# A Systematic Review of Selection of Facility Location in Health Care

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Eylül University	Facility location decisions are long-term, high-risk and vitally important strategic decisions for
Healthcare	organisations that require considering not only the current time conditions, but also the possible
Management	changes in the life-long environment of the organisation itself. For organisations in the sector,
Department	which stands out with its social benefit dimension and complex and uncertain structure, such as the
	health sector, the methods used in the decision process are important because of these strategic
E-mail:	vitally important decisions. In this study, a systematic review method was used in order to examine
dilaraarslan98@	the studies in the literature. 23 studies published in the English-Turkish language between the
gmail.com	years of 2015-2020 and whose full texts can be accessed were included within the scope of this review. It has been observed that more than half of the studies use multi-criteria decision making
	methods and also more than half of them use only one single method. Additionally, %30.4 of the
	studies carried out their decision-making processes by taking into account the uncertainty factor.

# INTRODUCTION

The facility location is defined as the most appropriate place where an enterprise carries out operational and managerial activities such as production, storage, demand-sales planning, resource allocation planning (Öner 2014, Tarım, Zaim and Bayraktar 2011). Additionally, it is a place where provides minimum cost and maximum profit to able to meet the long-term objectives of organisations (Ar, Baki and Özdemir 2014).

Selection of facility location is an important process that affects the inputs of operational and managerial activities within the organisations (Boran 2011). The high costs incurred due to the property acquisition and construction of the organisation cause the facility location selection decisions to be evaluated in the category of long-term investments (Owen and Daskin 1998). Location selection is a strategic decision issue that directly affects all processes on the value chain of an organisation, requires long-term resource allocation and takes into account not only the current environmental conditions of the organisation, but also how these conditions will change throughout the life-cycle of the organisation (Owen and Daskin 1998, Özcan 2013, Tarım et al 2011). Selecting the right or wrong facility location alternative has some effects on the vital activities of the organisations such as transportation cost, qualified personnel supply, competitive advantage that the company has / may have, access to raw material resources (Boran 2011). According to Öner (2014), the main objectives in choosing facility location are the availability of the needs of the organisations, efficiency and performance increase, and most importantly, providing cost advantage. To be able to ensure these objectives in detail.



## Figure 1. Steps of selection of facility location process (Özcan 2013, Tarım et al 2011)

The first study in the literature on the selection of facility location was seen in the early 1900s when Alfred Weber (1909) tried to position a warehouse according to its distance to several customers by minimizing costs (Owen and Daskin 1998, Arslan 2018). Although the cost minimization factor attracted attention at the beginning in the selection of facility location studies, it has been proven by several researches that conflicting factors such as the political environment, the distance of the market and customers, and the supplier network have significant effects in the selection of facility location process (Boran 2011, Akyüz and Kılınç 2016). Due to the process which becomes increasingly complex because of the desire to optimize many criteria at the same time, the expectations about the selection of facility location process can be met thanks to the rational use of scientific approach and methods which are developed as a result of the studies (Öner 2014, Akyüz and Kılınç 2016).

In facility location decisions, classical methods which may be examined under two group as comparative methods and linear programming first started to be used (Öner 2014). However, in time, the concept of 'multi-criteria decision making' has entered the literature as the classical methods of selection of facility location have become insufficient (Ar et al 2014). Multi-criteria decision making is defined as "the process of determining the best feasible solution according to established criteria and problems that are common occurrences in everyday life" (Jahan, Edwards and Bahraminasab

2016). Many decision-making techniques have been developed and have being used in several distinct fields under the subject of multi-criteria decision making such as AHP (analytic hierarchy process), TOPSIS (technique for order preference by similarity to ideal solution), PROMETHEE (preference ranking organization method for enrichment evaluations), ELECTRE (elimination and choice translating reality), ARAS (additive ration assessment), VIKOR (Öner 2014, Yıldırım 2015).

In classical multi-criteria decision making techniques, exact expressions are used when evaluating criterias or alternatives (Ar et al 2014). However, since the criterias/alternatives in the decision process are evaluated with human perceptions and judgments that cannot be measured precisely, there are problems seen in the use of classical multi-criteria decision making techniques regarding the ambiguity of the language used (Boran 2011). In order to deal with this problem, fuzzy logic/number and gray theory has also been applied in decision-making processes (Ar et al 2014) with especially multi-criteria decision making techniques such as AHP, TOPSIS, ELECTRE etc (Öner 2014).

