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Analytic hierarchy process for hospital site selection

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ABSTRACT

Aim: This study investigated a decision support model for site selection to establish a new hospital based on the analytic hierarchy process (AHP). The main purpose of this study was to select the best site for a hospital using this process in Muğla, Turkey.

Method: AHP was employed as the methodological tool for the selection of the site. The study was based on 6 criteria and 19 sub-criteria. All districts in the province of Muğla were evaluated as alternatives. These districts include: Bodrum, Dalaman, Datça, Fethiye, Kavaklıdere, Koyceğiz, Marmaris, Menteşe, Milas, Seydikemer, Ula, and Yatağan. The alternatives were ranked using a 1–9 Saaty scale. The analysis of the hierarchy model was conducted by using the Super Decisions 2.2.6 software program.

Results: Results show that demand is the most important factor in determining the appropriate hospital site, followed by accessibility, competitors, government, related industry and environmental conditions. According to the results, Bodrum was chosen to be the best site to establish a new hospital.

Conclusion: Due to limited resources in developing countries such as Turkey, it is critical that decisions are made as a result of scientific research. In this context, investors need to take into account some factors in line with this aim. The proposed evaluation criteria provide a reference for hospital administrators and investors in the selection of hospital sites using AHP.

Introduction

Site selection for the location of new hospital investments is one of the crucial policy-related decisions considered by government, health policy makers [1]. The priority of health services is to provide the right service to all people at all times in the right place and to be fair [2]. Selecting the optimal site is critical and important for effectiveness, quality, and equity of health care services [3,4]. It is also important for enterprise and health care users/customers. The choice for a hospital location is a tactical decision [5]. A top-quality hospital site selection will influence the overall functioning of the organization and will also support the strategy of production, finance, marketing, brand, and human resources, thus enhancing competitiveness and affecting organizational effectiveness and efficiency. Hospitals wanting to maintain a significant market share of the health care industry must be sensitive and pay close attention to the site selection [6] because it is important not only for initial investment, but also for future sustainability. Moreover, choosing an undesirable location will result in increased expenses and lead to a decrease in customer satisfaction due to its inability to meet customer needs. Therefore, in the optimal site selection process, many criteria must be considered. Because the problem of establishing a new hospital is a decision based on various environmental factors (demand situation, infrastructure investments, transportation etc.), for the solution, an objective method is needed where all the impressive factors are evaluated together rather than randomly or subjectively. Therefore, the choice of hospital location can be considered as a multi-criteria decision making (MCDM) problem [7].

Location selection is an investment that is irreversible or has a high return cost and requires the allocation of long-term funds. Appropriate decision-making tools and analytical skills are needed to determine the most appropriate facility site options for both physical area and growth method selection. Health facility managers or entrepreneurs follow these steps when determining a hospital site [8–10]:

- Determination of criteria for the evaluation of facility site selection (profits, market share, community characteristics, etc.)
- Determination of factors which are critically important
- The development of facility site options

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- Evaluation of facility site options
- The final decision

The AHP method is proposed to help the healthcare management and policy decision makers to select the most advantageous location for their new hospital investments in both the public and private sectors [11]. There are studies available regarding hospital site selection using AHP or its extended forms in countries other than Turkey. However, there is scant research using AHP or its extended forms in Turkish health services and health care organizations. Based on the review of existing literature, it can be inferred that few studies about hospital site selection have been conducted in Turkey where MCDM is used. This study investigated this gap in the literature by assessing potential hospital sites in the Turkish health care system and public health using AHP. The main purpose of this study was to select the best site for a hospital using the AHP in the Muğla province of Turkey. We also aim to establish criteria affecting the venue process and to determine the weight of the criteria.

Literature review

AHP is a method that can be used successfully in both subjective and objective evaluations. AHP, as proposed in this paper, can be a valuable tool in screening and prioritizing venue indicators. Decision makers can use the assessment of each division's priorities as determined by AHP so that, both today and in future investment decisions, these priorities will be valuable in evaluating various alternatives. AHP has seen extensive and on-going use in the evaluation and selection of medical technology, capital and information systems projects, project and technology evaluation, and the selection category with substantial activity in patient participation, therapy/treatment, and health care evaluation and policy [12]. AHP is "a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales" [13]. The AHP is a "model that a problem can be conceptualized and structured in it" [14]. The method has been used in a wide range of decision settings: to measure individuals' weightings of the medical ethical principles of beneficence, non-malfeasance, autonomy, justice, confidentiality, and veracity; to examine the importance of health information for patients with rare diseases [15]; to assess environmental impact [16]; to select a supplier [17,18]; to support group decision making [19,20]; and to evaluate performance [21,22].

