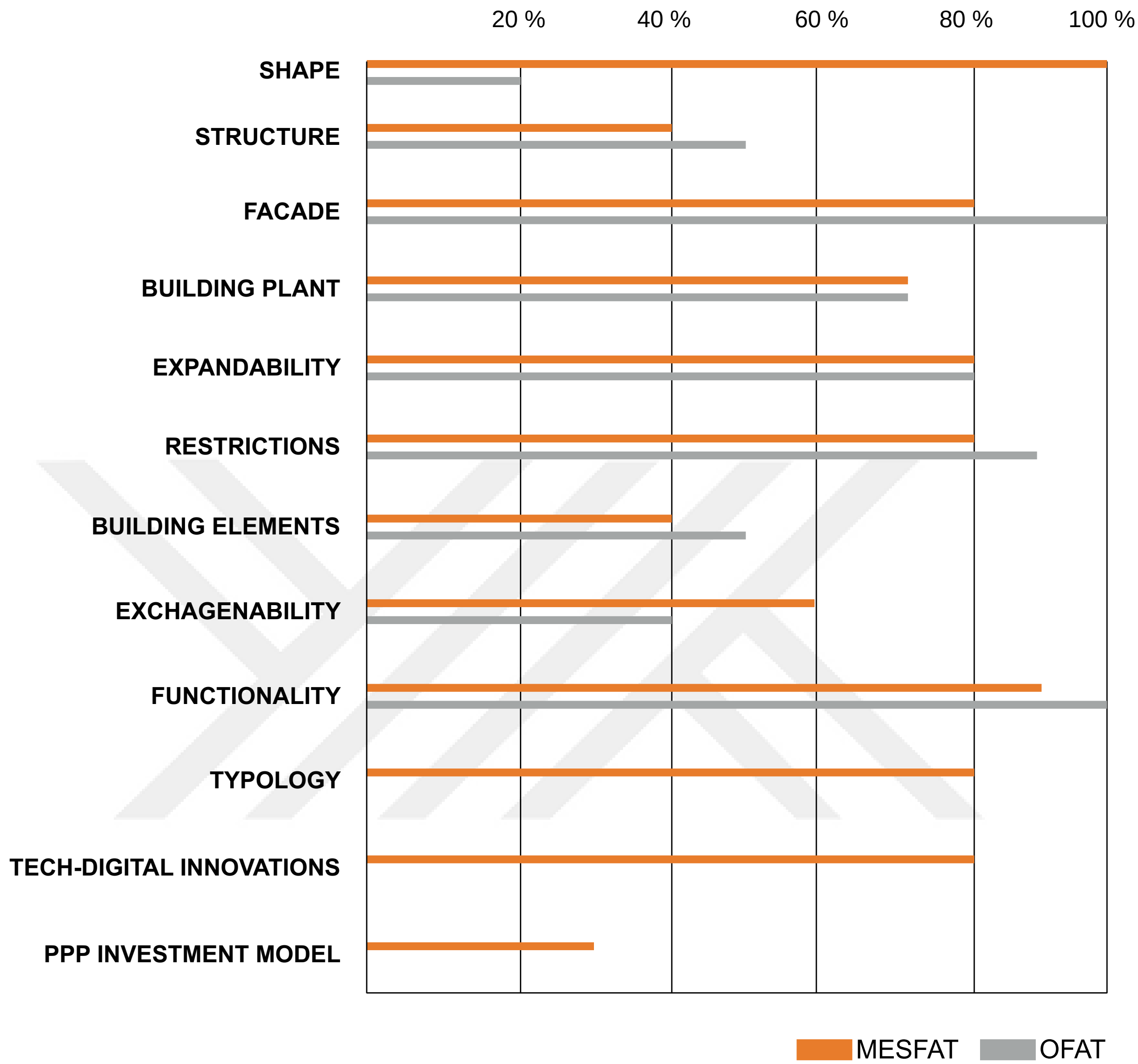


Figure 4.11: Istanbul Basaksehir Cam and Sakura City Hospital Comparative Histogram with Percentage of Application of Evaluation Parameters of OFAT & MESFAT (Source: Author)

Case study 02: Kayseri City Hospital

The mega structure flexibility assessment tool was used on the healthcare building, and the overall given score was 82/114 | 72 %, classifying it as a Flexible Megastructure with certain features that could be developed. Because of the unavailability, 6 marks are deducted.

The particular scores for each Evaluation Parameter are as following:

•Shape: 8/10 | 80%
•Structure: 3/8 | 38%
•Facade: 6/10 | 60%
•Building Plant: 4/7 | 57%
•Expandability:8/10 | 80%
•Restrictions: 9/10 | 90%
•Building Elements: 4/9 | 45%
•Exchange of Large Equipments: 6/10 | 60%
•Functionality: 9/10 | 90%
•Typology:10/10 | 100%
•Technology & Digital Innovations: 8/10 | 80%
•PPP Investment Model: 7/10 | 70%

The final results, the overall allocated score, the degree to which each of the test criteria is achieved, and the facility rating are represented in Figures 4.12 & 4.13.

Kayseri City Hospital Assessment

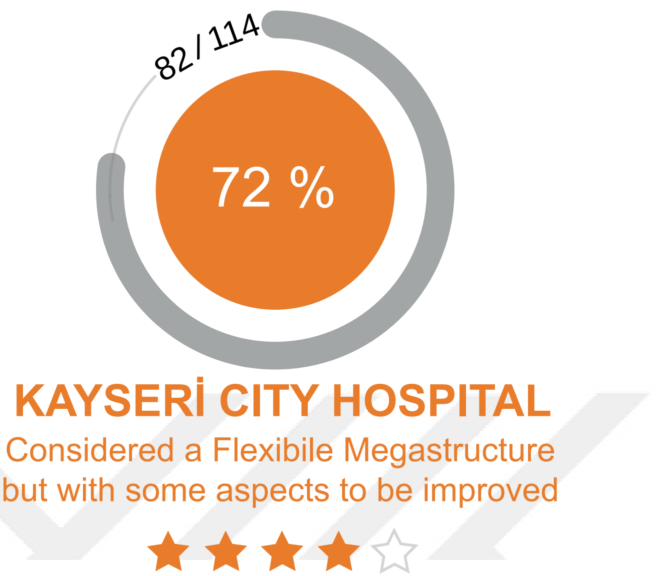


Figure 4.12: Kayseri City Hospital Flexibility Megastructure Assessment Score & Classification

(Source: Author)

