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Identifying and Ranking Hospital Suppliers and Choosing the Right Supplier in Supply Chain Management

Alireza Ebrahimi[1]

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Original Article

Abstract

INTRODUCTION: Identifying and classifying hospital suppliers and choosing the right hospital supplier are based on some criteria, such as price, quality, timely product delivery, and after-sales service.

METHODS: The research method was to select a suitable supplier through multi-criteria decision-making methods, including fuzzy TOPSIS and fuzzy Delphi. This research analyzed the selection criteria of hospital suppliers using fuzzy TOPSIS and fuzzy Delphi methods. The weight of the selected criteria and their importance were determined by holding interviews with hospital experts. In the next stage, the suppliers were evaluated, and finally, they were ranked using the TOPSIS fuzzy method.

FINDINGS: In this research, the criteria for selecting suppliers were based on the criteria determined by Dickson. According to the fuzzy Delphi method, 7 criteria of product quality, timely delivery, final product price, after-sales service, technical ability, product position among competitors, and easy-to-use product were selected for supplier evaluation.

CONCLUSION: The selection of a reliable supplier is becoming increasingly crucial given the critical role played by the healthcare sector, which includes hospitals and the Red Crescent as its constituents, the expanding development of technology, and the growing variety of medical equipment. According to the results obtained by the fuzzy Delphi method, the criterion of product quality with a score of 0.88 was chosen as the most important criterion, while the ease-to-use product index with a score of 0.7 was chosen as the least important criterion. The selection and evaluation of suppliers were accomplished through several different quantitative and qualitative indicators, such as cost, quality, timely delivery, and after-sales service. As a result, companies must choose key indicators and suitable suppliers because the right supplier leads to a reduction in purchase costs, as well as an increase in the quality of the products and ultimately the success of the organization in reaching its goals.

Keywords: Fuzzy Delphi method; Fuzzy TOPSIS method; Supply chain; Selection of suppliers.

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Introduction

With the emergence of the supply chain and its management, several studies have been conducted on the supply chain and its related issues. The supply chain includes all activities associated with the flow and transformation of goods from the stage of raw material (extraction) to delivery to the final consumer, as well as information flows related to them. In the last decade, the methods of supplying raw materials and choosing suppliers in the supply chain have been a challenge for most organizations. Since the performance of suppliers has a fundamental effect on the success or failure of the supply chain, supplier selection is known as a strategic task. Choi et al. have stated that evaluating and selecting a supplier constitute the process of evaluating, comparing, and finding the right supplier that can meet the needs of the purchaser with the best-expected quality, in the right place,

1.Assistant Professor of Human Resources Management, Faculty Member of the Islamic Azad University Isfahan, Khorasgan, Iran
Correspondence to: Alireza Ebrahimi, Email: Ealireza1388@gmailcom

in the right volume, and at the right time (1).

In the field of health and treatment, Choi and Hartly have mentioned that hospitals are considered one of the important institutions that provide health, treatment, and educational services in the country, and with their special services, they play a crucial role in helping sick people regain their physical and emotional health and rejoin society, training health care specialists, conducting medical research, and promoting community health (2).

When a supplier is managed as part of a supply chain, it will have a permanent effect on the competitiveness of the entire company. Therefore, organizations are forced to review one of the most basic responsibilities of supplier management, which is the selection of suppliers. The importance of supplier selection stems from the fact that they commit the supply of resources, while simultaneously affecting activities such as inventory management, production planning and control, cash flow requirements, and product quality (2).

Supply chain is defined as a set of three entities (i.e., organization, information, and people) or more that are directly involved in the upward or downward flow of products, services, finance, and information from resources to customers (3). Another definition provided for a supply chain is a network of activities that deliver final products or services to customers (4). Helo and Szekely state that supply chain management is engaged in controlling and improving the flow of information, materials, and money throughout this chain (5).

Percin conducted research to evaluate logistics providers using two techniques, namely Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). In his research, he first identified the weight of the criteria using the AHP technique and then ranked the logistics suppliers using the TOPSIS technique (6).