AHP is a decision-making model that consists of three parts: identifying and organizing decision objectives, criteria, constraints and alternatives into a hierarchy; evaluating pairwise comparisons between the relevant elements at each level of hierarchy; and synthesizing using the solution algorithm of the result of the pairwise comparisons over all levels [23]. The AHP is a flexible, quantitative method for selecting among alternatives. The AHP approach is based on the relative performance of alternative projects or investments with respect to one or more criteria of interest [24,25]. The hierarchy of AHP is constructed through pairwise comparisons of individual judgments, rather than attempting to prioritize the entire list of decisions and criteria simultaneously [26,27].

While setting up a business, factors such as proximity to raw materials, military threats, etc. remain in the foreground, but when establishing a hospital, public health requirements are kept in the forefront [28]. This means that hospitals should be turned into a structure by prioritizing the needs of patients/customers in the best possible way. When people decide to buy products or services, i.e., when they need health services, they consider various elements. For example, people living in rural areas need to move to other areas in order to get access health services, and they will probably choose a hospital that optimally responds to their needs. Therefore, evaluation of factors, such as demand, environmental conditions, and accessibility, is very important in solving the various problems hospitals may encounter. Although the primary importance of the patients has been mentioned, hospitals are also enterprises, and, therefore, they should manage all of their resources considering environmental factors. Hospital site selection is affected by many factors, such as economic, political, cultural, geographic, environmental, demographic, costs, sales prices, related industries, and payer institutions [4,6,7,29].

The literature offers many different suggestions for site selection. For example, Özcan (2013) emphasizes that selection criteria should cover regional-social factors, costs associated with the establishment of the site, and non-financial factors. Soltani and Marandi (2011) reported that Virginia Hospital Center offers some criteria including population ratio, current and projected population density, proximity to main roads and public transport routes, distance to other hospitals, and impacts of the existing hospitals [6]. Schuurman et al. (2006) recommend that transport time, population density, and socio-demographic status of the region services to be served can be used as criteria [30]. According to Jalaliyoon et al. (2015), population, pollution, existing health centers, geological factors, economic factors, government policies and administrative laws and regulations should be taken into account in hospital site location and selection [31].

After reviewing the relevant literature, we concluded that the criteria and methods that should be used in selecting a site are not clear. In the present study, six criteria and sub-criteria widely accepted in the literature and used in many studies on the determination of the site selection are considered and shown in Table 1. Some sub-criteria were not found in other studies, but they were included because they were considered important, especially for Turkey. Detailed explanations about main and sub-criteria are discussed in the method section.

Hospital site selection is too complex to select with the traditional managerial tools [6,41,42], because this involves many factors to be measured and evaluated. Qualitative and quantitative factors affecting the hospital site selection are difficult to measure and assess. Quantitative evaluation of qualitative variables may cause serious problems [43]. Various techniques exist to handle these multi-criterion problems such as AHP, analytical network processes (ANP) and inner product vector (IPV) approaches. These use a pairwise comparison matrix to identify the importance between two attributes or data [29], for example, whether the population is more important than the rivals. İnce et al. 2016 [32], Chatterjee and Mukherjee 2013 [10], Soltani and Marandi 2011 [6], and Aydın et al. 2009 [8] argue that hospital health planners need to develop tools that help in the site selection, and one of these tools is AHP.

MCDA methods are generally divided into two groups. Firstly, the outranking methods use pairwise comparisons, a relation on a set of alternatives called the out-ranking relation, which is used to solve MCDA problems (choice, sorting, or ranking). This group covers the ELECTRE and PROMETHEE methods [44]. Seondly, the multi-attribute utility theory methods are used. These groups aim to build a numerical representation of the preferences of the decision maker on the set of alternatives. This category also covers the MAUT [45] and MACBETH methods. Another recent classification of MCDA includes 11 methods. These are 1) Multi-Attribute Utility Theory, 2) Analytic Hierarchy Process, 3) Fuzzy Set Theory, 4) Case-based Reasoning, 5) Data Envelopment Analysis, 6) Simple Multi-Attribute Rating Technique, 7) Goal Programming, 8) ELECTRE, 9) PROMETHEE, 10) Simple Additive Weighting, and 11) Technique for Order of Preference by Similarity to Ideal Solution [46].

Table 1
Hospital Facility Site Criteria Used in the Study.