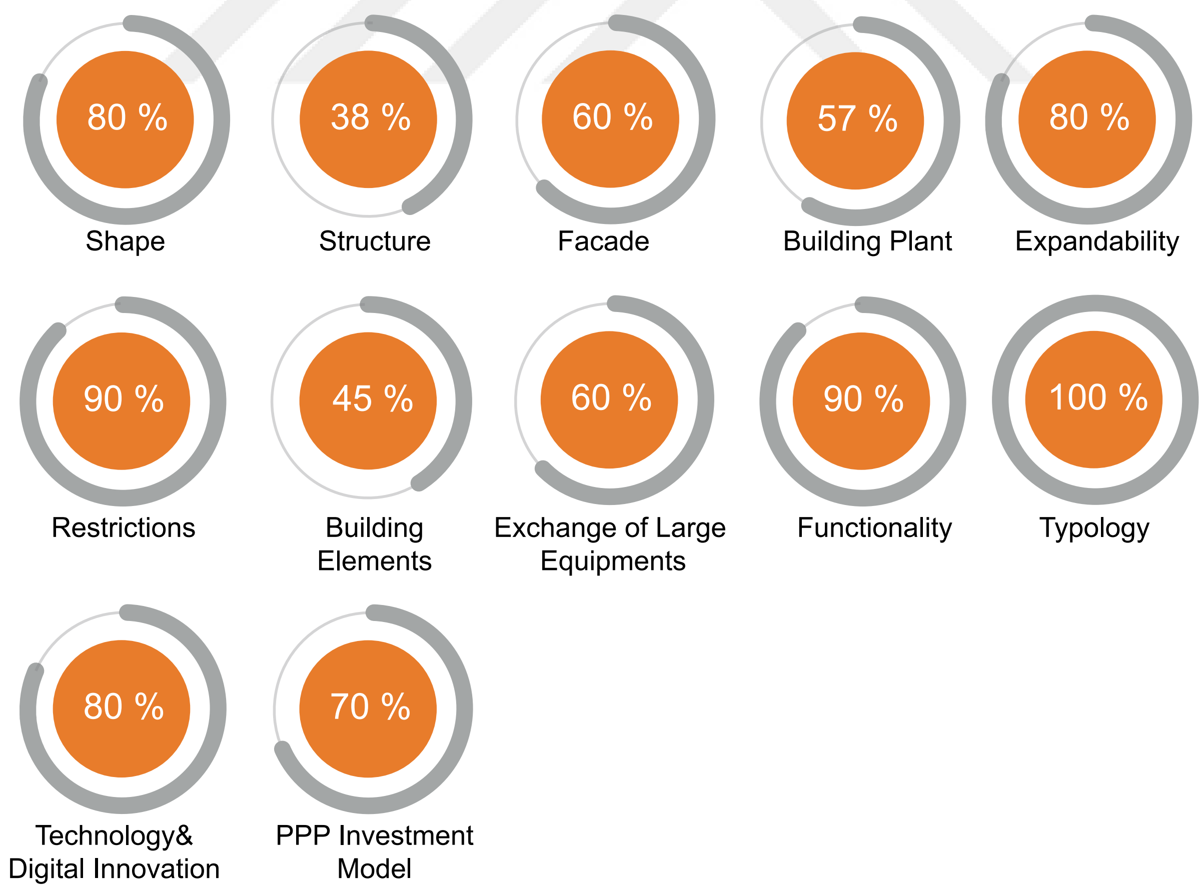


Figure 4.13: Kayseri City Hospital Megastructure Flexibility Assessment Parameters Score

(Source: Author)

The final results show that the total assigned score from the original assessment tool is 69%, and 71% using the developed one. However, the comparison between the total assigned scores is not valid, since an entire evaluation parameter "Typology", ''Technology & Digital Innovations'', and ''PPP Investment Model'' are added to the developed one, transforming the total score from 90 to 120. In addition to that significant changes in the analysis parameters and their scores have occurred (adding, removing, merging, splitting & modifying weights).

As for the **Shape** parameter, the assigned score is (+8) instead (+6). bSince the hospital is included in the new added analysis parameter which is Masses Linked with Bridges instead of Linear classification, its score has changed.

In the **Structure** parameter, it is assigned a score of 3/8 instead of 4/8. The ceiling height analysis parameter was defined in more detail and splitted into two different parameters which are Ceiling Height: Inpatient rooms ≥ 4m and Ceiling Height: Ground Floor ≥ 5 m. (+1) score is assigned for each.

The total assigned score to **Facade** is reduced from 8/10 to 6/10. As in the optimized assessment tool, the score of the modular panels parameter reduced because of the new adding prefabricated facade parameter.

As for the **Building Plant** parameter, it is assigned a score of 4/7 instead of 5/8. Service Shafts Area: Shafts Total Surface/Floor surface ≥ 0.01 analysis parameter have been eliminated. Since lack of information about Redundancy for Building Plant which is assigned (+3) instead of (+2), overall score is reduced from (+8) to (+7).

Expandability's cumulative allocated ranking remains constant at 8/10. However, the score of the internal already equipped spaces analysis parameter has been changed to (+3) instead of (+4), and the name has been updated. Removable Partitions, on the other hand, is a recent research parameter that has been given a score of (+1). As a result, the total allocated ranking remains unchanged.

Its allocated score in the **Restriction** parameter stands at 9/10. Since Flat Land:slope 5 %, a new analysis parameter of (+1) value has been introduced, the score allocated to Drain Pipe parameters has been reduced from (+2) to (+1). As a result, the overall assigned ranking does not change.

Since the Internal Partitions: Dry Walls Built in Situ analysis parameter was removed, the overall score for the Building Elements parameter dropped from 5/9 to 4/9. A new Prefabricated Slab or Roof: 50 % parameter, on the other side, has been implemented.

The overall score for the criteria of **Exchangeability** of Large Equipment raised from 4 to 6 on a scale of 10 points. The Disassembly of Facade Panels and Internal Partitions ratings has risen from (+4) to (+6).

The overall allocated value for the *Functionality* parameter decreases marginally from 10/10 to 9/10. The score for Generic/Universal Rooms analysis has been modified from (+4) to (+2), and the score for Space Standardization analysis has been reduced from (+2) to (+1). Redundancy in Room Space and Progressive Shutdown, on the other hand, are two recent research metrics of (+2) and (+1) scores, respectively.

The newly introduced assessment parameter **“Typology”** received an overall score of 10/10 for meeting the research criteria of (Innovative Distribution in Departments,Classical Distribution in Departments,A Corridor and Rooms in One of the Two sides,Central Corridor and Rooms at the Two Sides,Double Corridor,Radial Disposition of the Rooms and Central Control Zone, Separation of Corridors: d ≥ 2,5 m, Separation of the Accesses and Distribution of Emergency Department and Infectious Wards with Direct Connection). Another newly introduced criterion, **“Technology & Digital Innovation”** receives an average score of 8/10, with 4 analysis parameters (Innovative HVAC System, Negative Pressure Rooms, Innovative & Movable Materials & Monitoring & Digital Storage). Finally, the latest added parameter **“PPP Investment Model”** gives it a 7/10 score because it includes Concept and Construction Project Difference: c < %15 and %15 < c < %30, Alternative Project Sites & Inclusion of International Association.