It is admittedly a vital strategic process for an organisation to decide on the facility location - regardless of the industry. However, in the health sector, considering the social benefit dimension of the services provided, choosing the appropriate location is very critical in terms of human life, objectives of country and etc. In addition, the health sector differs in decision-making processes in selection of facility location due to government interventions from other sectors (Tarım et al 2011). As in many countries, the criterias included in the WHO's indicator list and may considered to be recommendations for countries have become used for hospital location selection in Turkey.

Table 1. List of recommended core indicators by WHO (2010)

Building blocks and indicators	Data collection methods/Data sources
Number and distribution of health facilities per 10 000 population	District and national databases of health facilities. Special efforts –notably facility censuses- are often required to
Number and distribution of inpatient beds per 10 000 population	obtain the number of private facilities, especially if no registration system is enforced.
Number of outpatient department visits per 10 000	Routine health facility reporting system
population per year	Population-based surveys
General service readiness score for health facilities	Health facility assessments
Proportion of health facilities offering specific services	
Number and distribution of health facilities offering specific services per 10 000 population	
Specific-services readiness score for health facilities	

# **1. METHODOLOGY**

This study is a descriptive research which aimed to examine the scientific studies published in national and international literature on facility location selection and facility location in health services between the years of 2015-2020.

## 1.1. Sample Group of the Study

In this study, criterion sampling method which is one of the purposive sampling methods was used. Studies that were published between January 2015 and 25th of December 2020 were included in the research group.

#### 1.2. Data Collection Tool and Method

Systematic review method was used as data collection method. ProQuest, Science Direct, Scopus, Web of Science and Google Scholar databases were scanned between 15th of December 2020 and 25th of December 2020. During scanning the databases, keywords determined as 'hospital', 'site selection', 'location selection' and 'facility location' were used.

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Table 2. Inclusion process of articles for research	
Total number of studies reached in databases	 2.940
Studies which do not meet the criterias are excluded	 329
Studies whose full text is not available are excluded	 184
Repeated studies are excluded	 117
The number of studies included in the reports as a results of detailed examination-	 23

The databases were scanned between the specified dates which are using the determined keywords. In the scanning process, firstly, the condition that the keywords should be in the whole context of the research was sought and 562,317 results were found. In order to make the research more workable, the condition that the keywords should be in the title of the research was brought. In the next scanning process, 2,940 results were found. The criterias of being published between January 2015 and 25th of December 2020, and, being written in English or Turkish languages were determined. After the evaluation process, 23 studies were included in the study as a result of the elimination by considering these criterias.

#### **1.3.** Limitations of the Study

The studies which were published between January 2015 and 25th of December 2020 and included the determined keywords in the title of the study were included in the research. The research was limited to English and Turkish research studies, and studies whose full text could not be reached were excluded.

# 2. FINDINGS

As a result of the scanning of the related literature, 23 studies were included in the study. Information on the language in which the studies were published, the country where the study was conducted, the method used in the study, and the year in which the studies were published are given in Table 3, and, studies were analyzed according to these characteristics.

AUTHORS	YEAR	TYPE OF STUDY	LANGUAGE	COUNTRY	METHOD
Eldemir and Önden	2016	Research Article	English	Turkey	AHP with GIS
Golrisgashti, Darvish and Hosein	2018	Research Article	English	Iran	Linear Mathematical Modeling
Soltani, Inaloo, Rezai, Shaer and Riyabi	2019	Research Article	English	Iran	AHP with GIS
Zolfani, Yazdani, Torkayesh and Derakhti	2020	Research Article	English	Turkey	GRA (Gray Relational Analysis)
Adalı and Tuş	2019	Research Article	English	Turkey	TOPSIS, EDAS and CODAS
Şen and Demiral	2016	Research Article	English	Turkey	AHP and GRA
Kim, Senaratna, Ruza, Kam and Ng	2015	Research Article	English	USA	Evidence-based Decision Making with GIS
Şahin, Ocak and Top	2019	Research Article	English	Turkey	AHP
Şenvar, Otay and Boltürk	2016	Research Article	English	Turkey	Hesitant Fuzzy TOPSIS
Miç and Antmen	2019	Research Article	English	Turkey	Fuzzy TOPSIS
Kumar, Singh and Sinha	2016	Research Article	English	India	Fuzzy Extended ELECTRE
Şen	2017	Research Article	English	Turkey	ARAS-G (GRA)
Nsaif, Khaleel and Khateeb	2020	Research Article	English	Diyala Governorate	GIS-based MCA (Multi Criteria Analysis)
Çelikbilek	2018	Research Article	English	Turkey	Fuzzy VIKOR
Han, Hu and Wang	2020	Research Article	English	China	GIS with Set Covering Model

