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A combined fuzzy AHP and fuzzy TOPSIS based strategic analysis of electronic service quality in healthcare industry

Gülçin Büyüközkan *, Gizem Çifçi

Industrial Engineering Department, Faculty of Engineering and Technology, Galatasaray University, 34357 Ortaköy, İstanbul, Turkey

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ABSTRACT

Service sector is under pressure to deliver continuing performance and quality improvement while being customer-focused. In recent terms, there exists web based or electronic service quality (e-sq) concept. With the birth of electronic commerce, it has become important to be able to monitor and enhance e-sq. Therefore, this study will examine the e-sq concept and determine the key components of e-sq. The e-sq framework is employed by the aid of service quality (SERVQUAL) methodology as the theoretical instrument. Finally, proposed e-sq framework is illustrated with a web service performance example of healthcare sector in Turkey by using a combined multiple criteria decision making (MCDM) methodology containing fuzzy analytic hierarchy process (AHP) and fuzzy technique for order performance by similarity to ideal solution (TOPSIS). The work presented in this paper shows the applicability of the e-sq framework in explaining the complexity of aspects observed in the implementation of healthcare services via internet.

1. Introduction

From now on, firms must compete not only with internal firms, but also with external firms in today's global conditions. It is very important to get the whip hand of competition by providing the congruity of the services to the expectations of consumers. It is also important to achieve a desirable, qualified service because quality is achieved when the needs and expectations of the customer are met. By the meaning, the qualities of the services should be measured.

Also in recent terms there exists web based or e-service quality (e-sq) concept. With the birth of electronic commerce (e-commerce), it has become important to be able to monitor and enhance e-sq. So in this study, e-sq concept and the accompanying e-sq of healthcare sector are researched and analyzed. There are many affords to measure e-sq, but service quality (SERVQUAL) methodology (Brown, Churchill, & Peter, 1993; Cronin & Taylor, 1992; Parasuraman, Zeithaml, & Berry, 1985) is chosen because it is the most used and preferred methodology. Our aim is to adapt the SERVQUAL instrument to assess healthcare e-sq. While a significant body of academic literature exists on service quality in healthcare industry (Babakus & Mangold, 1992; Bakar, Akgün, & Al Assaf, 2008; Bowers & Kiefe, 2002; Chae, Kim, Tark, Park, & Ho, 2003; Chang, Hsiao, Huang, & Chang, 2011; Isaac, Zaslavsky, Cleary, & Landon, 2010; Lee, Delene, Bunda, & Kim, 2000; Li, 1997), little is known about e-sq (Bilsel, Büyüközkan, & Ruan, 2006; Bose, 2003; Chang, 2007; Chou & Chou, 2002; Gruca & Wakefield, 2004; Hadwich, Georgi, Tuzovic, Büttner, & Bruhn, 2010; Provost, Koompalum, Doong, & Martin, 2006).

To effectively evaluate e-sq, both qualitative and quantitative factors must be considered. Thus, e-sq performance measurement is a kind of multiple criteria decision making (MCDM) problem. This study includes a combined fuzzy analytic hierarchy process (AHP) (Saaty, 1980) and fuzzy technique for order performance by similarity to ideal solution (TOPSIS) (Hwang & Yoon, 1981) methods to measure e-sq performance. Fuzzy set theory aids (Zadeh, 1965) in measuring the ambiguity of concepts that are associated with human being's subjective judgment. Since the performance evaluations are done with decision makers' preferences, its evaluation must therefore be conducted in an uncertain, fuzzy environment. Also by applying AHP in obtaining criteria weight and TOPSIS in ranking, the comprehensiveness and reasonableness of the e-sq measurement process is strengthened.

The paper is organized as follows: In the second section, the background of e-sq is examined by literature survey. Then in the third section, e-sq concept is discussed in healthcare industry. After expressing the methodology of the study in section four, section five presents the case study. Finally, the sixth section concludes the paper.

2. Web based/electronic service quality concept (e-sq)

With the development of internet commerce the physical business unit has been replaced by a web site (Cristobal, Flavian, & Guinaliu,

* Corresponding author. Tel.: +90 212 227 4480.
E-mail addresses: gbuyukozkan2003@yahoo.com, gulcin.buyukozkan@gmail.com (G. Büyüközkan).

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2007). With the increase of web sites and the commercial internet invested in them, assessment of web site quality has highlighted its importance. Business organizations throughout the world invest time and money in order to develop and maintain user-perceived quality web sites. These web sites should provide an effective communication and information channel between companies and their customers (Grigoroudis, Litos, Moustakis, Politis, & Tsironis, 2008).

Measurement of service quality delivery through web sites is in its early stages comparing to traditional service quality (Zeithaml, 2002). The first formal definition of web site service quality, or e-sq was provided by Parasuraman, Zeithaml, and Malhotra (2002). In their terms, e-sq can be defined as the extent to which a web site facilitates efficient and effective shopping, purchasing, and delivery of products and services. As can be observed in this definition, the meaning of service is comprehensive and includes both pre- and post-web site service aspects. In order to deliver a high level of service quality, companies with web presences must first understand how customers perceive and evaluate online customer service. Although low price and web presence were thought to be as success drivers, service quality issues cannot be overemphasized.

As well as being information providers, web sites are also service providers. Therefore the literature on service quality is relevant to web sites, since information quality will be accompanied by a perception of service quality. The SERVQUAL instrument (Parasuraman et al., 1985) is a well-established model of service quality and has been used for the web based service quality assessment by several authors. Yoo and Donthu (2001) developed a nine-item SITEQUAL scale for measuring site quality on four dimensions: *ease of use, aesthetic design, processing speed,* and *security*. Parasuraman et al. (2002) identified 11 dimensions about e-sq as *reliability, responsiveness, access, flexibility, ease of navigation, efficiency, assurance/trust, security/privacy, price knowledge, site aesthetics, and customization/personalization*. Then after preliminary scale, sample design, data collection, data analysis; they go to scale reduction because the purpose was to produce a general scale that would be appropriate for assessing service quality of a variety of sites. And it resulted in four dimensions: *efficiency, fulfillment, system availability, privacy*. And lastly, again with the same iterative process, they created an e-ResSQ (e-recovery service quality scale) with three dimensions: *responsiveness* (effective handling of problems and returns through the site), *compensation* (the degree to which the site compensates customers for problems), *contact* (the availability of assistance through telephone or online representatives). As another research, Wolfinbarger and Gilly (2003) used online and offline focus groups, a sorting task, and an online-customer-panel survey to develop a 14-item scale called eTailQ. The scale contains four factors: *web site*, *reliability/fulfillment*, *privacy/security*, and *customer service*. Barnes and Vidgen (2006) developed a completely different scale to measure an organization's e-commerce offering, which they also call WebQual. This scale provides an index of a site's quality (customer perceptions weighted by importance) and has four factors: *usability, information quality, service interaction* and *overall*. Ladhari (2010) proposed a literature review on developing e-service quality scales and expressed that there is no consensus on the number and the nature of the dimensions in the e-sq construct; but globally six dimensions recur more consistently: *reliability/fulfillment*, *responsiveness*, *ease of use/usability*, *privacy/security*, *web design*, and *information quality*. Summary of several works are exist in Table 1 containing the factors for web sites to say that they deliver qualified services.

3. e-sq in healthcare industry

Quality assessment and control in healthcare date back to the mid-19th century. Healthcare quality has been one of the major issues facing healthcare providers, employees, employers, and governmental agencies (Chou & Chou, 2002). As the Internet has increased dramatically, the healthcare industry has recognized the benefits of integrating the Internet to improve their offered services. Hospital web sites are now being seen as appropriate media to facilitate information exchange between patients and providers. Therefore, more and more healthcare institutions are transferring some of their services on the Internet to further their often competing goals of increasing the quality of patient care and controlling costs (Bilsel et al., 2006).

If the healthcare service industry were similar to other industries that provide services for their customers, a patient could choose among many doctors who offer different prices, and provide service that differs in terms of medical technical quality or other service-related dimensions (Lee et al., 2000). However the reality differs in the healthcare sector that doctor choice is often made not by the patients individually. Referral from the patient's primary doctor, from his or her health organization, and/or from friends affects this choice. So, service recipients' perceptions toward service are valuable for improving healthcare service quality. As also ethics dictate that healthcare provider must provide the best and most appropriate care accessible to the patient, it should be endeavoured to have continuous quality improvements such as online service.

Hospital web sites are significantly important to deliver healthcare services to working citizens living in metropolises that might not spare enough time to meet healthcare needs (Bilsel et al., 2006). Nevertheless studies of e-sq remain limited. Researchers Bedell, Agrawal, and Petersen (2004) established criteria for excellence of web sites for diabetes. In their work web site quality evaluation is mainly based on *usability, content,* and *reliability*. Another research by Provost et al. (2006) represents WebMedQual for quality assessment of health web sites. It consists of dimensions such as *content, authority of source, design, accessibility, links, user support, confidentiality,* and *e-commerce*. Bilsel et al. (2006) proposed a fuzzy preference-ranking model for a quality evaluation of hospital web sites. *Tangibles, reliability, responsiveness, assurance, empathy, quality of information,* and *integration of communication* were their evaluation criteria. Chang (2007) studied on e-hospital web site measurement architecture approach and the measurement of website delivery service quality was based on *security, network capacity, data processing, operating performance,* and *database system* main-criteria. Recently, Patsioura, Kitsiou, and Markos (2009) evaluated the Greek public hospital web sites in their study and they identified two key categories for hospitals' web site evaluation as *information* and *communication and transaction*. Hadwich et al. (2010) proposed a study focusing on perceived quality of e-health services. They have identified three primary dimensions: potential, process, and outcome qualities. These primary dimensions are driven by 13 sub-dimensions: *accessibility*, *competence*, *information*, *usability/user friendliness*, *security*, *system integration*, *trust*, *individualization*, *empathy*, *ethical conduct*, *degree of performance*, *reliability*, and *ability to respond*. In these studies, researchers that develop e-sq scales have taken a combination of traditional sq dimensions, often based on the SERVQUAL instrument, and web interface quality dimensions as a starting point.