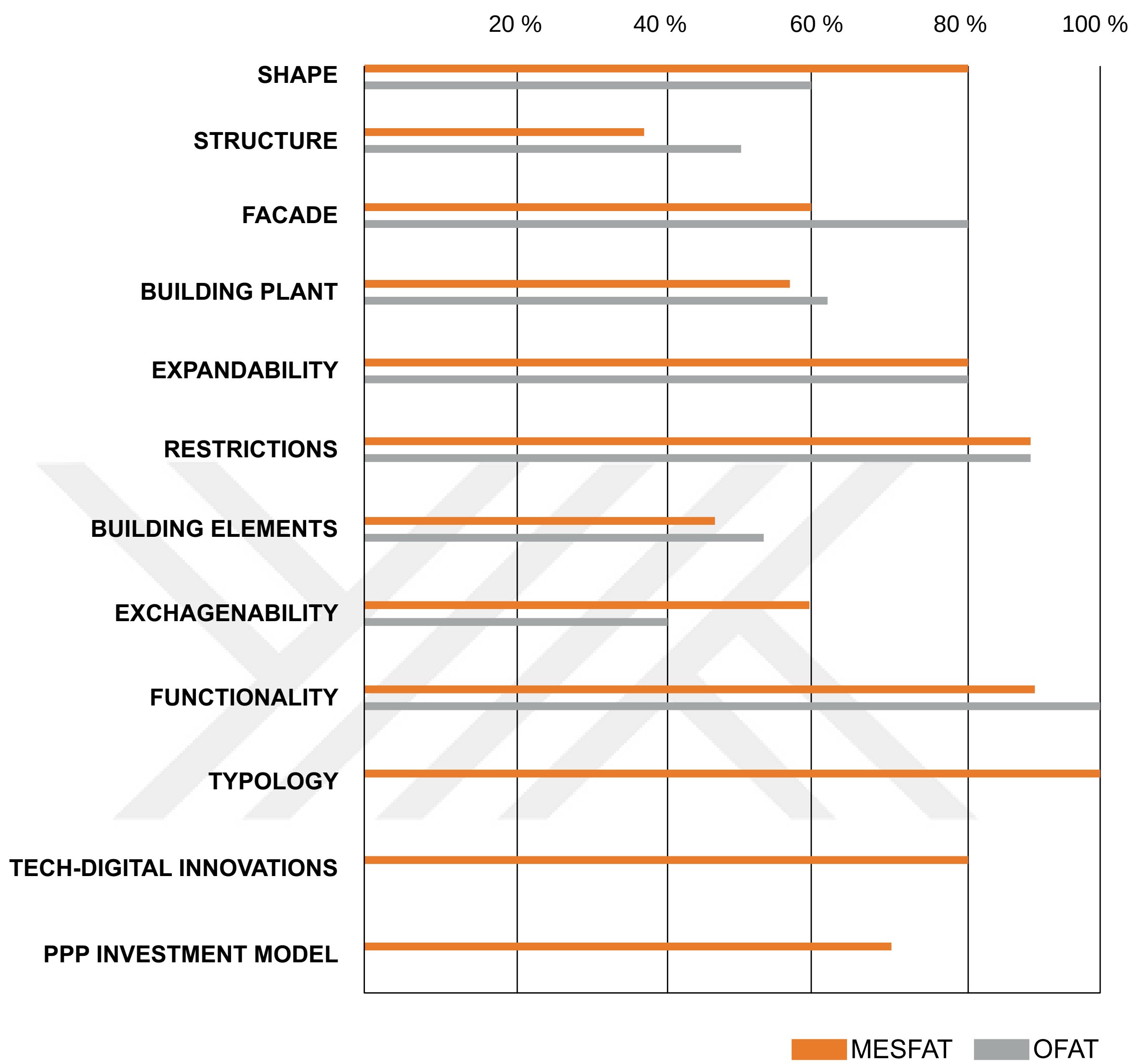


Figure 4.14: Kayseri City Hospital Comparative Histogram with Percentage of Application of Evaluation Parameters of OFAT & MESFAT (Source: Author)

Case study 03: Elazığ Fethi Sekin City Hospital

The mega structure flexibility assessment tool was used on the healthcare building, and the overall given score was 87/114 | 76 %, classifying it as a Flexible Megastructure with certain features that could be developed. Because of the unavailability, 6 marks are deducted.

The particular scores for each Evaluation Parameter are as following:

•Shape: 10/10 | 100%
•Structure: 4/8 | 50%
•Facade: 8/10 | 80%
•Building Plant: 6/7 | 86%
•Expandability: 8/10 | 80%
•Restrictions: 9/10 | 90%
•Building Elements: 4/9 | 45%
•Exchange of Large Equipments: 6/10 | 60%
•Functionality: 9/10 | 90%
•Typology: 7/10 | 70%
•Technology & Digital Innovations: 8/10 | 80%
•PPP Investment Model: 8/10 | 80%

The final results, the overall allocated score, the degree to which each of the test criteria is achieved, and the facility rating are represented in Figures 4.15 & 4.16.

Elazığ Fethi Sekin City Hospital Assessment

Figure 4.15: Elazığ Fethi Sekin City Hospital Flexibility Megastructure Assessment Score & Classification

(Source: Author)

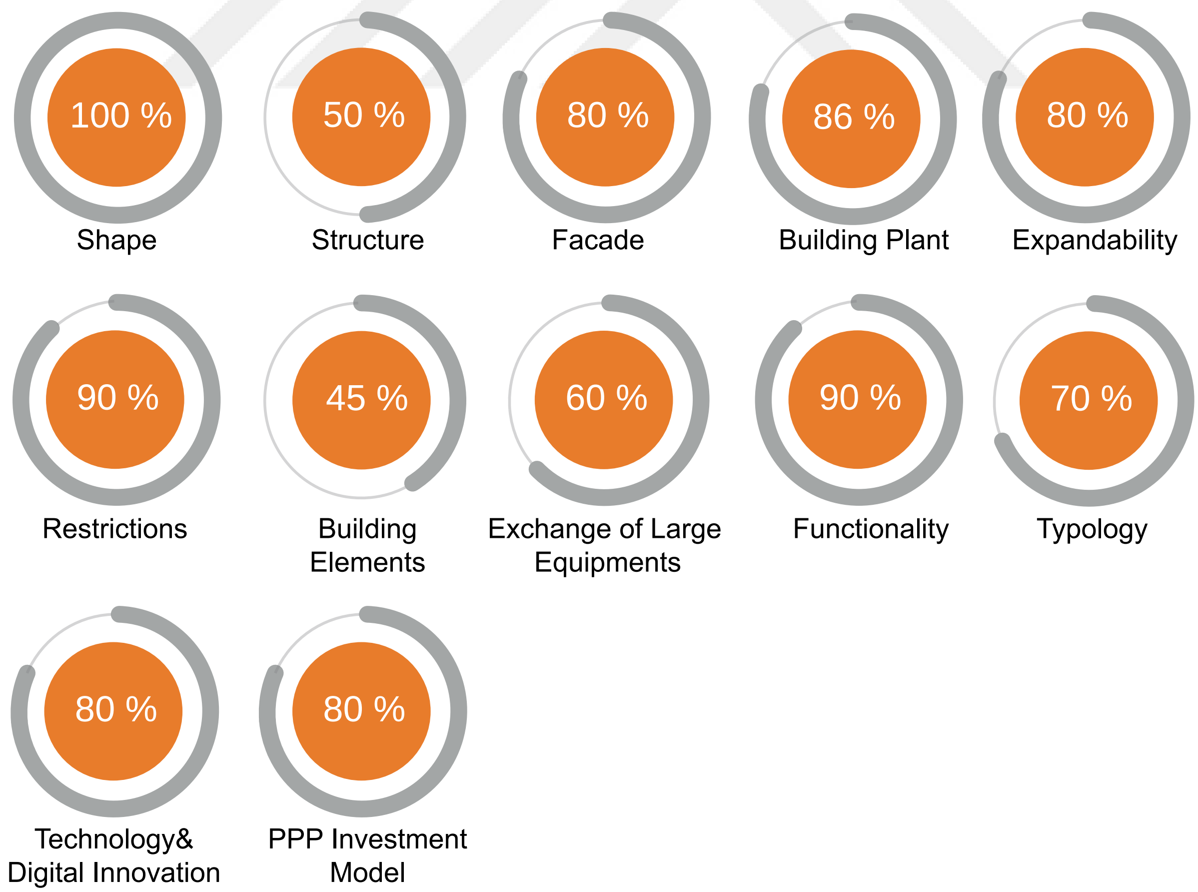


Figure 4.16: Elazığ Fethi Sekin City Hospital Megastructure Flexibility Assessment Parameters Score

(Source: Author)

The final results show that the total assigned score from the original assessment tool is 69%, and 76% using the developed one. However, the comparison between the total assigned scores is not valid, since an entire evaluation parameter “Typology”, ‘’Technology & Digital Innovations’’, and ‘’PPP Investment Model’’ are added to the developed one, transforming the total score from 90 to 120. In addition to that significant changes in the analysis parameters and their scores have occurred (adding, removing, merging, splitting & modifying weights).