Table 3. Features of the researches which are included in the study

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AUTHORS	YEAR	TYPE OF STUDY	LANGUAGE	COUNTRY	METHOD
Yang, Yin, Ye, She and Yu	2020	Research Article	English	China	GIS with Maximal Covering Location Model
Rajmohan, Theophilus, Sumalatha and Saravanakumar	2017	Research Article	English	India	P-median Model
Demirtaş	2016	PhD Thesis	English	Canada	Maximal Covering Location Model
Ince, Bedir and Eren	2016	Research Article	Turkish	Turkey	AHP
Kmail, Jubran and Sabbah	2017	Research Article	English	Jenin Governorate (Palestine)	AHP with GIS-based MCA
Rezayee	2020	Research Article	English	Malaysia	GIS-based MCA
Paköz	2015	PhD Thesis	Turkish	Turkey	The Weighted Sum of Distances Method
Tierney, Mira, Reinhold, Arbia, Clifford, Auricchio, Moccetti, Peluso and Mengersen	2019	Research Article	English	Switzerland	Bayesian Spatial Model with Optimization Method

All of the studies included in this research are research studies, furthermore, two of the studies are doctoral dissertation and the remaining 21 of the studies are evaluated in the research article category. As shown in Figure 2, %91,3 of the studies (21 of the studies) included in the research were published in English.



## Figure 2. Distribution of the types of studies by its publication language

It was seen that %17,4 of the total included studies which are published in 2015 and 2018 used one single method in the decision-making process, while %39,15 of the total studies used multiple method in the decision-making process. The study, in which the most numerous decision-making methods used together which are three of multi-criteria decision-making methods, was published in 2019. As it can be seen in figure 3, it was seen that the year of publication with the highest number of studies included in the research in the relevant literature was 2016.

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Studies were categorized and analyzed according to the countries in which they conducted their research. As seen in Table 4, it was observed that the majority of the studies with %47,8 percentile carried out in Turkey. It is also observed that studies carried out in Turkey are followed by the researches conducted in China, India and Iran %8,7 percentile. Other locations where researches of the studies included in this study were conducted include Switzerland, Malaysia, Canada, Jenin Governorate, USA, Diyala Governorate, as it's shown in Table 4.

 Table 4. Distribution of studies by its country

Country	Amount	Percentage
Turkey	11	%47,8
Switzerland	1	%4,35
Malaysia	1	%4,35
Canada	1	%4,35
Jenin Governorate	1	%4,35
Diyala Governorate	1	%4,35
China	2	%8,7
India	2	%8,7
Iran	2	%8,7
USA	1	%4,35
Total	23	%100

The studies included in the research were categorized according to whether the facility location decision making method they used was a multi-criteria decision making technique and their distribution by years is shown in Table 5.

**Table 5.** Distribution of studies according to its method category and publication year

Publication Year	Amount of Studies in which MCDM Methods used	Amount of Studies in which Non-MCDM Methods used	Total
2015	1	1	2
2016	5	1	6
2017	2	1	3

2018	1	1	2
2019	4	1	5
2020	2	3	5
Total	15	8	23

According to Figure 4, %65,2 of the studies included to the research have used multi-criteria decision making techniques. %30,4 of the studies included to the research used fuzzy and gray theories in their decision making processes in order to make the use of certain judgment more appropriate to the real conditions of the sector and to be able to make more rational decisions. And also, it has been observed that all of the studies using fuzzy and gray theories use multi-criteria decision making techniques in their decision processes.



Figure 4. Distribution of studies according to its methods categories

The studies included in the research are divided according to what they have aimed and the distribution of their purposes is shown in Table 6. While all of the studies aimed to optimize the facility location, meanwhile, it was also observed that %65,2 of the studies aimed cost minimization, %47,8 of the studies aimed the maximum coverage for population, %34,8 of the studies aimed minimization of the time spent in accessing health services, and %30,4 of the studies aimed minimization of the effect of distance.