Criteria	Sub-criteria	Researchers
Competitors	Medical technology	İnce et al. 2016 [32].
	Number of total beds	İnce et al. 2016 [32].
	Units	İnce et al. 2016 [32].
	Total hospitals	Chiu and Tsai 2013 [33]; Wu et al. 2007 [34]; 2009 [35]; Vahidnia et al. 2009 [36]; Sharmin and Neema 2013 [37]; Rahimi et al. 2017 [38]; Busief and Shouman 2012 [11].
Demand Factors	Population	Chiu and Tsai 2013 [33]; Wu et al. 2007 [34]; 2009 [35]; Vahidnia et al. 2009 [36]; Rahimi et al. 2017 [38]; Zhang et al. 2016 [40].
	Possibility of population change	İnce et al. 2016 [32].
	Population age structure	Wu et al. 2007 [34]; 2009 [35]; İnce et al. 2016 [32]
	Income	Aydın 2009 [9]; Chatterjee and Mukherjee 2013 [10].
Environmental conditions	Air pollution	Vahidnia et al. 2009 [36].
	Access to water resources	Oppio et al. 2016 [39].
Accessibility	Inner-city	Chiu and Tsai 2013 [33]; Soltani and Marandi 2011 [6]; Vahidnia et al. 2009 [36]; Sharmin and Neema 2013 [37]; Rahimi et al. 2017 [38]; Murad 2007 [2].
	Upstate	Chiu and Tsai 2013 [33]; Soltani and Marandi 2011 [6]; Vahidnia et al. 2009 [36]; Sharmin and Neema 2013 [37]; Rahimi et al. 2017 [38].
Related industry	Medical industry	Chiu and Tsai (2013), Soltani and Marandi (2011), Lin and Tsai (2009;2010)
	Medicine industry	Chiu and Tsai 2013 [33]; Wu et al. 2007 [34]; 2009 [35]; Lin and Tsai 2009 [41]; 2010 [42].
	Labor market	Wu et al. 2007 [34]; 2009 [35]; Lin and Tsai 2009 [41]; 2010 [42].
Government	Incentive	Wu et al. 2007 [34]; 2009 [35].
	LegislationPolicies	Wu et al. 2007 [34]; 2009 [35]; Lin and Tsai 2009 [41]; 2010 [42].
	Tax	Wu et al. 2007 [34]; 2009 [35]; Lin and Tsai 2009 [41]; 2010 [42].

Methodology

Case study

This study was planned and conducted to solve the decision-making problem regarding selecting the best alternative (site) to establish a new hospital. The research model is shown in Fig. 1.

Selection of the best hospital site problem can be solved in six steps. These steps are described below.

First step

Define the decision problem: The main problem of this study is to select a suitable site for the new public hospital.

Second step

Establish the working group: As a result of the evaluation, it was decided to get support from academicians who could extensively analyze the process of site selection appropriate for the study. Fifteen academicians were included in the working group. This group included faculty members of the department of health care management, health administration, and health institutions management. Seven percent of them were assistant professors with an average experience of ten years. Forty percent of the academicians were associate professors with a mean experience of 18 years. The remaining 53% were professors with a mean experience of 25 years. Their specialties included health care management, health policy, and health planning.

Third step

Determine the main and sub-criteria: For the selection of the hospital site, 6 main criteria and 19 sub-criteria were identified, which adhered to the literature review. These included:

- Competitors: One of the criteria used to determine the most appropriate site is the status of other hospitals operating in the region. In particular, the site for a new hospital may be decided taking into account the technology service departments, the total number of beds of the hospitals operating in the region, and the total number of hospitals. New hospitals can be established in the most appropriate place and can meet the needs of patients thorough expanding the range of services by the determination of the departments, medical technology, and devices not included in the existing hospitals. In this way, a hospital located in the most appropriate place can easily reach its goals and objectives. Therefore, the competitors in the region are taken into consideration in our research as one of the main criteria; total numbers of beds, the units, the competitors' medical technology, and the total number of hospitals were used as sub-criteria.
- Demand factors: It is compulsory to make effective demand forecasting in determining the location for a new hospital [8,9,32]. The basic characteristics of the population, such as age, sex, education, employment, the epidemiological situation [32–36,38,40], income level, family income, health insurance, and social class differences [9,10,32] should be examined in depth in determining the healthcare demand. Hospitals should be established in a place that health services can be marketed. This critically depends on accurate demand forecasts. Supply of health services is directly proportional to the intensity of the demand for the services [32–36,38,40]. The hospital's service mix elements can be determined according to the demand analysis. For example, demand analysis of some units are taken into account, such as maternity services or child health services for young people; neurological diseases services, geriatric services, cardiology intensive care units for the elderly population; and aesthetic surgery, aesthetic dental care and check-ups for patients with high income levels. Also the region's total population and the possibility of population change are the other factors determining the number of beds, size, and capacity of the hospital. Therefore, demand factors are taken into consideration in our research as one of the main criteria; the total population, population age structure, possibility of population change and income level are used as sub-criteria.
- Environmental conditions: Air quality (pollution and cleaning), noise pollution and access to water resources are some of the important criteria in determining the best hospital facility site. It is important for the environment of the hospital to be supportive for health while providing services to restore the health of individuals who have lost their health. If there is air pollution in the area where the hospital is