As for the **Shape** parameter, the assigned score is (+10) instead (+2). bSince the hospital is included in the new added analysis parameter which is Masses Linked with Bridges instead of Linear classification, its score has changed.

In the **Structure** parameter, it is assigned a score of 4/8. The ceiling height analysis parameter was defined in more detail and splitted into two different parameters which are Ceiling Height: Inpatient rooms ≥ 4m and Ceiling Height: Ground Floor ≥ 5 m. (+1) score is assigned for each.

The total assigned score to **Facade** is reduced from 10/10 to 8/10. As in the optimized assessment tool, the score of the modular panels parameter reduced because of the new adding prefabricated facade parameter.

As for the **Building Plant** parameter, it is assigned a score of 6/7 instead of 7/8. Service Shafts Area: Shafts Total Surface/Floor surface ≥ 0.01 analysis parameter have been eliminated. Since lack of information about Redundancy for Building Plant which is assigned (+3) instead of (+2), overall score is reduced from (+7) to (+6).

Expandability’s cumulative allocated ranking increased from 7/10 to 8/10. However, the score of the internal already equipped spaces analysis parameter has been changed to (+3) instead of (+4), and the name has been updated. Removable Partitions, on the other hand, is a recent research parameter that has been given a score of (+1).

Its allocated score in the **Restriction** parameter stands at 9/10. Since Flat Land:slope 5 %, a new analysis parameter of (+1) value has been introduced, the score allocated to Drain Pipe parameters has been reduced from (+2) to (+1). As a result, the overall assigned ranking does not change.

Since the Internal Partitions: Dry Walls Built in Situ analysis parameter was removed, the overall score for the Building Elements parameter dropped from 5/9 to 4/9. A new Prefabricated Slab or Roof: 50 % parameter, on the other side, has been implemented.

The overall score for the criteria of **Exchangeability** of Large Equipment raised from 5 to 6 on a scale of 10 points. The Disassembly of Facade Panels and Internal Partitions ratings has risen from (+4) to (+6).

The overall allocated value for the **Functionality** parameter decreases marginally from 10/10 to 9/10. The score for Generic/Universal Rooms analysis has been modified from (+4) to (+2), and the score for Space Standardization analysis has been reduced from (+2) to (+1). Redundancy in Room Space and Progressive Shutdown, on the other hand, are two recent research metrics of (+2) and (+1) scores, respectively.

The newly introduced assessment parameter **"Typology"** received an overall score of 7/10 for meeting the research criteria of (Innovative Distribution in Departments,Classical Distribution in Departments,A Corridor and Rooms in One of the Two sides,Central Corridor and Rooms at the Two Sides,Double Corridor,Radial Disposition of the Rooms and Central Control Zone, Separation of Corridors: d ≥ 2,5 m, Separation of the Accesses and Distribution of Emergency Department and Infectious Wards with Direct Connection). Another newly introduced criterion, **"Technology & Digital Innovation"** receives an average score of 8/10, with 4 analysis parameters (Innovative HVAC System, Negative Pressure Rooms, Innovative & Movable Materials & Monitoring & Digital Storage). Finally, the latest added parameter **"PPP Investment Model"** gives it a 8/10 score because it includes Concept and Construction Project Difference: c < %15 and %15 < c < %30, Alternative Project Sites & Inclusion of International Association.