Table 6. Distribution of the studies according to its purposes

Purpose of the Study	Amount	Percentage
Maximum population coverage	11	%47,8
Minimizing the costs	15	%65,2
Minimizing the time to reach the services	8	%34,8
Minimizing the distance	7	%30,4
Optimal Location Selection	23	%100

# **3. DISCUSSION**

According to Yang, Yin, Ye, She, and Yu (2020), many studies have been carried out with traditional location selection methods in the past few decades, although most of the studies in this research use MCDM methods. The most popular of these traditional methods are the P-Median Model, set covering model and maximum covering location model which are applied in studies included. However, according to Şahin, Ocak and Top (2019) and Adalı and Tuş (2019), the use of MCDM methods was assumed to be more effective due to the selection of the establishment site is a complex process that requires considering many criterias, evaluating and ranking many alternatives. In addition, Miç and Antmen (2019) have stated in their study that it is more convenient to use fuzzy methods as the location selection process involves

many uncertainties. The data obtained in this research also supports that the researchers are more tended to use fuzzy methods. Moreover, most of the studies in the literature used methods addressing the uncertainty issue (Şen, 2017).

In the research it was seen that %39,15 of the studies have used multiple techniques/methods during their selection of facility location decision making processes. Similarly Erbay and Akyürek (2020) have observed that it is quite common to see the studies used more than one method in decision making process about facility location and have explained the situation with the complexity and risks of the facility location decisions.

According to Rezayee (2020), when the studies in the field are examined in terms of investors, they are considering the cost as an important criterion, when the studies are examined in terms of government and health organisations, they are considering the allocation of medical resources and the optimization of the match between the supply and demand of health services as an important criterian. Kmail, Jubran and Subbah (2017) also have supported that social aspect of health facilities are more important for government and public investors. In the research, it was seen that the included studies aimed at optimizing the facility location, as well as minimizing cost, time and distance, and maximizing population coverage. Similarly, Şen (2017) has stated that some studies in the literature focused on minimizing the density of the society -which its reason can be thought as a maximization of the population coverage- and the cost minimization. Erbay and Akyürek (2020) have stated in their study that the criteria for which the facility location is high is cost, accessibility, environment, safety and population structure. In addition, according to Gonçalves, Ferreira, Condessa (2014), in many studies in the literature, different location choices are seen quite frequently in order to minimize time-distance and cost-distance. Especially in private investments, aiming cost minimization in order to achieve profit maximization is seen as a very common situation and cost minimization takes its place as one of the most important factors in the selection of facility location.

# 4. CONCLUSION & RECOMMENDATIONS

In the study, it was aimed to examine the studies of facility location selection in health services conducted between 2015 and 2020, and 23 studies were included in the study as a result of the scaning procedures carried out by bringing some limitations. Almost all of the studies included (%91,3) preferred English as the language of publication. Although the studies performed show a very fluctuating graphic according to the years of publication, it was observed that the year in which the most studies (%26,1 of all included studies) were conducted was in the year of 2016.

The studies examined in the research have used multi-criteria decision making methods as well as traditional methods in their decision making processes. It was observed that %65,2 of the studies preferred multi-criteria decision making methods and %60,85 of the studies included used a single decision-making method in their processes. In addition, %34,8 of the studies included in the study -%46,7 of the studies in which MCDM methods were used- have included the uncertainty factor in decision-making processes with using fuzzy and gray theories. All of the studies examined within the scope of the research aimed the optimization of the facility location, but at the same time, it was observed that %65,2 of them aimed to reach cost minimization as a secondary purpose.

Facility location decisions are considered as long-term and high-risk investments in the literature. Considering the high expenditures in the health services sector and the social aspects of health services, it is necessary to identify and know well the situations that affect and interact with this decision process. For this reason, in the health care sector, which is affected by many different factors, especially the use of MCDM methods should be emphasized and it is thought that due to high complexity and uncertainty of health care sector, approaches such as fuzzy and gray theories should be used more in order to make more rational decision and to evaluate the status of alternatives more closely. It was determined that most of the studies included used only one single method in decision making. For subsequent studies, using more than one method and making comparisons between the results and making a decision or, using a new method/model in which several methods are adapted together and developed will be more beneficial as it will provide the opportunity to evaluate from different perspectives to decision makers. In addition, stating the type of investment (private, public, not-for-profit etc.) and the reason for choosing the method(s) used in the studies will provide a wider evaluation opportunity for future studies and decision-makers on facility location selection.

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