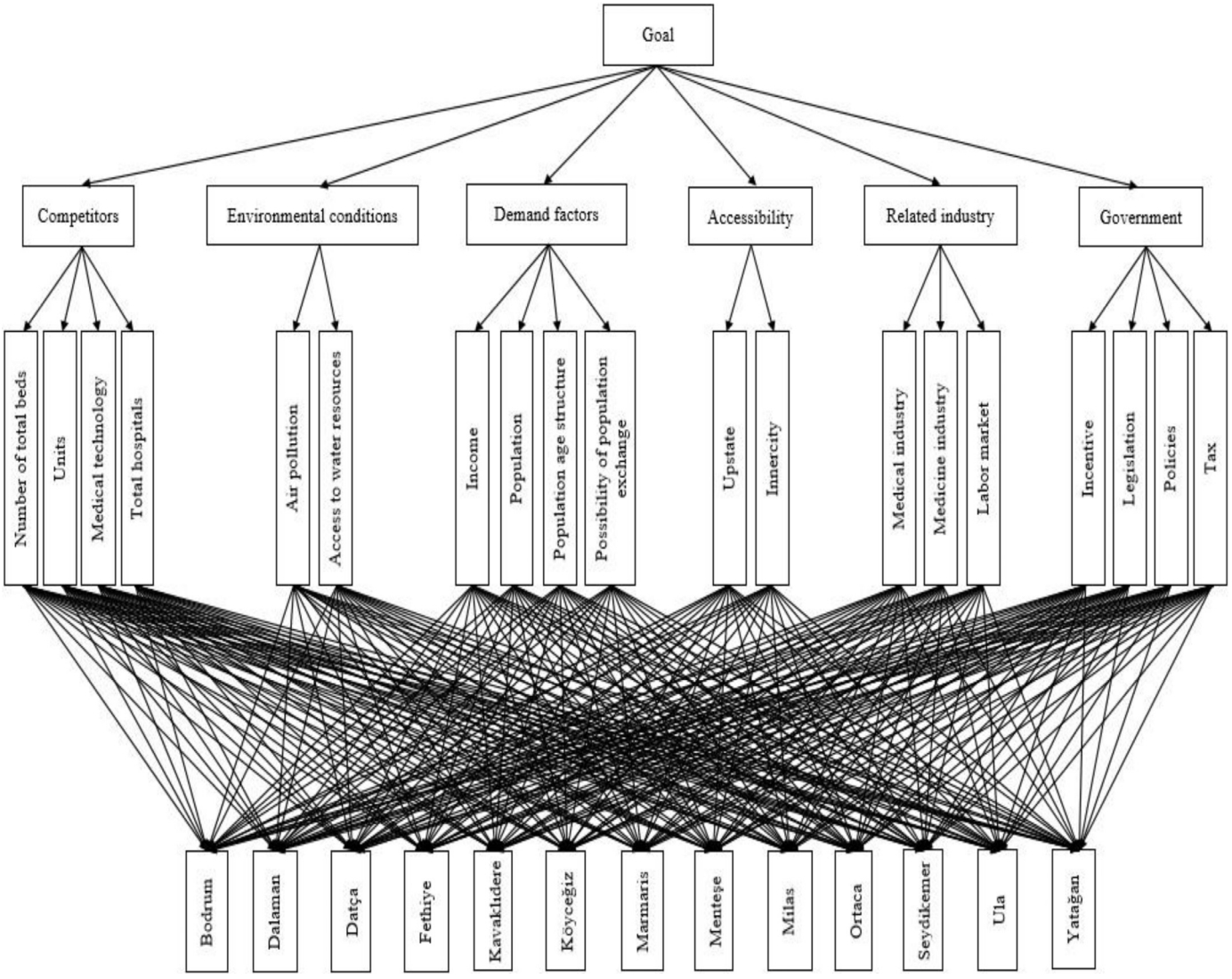

Fig. 1. AHP Model for Hospital Site.

established, the effectiveness of services provided to patients may decrease. For example, air pollution will negatively impact individuals with chronic obstructive pulmonary disease and it may prolong the duration of treatment. Likewise, hospitals are also required to provide sufficient water from freshwater resources. The water needs of hospitals are high. Therefore, it is important to select a site/region where the water supply is easily accessible. The use of polluted water will, of course, negatively affect the quality of hospital care. For these reasons, environmental conditions are a main criterion and air pollution and access to water resources are viewed as sub-criteria. However, noise pollution could not be included in the criteria because of lack of data.