4. Research design

According to all literature surveys in Sections 2 and 3, our dimensions for evaluating web based healthcare service quality are determined as *tangibles, responsiveness, reliability, information quality, assurance,* and *empathy*.

In e-sq *tangibles* (Aladwani & Palvia, 2002; Bilsel et al., 2006; Li, Tan, & Xie, 2002) mean physical attributes, animations and

Table 1
Overview of authors' dimensions in e-sq.

e-sq dimensions	Studies in literature
Tangibles	Aladwani and Palvia (2002), Li et al. (2002), and Bilsel et al. (2006)
Responsiveness/fulfillment	Li et al. (2002), Wolfinbarger and Gilly (2003), Rabinovich and Bailey (2004), Bilsel et al. (2006), Ladhari (2010), and Hadwich et al. (2010)
Compensation	Parasuraman, Zeithaml, and Malhotra (2005)
Customer service/empathy	Li et al. (2002), Wolfinbarger and Gilly (2003), Barnes and Vidgen (2006), Bilsel et al. (2006), Cristobal et al. (2007), Grigoroudis et al. (2008), and Hadwich et al. (2010)
Assurance/trust	Ma, Pearson, and Tadisina (2005), Barnes and Vidgen (2006), Bilsel et al. (2006), Ahn et al. (2007), Cristobal et al. (2007), and Hadwich et al. (2010)
Usability/ease of use	Yoo and Donthu (2001), Yang et al. (2001), Yang, Cai, Zhou, and Zhou (2005), Grigoroudis et al. (2008), Ladhari (2010), and Hadwich et al. (2010)
Design/aesthetic design	Szymanski and Hise (2000), Wolfinbarger and Gilly (2003), Iwaarden et al. (2004), Provost et al. (2006), Cristobal et al. (2007), and Ladhari (2010)
Information quality/ability/ content	Li et al. (2002), Aladwani and Palvia (2002), Yang, Cai, Zhou, and Zhou (2005), Bilsel et al. (2006), Provost et al. (2006), Ahn et al. (2007), Grigoroudis et al. (2008), Ladhari (2010), and Hadwich et al. (2010)
Reliability	Li et al. (2002), Wolfinbarger and Gilly (2003), Rabinovich and Bailey (2004), Ma et al. (2005), Barnes and Vidgen (2006), Bilsel et al. (2006), Provost et al. (2006), and Ladhari (2010)
Security/privacy	Szymanski and Hise (2000), Yoo and Donthu (2001), Yang et al. (2001), Ma et al. (2005), Ahn et al. (2007), and Ladhari (2010)
Order management/ effectiveness	Iwaarden et al. (2004) and Cristobal et al. (2007)
Interactivity/integration of communication	Bilsel et al. (2006), Yang et al. (2005), Barnes and Vidgen (2006), Ahn et al. (2007), and Grigoroudis et al. (2008)
Accuracy	Lociacono, Watson, and Goodhue (2000), Li et al. (2002), Aladwani and Palvia (2002), Ahn et al. (2007), and Grigoroudis et al. (2008)
Web site performance	Szymanski and Hise (2000), Rabinovich and Bailey (2004), Iwaarden et al. (2004), Yang et al. (2005), Ahn et al. (2007), Grigoroudis et al. (2008), and Hadwich et al. (2010)
Innovation	Lociacono et al. (2000)
Technical service/adequacy	Yoo and Donthu (2001), Aladwani and Palvia (2002), Yang et al. (2005), Ma et al. (2005), and Grigoroudis et al. (2008)
Flexibility	Ma et al. (2005)

appearance of site. With tangibles dimension, these are evaluated for the web site. It can be demonstrated as suitable infrastructure of the web site includes design, ease of use and functionality. Web sites should have ability to appeal to a universal audience by multilingual translations, should declaim to people of different ages, should have aesthetic, should operate or execute the commands of the customer, and should be used easily by user. It is directly related with human & computer interaction. This dimension (and criteria) carries weight with users for visual aspect and is the only evaluates the appeal of the site.

Responsiveness (Bilsel et al., 2006; Hadwich et al., 2010; Ladhari, 2010; Li et al., 2002; Wolfinbarger & Gilly, 2003) means willingness to help customers and provide prompt service accurately and consistently. It includes customer service, the ability to get help if there is a problem or question, and effective handling of problems and returns through the site. Criterion interactivity is critical, and providing this website-user meeting is so important for hospital websites to serve briefing to the customers, online help, etc. Also today, users expect sites to be more rapid, due to the technological advances. On the other hand, they want hospital web sites to be visually appealing with pictures, sounds, animations related to site or medicine, and that makes the site and its' services slow. So according to us, technical performance is also critical to provide good customer service via the Internet with being available and quick.

The dimension *reliability* (Bilsel et al., 2006; Grigoroudis et al., 2008; Hadwich et al., 2010; Iwaarden, Wiele, Ball, & Millen, 2004; Ladhari, 2010; Li et al., 2002) is determined as the quality of being credible of the web site. If customers cannot trust an organization to do what they ask, they will be dissatisfied, and this can be provided by criteria specialization, standardization, reputation, accuracy of service. If hospital web site is clear about policy, has repute in media or environment, has authority, and provides its services accurately then people can put faith in that web site, and will come again.

Information quality (Bilsel et al., 2006; Grigoroudis et al., 2008; Hadwich et al., 2010; Ladhari, 2010; Li et al., 2002; Provost et al., 2006; Yang, Peterson, & Huang, 2001) represents the information featured in hospital web sites. Customers expect to find everything they want on the web site as hospitals and doctors' data, medical news, etc. So the richness of content and also the accuracy of the information are vital for the web site. For good service, web sites should contain consistent, relevant and up-dated information about hospital and services.

In traditional service quality, assurance dimension defines knowledge and courtesy of employees and their ability to inspire trust and confidence. As web sites are members of imaginary world, in e-sq, *assurance* (Ahn, Ryu, & Han, 2007; Bilsel et al., 2006; Cristobal et al., 2007) does not contain courtesy by physically, means the guarantee and confidence that the customer feels in dealing with the site. Users share personal information with an organization they do not know well, and at this time security/privacy comes into question. Also the criterion, the degree to which the organization compensates to users' problems as returning customers money, etc., is one of the issues contained in assurance of the web sites. The more customers feel safe and trust the site, the more qualified it will be.

In e-sq, *empathy* (Bilsel et al., 2006; Cristobal et al., 2007; Grigoroudis et al., 2008; Hadwich et al., 2010; Iwaarden et al., 2004; Provost et al., 2006; Wolfinbarger, & Gilly, 2003) symbolizes, the same way as in traditional service quality, caring and understanding the customer. Also individualized attention that the hospital provides to its patients through the web site is the important point in empathy. So the hospital can know more about their patients/visitors and about meeting their needs. It includes adapting individual customers' preferences, histories, etc. Availability of links to other health institutions, or other health related web sites should be in a hospital web site as the same way. So these issues compose our criteria and attributes for evaluating the web site service quality. The summary view of e-sq criteria for hospital web site evaluation can be seen in Table 2.

5. Hybrid methodology of the study

There are several methods for evaluating service quality such as statistical approaches (Collier & Bienstock, 2006; Cristobal et al.,

Table 2
e-sq evaluation criteria for hospital web sites.