In another study, various criteria used in the selection and evaluation of suppliers of coagulation indicators for hospitals were identified and examined. Coagulation indicators are used in hospital laboratories and blood banks for countless procedures, such as blood analysis, immunology tests, and diagnosis of blood diseases. The researchers of the mentioned study used four criteria of price, quality, timely delivery, and after-sales service to select suppliers (7).

An article was carried out under the title of "Prioritization of Green Supply Chain Suppliers Using a Hybrid Fuzzy Multi-Criteria Decision-Making Approach". By examining the current situation of Saipa Company, consulting with experts, and using the fuzzy Delphi method, the researchers of the mentioned study identified criteria with a higher degree of importance. In the next step, the final criteria were provided to the company's experts in the form of a pairwise comparison questionnaire, and the necessary data for their prioritization was collected based on the fuzzy AHP (FAHP) technique. Finally, using the fuzzy VIKOR technique, 100 suppliers of Saipa Company were evaluated. The obtained results showed that the presented approach was an efficient framework for prioritizing the green suppliers of Saipa (8).

The selection of hospital suppliers was studied using fuzzy methods. The researchers conducted their study in a military hospital. The obtained results indicated that the quality, with the highest weight, was the most effective criterion in the selection of the supplier, followed by the criteria of price, on-time delivery, packaging and quality of transportation, the background of the supplier, and payment conditions (9).

Taking into account the vital role of the healthcare sector, which includes hospitals and other Red Crescent centers as its components, as well as the growing trend of technology and the proliferation of medical equipment, selecting the right supplier has become increasingly important.

Methods

The current research, in terms of objective classification, was a practical study because it aimed at ranking and evaluating suppliers according to the factors influencing their desirability in the field of healthcare (hospital). Regarding the method adopted to collect the required data, or in other words, the research plan, this research was descriptive survey research. The required data were gathered using research literature review methods, conducting interviews with experts, administrating questionnaires, and collecting information from the hospital bulletin. (Fig.1)

The criteria of supplier desirability in the hospital were identified by studying the

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available research literature in the field of supplier evaluation as well as using the opinion of hospital experts. After confirming the indicators, the importance of each factor was determined using experts' opinions and considering questionnaire design, and fuzzy Delphi and fuzzy TOPSIS techniques were employed to rank the suppliers according to the evaluation of the indicators. Professor Lotfi Asgarzadeh introduced fuzzy sets for the first time in 1965. These collections were the foundation of a successful method for modeling uncertainty and ambiguity. Since then, the use of fuzzy sets in computer systems has been expanded, especially in control applications.

A fuzzy set is defined by a membership function that assigns a degree of membership between 0 and 1 to each of its members. This degree of membership demonstrates to what extent a member belongs to a group. As a result, in fuzzy logic, defining terms, such as good, bad, or average, can be interpreted as certain defined numbers.

If the S set is assumed with elements X_i, we can show the membership of X_i to the set as follows:

$X_i \in S$

To show the membership of X_i to the S set, we can use the concept of the membership function $\mu_s(x)$, thus:

$$\begin{vmatrix} \mu_s(x_i) = 1 \xrightarrow{if} x_i \in S \\ \mu_s(x_i) = 0 \xrightarrow{if} x_i \notin S \end{vmatrix}$$

If we assume that the membership function $\mu_s(x)$ can take values between [0,1], then we can accept the following definitions:

X_i is weakly a member of S $\rightarrow$ the value of $\mu_s(x)$ is close to zero

X_i is moderately a member of S $\rightarrow \mu_s(x)$ is neither very close to zero nor very close to one

X_i is strongly a member of S $\rightarrow \mu_s(x)$ is close to one

A triangular fuzzy number is illustrated in Figure 1. A triangular fuzzy number is represented as (l, m, u) the parameters l, m, and u respectively show the maximum possible value, the maximum expected value, and the minimum possible value to describe a triangular fuzzy number. When the three parameters are the same, it means a common non-fuzzy number.