- Accessibility: Transportation conditions should be positively assessed. It is especially important for the people who will benefit from the health services. Considering accessibility limits, establishment sites shall be determined as a place where individuals can arrive at the hospital as soon as possible in a reliable, and economic manner [32–36,38,40]. The literature indicates that distance and accessibility are effective in the use of health care. People living in remote regions use fewer health care services [9,10,32]. For these reasons, accessibility is used as one of the main criteria and transportation within the city and upstate transportation are viewed as sub-criteria.
- Related industry: In health services both finished and semi-finished materials are also used as input. If the supply of these materials is easily accessible, production of services also becomes rapid and efficient [32–36,38,40]. In addition, the ease of employing a sufficient number of qualified health professionals who are the main actors of health care production is an important factor to consider in the selection of the site of the hospital. Therefore, related industries are taken into consideration in our research as one of the main criteria; medical industries, medicinal industries, and the labor market are used as sub-criteria.
- Government: In the health care field, the density of government interference is very large. For example, government can interfere in different forms, such as allowing a new hospital to open at a specific site. Government is also involved in determining the quality of health care, principles of service delivery, qualifications and number of health professionals, and equipment. Furthermore the government supervises all of these services. In addition, the government also determines the private health business tax rates and investment incentives. Therefore, government is considered as

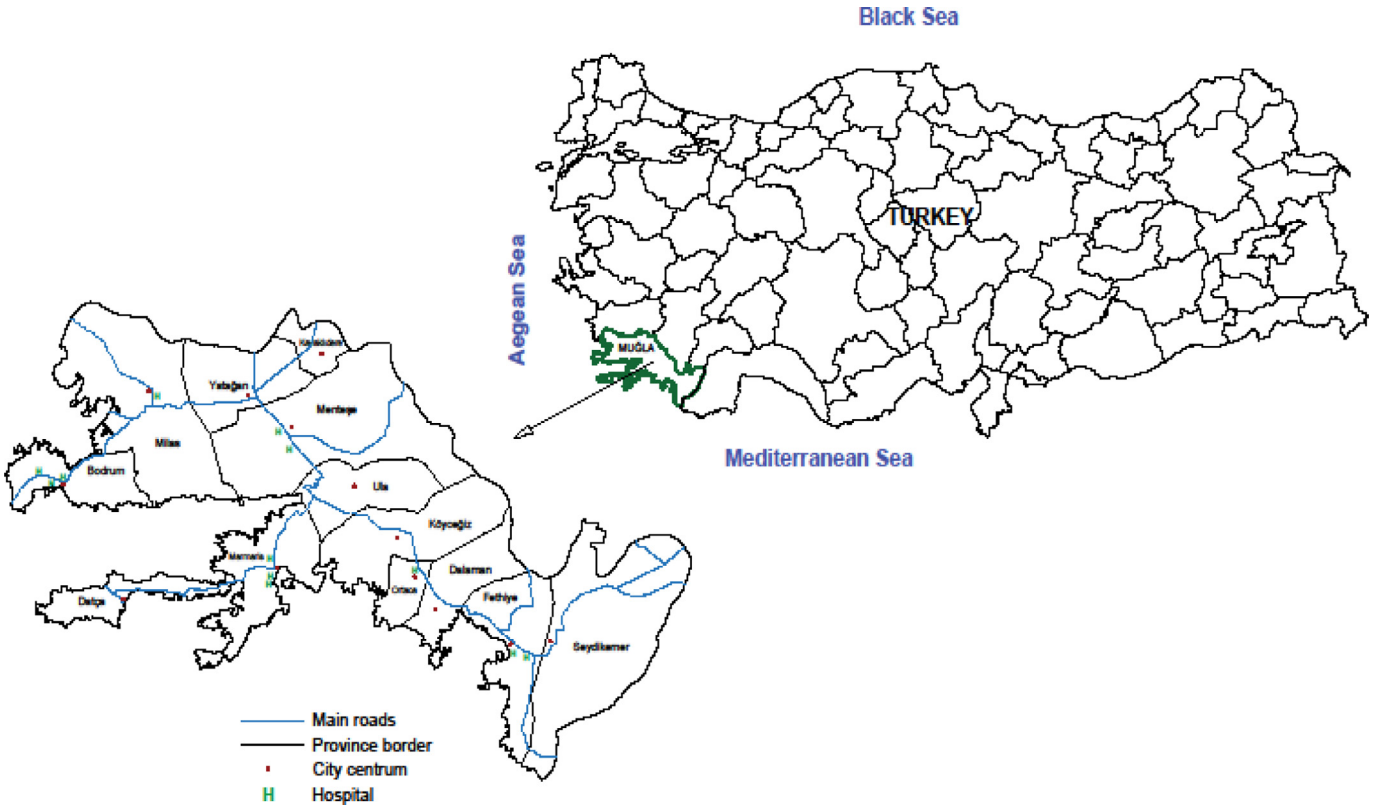

Fig. 2. The Location Map of the Muğla and It's Districts.

the final main criteria. The sub-criteria used in our search are the legislation of hospital organizations, health planning policies, investment incentives, and taxes [34,35,41,42].