Criteria	Sub-criteria	Definition
Tangibles (C1)	Usability (C11)	Ease of use and navigation in site (Grigoroudis et al., 2008; Hadwich et al., 2010; Ladhari, 2010; Ma et al., 2005; Patsioura et al., 2009; Yang et al., 2005; Yoo & Donthu, 2001)
	Animation (C12)	Presentation of information about site, medical services, etc.
	Design (C13)	Aesthetic and graphical design of the site, appearance (Cristobal et al., 2007; Grigoroudis et al., 2008; Iwaarden et al., 2004; Ladhari, 2010; Provost et al., 2006; Yoo & Donthu, 2001)
	Functionally (C14)	Ability to appeal to a universal audience, operating or executing the commands of the customer (Chang, 2007; Grigoroudis et al., 2008; Ma et al., 2005)
Responsiveness (C2)	Customer service (C21)	Willingness and availability of help-frequently asked questions (Bilsel et al., 2006; Cristobal et al., 2007; Grigoroudis et al., 2008; Li et al., 2002; Provost et al., 2006).
	Technical performance (C22)	Quick/on time service process, speed, availability (Chang, 2007; Grigoroudis et al., 2008; Hadwich et al. 2010; Ma et al., 2005; Yang et al., 2005; Yoo & Donthu, 2001)
	Interactivity (C23)	Contact to customers against to problems, online appointment (Bilsel et al., 2006; Grigoroudis et al., 2008; Li et al., 2002; Patsioura et al., 2009)
Reliability (C3)	Specialization (C31)	Authority of staff providing reliability (Bedell et al., 2004; Hadwich et al. 2010)
	Standardization (C32)	Clearness of procedures, policies on the website
	Reputation (C33)	Knowledgeable of the hospital, site, rewards-advertisement
	Accuracy of service (C34)	Performing service accurately (Ahn et al., 2007; Grigoroudis et al., 2008; Li et al., 2002)
Information quality (C4)	Information richness (C41)	Comprehensive content of the information providing all about services and personnel (Bilsel et al., 2006; Grigoroudis et al., 2008; Li et al., 2002; Patsioura et al., 2009)
	Information accuracy (C42)	Clearness, consistency and relevancy of the information content (Ahn et al., 2007; Grigoroudis et al., 2008; Hadwich et al. 2010; Li et al., 2002; Patsioura et al., 2009)
	Information up-date (C43)	Currency of information presented web site (Bedell et al., 2004; Bilsel et al., 2006)
Assurance (C5)	Compensation (C51)	The degree to which the site compensates customers for problems (Parasuraman et al., 2005)
	Trust (C52)	Confidence the customer feels in dealing with the site (Ahn et al., 2007; Barnes & Vidgen, 2006; Bilsel et al., 2006; Cristobal et al., 2007; Hadwich et al. 2010)
	Security/privacy (C53)	Security of web site environment, protection of every type of customers' data as credit card, contact (Ahn et al., 2007; Chang, 2007; Hadwich et al. 2010; Ladhari, 2010; Ma et al., 2005; Yoo & Donthu, 2001)
Empathy (C6)	Customer care (C61)	Care and guidelines to the customers (Bilsel et al., 2006; Patsioura et al., 2009)
	Links (C62)	Availability of links to other health institutions, or other health related web sites (Bedell et al., 2004; Bilsel et al., 2006)
	Customization (C63)	Individualized attention to customers, adapting customers' histories (Bilsel et al., 2006; Hadwich et al. 2010)

2007; Li et al., 2002), quality function deployment (QFD) (Li et al., 2002), multi criteria satisfaction analysis for benchmarking analysis (Grigoroudis et al., 2008), AHP (Liu, Bishu, & Najjar, 2005), AHP and fuzzy PROMETHEE (Bilsel et al., 2006). In this study, AHP and TOPSIS methods are used in fuzzy environment. As the e-sq perceptions are resulted from different people's view of linguistic variables, it must be conducted in an uncertain, fuzzy environment. Also fuzzy AHP and fuzzy TOPSIS methods are powerful and widely used tools for evaluating and ranking problems containing multiple criteria (Dağdeviren, Yavuz, & Kılınç, 2009; Onüt, Efendigil, & Kara, 2010). Although there are several studies that combine these two methods in fuzzy environment, service quality evaluation studies are limited in literature. Tsaur, Chang, and Yen (2003) used fuzzy set theory, AHP and TOPSIS together for evaluation of airline service quality. Similarly, Büyüközkan and Ruan (2007) evaluated government websites based on these fuzzy MCDM tools. Fig. 1 depicts the evaluation framework of the study based on this hybrid methodology.

5.1. Fuzzy sets and fuzzy numbers

Fuzzy set theory is a mathematical theory pioneered by Zadeh (1965), which is designed to model the vagueness or imprecision of human cognitive processes. The key idea of fuzzy set theory is that an element has a degree of membership in a fuzzy set (Negoita, 1985; Zimmermann, 1985). A fuzzy set is defined by a membership function that maps elements to degrees of membership within a certain interval, which is usually [0, 1]. If the value assigned is zero, the element does not belong to the set (it has no membership). If the value assigned is one, the element belongs completely to the set (it has total membership). Finally, if the value lies within the interval, the element has a certain degree of membership (it belongs partially to the fuzzy set) (Ayağ, 2005). Fig. 2 and Table 3 show the structure of triangular fuzzy numbers that are used in this paper.A fuzzy number is a special fuzzy set $A = \{(x, \mu\widetilde{A}(x)), x \in R\}$, where x takes values on the real line, R: $-\infty < x < +\infty$ and $\mu\widetilde{A}(x)$ is a continuous mapping from R to the closed interval [0, 1]. A triangular fuzzy number denoted as $\widetilde{A} = (l, m, u)$, where $l \leqslant m \leqslant u$, has the following triangular-type membership function:

$$\mu_{\widetilde{A}}(x) = \begin{cases} 0, & x \prec 1 \text{ or } x \succ u \\ \frac{x-l}{m-l}, & l \leqslant x \leqslant m \\ \frac{u-x}{u-m}, & m \leqslant x \leqslant u \end{cases} \quad (1)$$

Alternatively, by defining the interval of confidence level α, the triangular fuzzy number can be described as

$$\forall \alpha \in [0,1] \quad \widetilde{A}_\alpha = [l^\alpha, u^\alpha] = [(m-l)\alpha + l, -(u-m)\alpha + u] \quad (2)$$

5.2. The fuzzy AHP methodology

The AHP (Saaty, 1980) is a quantitative technique that structures a multi-attribute, multi-person and multi-period problem hierarchically so that solutions are facilitated. One of the main advantages of this method is the relative effectiveness with which it handles multiple criteria. It can effectively handle both qualitative and quantitative data (Kahraman, Cebeci, & Ruan, 2004). Even though the aim of AHP is to capture the expert's knowledge, the conventional AHP still cannot reflect the ambiguity in human thinking style. Therefore, fuzzy AHP, a fuzzy extension of AHP, was developed to solve the hierarchical fuzzy problems and many fuzzy AHP methods by various authors are proposed (Chamodrakas, Batis, & Martakos, 2010; Durán & Aguilo, 2008).

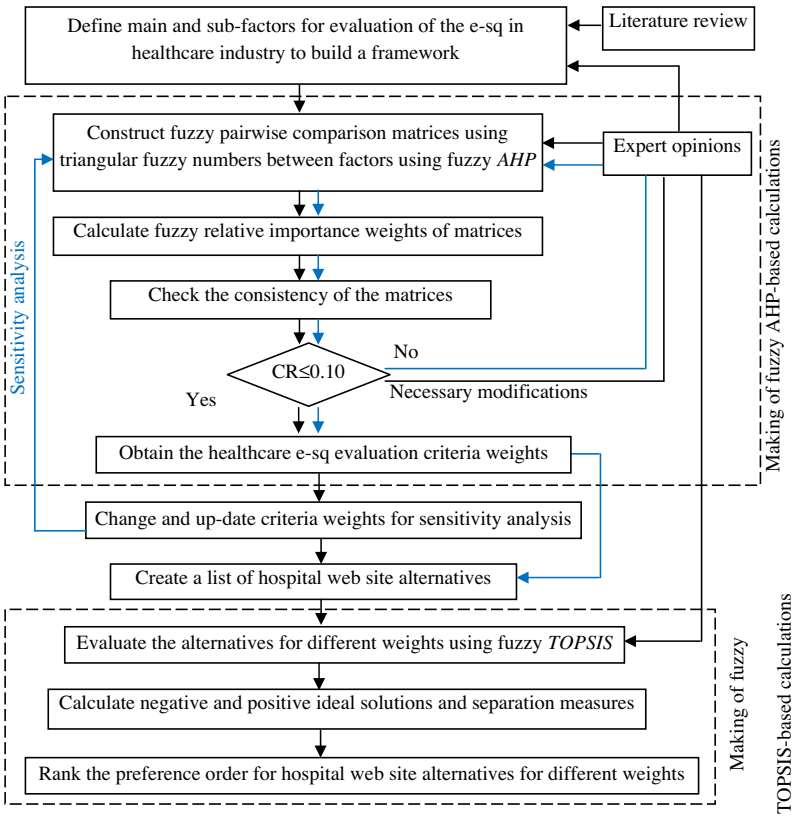

Fig. 1. Evaluation framework of e-sq performance evaluation.

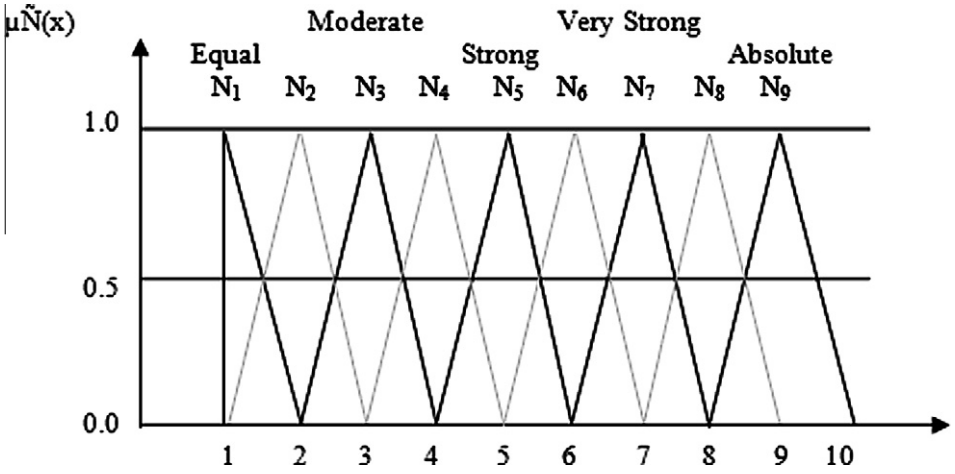

Fig. 2. Fuzzy membership function for linguistic values.