The membership function of a triangular fuzzy number is as follows:

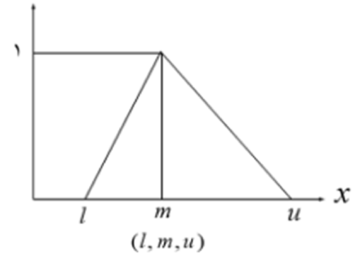

Figure 1. A triangular fuzzy number

$$\begin{cases} 0, x < 1 \\ \dfrac{x-1}{m-1}, 1 \le x \le m \\ \dfrac{u-x}{u-m}, m \le x \le u \\ 0, x > u \end{cases}$$

Research statistical population and sample

In this research, the statistical population consisted of managers, experts of hospitals, and suppliers of medical equipment of hospitals. The sample size was determined at 234 individuals using the stratified sampling method relative to the size of the population, employing the Cochran formula, and considering the maximum acceptable estimation error of 0.05 for determining the sample size. The Cochran's formula used was as follows:

Z: the area under the standard normal curve for alpha 0.05 is equal to 1.96.

P: the proportion of the desired attribute in the society, which is considered equal to 0.5 at the time of unavailability.

q=1-p

a=0.05: error or the possibility of committing the first type of error.

d=0.05: the maximum acceptable estimation error, which is generally considered equal to 0.05.

Cochran's formula:

$$n_{max} = \frac{\frac{z^2 pq}{d^2}}{1+\frac{1}{N}[\frac{pqz^2}{d^2}-1]} = \frac{384/16}{1+\frac{343/16}{600}} = 233.59=234$$

Validity of the questionnaire

In the present research, the content validity method was used to determine the validity of the questionnaire. To this aim, the questionnaire was given to five experts as academic staff members of the university to use, and its validity was confirmed. The confirmatory factor analysis of the questionnaire was performed as follows:

The standardized factor loadings in confirmatory factor analysis to measure the strength of the relationship between each factor (latent variable) and its manifest variables (questionnaire items) were obtained in all cases greater than 0.3. Therefore, the factorial structure of the questionnaire can be confirmed.

After calculating the standardized factor loadings, a significance test should be performed. The factor loading of the t statistic of each of the studied dimensions at the 5% confidence level is greater than 1.96.

Reliability of the questionnaire

In this research, the reliability of the questionnaire was confirmed by management supervisors, consultants, and experts. After entering the data, the reliability coefficient (Cronbach's alpha) was calculated using SPSS software (Table 1). The below Formula shows the calculation of Cronbach's alpha:

$$\text{Cronbach's alpha coefficient: } \alpha = \frac{n}{n-1}\left(1 - \frac{\Sigma s_j^2}{s_t^2}\right)$$

n: number of test questions; $\mathbf{s_j^2}$:question variance; $\mathbf{s_t^2}$: total variance of test questions

The value of the alpha coefficient obtained from this method for the items of the questionnaire and all the questions of the questionnaire was higher than 0.7, which indicated the high consistency of the questionnaire.

Table 1. Calculation of Cronbach's alpha coefficient

Dimension	Number of questions	Cronbach's alpha
Whole questionnaire	13	0.824
Product quality	5	0.845
Timely delivery	3	0.835
Product price	3	0.721
After-sales service	2	0.803

Data analysis

The data were analyzed in two stages. The first stage involved using the fuzzy Delphi method in three steps, and the second stage involved using the fuzzy TOPSIS ranking method.

Fuzzy sets of a set are specified by a membership function of 1, to each member of which a value of membership between 0 and 1 is assigned. This degree of membership demonstrates the extent of how much each member belongs to a group. As a result, in fuzzy logic, defining words, such as good, bad, or average, can be interpreted as certain defined numbers.

Steps of fuzzy Delphi method

One of the best ways to eliminate the effects of the opinions of top managers of the organization on the opinions of other people is to receive information in person. For this purpose, three basic steps were considered in the research:

Step 1: Identifying research indicators;

Step 2: Collecting the opinions of decision-making experts; and

Step 3: Confirming and screening indicators.

Criteria selection method in fuzzy Delphi method

The criteria selected in this research were based on Dickson's supplier selection criteria.

Identification of criteria using the fuzzy Delphi method

The reason for using the Delphi technique was to neutralize the effects of the opinion of the chief executive officer or other managers. By using this method, all the managers expressed their opinions about the indicators of technology selection independently and according to the personal information and guidance of the researcher.

The questionnaire designed for the fuzzy Delphi method, which basically contained all the criteria extracted from the research literature, along with the definitions of the criteria, was sent to the experts. Experts expressed their opinion about each criterion.