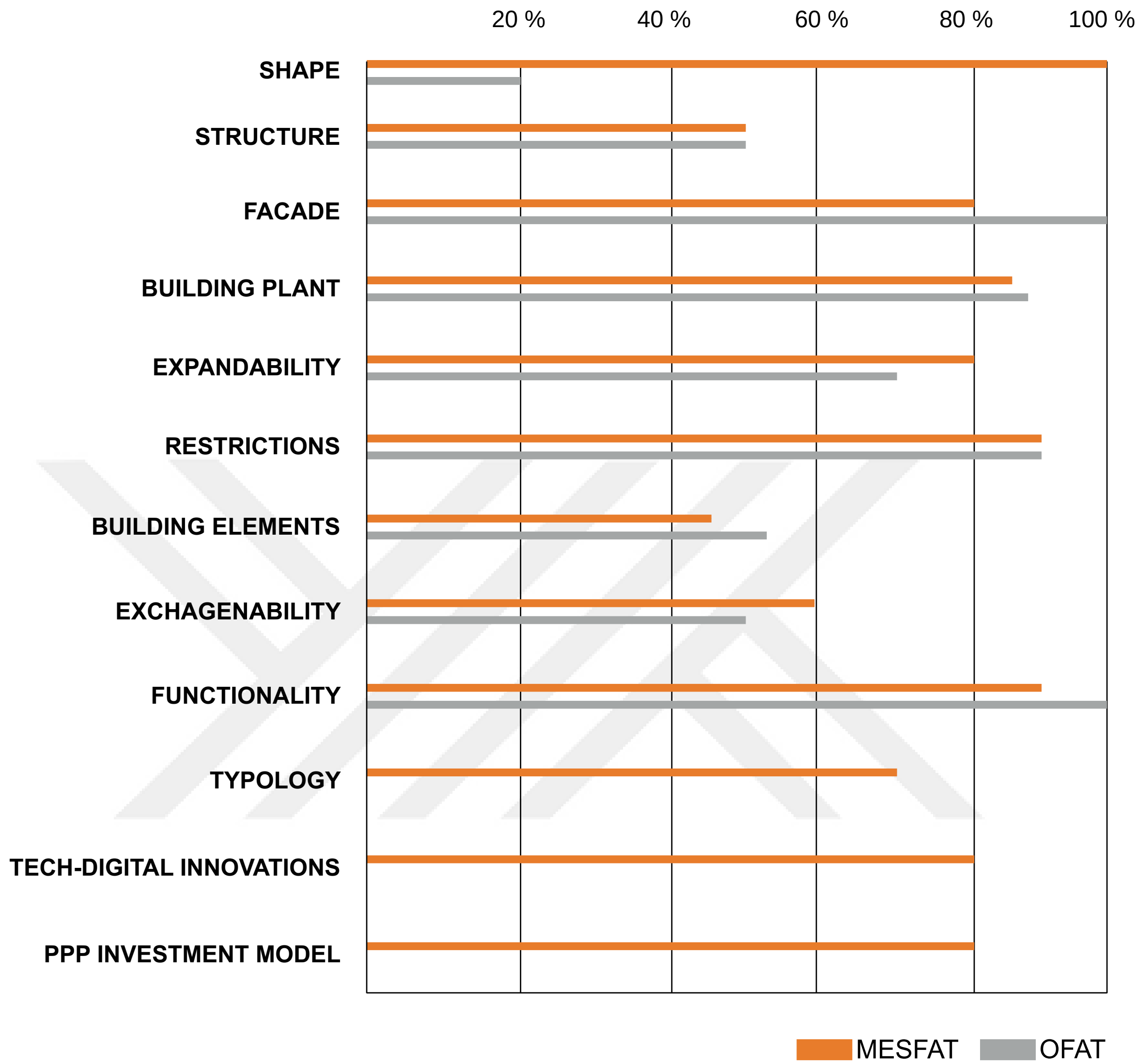


Figure 4.17: Elazığ Fethi Sekin City Hospital Comparative Histogram with Percentage of Application of Evaluation Parameters of OFAT & MESFAT (Source: Author)

4.4 Test on A Pilot Case Study: Elazig Fethi Sekin City Hospital

Elazığ Fethi Sekin Hospital is the top scorer among the other 7 city hospitals in testing the flexibility of megastructures with the MeSFAT tool as it gets a score of 76%. However, It is examined that there is still some potential in developing and pushing forward the existing level of flexibility to further extend. Elazığ Fethi Sekin Hospital is chosen as pilot case study for developed design strategies to be applied as it specifically creates a feasible development ground. After the application of related design strategies and development plans, it is aimed to test the hospital with MeSFAT one more time to see if there is any improvement in flexibility and resilience.

Extracted Design Strategies

6 main issues are taken into consideration as a source for extracting emerging principles for selected pilot case study, those are: Literature Review, Assessment Tools, Interviews, Healthcare Design Guidelines, Case Studies and Covid-19. With the help of these issues the study focuses on 10 emerging principles for flexibility & resilience which are Operational Flexibility, Infection Control, Indebility, Modularity, Expandability, Mobility, Convertibility, Technology, Adaptability and Redundancy (see Figure 4.18). After that, 9 applicable design strategies to be applied for the pilot case study are developed and extracted based on related emerging flexibilities. These design strategies are as follows: Solar Shading Panels, Soft Spaces, External Volumes on Facade, Innovative Temporary Structures, Redundant Equipment Spaces, Progressive Shutdown, Innovative & Movable Materials, Separation of Units and Wayfinding (see Figure 4.19).

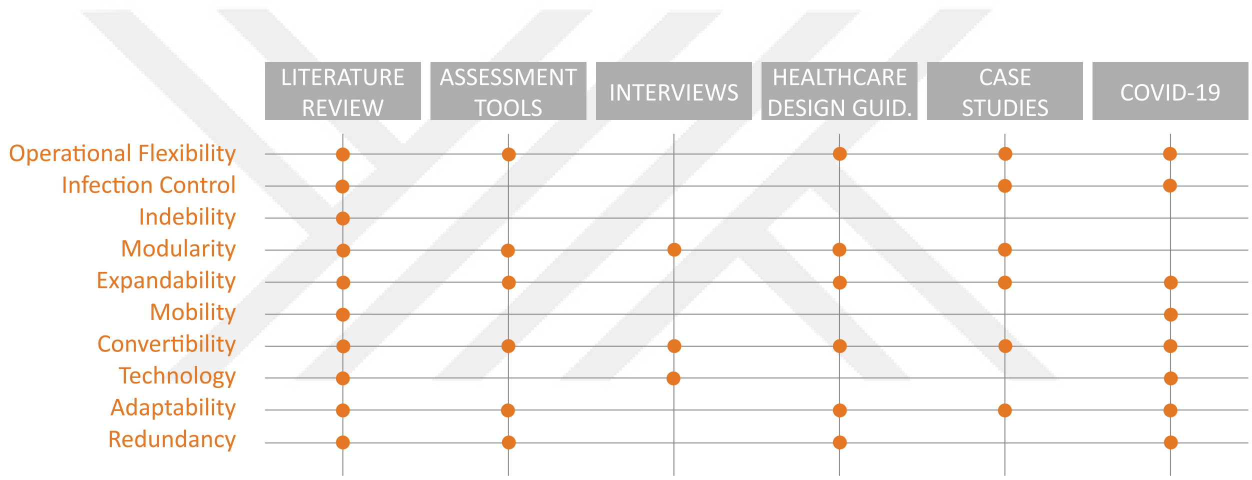


Figure 4.18: 6 Main Issues & 10 Emerging Principles Matrix

(Source: Author)

	OPERATIONAL FLEXIBILITY	INFECTION CONTROL	INDEBILITY	MODULARITY
Solar Shading Panels			●	
Soft Spaces		●		
External Volumes on Facade				
Innov. Temporary Str.		●		●
Redundant Equip. Spaces				
Progressive Shutdown	●			
Innov. & Movable Materials		●		
Seperation of Units	●	●		
Wayfinding	●	●		

Figure 4.19: 10 Emerging Principles & 9 Extracted Design Strategies Matrix

(Source: Author)

EXPANDABILITY	MOBILITY	CONVERTIBILITY	TECHNOLOGY	ADAPTABILITY	REDUNDANCY
			●		
●		●		●	●
●			●		
●	●		●	●	
●		●		●	●
				●	
	●	●	●	●	
		●		●	
			●		

Application of Design Strategies

The final results show that the total assigned score from the MeSFAT is 84% after the application of design strategies (see Figure 4.20 & 4.21). There is an 8% increase from the previous score which is 76%. As a result, the hospital which is selected as pilot case study shifts from Flexible Megastructure with 4 stars to Flexible Megastructure Model with 5 stars. There is a remarkable change in level of flexibility & resilience after applying design strategies for the operational stage (see Figure 4.22). Applied design strategies are as follows (see Figure 4.23 & 4.24):

Solar Shading Panels

Solar Shading Panels help skin materials and indoor appliances last longer. It is also useful in providing patients with thermal comfort at a low cost with energy efficiency. Addition of these panels on the southern facade of the hospital will result in extension of the life cycle of the materials and equipment by protecting them from direct sunlight. This eventually provides durability and cost efficiency with the help of technology.

Soft Spaces

Extra room to accommodate backup facilities in the event of a disaster or pandemic. Soft spaces near technical facilities are chosen because they can be retrofitted as utility spaces to fulfill potential service demands with little disruption to the existing operations of the healthcare facility.

External Volumes on Facade

The structure calculations for the facilities include extruded volumes from the facade, but no additional supporting structure will be required in the event of an expansion.

Innovative Temporary Structures

Temporary facilities such as containers, inflatable systems, tent structures, modules, partition panels, and other similar structures can be used in unexpected scenarios such as pandemics where the capacity of the healthcare facility does not match demand. These approaches provide consistency as well as cost savings by simple assembly techniques.

Redundant Equipment Spaces

Since it is impossible to estimate the physical space required for the latest up-to-date facilities, equipment rooms should be constructed with extra storage to accommodate for more developments in medical technology.

Progressive Shutdown

A Progressive Shutdown technique may be applied where those units or departments are not in use. As a result, energy, repairs, and staffing costs will all be reduced. It also concentrates staff in close proximity to patients, improving teamwork and safety.