The proposed approach (Ayağ, 2005) can be explained with five steps. In the first step, the performance scores are compared. Linguistic terms are used to indicate the relative strength of each pair of elements in the same hierarchy.

Then in the second step, the fuzzy comparison matrices are constructed. By using triangular fuzzy numbers, via pair-wise comparison, the fuzzy judgment matrix $\tilde{A}$ is constructed as given below:

$$\tilde{A} = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ \tilde{a}_{21} & \tilde{a}_{22} & \dots & \tilde{a}_{2n} \\ \vdots & & & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \dots & \tilde{a}_{nn} \end{bmatrix} \quad (3)$$

where $\tilde{a}_{ij}^{\alpha} = 1$, if i is equal to j, and $\tilde{a}_{ij}^{\alpha} = \tilde{1}, \tilde{3}, \tilde{5}, \tilde{7}, \tilde{9}$ or $\tilde{1}^{-1}, \tilde{3}^{-1}, \tilde{5}^{-1}, \tilde{7}^{-1}, \tilde{9}^{-1}$, if i is not equal to j.

In the third step, the fuzzy eigenvalues are solved. A fuzzy eigenvalue, $\tilde{\lambda}$, is a fuzzy number solution to:

$$\tilde{A}\tilde{x} = \tilde{\lambda}\tilde{x} \quad (4)$$

where $\tilde{\lambda}_{\max}$ is the largest eigenvalue of $\tilde{A}$ and $\tilde{x}$ is a non-zero $n \times 1$, fuzzy vector containing fuzzy number $\tilde{x}_i$. To perform fuzzy multiplications and additions by using the interval arithmetic and α-*cut*, the equation $\tilde{A}\tilde{x} = \tilde{\lambda}\tilde{x}$ is equivalent to:

$$[a_{i1l}^{\alpha}x_{1l}^{\alpha}, a_{i1u}^{\alpha}x_{1u}^{\alpha}] \oplus \dots \oplus [a_{inl}^{\alpha}x_{nl}^{\alpha}, a_{inu}^{\alpha}x_{nu}^{\alpha}] = [\lambda x_{il}^{\alpha}, \lambda x_{iu}^{\alpha}]$$

where,

$$\widetilde{A} = [\tilde{a}_{ij}^{\alpha}], \tilde{x}^{t} = (\tilde{x}_1, \ldots, \tilde{x}_n),$$

$$\tilde{a}_{ij}^{\alpha} = [a_{ijl}^{\alpha}, a_{iju}^{\alpha}], \tilde{x}_{ij}^{\alpha} = [x_{il}^{\alpha}, xj_{1u}^{\alpha}], \tilde{\lambda}^{\alpha} = [\lambda_l^{\alpha}, \lambda_u^{\alpha}] \quad (5)$$

for $0 < \alpha \leqslant 1$ and all i, j, where $i = 1, 2, \ldots, n$, $j = 1, 2 \ldots, n$.

The α-*cut* is known to incorporate the experts or decision-maker(s) confidence over his/her preferences. The degree of satisfaction for the judgment matrix $\widetilde{A}$ is estimated by the index of optimism μ. A larger value of the index μ indicates a higher degree of optimism. The index of optimism is a linear convex combination defined as (Lee, 1999):

$$\tilde{a}_{ij}^{\alpha} = \mu a_{ijl}^{\alpha} + (1-\mu) a_{ijl}^{\alpha}, \quad \forall \alpha \in [0,1] \quad (6)$$

When α is fixed, the following matrix can be obtained after setting the index of optimism, μ, in order to estimate the degree of satisfaction:

$$\widetilde{A} = \begin{bmatrix} \tilde{a}_{11}^{\alpha} & \tilde{a}_{12}^{\alpha} & \ldots & \tilde{a}_{1n}^{\alpha} \\ \tilde{a}_{21}^{\alpha} & \tilde{a}_{22}^{\alpha} & \ldots & \tilde{a}_{2n}^{\alpha} \\ \vdots & & & \vdots \\ \tilde{a}_{n1}^{\alpha} & \tilde{a}_{n2}^{\alpha} & \ldots & \tilde{a}_{nn}^{\alpha} \end{bmatrix} \quad (7)$$

The eigenvector is calculated by fixing the μ value and identifying the maximal eigenvalue.

In the forth step, in order to control the result of the method, the consistency ratio for each of the matrices and the overall inconsistency for the hierarchy are calculated. The CR (Consistency Ratio) is used to directly estimate the consistency of the pairwise comparisons as:

$$\mathrm{CR} = \mathrm{CI}/\mathrm{RI}, \quad \text{where } \mathrm{CI} = \frac{\lambda_{\max} - n}{n-1} \quad (8)$$

And CR should be less than 0.10. Then it can be said the comparisons are acceptable, otherwise they are not acceptable and should be revised.In the fifth and the last step, the priority weight of each alternative can be obtained by multiplying the matrix of evaluation ratings by the vector of attribute weights and summing over all attributes.

5.2.1. Sensitivity analysis

Because the priorities are highly dependent on subjective judgments of the decision makers, the stability of the final ranking under varying the determinant weights should be checked out. For this reason, it is better to perform a sensitivity analysis based on a set of scenarios that reflect different views on the relative importance of the determinants. By this means, sensitivity analysis provides information on the stability of the ranking. If the ranking is highly sensitive to small changes in the criteria weights, a careful review of the weights is recommended.

According to certain studies in literature (Ayağ & Özdemir, 2009; Chang, Wu, Lin, & Chen, 2007; Wu, Lin, & Chen, 2007), sensitivity analysis is performed by increasing the weight of each criterion individually according to the results obtained from fuzzy AHP steps. Then with these different scenarios, fuzzy TOPSIS steps are performed and the resulting changes of the alternatives are observed.

5.2.2. The fuzzy TOPSIS methodology

Similarly for the same reason that human judgments are usually rely on imprecision, subjectivity and vagueness, subsequently fuzzy extension of TOPSIS method is needed. First to mention, TOPSIS is a multiple criteria method to identify solutions from a finite set of alternatives and initially proposed by Chen and Hwang (1992). The underlying logic of TOPSIS proposed by Hwang and Yoon (1981) is to define the ideal solution and negative ideal solution. The optimal solution should have the shortest distance from the positive ideal solution and the farthest from the negative ideal solution. A number of fuzzy TOPSIS methods and applications have been developed in recent years (Chen & Tsao, 2007; Gligoric, Beljic, & Simeunovic, 2010; Yong, 2006).

Here in fuzzy TOPSIS, evaluations expressed by linguistic terms and then set into fuzzy numbers. Fuzzy TOPSIS methodology requires preliminarily information about the relative importance of the criteria. This importance is expressed by attributing a weight to each considered criterion w_j. The weight of each criterion is evaluated by fuzzy AHP. The technique is adapted from Chen (2000) and the steps of the methodology are as follows.

Step 1: Establish fuzzy decision matrix for evaluation of the hospital web site alternatives. With m alternatives and n criteria, fuzzy MCDM problem can be expressed as:

$$\widetilde{D} = \begin{array}{c} \\ H_1 \\ H_2 \\ H_3 \\ H_4 \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \vdots & \ddots & & \\ \vdots & & \ddots & \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix} \end{array} \quad (9)$$

where $\widetilde{D}$ represents the fuzzy decision matrix with alternatives H and criteria C.

Step 2: Normalize the decision matrix. Normalized fuzzy decision matrix $\tilde{R}$ is calculated as:

$$\widetilde{R} = [\tilde{r}_{ij}]_{m*n}, \quad i = 1, 2, \ldots, m; \; j = 1, 2, \ldots, n$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{C_j^+}, \frac{b_{ij}}{C_j^+}, \frac{c_{ij}}{C_j^+} \right) \quad \text{where } C_j^+ = \max_i C_{ij}. \quad (10)$$

To avoid the complicated normalization formula used in the classical TOPSIS, the linear scale transformation is used to transform the various criteria scales into a comparable scale (Chen, 2000). Linear scale transformation for normalization is also employed by other authors (Celik, Cebi, Kahraman, & Er, 2009; Kuo, Tzeng, & Huang, 2007).

Step 3: Compute weighted decision matrix. Weighted normalized fuzzy decision matrix is computed by using Eq. (11), where w_j is the weight for the criterion j obtained from supermatrix.

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes \tilde{w}_j, \quad (11)$$

where $\tilde{v} = [\tilde{v}_{ij}]_{m*n}, \quad i = 1, 2 \ldots, m; \; j = 1, 2 \ldots n.$

Step 4: Calculate the distances from positive and negative ideal points. Since the triangular fuzzy numbers are included in [0, 1] range, positive and negative ideal reference points (FPIRP, FNIRP) are as follows:

$$A^+ = \{\tilde{v}_1^+, \tilde{v}_2^+, \ldots, \tilde{v}_n^+\}, \quad A^- = \{\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-\} \quad (12)$$

where $\tilde{v}_j^+ = (1,1,1)$, $\tilde{v}_j^- = (0,0,0)$.