First step: The criteria extracted from the research literature were sent to the experts.

In the following, after selecting the final criteria by the experts, 5 supplier companies, which are called A1 to A6 here, were ranked using the fuzzy TOPSIS method. The fuzzy TOPSIS method can detect the most similar alternative to the ideal one.

At this stage, 8 experts using linguistic vocabulary valued the companies according to each criterion in order to prioritize hospital suppliers. To this aim, a questionnaire was designed and rated on a 5-point Likert scale as mentioned earlier in the third chapter (Table 2).

Second step: This step involved the application of the TOPSIS fuzzy method. To rank the suppliers and choose the right supplier using the TOPSIS fuzzy method, the following steps will be performed:

Table 2. Criteria selected by experts

Criterion	Definition
Product quality-C1	To supply a high-quality product, the supplier must have a quality system, including quality assurance, quality control procedures, quality control charts, and continuous quality improvement
Timely delivery-C2	Due to the high sensitivity of healthcare equipment, orders must arrive at the buyer's place at the determined time
Product price-C3	It is an important part of product supply costs; therefore, a product with a lower price should be purchased to reduce supply chain costs
After-sales service-C4	It consists of the provision of service, support, and spare parts after an initial sale
Technical ability-C5	The amount of knowledge and existing infrastructure of the supplier to produce the product
Position in the industry among competitors-C6	Position and rank of the supplier's brand among similar competitors
Easy-to-use product-C7	Features that make it easier to use and reduce user errors

Each column represents an index of measurement and each row an alternative Xij is representative of the quantity of the i-th alternative in the j-th sub-criterion. The sub-criteria may be negative or positive depending on the impact on the alternatives. Xij values can be entered into the decision matrix based on a fuzzy spectrum. To complete the fuzzy decision matrix, the 5-point Likert scale of "very poor" to "very good" can be used.

Using the information collected by experts, we created a decision matrix.

The second stage is to normalize the decision matrix.

To rank the suppliers and choose the appropriate supplier using the TOPSIS fuzzy method, the following steps will be adopted:

1- Creating the decision matrix by means of using the information collected by the experts;

2- Normalizing the decision matrix;

3- Forming the weighted matrix;

4- Determining the fuzzy positive ideal (A+) and negative ideal (A-) points for the components;

5- Calculating the total distances between each component and the fuzzy positive ideal and the fuzzy negative ideal points;

6- Calculating the rating index;

7- Ranking the obtained values in descending order; and

8- Final ranking of alternatives.

In this section, to better understand the performed calculations, first, an example of the performed mathematical operations will be given in detail. To prevent an unreasonable increase in the volume of the research, the details of all the mathematical operations have been avoided.

First, to calculate the decision matrix of triangular fuzzy numbers from the information gathered from the matrix of experts' opinions, for option A1, which is formed by the opinion of 8 experts (Table 3), the following relations were used:

If we show the opinions of experts with triangular numbers (aij,bij,cij), the calculation of the decision matrix for the product quality index would be:

aijk = Min (7,5,5,7,7,7,5,5) = 5

bijk = (9+7+7+9+9+9+7+7)/8 = 8

cijk = Max (11,9,9,11,11,9,9) = 11

Table 3. Matrix of experts' opinions

Supplier	Experts' opinions							
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8
A_1	(5,7,9)	(5,7,9)	(7,9,11)	(7,9,11)	(7,9,11)	(5,7,9)	(5,7,9)	(7,9,11)

Third Step: Formation of the weighted matrix

1- Determining the positive ideal (A+) and negative ideal (A-) points for the components;

2- Calculating the total distances between each component and the fuzzy positive ideal and the fuzzy negative ideal points;

3- Calculating the rating index;

4- Ranking the obtained values in descending order; and

5- Final ranking of alternatives.

In this section, to better understand the performed calculations, first, an example of the mathematical operations will be given in detail. To prevent an unreasonable increase in the volume of the research, the details of all the calculations have been avoided.