Fourth step

Determination of alternatives: All districts in the province of Muğla were evaluated as alternatives. These districts are Bodrum, Dalaman, Datça, Fethiye, Kavaklıdere, Köyceğiz, Marmaris, Menteşe, Milas, Seydikemer, Ula, and Yatağan. One of the main reasons for choosing Muğla as a sample was the international tourism potential. More than three million international tourists visited Muğla in 2015, which was similar to the previous year [47]. The population of Muğla province was 908,877 in 2015 [48]. When an evaluation is made in terms of this data, it can be said that population fluctuation of the province is quite high. Additionally, Muğla is located in a mountainous region, and it has the longest coastline in Turkey [49]. It is assumed that this geographical structure may bring problems that communities may face in accessing health services. When all these conditions are evaluated, hospital site selection emerges as a major issue to meet the desired health care needs of the community in Muğla. Fig. 2 shows a map of the province of Muğla, where the study was conducted.

Fifth step

Making the comparison between criteria and alternatives: The working group evaluated the comparisons of the main and sub-criteria, according to the Saaty scale (using 1–9 to rate the relative importance of one criterion over another) [50]. The meanings of the numerical ratings are shown in Table 2. Next pairwise comparison matrices were formed and comparisons were made with the Super Decisions 2.2.6 software program. The relative scores provided by all decision makers were calculated with the geometric mean method and the relative weight of the elements of each level was estimated. All comparison matrixes were analyzed to determine the data consistency for each item. The consistency rate (CR) was less than 0.10 and Saaty suggests the value of CR should be less than 0.1. If the CR $\leq$0.1, the estimate is accepted; otherwise, a new comparison matrix is solicited until CR$\geq$0.1 [35,50,51].

Table 2
Pair wise Comparison Scale for AHP.

Intensity of judgments	Numerical rating
Extreme importance	9
Very strong importance	7
Strong importance	5
Moderate importance	3
Equal importance	1
For compromise between the above values	2,4,6,8

Resource: Kassab M. (2014) 'Early Effort Estimation for Quality Requirements by AHP'. In: Murgante B., Misra S., Rocha A.M.A.C., Torre C., Rocha J.G., Falcão M.I., Taniar D., Apduhan B.O. and Gervasi O. (eds.) **Computational Science and Its Applications-ICCSA** 2014. Springer, London.

First, the sub-criteria rates that affected the main criteria were identified. Results of the comparisons of sub-criteria are presented in Table 3. According to these data, the most important criterion for accessibility is inner city transportation; for demand factors, people's level of income; for environmental conditions, access to water resources; for government, policies; for related industry, labor market; and for competitors, medical technology.

Next the rates of the main criteria affecting the goals were identified. Results of the comparisons of main criteria are shown in Table 4. As shown in Table 4, the most significant criterion to select a new hospital site was the demand factor. The second significant criterion was accessibility, and the least important criterion was environmental conditions. Table 4 presents the main criteria arranged in descending order based on the statistical analysis.

Table 3
The Relative Importance of Sub-Criteria.

Criteria	Sub-criteria	Normalized	Idealized
Accessibility	Upstate	0.12500	0.14286
	Inner-city	0.87500	1.00000
Demand factors	Income	0.57524	1.00000
	Population	0.13714	0.23841
	Population age structure	0.11927	0.20735
	Possibility of population change	0.16835	0.29265
Environmental conditions	Access to water resources	0.83336	1.00000
	Air pollution	0.16664	0.20000
Government	Incentive	0.21867	0.52969
	Legislation	0.13235	0.32059
	Policies	0.41282	1.00000
	Tax	0.23616	0.57206
Related industry	Labor market	0.76411	1.00000
	Medical industry	0.12097	0.15832
	Medicine industry	0.11491	0.15039
Competitors	Medical technology	0.44552	1.00000
	Number of total beds	0.04458	0.10006
	Total hospitals	0.12241	0.27476
	Units	0.38749	0.86974

Table 4
The Pair Wise Comparisons of Main Criteria.

Name	Normalized	Idealized
Demand factors	0.41977	1.00000
Accessibility	0.28320	0.67464
Competitors	0.11260	0.26824
Related industry	0.05243	0.12490
Government	0.09122	0.21731
Environmental conditions	0.04078	0.09714

To make comparisons between alternatives, information was collected from the Provincial Directorate of Health, Directorate of Public Health and hospital and other related public office websites and digitized data were entered into the program. By the determination of the main and sub-criteria's weight, the best hospital location was determined through data analysis. A statistical analysis was used to determine the best site of the available locations and it was determined that Bodrum was the best location for construction of a new hospital in Muğla province. These results are shown in Fig. 2. Rankings of the other alternatives were, respectively, as follows: Datça, Marmaris, Menteşe, Fethiye, Ortaca, Dalaman, Kavaklıdere, Milas, Yatağan, Ula, Köyceğiz, and Seydikemer (Fig. 3).