The next step is to calculate the distance of alternatives from FPIRP and FNIRP.

$$d_i^+ = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^+), \quad i = 1, 2, \ldots, m; \; j = 1, 2, \ldots, n \quad (13)$$

$$d_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i = 1, 2, \ldots, m; \; j = 1, 2, \ldots, n \quad (14)$$

$$d(\widetilde{A}, \widetilde{B}) = \sqrt{\frac{1}{3}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2\right]} \quad (15)$$

Step 5: Rank the alternatives. The performance indices are computed to rank the alternatives.

6. Implementation of the proposed model for e-sq evaluation to hospital web sites

Part 1 – Hospital web site evaluation criteria. In e-sq measurement of hospital web sites, the objective is to find out the best qualified healthcare service delivery performance through web sites. The evaluation criteria presented in Section 4 are used and decision making process is done by the aid of experts. The questionnaire is explained in Appendix A that shows how the fuzzy comparison data are obtained. Fig. 3 depicts the hierarchy of the e-sq model.

Part 2 – Determination of the hospital web site performance evaluation criteria weights. Firstly, pair-wise comparisons are performed in linguistic and fuzzy terms. Then, the required data for analysis are entered and the fuzzy comparison matrices are obtained. Consensus of opinions was exists among expert judgments. The evaluation matrix with respect to goal can be seen in Table 4.

Then, by using Eq. (2), lower limit and upper limit of the fuzzy numbers with respect to α were defined. And after the value $\alpha = 0.5$ is substituted into the relevant expression, the α-*cut* fuzzy comparison matrices are obtained. Table 5 shows α-cut fuzzy comparison matrix for the relative importance of the criteria with respect to goal.

Table 3
Definition and membership function of fuzzy scale.

Intensity of importance	Fuzzy number	Definition	Membership function
9	$\tilde{9}$	Extremely more importance (EMI)	(8, 9, 10)
7	$\tilde{7}$	Very strong importance (VSI)	(6, 7, 8)
5	$\tilde{5}$	Strong importance (SI)	(4, 5, 6)
3	$\tilde{3}$	Moderate importance (MI)	(2, 3, 4)
1	$\tilde{1}$	Equal importance (EI)	(1, 1, 2)

Finally by putting the value $\mu = 0.5$ in Eq. (6), the eigenvectors of all the comparison matrices can be calculated by using Eqs. (4) and (5). Afterwards, the matrices are normalized and the priorities are found. And lastly, the consistencies are measured by applying Eq. (8). The remaining sub-criteria can be calculated in a similar fashion and evaluation matrices can be seen from Tables 6–11.

In the finalization of AHP steps, results are shown in Table 12. From these obtained results, it may be conducted that the specialization, interactivity and the accuracy of service play a predominant role for hospital web sites quality.

Part 3 – Ranking of the hospital web sites. As the following step, decision makers assessed the quality of the alternative hospital web sites. The same fuzzy scale is used for evaluation as in fuzzy AHP and the decision matrix with alternatives and criteria can be

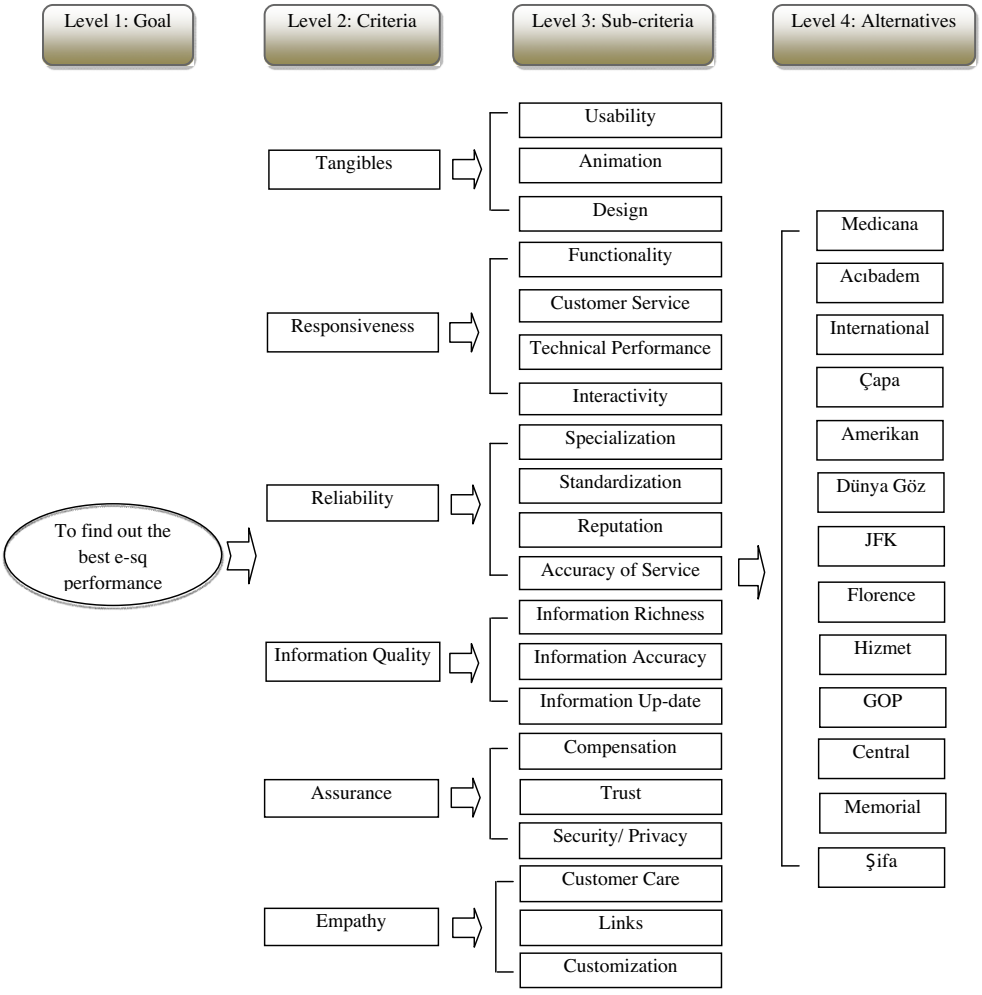

Fig. 3. Hierarchy of the e-sq model.

Table 4
Evaluation matrix with respect to the goal.

	Matrix in linguistic terms						Matrix in fuzzy terms					
	C1	C2	C3	C4	C5	C6	C1	C2	C3	C4	C5	C6
Tangibles (C1)	–				EI	EI	1	(1/4, 1/3, 1/2)	(1/6, 1/5, 1/4)	(1/4, 1/3, 1/2)	(1, 1, 2)	(1, 1, 2)
Responsiveness (C2)	MI	–		MI	MI	MI	(2, 3, 4)	1	(1/4, 1/3, 1/2)	(2, 3, 4)	(2, 3, 4)	(2, 3, 4)
Reliability (C3)	SI	MI	–	MI	SI	SI	(4, 5, 6)	(2, 3, 4)	1	(2, 3, 4)	(4, 5, 6)	(4, 5, 6)
Information quality (C4)	MI			–	EI	MI	(2, 3, 4)	(1/4, 1/3, 1/2)	(1/4, 1/3, 1/2)	1	(1, 1, 2)	(2, 3, 4)
Assurance (C5)	EI			EI	–	MI	(1/2, 1, 1)	(1/4, 1/3, 1/2)	(1/6, 1/5, 1/4)	(1/2, 1, 1)	1	(2, 3, 4)
Empathy (C6)	EI					–	(1/2, 1, 1)	(1/4, 1/3, 1/2)	(1/6, 1/5, 1/4)	(1/4, 1/3, 1/2)	(1/4, 1/3, 1/2)	1

Table 5
α-Cut fuzzy comparison matrix for the relative importance of the criteria with respect to goal ($\alpha = 0.5$, $\mu = 0.5$).

	C1	C2	C3	C4	C5	C6
Tangibles (C1)	1	[1/4, 1/2]	[1/6, 1/4]	[1/4, 1/2]	[1, 2]	[1, 2]
Responsiveness (C2)	[2, 4]	1	[1/4, 1/2]	[2, 4]	[2, 4]	[2, 4]
Reliability (C3)	[4, 6]	[2, 4]	1	[2, 4]	[4, 6]	[4, 6]
Information quality (C4)	[2, 4]	[1/4, 1/2]	[1/4, 1/2]	1	[1, 2]	[2, 4]
Assurance (C5)	[1/2, 1]	[1/4, 1/2]	[1/6, 1/4]	[1/2, 1]	1	[2, 4]
Empathy (C6)	[1/2, 1]	[1/4, 1/2]	[1/6, 1/4]	[1/4, 1/2]	[1/4, 1/2]	1

The weight vector is calculated as $W_G = (0.08, 0.22, 0.40, 0.15, 0.09, 0.06)$.

Table 6
Evaluation of the sub-dimensions with respect to tangibles.