Innovative & Movable Materials

Options such as reusable cotton fabrics, which are used in emergency circumstances, must be closely studied and evaluated. They could be used to provide a variety of sanitary spaces for social distance, and they could be disinfected, substituted, or eliminated as required, maintaining the spaces' adaptability and resilience.

Separation of Units

This setting means that parts of the building can be configured without affecting the general flow and path layout and unit isolation in the event of an emergency. In addition to the separation of pathways and alternative directions, these strategies prevent cross-contamination.

Wayfinding

By detecting risk points and having "mental anchors" for human activities, simple visual maps, wayfinding strategies, user nudges, and smartphone apps can help to deter infection transmission.

Elazığ Fethi Sekin City Hospital Assessment

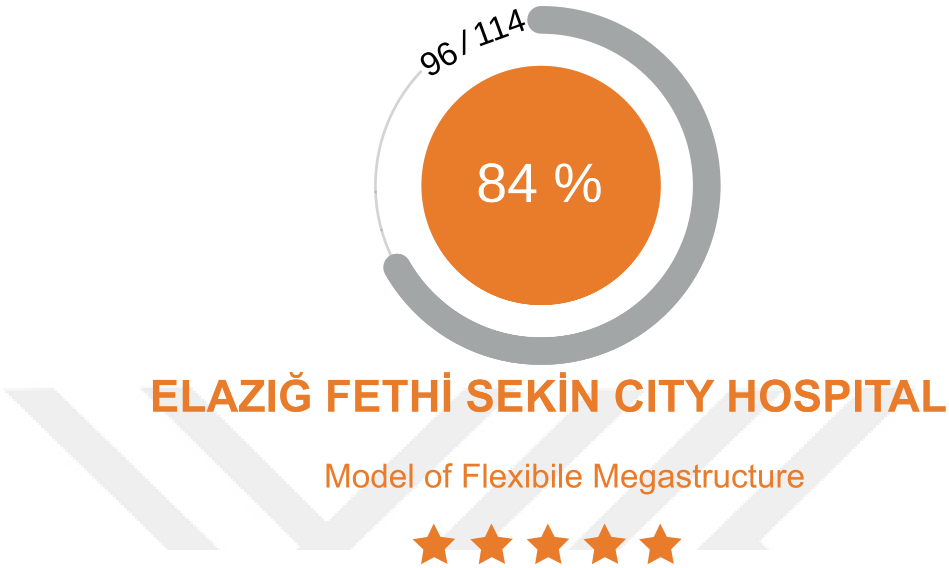


Figure 4. 20: Elazığ Fethi Sekin City Hospital Flexibility Megastructure Assessment Score & Classification with Applied Design Strategies (Source: Author)

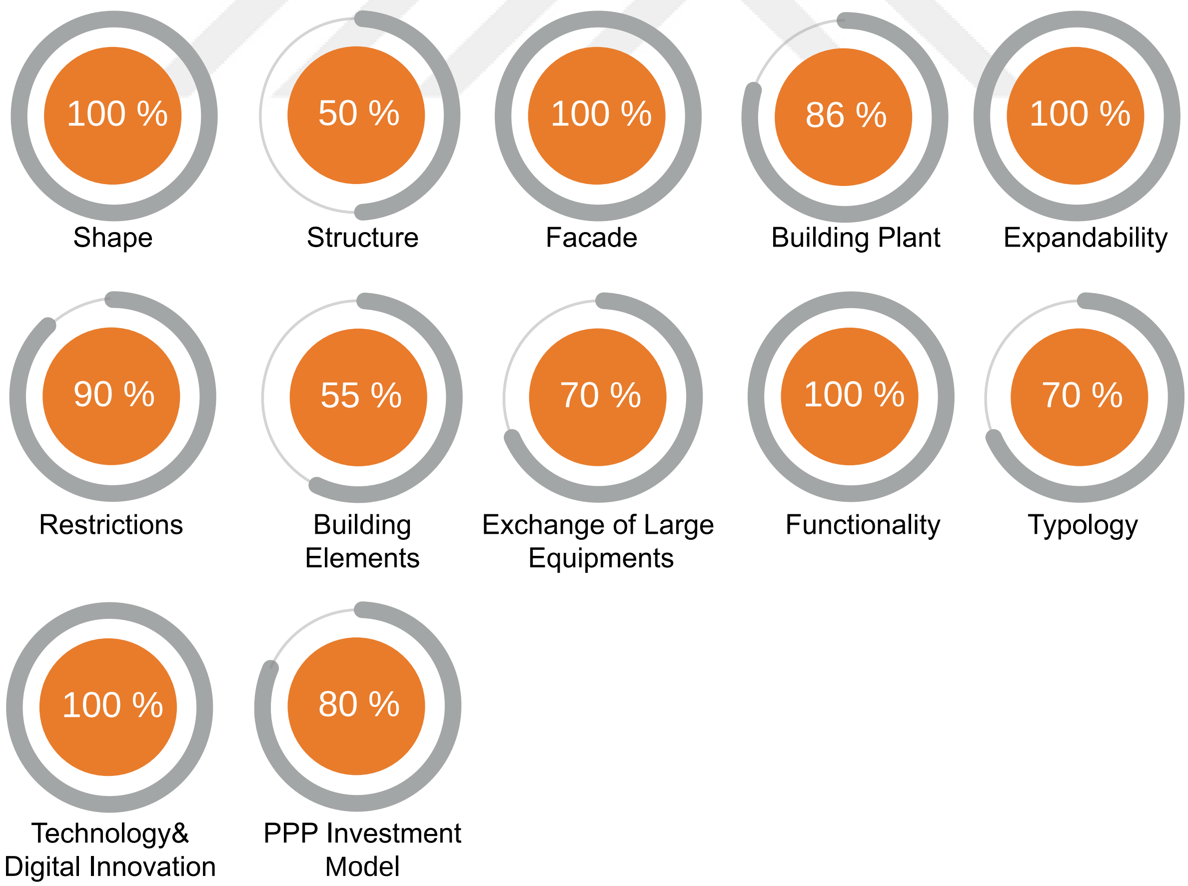


Figure 4.21: Elazığ Fethi Sekin City Hospital Megastructure Flexibility Assessment Parameters Score with Applied Design Strategies (Source: Author)