Sixth step

The sensitivity analysis of the alternatives (districts) ranking was performed using the Super Decisions 2.2.6 software program. This analysis is useful in understanding the effect of changing weights of the main criteria on the ranking (Dweiri et al. 2016) of provinces. The scenarios are performed by changing the weight of a criterion as shown in Table 5 and explained below.

- Scenario 1. Sensitivity analysis with respect to accessibility:

Name	Graphic	Ideals	Normals	Raw
bodrum		1.000000	0.120145	0.040048
dalaman		0.585752	0.070375	0.023458
datça		0.891928	0.107161	0.035720
fethiye		0.692204	0.083165	0.027722
kavaklidere		0.583398	0.070092	0.023364
koycegiz		0.397559	0.047765	0.015922
marmaris		0.825577	0.099189	0.033063
menteşe		0.766140	0.092048	0.030683
milas		0.551893	0.066307	0.022102
ortaca		0.639850	0.076875	0.025625
seydikemer		0.357758	0.042983	0.014328
ula		0.503186	0.060455	0.020152
yatagan		0.528038	0.063441	0.021147

Fig. 3. Evaluation of All Alternatives According to the Criteria.

Table 5
Rank Differences by Scenarios.

Alternatives	Scenario 1		Scenario 2		Scenario 3	
	Rank	Weight	Rank	Weight	Rank	Weight
Bodrum	2	0.109	1	0.134	1	0.115
Dalaman	8	0.069	7	0.074	6	0.071
Datça	1	0.115	3	0.107	5	0.092
Fethiye	7	0.078	5	0.085	4	0.094
Kavaklıdere	5	0.083	11	0.054	7	0.071
Köyceğiz	12	0.049	12	0.043	11	0.059
Marmaris	3	0.092	2	0.112	2	0.096
Menteşe	4	0.086	4	0.095	3	0.095
Milas	10	0.064	8	0.070	13	0.056
Ortaca	6	0.080	6	0.077	10	0.062
Seydikemer	13	0.043	13	0.038	12	0.056
Ula	11	0.064	10	0.055	9	0.066
Yatağan	9	0.068	9	0.056	8	0.068

The first three district rankings changed from Bodrum, Datça, and Marmaris to Datça, Bodrum, and Marmaris when the accessibility weight on the goal was increased to 40%. The result is shown in Table 5.

- Scenario 2. Sensitivity analysis with respect to demand factor:

The first three district rankings changed from Bodrum, Datça, Marmaris to Bodrum, Marmaris, Datça when the demand factor weight on the goal was increased to 60%. The result is shown in Table 5.

- Scenario 3. Sensitivity analysis with respect to competitors:

The first three district rankings changed from Bodrum, Datça, Marmaris to Bodrum, Marmaris, Menteşe when competitors' weight on the goal was increased to 50%. The result is shown in Table 5.

Discussion and conclusion

Due to the limited resources in developing countries such as Turkey, it is critical that decisions are informed by the results of scientific research. Therefore, limited resources must be used efficiently in the right place at the right time. Feasibility and planning studies done incorrectly cause incompetence in choosing the correct location, and these costs, as a result, could threaten the future of the hospital. Making the appropriate site selection creates competitive advantages that make the difference between health enterprises. The best hospital site selection should be determined considering the macro and micro factors, which will serve effectively and efficiently for many years. Making the most appropriate hospital site selection will also contribute to the level of public health in the region.

In this context, while establishing a business, especially in regard to hospitals, making site-based work is important. It is thought that it may be possible through a number of decision techniques that will serve as a guide to the selection of the best places. In this paper, the relevant literature of hospital site selection was reviewed. This study presents an effective framework using AHP methods to select the most appropriate site for a new hospital in the Muğla province. We employed Super Decision 2.2.6 software to analyze all main and sub-criteria's weight and to answer our research question.

As a result of the analysis, demand factor is the most important criterion when selecting a new hospital site. Chiu and Tsai (2013) also found that demand had the highest scores for the selection of the hospital site [33] and according to Aydın et al.'s (2009) study, the most important criterion was demographic structure [8]. However, Wu et al. (2009) found that a demand condition is the criterion with the second highest score for selecting a hospital site in Taiwan [35]. As seen in the literature and analysis, it is apparent that demand is an important criterion for hospital site selection. Health care organizations have to plan how to meet the health services needs of the community, taking into account the availability of demand for services they produce.