	Matrix in linguistic terms				Matrix in fuzzy terms			
Tangibles (C1)	C11	C12	C13	C14	C11	C12	C13	C14
Usability (C11)	–	SI	EI	EI	1	(4, 5, 6)	(1, 1, 2)	(1, 1, 2)
Animation (C12)		–			(1/6, 1/5, 1/4)	1	(1/6,1/5,1/4)	(1/4, 1/3, 1/2)
Design (C13)		SI	–	EI	(1/2, 1, 1)	(4, 5, 6)	1	(1, 1, 2)
Functionality (C14)		MI		–	(1/2, 1, 1)	(2, 3, 4)	(1/2, 1, 1)	1

The weight vector is calculated as $W_{C1} = (0.38, 0.07, 0.32, 0.23)$.

Table 7
Evaluation of the sub-dimensions with respect to responsiveness.

	Matrix in linguistic terms			Matrix in fuzzy terms		
Responsiveness (C2)	C21	C22	C23	C21	C22	C23
Customer service (C21)	–			1	(1/4, 1/3, 1/2)	(1/8, 1/7, 1/6)
Technical performance (C22)	MI	–		(2, 3, 4)	1	(1/4, 1/3, 1/2)
Interactivity (C23)	VSI	MI	–	(6, 7, 8)	(2, 3, 4)	1

The weight vector is calculated as $W_{C2} = (0.09, 0.25, 0.66)$.

Table 8
Evaluation of the sub-dimensions with respect to reliability.

	Matrix in linguistic terms				Matrix in fuzzy terms			
Reliability (C3)	C31	C32	C33	C34	C31	C32	C33	C34
Specialization (C31)	–	MI	SI	EI	1	(2, 3, 4)	(4, 5, 6)	(1, 1, 2)
Standardization (C32)		–	MI		(1/4, 1/3, 1/2)	1	(2,3,4)	(1/4, 1/3, 1/2)
Reputation (C33)			–		(1/6, 1/5, 1/4)	(1/4, 1/3, 1/2)	1	(1/6, 1/5, 1/4)
Accuracy of service (C34)		MI	SI	–	(1/2, 1, 1)	(2, 3, 4)	(4, 5, 6)	1

The weight vector is calculated as $W_{C3} = (0.42, 0.16, 0.07, 0.35)$.

Table 9
Evaluation of the sub-dimensions with respect to information quality.

	Matrix in linguistic terms			Matrix in fuzzy terms		
Information Quality (C4)	C41	C42	C43	C41	C42	C43
Info. richness (C41)	–			1	(1/6, 1/5, 1/4)	(1/4, 1/3, 1/2)
Info. accuracy (C42)	SI	–	EI	(4, 5, 6)	1	(1, 1, 2)
Info. up-date (C43)	MI		–	(2, 3, 4)	(1/2, 1, 1)	1

The weight vector is calculated as $W_{C4} = (0.12, 0.53, 0.35)$.

Table 10
Evaluation of the sub-dimensions with respect to assurance.

	Matrix in linguistic terms			Matrix in fuzzy terms		
Assurance (C5)	C51	C52	C53	C51	C52	C53
Compensation (C51)	–			1	(1/6, 1/5, 1/4)	(1/4, 1/3, 1/2)
Trust (C52)	SI	–	EI	(4, 5, 6)	1	(1, 1, 2)
Security/privacy (C53)	MI		–	(2, 3, 4)	(1/2, 1, 1)	1

The weight vector is calculated as W_{C5} = (0.12, 0.53, 0.35).

Table 11
Evaluation of the sub-dimensions with respect to empathy.

	Matrix in linguistic terms			Matrix in fuzzy terms		
Empathy (C6)	C61	C62	C63	C61	C62	C63
Customer Care (C61)	–	MI	SI	1	(2, 3, 4)	(4, 5, 6)
Links (C62)		–	EI	(1/4, 1/3, 1/2)	1	(1, 1, 2)
Customization (C63)			–	(1/6, 1/5, 1/4)	(1/2, 1, 1)	1

The weight vector is calculated as W_E = (0.64, 0.22, 0.14).

Table 12
Summary of the evaluation criteria weights.

Criteria	Local importance	Sub-criteria	Local importance	*Global importance*
Tangibles (C1)	0.08	Usability (C11)	0.38	0.030
		Animation (C12)	0.07	0.005
		Design (C13)	0.32	0.025
		Functionality (C14)	0.23	0.018
Responsiveness (C2)	0.22	Customer service (C21)	0.09	0.019
		Technical performance (C22)	0.25	0.055
		Interactivity (C23)	0.66	0.145
Reliability (C3)	0.40	Specialization (C31)	0.42	0.168
		Standardization (C32)	0.16	0.064
		Reputation (C33)	0.07	0.028
		Accuracy of service (C34)	0.35	0.140
Information quality (C4)	0.15	Info. richness (C41)	0.12	0.018
		Info. accuracy (C42)	0.53	0.079
		Info. up-date (C43)	0.35	0.052
Assurance (C5)	0.09	Compensation (C51)	0.12	0.018
		Trust (C52)	0.53	0.047
		Security/privacy (C53)	0.35	0.031
Empathy (C6)	0.06	Customer care (C61)	0.64	0.038
		Links (C62)	0.22	0.013
		Customization (C63)	0.14	0.008

Table 13
Linguistic evaluation data of alternatives.

	C11	C12	C13	C14	C21	C22	C23	C31	C32	C33	C34	C41	C42	C43	C51	C52	C53	C61	C62	C63
Medicana (H1)	SI	MI	SI	MI	MI	MI	MI	MI	MI	MI	EI	MI	SI	MI	EI	MI	MI	EI	EI	MI
Acibadem (H2)	SI	SI	SI	SI	SI	SI	SI	MI	SI	MI	SI	VSI	MI	VSI	VSI	SI	SI	SI	VSI	MI
International (H3)	MI	MI	MI	MI	SI	SI	SI	SI	SI	MI	MI	MI	MI	MI	VSI	VSI	SI	SI	VSI	MI
Çapa (H4)	MI	SI	MI	SI	EI	EI	EI	EI	EI	EI	MI	EI	MI	EI	EI	EI	EI	EI	EI	MI
Amerikan (H5)	MI	MI	MI	EI	SI	MI	SI	MI	SI	SI	SI	MI	MI	MI	EI	MI	MI	EI	EI	MI
Dünya Göz (H6)	SI	SI	SI	SI	MI	MI	MI	VSI	SI	VSI	VSI	MI	SI	MI	VSI	SI	MI	MI	MI	SI
JFK (H7)	EI	EI	EI	EI	EI	EI	EI	EI	MI	EI	EI	EI	EI	EI	EI	EI	EI	EI	EI	MI
Florence (H8)	EI	EI	EI	EI	EI	EI	EI	VSI	SI	VSI	VSI	EI	EI	EI	EI	EI	MI	EI	EI	EI
Hizmet (H9)	EI	MI	EI	EI	MI	MI	MI	EI	MI	EI	EI	EI	MI	EI	EI	MI	EI	EI	EI	MI
GOP (H10)	EI	EI	EI	EI	EI	EI	EI	EI	EI	EI	EI	EI	MI	EI	EI	MI	EI	EI	MI	MI
Central (H11)	MI	VSI	MI	VSI	SI	SI	SI	EI	EI	EI	EI	VSI	MI	VSI	EI	MI	EI	MI	MI	MI
Memorial (H12)	MI	EI	MI	EI	MI	MI	MI	MI	MI	MI	EI	MI	MI	MI	EI	MI	MI	MI	MI	MI
Şifa (H13)	MI	SI	SI	SI	MI	MI	MI	EI	EI	EI	EI	MI	MI	MI	SI	MI	EI	SI	VSI	MI

seen with linguistic terms in Table 13. In the case study there are 13 web site alternatives which belong to Medicana (www.medicana.com.tr), Acıbadem (www.acibadem.com), Florence (www.florence.com.tr), International (www.internationalhospital.com.tr), Dünya Göz (www.dunyagoz.com.tr), JFK (www.jfkhastanesi.com), Çapa (www.capahastanesi.com), Central (www.centralhospital.com), Amerikan (www.amerikanhastanesi.com.tr), Memorial (www.memorial.com.tr), GOP (www.gophastanesi.com.tr), Hizmet

Table 14
Positive distance of hospital web site alternatives.