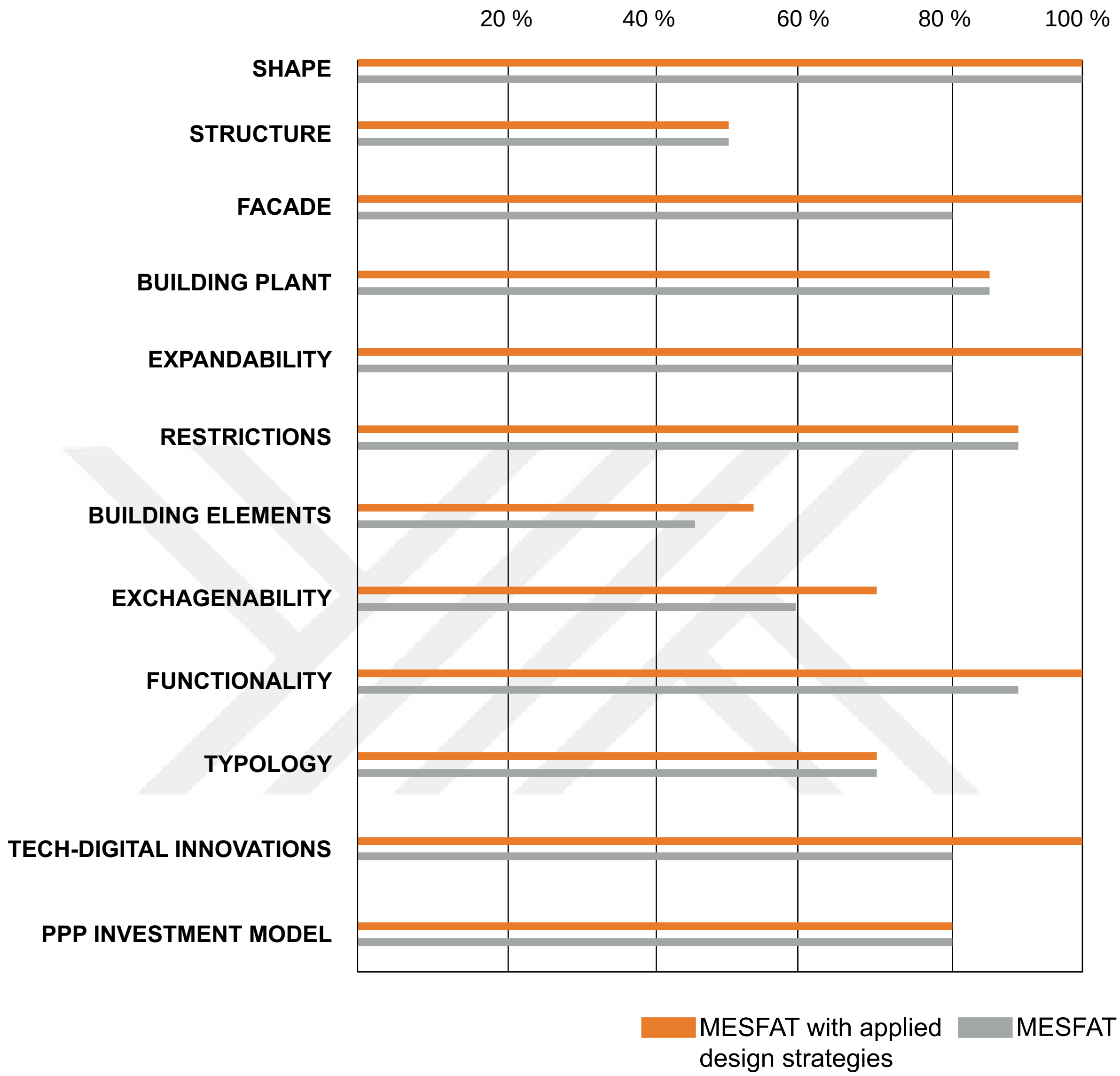


Figure 4.22: Elazığ Fethi Sekin City Hospital Comparative Histogram with Percentage of Application of Evaluation Parameters of MESFAT & MESFAT with Applied Design Strategies (Source: Author)

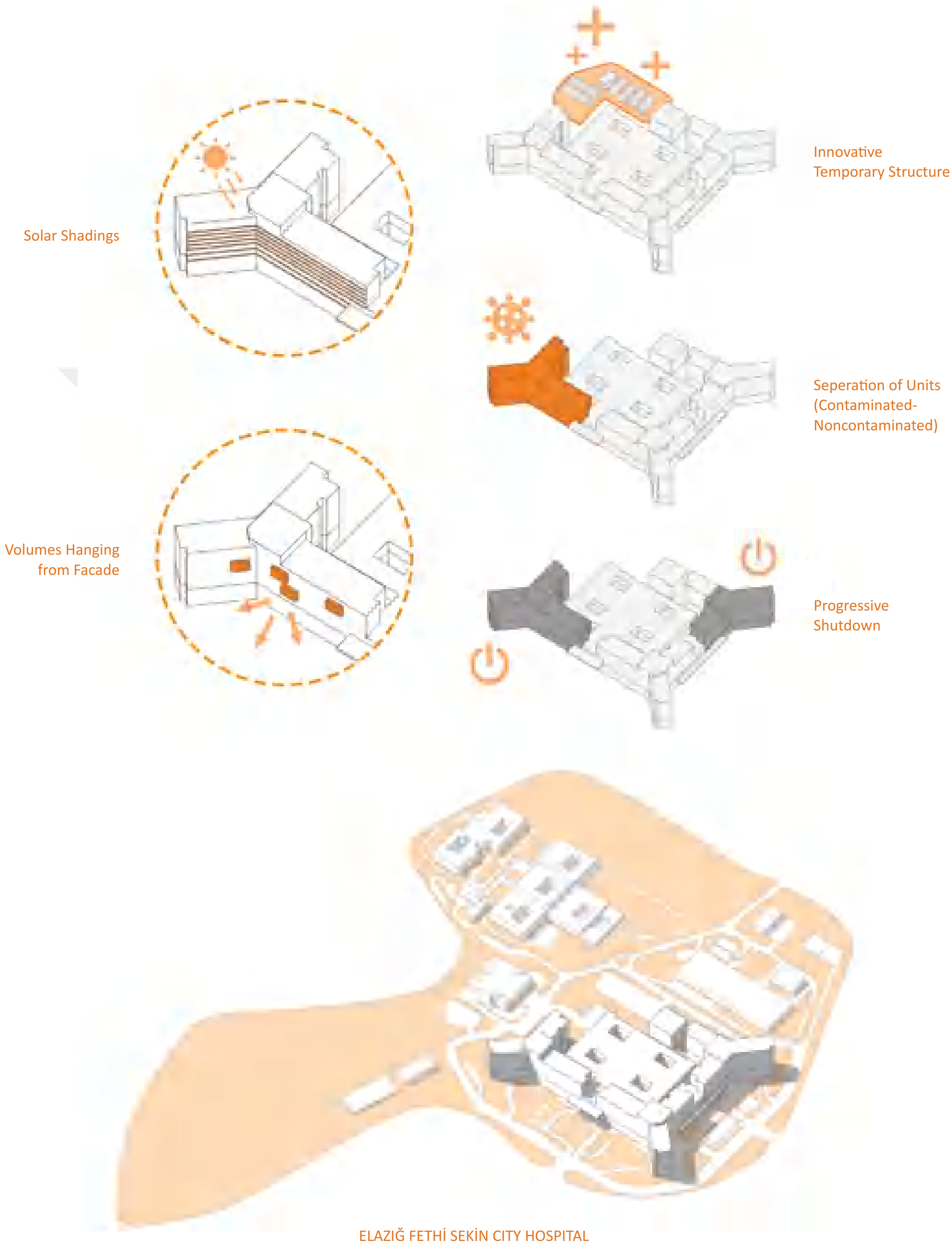


Figure 4.23: Elazığ Fethi Sekin City Hospital Applied Design Strategies Diagrams 1
(Source: Author)