Our research found that availability is the second most important criterion. The similarities from other research are noteworthy. Main roads, which will ensure access, have been identified as the highest criteria by some researchers. For example, Vahidnia et al. (2009) found that a main transport route is an important criterion and emphasized the importance of being close to the main roads [36]. Rahimi et al. (2017) in their study revealed that "proximity to the main roads" was the most important criterion among all of the applied criteria for selecting a hospital location in Shiraz, Iran [38]. According to Chiu and Tsai (2013), transportation was the fourth important criterion in this process. Time and convenience in reaching the hospital are important factors affecting the patient's satisfaction and are also important in intervening in a timely manner for emergencies [33].

The third most important criterion is the situation of competitors. In recent years, competition in health care with legal regulations in the health care industry in Turkey has been widely discussed. In particular, the principle of competition in services, which is the component of the health transformation program implemented by the Ministry of Health, has paved the way for provision of health services with different actors who must conform to certain standards, and, as a result, health service delivery has ceased to be a monopoly. Therefore, it could be argued that to research the status and the potential of competitors has become important. Recently in Turkey, many new hospitals, established by both the public and private sectors, have brought competition to the fore. The hospital's site in this competitive environment has become of major importance. It is, therefore, one of the most important issues to be considered in hospital site selection.

The fourth important criterion is government. As is known, government is a router, planner and position controller in the health service delivery. This is because health is a constitutional right in Turkey and health service has public aspects.

Related industry was found to be the fifth most important criterion in selecting a new hospital site, which differs somewhat from other research. For example, related industry is the third most important criterion in Chiu and Tsai's research [33], but the sixth most important criterion in Wu et al.'s study [35]. In our research, a labor market is the most important sub-criterion and the medical and medicinal industries are equally important criteria. Hospitals must consider factors to achieve the main production, such as medical technology, materials and drugs. If these elements cannot to be provided at the right time and place, disruptions and inefficiencies in service will occur.

Environmental conditions ranked as the least important criterion. Access to water resources was the most important and air pollution was the second most important sub-criterion. Hospitals should be established in areas with sufficient water and favorable weather conditions.

After the determination of criteria weights, comparisons between alternatives were evaluated. According to the results, Bodrum was chosen to be the best site to establish a new hospital. It was followed by the following districts: Datca, Marmaris, Menteşe, Fethiye, Ortaca, Dalaman, Kavaklıdere, Milas, Yatağan, Ula, Köyceğiz, and Seydikemer.

Finally, sensitivity analysis was performed to analyze the effect of changing the weights of the main criteria on the ranking of

districts. The differences in the ranking of districts was shown using three scenarios.

As a result of several key health policy reforms in Turkey, hospitals are now operating in a more competitive environment than ever before. Due to the high level of competition, hospitals need to achieve their mission and goals by identifying various strategies and tactics in relation to their competitors. Therefore, it is important that site selection decisions are made as a result of strategic management priorities that will provide a sustainable competitive advantage over their competitors. We expect that AHP research will continue to be an important component of health care management, policy and operation research. The results of our study can be useful for health policymakers, health economists, clinicians, and public and private investment decision makers to select the most suitable locations for constructing new hospitals in the future.

Limitations

We used a limited number of criteria and potential alternatives in this study. Some of potentially significant factors (land ownership, geographical information systems, etc.) affecting a hospital site selection were not included in the analysis. For example, land cost is one of the important criteria in this process. However, in this study we only evaluated the districts, and did not include specific locations within the areas. Other limitations of the study included the omission of data and information from state-owned hospitals. Furthermore, criteria were weighted by only academicians; we could not interact with the other experts. All of the location selection criteria could not be taken into account due to the problem of access to data. In most previous studies, all criteria were not considered. Therefore, the results cannot be generalized.

Future research directions

In future research, we recommend examining the suitability of other approaches and methods for the problem of hospital site selection. The weights obtained for the criteria should be revised in different sites and recalculated. For future research AHP, extended and fuzzy AHP, and geographical information systems (GIS) could be used in the location selection for different hospitals and other health organizations with a varied set of factors and sub-factors of evaluation in Turkey and other countries. The utilization of other MCDM methods, such as hesitant fuzzy AHP, hesitant fuzzy VIKOR, and hesitant fuzzy ELECTRE are suggested to examine location alternatives for hospital investments. In the choosing and weighting of criteria, the evaluation of opinions from academicians, experts, and stakeholders would be very useful. This is because AHP is a very vulnerable process in terms of external validity. Sensitivity analysis with AHP applications can be conducted for effective decision making in the Turkish hospital sector. In selecting the location of the city hospital investments made in Turkey it was applied, as detailed AHP modeling can be useful and effective in hospital location choices.

Compliance with ethical standards

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Conflict of interest

Authors declare that they have no conflict of interest.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Supplementary materials

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