	C11	C12	C13	C14	C21	C22	C23	C31	C32	C33	C34	C41	C42	C43	C51	C52	C53	C61	C62	C63	Total
H1	1.69	1.72	1.52	1.71	1.66	1.69	1.72	1.62	1.68	1.71	1.69	1.72	1.62	1.70	1.73	1.70	1.71	1.72	1.73	1.73	33.77
H2	1.69	1.71	1.52	1.70	1.62	1.66	1.71	1.62	1.64	1.71	1.58	1.70	1.66	1.65	1.70	1.68	1.69	1.68	1.71	1.73	33.39
H3	1.71	1.72	1.61	1.71	1.62	1.66	1.71	1.55	1.64	1.71	1.64	1.72	1.66	1.70	1.70	1.66	1.69	1.68	1.71	1.73	33.54
H4	1.71	1.71	1.61	1.70	1.70	1.71	1.73	1.68	1.71	1.72	1.64	1.73	1.66	1.72	1.73	1.72	1.72	1.72	1.73	1.73	34.07
H5	1.71	1.72	1.61	1.72	1.62	1.69	1.71	1.62	1.64	1.70	1.58	1.72	1.66	1.70	1.73	1.70	1.71	1.72	1.73	1.73	33.71
H6	1.69	1.71	1.52	1.70	1.66	1.69	1.72	1.48	1.64	1.69	1.52	1.72	1.62	1.70	1.70	1.68	1.71	1.70	1.72	1.72	33.30
H7	1.72	1.73	1.68	1.72	1.70	1.71	1.73	1.68	1.68	1.72	1.69	1.73	1.70	1.72	1.73	1.72	1.72	1.72	1.73	1.73	34.25
H8	1.72	1.73	1.68	1.72	1.70	1.71	1.73	1.48	1.64	1.69	1.52	1.73	1.70	1.72	1.73	1.72	1.71	1.72	1.73	1.73	33.79
H9	1.72	1.72	1.68	1.72	1.66	1.69	1.72	1.68	1.68	1.72	1.69	1.73	1.66	1.72	1.73	1.70	1.72	1.72	1.73	1.73	34.12
H10	1.72	1.73	1.68	1.72	1.70	1.71	1.73	1.68	1.71	1.72	1.69	1.73	1.66	1.72	1.73	1.70	1.72	1.72	1.72	1.73	34.22
H11	1.71	1.70	1.61	1.69	1.62	1.66	1.71	1.68	1.71	1.72	1.69	1.70	1.66	1.65	1.73	1.70	1.72	1.70	1.72	1.73	33.83
H12	1.71	1.73	1.61	1.72	1.66	1.69	1.72	1.62	1.68	1.71	1.69	1.72	1.66	1.70	1.73	1.70	1.71	1.70	1.72	1.73	33.91
H13	1.71	1.71	1.52	1.70	1.66	1.69	1.72	1.68	1.71	1.72	1.69	1.72	1.66	1.70	1.71	1.70	1.72	1.68	1.71	1.73	33.86

Table 15
Negative distance of hospital web site alternatives.

	C11	C12	C13	C14	C21	C22	C23	C31	C32	C33	C34	C41	C42	C43	C51	C52	C53	C61	C62	C63	Total
H1	0.04	0.01	0.21	0.02	0.07	0.04	0.01	0.11	0.06	0.02	0.04	0.01	0.12	0.04	0.01	0.03	0.03	0.02	0.00	0.01	0.90
H2	0.04	0.02	0.21	0.03	0.12	0.07	0.02	0.11	0.09	0.02	0.15	0.03	0.07	0.08	0.03	0.05	0.04	0.06	0.02	0.01	1.27
H3	0.03	0.01	0.13	0.02	0.12	0.07	0.02	0.18	0.09	0.02	0.09	0.01	0.07	0.04	0.03	0.07	0.04	0.06	0.02	0.01	1.13
H4	0.03	0.02	0.13	0.03	0.03	0.02	0.01	0.05	0.03	0.01	0.09	0.01	0.07	0.02	0.01	0.01	0.01	0.02	0.00	0.01	0.60
H5	0.03	0.01	0.13	0.01	0.12	0.04	0.02	0.11	0.09	0.03	0.15	0.01	0.07	0.04	0.01	0.03	0.03	0.02	0.00	0.01	0.95
H6	0.04	0.02	0.21	0.03	0.07	0.04	0.01	0.26	0.09	0.04	0.21	0.01	0.12	0.04	0.03	0.05	0.03	0.03	0.01	0.01	1.36
H7	0.01	0.01	0.06	0.01	0.03	0.02	0.01	0.05	0.06	0.01	0.04	0.01	0.03	0.02	0.01	0.01	0.01	0.02	0.00	0.01	0.42
H8	0.01	0.01	0.06	0.01	0.03	0.02	0.01	0.26	0.09	0.04	0.21	0.01	0.03	0.02	0.01	0.01	0.03	0.02	0.00	0.00	0.87
H9	0.01	0.01	0.06	0.01	0.07	0.04	0.01	0.05	0.06	0.01	0.04	0.01	0.07	0.02	0.01	0.03	0.01	0.02	0.00	0.01	0.55
H10	0.01	0.01	0.06	0.01	0.03	0.02	0.01	0.05	0.03	0.01	0.04	0.01	0.07	0.02	0.01	0.03	0.01	0.02	0.01	0.01	0.44
H11	0.03	0.03	0.13	0.04	0.12	0.07	0.02	0.05	0.03	0.01	0.04	0.03	0.07	0.08	0.01	0.03	0.01	0.03	0.01	0.01	0.84
H12	0.03	0.01	0.13	0.01	0.07	0.04	0.01	0.11	0.06	0.02	0.04	0.01	0.07	0.04	0.01	0.03	0.03	0.03	0.01	0.01	0.76
H13	0.03	0.02	0.21	0.03	0.07	0.04	0.01	0.05	0.03	0.01	0.04	0.01	0.07	0.04	0.02	0.03	0.01	0.06	0.02	0.01	0.81

Table 16
Final performance indices of hospital web site alternatives.

Performance index		Ranking
Medicana (H1)	0.0259	5
Acibadem (H2)	0.0367	2
International (H3)	0.0325	3
Çapa (H4)	0.0172	10
Amerikan (H5)	0.0275	4
Dünya Göz (H6)	0.039	1
JFK (H7)	0.012	13
Florence (H8)	0.0252	6
Hizmet (H9)	0.0157	11
GOP (H10)	0.0128	12
Central (H11)	0.0241	7
Memorial (H12)	0.0219	9
Şifa (H13)	0.0233	8

(www.hizmethastanesi.com), and Şifa (www.kadikoysifa.com) hospitals.

After constructing the fuzzy decision matrix, the normalized matrix using Eq. (10) and weighted matrix using Eq. (11) are calculated. Then FPIRP and FNIRP are determined according to Eqs. (13)–(15) as given in Tables 14 and 15.

The last step of the methodology consists of ranking the hospital web sites according to their closeness to the ideal solution. The performance indices are computed to rank the alternatives and the obtained results are given in Table 16. The evaluation results point out that the web site of Dünya Göz Hospital has the best e-sq performance overall, trailed by the web sites of Acıbadem Hospital and International Hospital.

Part 4 – Sensitivity analysis. By increasing the weight of each determinant, the resulting changes of the priorities and the final

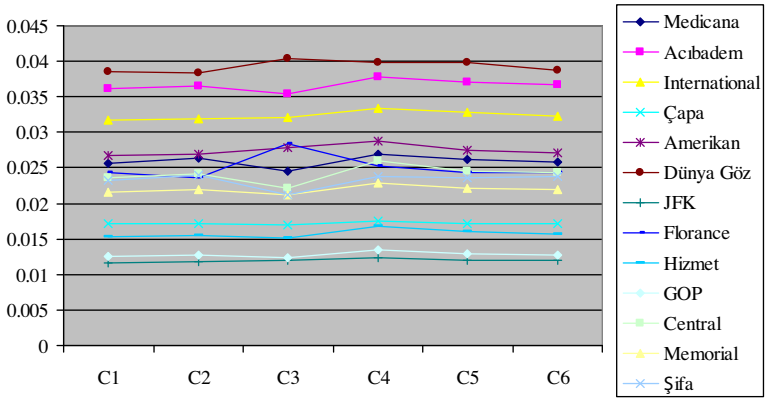

Fig. 4. Performance sensitivity of web site alternatives when criteria weights are changed.

ranking of the alternatives are observed. Therefore, the weights of the criteria are separately altered, simulating weights between 0% and 100% (note that the weights of the other criteria change simultaneously, reflecting the relative nature of the weights, i.e., the total weights has to add up to 100%). Performance sensitivity of alternatives has been analyzed when tangibles (C1), responsiveness (C2), reliability (C3), information quality (C4), assurance (C5) and empathy (C6) are increased by 25%.

Fig. 4 depicts the changes in final ranking of hospital web sites when criteria are changed. Increasing tangibles (C1) at 25% modifies the rank of the first tree alternatives as Dünya Göz (0.0385), Acıbadem (0.0361), and International (0.0318). Increasing responsiveness (C2) at 25% modifies the rank as Dünya Göz (0.0384), Acıbadem (0.0365), and International (0.0319). Increasing reliability (C3) at 25% modifies the rank as Dünya Göz (0.0403), Acıbadem (0.0354), and International (0.0320). Increasing information quality (C4) at 25% modifies the rank as Dünya Göz (0.0398), Acıbadem (0.0378), and International (0.0334). Increasing assurance (C5) at 25% modifies the rank as Dünya Göz (0.0389), Acıbadem (0.0370), and International (0.0329). And increasing empathy (C6) at 25% modifies the rank as Dünya Göz (0.0388), Acıbadem (0.0367), and International (0.0323). Other changes can be seen from Fig. 3 and finally it can be said that almost all of the changes in the weight of each determinant do not change the final ranking of the alternatives. It means that the final ranking has stability.

7. Conclusion and future research

The objective of the research was, to use a hybrid multi criteria technique which combines fuzzy AHP and fuzzy TOPSIS to evaluate a set of hospital web site alternatives in order to reach to best qualified alternative that satisfies the needs and the expectations of customers. After a comprehensive literature survey, e-sq framework was proposed for the quality assessment of the hospital web sites by aiding SERVQUAL tool. The e-sq instrument developed in this study can be used to monitor and improve the quality of service delivered to customers via internet. According to the case study, results showed that hospitals should focus more on specialization, interactivity and the accuracy of service (sub-criteria); reliability and responsiveness (main criteria) to perform satisfying and qualified web service.