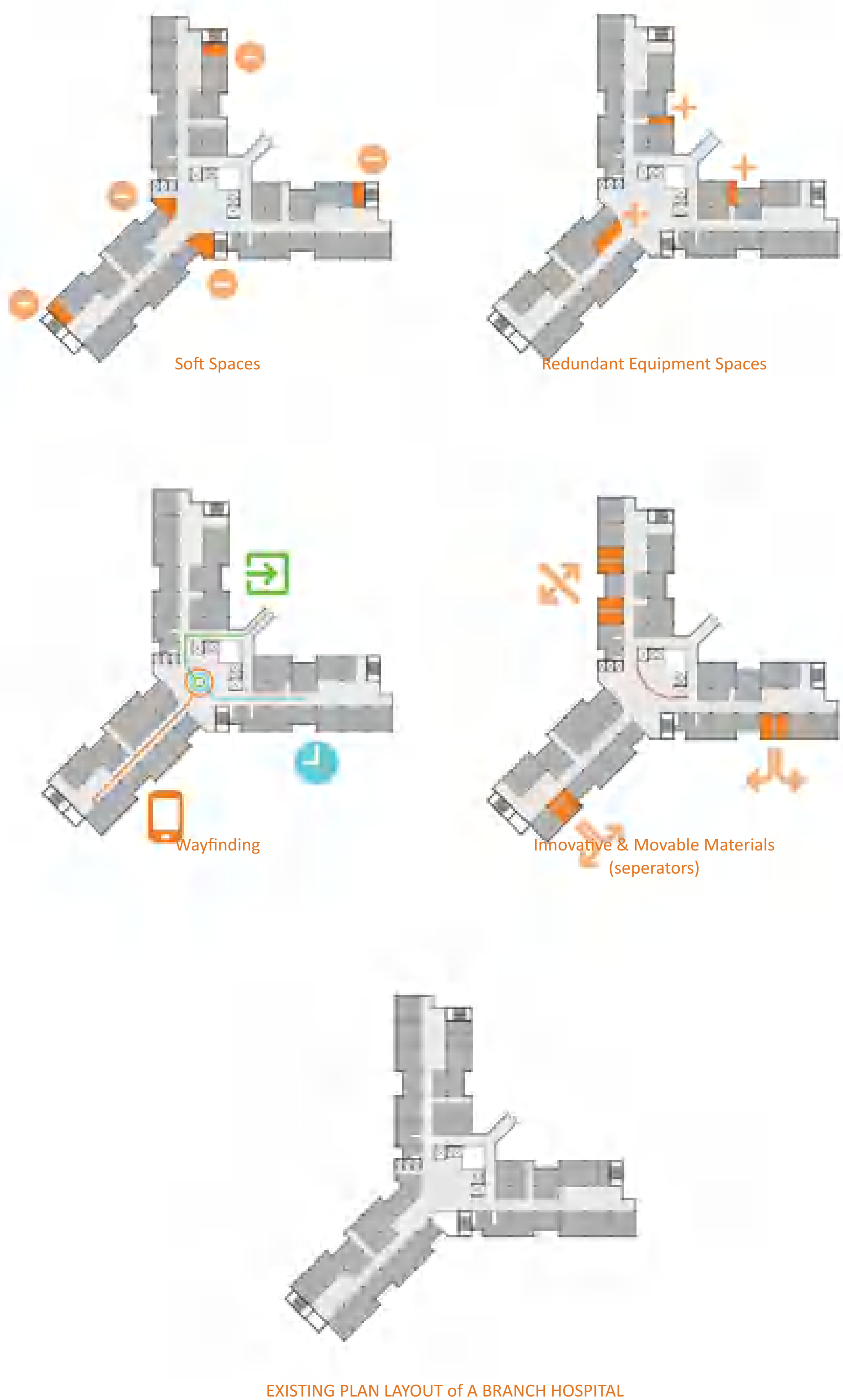


Figure 4.24: Elazığ Fethi Sekin City Hospital Applied Design Strategies Diagrams 2
(Source: Author)

CONCLUSIONS

05

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5.1 Final Considerations

Healthcare facilities are dynamic complexes with a large number of organisations, as well as a combination of social, cultural, economic, technical, and architectural factors. It is essential that healthcare services should be designed for the present and tomorrow in order to be able to perform their current and future roles. The facility's design should encourage the use of innovation and contribute to the efficiency and transparency of every operation. Therefore, hospitals must be adaptable to changing requirements. Buffoli et. al., (2012) asserts that flexibility is at the forefront of all improvements undertaken in response to developments in medical research. The potential challenge will be to create systems that encourage long-term flexibility while still providing for wellbeing through coordination with complementary external practices.

MeSFAT is improved to asset flexibility and resilience in megastructure healthcare facilities during the designing stage that enables a monitoring mechanism for designers to develop their projects. Besides, it can be used on current structures to determine how well they meet flexibility and resilience issues and what requirements to be altered if necessary.

5.2 Innovative Contribution

Although physical aspects of healthcare facilities are important regarding flexibility, there are other intangible contemporary side factors to be taken into consideration. "PPP Investment Model" is one of them as it became more common in the contemporary healthcare sector and a key element starting from the tender to construction phase. Emerging issues like pandemic are another one since they question the healthcare system fundamentally with patient intensity and increased infection risk. In this case, "Technology" would play an auxiliary key role to strengthen and take advantage of existing facilities. In addition to these, to broaden physical criteria, "Typology" is architecturally a vital concern which deals with space organisations so functional relations.This is to help designers and professionals in this area to reach a higher degree of flexibility and resilience for mega healthcare structures while respecting constantly changing issues of the system.

5.3 Implication for Research Practice

Flexibility and resilience are two of the vital concepts of contemporary healthcare facilities, especially with recently emerging issues and perpetually changing advancements discussed in State of the Art.

The evaluation of selected case studies with chosen assessment tool showed that there are inadequacies because of neglected tangible and intangible parameters based on recently discussed or emerging issues to be taken into account. This has a huge impact on the final allocated ranking and the facility's categorization, leading to a misplaced action plan. As a result, it becomes essential to improve the evaluation method and create a new one. As a larger framework that involves the Optimized Flexible Assessment Tool dynamics, the new appraisal method is planned and tailored to evaluate the degree of fulfillment of the fundamental concepts of flexibility and resilience.

5.4 Limitations and Further Research

Clearly, there are some limitations to the study. First, due to the lack of a freely accessible drawings of the City Hospitals, it affects comprehensive understanding of architectural features of these healthcare facilities because of the agreement between the private and public actors. Second, in certain situations, information about Analysis parameters was unavailable, thus their weights were subtracted from the final score to avoid any possible misinterpretation. This is to allow a more accurate assessment by establishing an unbiased comparison between the case studies. Third, because of the extraordinary pandemic (COVID-19) conditions of the hospitals, it was not possible to investigate these structures in presence. Finally, only 3 businesses out of the 11 that were contacted participated in the structured interviews. As a consequence, the outcomes and comparisons were done accordingly.

Future research is expected to test the types of data that can be taken from this report. Next studies should look at the implications of using the technique on a wider range of facilities on a local or even global level. Furthermore, the weighting method and ratings of the research criteria should be further improved and updated by a team of skilled experts based on their prior expertise. Finally, new assessment criteria can be applied to the 12 existing ones, likewise incorporation of “Typology”, “Technology & Digital Innovations’’ and ‘’PPP Investment Model’’ evaluation parameters during the tool improvement phase.

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06

06 REFERENCES

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