Humans are often uncertain in assigning the evaluation scores. There for AHP and TOPSIS methods are performed in fuzzy environment to capture this difficulty. There are many other multi-attribute evaluation methods to use in evaluation of web based healthcare service quality (i.e. Analytic network process (Saaty, 1996)). Further research may be the application of a hybrid method that combines ANP and TOPSIS methods to the service quality performance problem and the comparison of the results. The model also could be applied to several studies to investigate how customers' perceptions and evaluations of web based service quality change over time.

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Appendix A

A.1. Questionnaire for e-sq evaluation

With respect to the overall goal "to find out the best healthcare service quality performance"

Q1. How important is tangibles when it is compared with responsiveness?
Q2. How important is tangibles when it is compared with reliability?
Q3. How important is tangibles when it is compared with information quality?
Q4. How important is tangibles when it is compared with assurance?
Q5. How important is tangibles when it is compared with empathy?
Q6. How important is responsiveness when it is compared with reliability?
Q7. How important is tangibles when it is compared with information quality?
Q8. How important is responsiveness when it is compared with assurance?
Q9. How important is responsiveness when it is compared with empathy?
Q10. How important is tangibles when it is compared with information quality?
Q11. Ho important is reliability when it is compared with assurance?
Q12. How important is reliability when it is compared with empathy?
Q13. How important is assurance when it is compared with assurance?
Q14. How important is assurance when it is compared with empathy?
Q15. How important is empathy when it is compared with empathy?

A.2. An example of the responses

With respect to: Best hospital web-site	Importance of one main-attribute over another										
Questions	Attributes	Extreme (8,9,10)	Very strong (6,7,8)	Strong (4,5,6)	Moderate (2,3,4)	Equal (1,1,2)	Moderate (2,3,4)	Strong (4,5,6)	Very strong (6,7,8)	Extreme (8,9,10)	Attributes
Q1.	Tangibles						√				Responsiveness
Q2.	Tangibles							√			Reliability
Q3.	Tangibles						√				Information quality
Q4.	Tangibles					√					Assurance
Q5.	Tangibles					√					Empathy

(continued on next page)

Appendix A (*continued*)

With respect to: Best hospital web-site	Importance of one main-attribute over another										
Questions	Attributes	Extreme (8,9,10)	Very strong (6,7,8)	Strong (4,5,6)	Moderate (2,3,4)	Equal (1,1,2)	Moderate (2,3,4)	Strong (4,5,6)	Very strong (6,7,8)	Extreme (8,9,10)	Attributes
Q6.	Responsiveness						√				Reliability
Q7.	Responsiveness				√						Information quality
Q8.	Responsiveness				√						Assurance
Q9.	Responsiveness				√						Empathy
Q10.	Reliability				√						Information quality
Q11.	Reliability			√							Assurance
Q12.	Reliability			√							Empathy
Q13.	Information Quality					√					Assurance
Q14.	Information Quality				√						Empathy
Q15.	Assurance				√						Empathy

Appendix B

B.1. Detailed information about hospital alternatives

B.1.1. Medicana Hospital

As Medicana Hospital Group there are three hospitals in İstanbul: Avcılar, Çamlıca and Bahçelievler. As well as all branches there are oncology, cardiology, vascular surgery of heart, transplantation, burn treatment center and especially the tube baby units.

B.1.2. Acıbadem Hospital

Turkey's leading healthcare institution, Acıbadem, operates with over 6.500 employees in 21 different location through a network of 6 general hospitals, medical centers, outpatient clinics, 1 ophthalmology center and laboratories. Besides its partnership with one of the most important hospitals of Istanbul International Hospital and International Etiler Outpatient Clinic, Acıbadem expands its ''healthcare chain'' continuously outside of Istanbul with Adana, Kayseri, Eskişehir and Bodrum Hospitals and in Istanbul with Maslak and Beşiktaş (Fulya) Hospitals.

B.1.3. International Hospital

International Hospital, Istanbul that is dedicated to provide a high quality healthcare using the most advanced diagnostic procedures and treatment modalities, is in a unique position to be one of the milestones in healthcare history of Turkey. International Hospital Istanbul serves its patients with 106 beds which includes 12 Intensive Care Unit, 6 Coronary Care Unit, 9 Heart Surgery Intensive Care Unit beds, plus 4 Neonatal Intensive Care Unit incubators, 7 haemodialysis beds, 10 angiography laboratory beds, 9 Emergency Room beds, and 6 operating theatres.

B.1.4. Çapa Hospital

Çapa Hospital starts to serve in Fatih county, Çapa district, which is one of the most central places of Istanbul and easily accessible from each region of Istanbul. Çapa Hospital maintains its activities without concession of quality by renewing and developing itself since its establishment up to now. Çapa Hospital has 40 bed capacities in its renewed building today. Our rooms are decorated with an understanding based on patient satisfaction by benefiting from opportunities of modern technology.

B.1.5. Amerikan Hospital

The Amerikan Hospital offers diagnostic, inpatient and outpatient care in 38 medical specialities. Its 24 h service at international standards is given by 500 physician specialists and a healthcare and support service staff of 1.1500 persons. The world standard services are provided with the support of the most modern medical equipment and systems. In addition to emphasizing excellence in healthcare services, the Amerikan Hospital also utilizes programs to meet the needs of patients and their families, through its Quality Assurance Control Programs and Patient's Relations Services.

B.1.6. Dünya Göz Hospital

The World Eye Hospital and its 120 eye- surgeons is the largest eye hospital in the world. They comply with all international standards. The hospital was founded in Levent, Istanbul in 1996 and has introduced a new medical era by offering solutions for several ophthalmologic problems. Twenty-four hours a day and 365 days a year. The World Eye hospital has taken its place in the exclusive company of ophthalmologic centers.

B.1.7. JFK Hospital

JFK Hospital was opened in December 1999. They treat their patients with the latest technology in medical equipment to provide the correct diagnosis and modern treatment facilities, patient satisfaction, gives priority to provide a health service. 96 beds to the capacity, 5 modern operating rooms, modern sterilization unit, surgery, intensive care, new born intensive care and coronary intensive care in 3 intensive care unit, clinic services, and also 24-hour emergency service with the JFK Hospital Istanbul-quality health services to give targets.

B.1.8. Florence Nightingale Hospital

Named after the world renowned Englishwoman nurse Ms. Florence Nightingale, the pioneer of modern hospital concept, Group Florence Nightingale Hospitals started its journey with Florence Nightingale Nursing School in 1960s and proceeded with the establishment of the first private Cardiovascular Disease Hospital of Turkey in 1989, at Şişli Istanbul, which has a capacity of 300 beds today. The group established Avrupa Florence Nightingale Hospital in 1994, at Fulya, Sisli, Istanbul; Gayrettepe Florence Nightingale Hospital in 1996 at Gayrettepe, Besiktas, Istanbul, which is the first private Comprehensive Cancer Centre in Turkey, and finally the Istanbul Kadıköy Florence Nightingale Hospital in 2007. Today, the Group Florence Nightingale Hospitals has a total of 484 patient beds, 26 operation rooms, 83 intensive care and 32 emergency care beds.

B.1.9. Hizmet Hospital

Hizmet Hospital was opened in 30 October 2000. Hizmet Hospital, advanced transplantation units as well as all other health sectors have the most modern equipment and specialist doctors in hospitals as a step forward with is unique.

B.1.10. GOP Hospital

In 1992, the region's first private hospital GOP Hospital began 24-h specialist medical services. 10 operating rooms, 196 beds capacity, the world's most advanced medical technology and until today more than 1 million people were provided health services. In the hospital Emergency Service, Organ Transplantation Centre, Cardiology, Cardiovascular Surgery, General Surgery, Internal Medicine, Gynaecology and Obstetrics, Child Health and Diseases, Radiology departments are exist.

B.1.11. Central Hospital

Aswell as offering surgical operations on 4 operating rooms equipped with state of art technology and equipments required by modern medicine thanks to its expert medical staff, trained nurses and anaesthesiologists, Central Hospital serves the needs of pregnant women thanks to its delivery rooms equipped sufficiently and experienced team of Maternity/Gynaecology Services. In the light of aim of providing customer satisfaction focused service for the patients and their families as well as reliable and modern service focused on informing, the hospital organizes trainings for the purpose of informing patients and their families within the scope of preventive healthcare services.

B.1.12. Memorial Hospital

Memorial Hospital is the first health services project of the Memorial Health Investments Corporation founded in 1995. Memorial hospital received its first patient in February 2000. Memorial hospital has a very prestigious reputation in areas like cardiology, cardiovascular surgery, organ transplantation, IVF and genetics and provides high quality healthcare services in every medical specialty. Memorial Hospital provides high quality healthcare services on international standards to its local and international patients with its 53.000 square meter closed area, 200 bed capacity, parking lot, central automated system, pressure support system to control temperature and humidity, pneumatic tube transfer system and 120 people capacity conference room.

B.1.13. Şifa Hospital

Şifa Hospital, the first private hospital of the Anatolian side of İstanbul, is a fully equipped health center where thousands of patients get healed. With Şifa Hospital which was founded in 1976, Şifa Hospital Polyclinic – Suadiye which was founded in 2003, and Şifa Hospital Medical Center – Ataşehir which started patient admission in 2005, Şifa Hospital is today providing health service at three different centers.

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