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Initially, to calculate the decision matrix of triangular fuzzy numbers from the information obtained from the matrix of experts' opinions, for option A1, which is formed by the opinion of 8 experts, (Table 3) the following relations were used:

Table 5. Distance of each option from ideal and anti-ideal

d+	Easy to use the product			Technical ability			After sales services			Price product			Timely delivery			Product quality			
0.1753	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0301	0.0000	0.0000	0.0000	A1

Table 6. Distance from negative ideal

d+	Easy to use the product			Technical ability			After sales services			Price product			Timely delivery			Product quality			
189628	0.04617	0.11134	0.027109	0.04617	0.13601	0.12048	0.04617	0.07896	0.12048	0.1154	0.01110	0.03012	0.01154	0.04441	0.12048	0.04617	0.16316	0.12048	**A1**

Table 7. Normalization of fuzzy values

d+	Easy to use the product			Technical ability			After sales services			Price product			Timely delivery			Product quality			
1.00	0.82	0.64	1.00	0.75	0.45	1.00	0.73	0.45	0.82	0.48	0.27	1.00	0.80	0.00	0.45	1.00	0.73	0.45	A1
1.00	0.77	0.45	1.00	0.75	0.45	1.00	0.73	0.27	0.82	0.50	0.27	1.00	0.82	0.00	0.64	0.82	0.57	0.27	A2
1.00	0.00	0.45	1.00	0.73	0.45	1.00	0.73	0.27	0.64	0.34	0.09	1.00	0.82	0.00	0.64	1.00	0.55	0.27	A3
1.00	0.77	0.45	0.82	0.59	0.27	1.00	0.68	0.09	0.64	0.36	0.09	1.00	0.80	0.00	0.45	0.64	0.30	0.09	A4
0.64	0.39	0.09	0.64	0.27	0.09	0.45	0.25	0.09	0.64	0.34	0.09	0.82	0.52	0.00	0.09	0.82	0.52	0.27	A5
0.82	0.61	0.27	1.00	0.55	0.27	0.82	0.50	0.27	0.64	0.41	0.09	1.00	0.75	0.00	0.45	0.64	0.20	0.09	A6

Analysis

In the level, we obtained the weighted matrix of the criteria with the previous method for averaging the opinion of experts for the product quality index (Table 4).

W11 = (1+1+0.82+1+1+0.82+1+1)/8 → 7.64/8 = 0.95

W12 = (0.82+0.82+0.64+0.82+0.82+0.82+0.82+0.82)/8 → 6.18/8 = 0.77

W13 = (0.64+0.64+0.45+0.64+0.64+0.45+0.64+0.64)/8 → 4.73/8 = 0.59

In the following, we descaled the fuzzy decision matrix. To this aim, according to the relationships presented in the research and considering that the product quality criterion had a positive loading, we used the relevant formula:

$$nij = \frac{(5.8.11)}{11} \quad \rightarrow \quad nij = \left(\frac{5}{11}.\frac{8}{11}.\frac{11}{11}\right) = (0.45.0.73.1)$$

The next step is to determine the weighted fuzzy decision matrix. For this purpose, according to the weight of different criteria, the weighted fuzzy decision matrix was obtained by multiplying the importance coefficient of each criterion in the unscaled fuzzy matrix as follows. In fact, this relationship states that to form a weighted matrix, the normal matrix must be multiplied by the weight of the criteria.

$$nij = (0.45 \times 0.95.0.73 \times 0.77.1 \times 0.59) = (0.43.0.56.0.59)$$

4- The next step is to find the positive and negative ideal alternatives. In this step, the positive ideal is equal to the largest entry of each criterion column, whereas the negative ideal is equal to the smallest entry of each criterion column.

Part of its calculation for the quality index is as follows:

$$c_1^+ = max(0.43.0.26.0.26.0.09.0.26.0.09) = 0.43$$
$$c_1^+ = max(0.56.0.44.0.42.0.23.0.40.0.16) = 0.56$$
$$c_1^+ = max(0.59.0.48.0.59.0.38.0.48.0.38) = 0.59$$

To find the negative ideal alternative, the smallest entry of each column for each criterion is selected:

$$c_1^- = min(0.43.0.26.0.26.0.09.0.26.0.09) = 0.09$$
$$c_1^- = min(0.56.0.44.0.42.0.23.0.40.0.16) = 0.16$$
$$c_1^- = min(0.59.0.48.0.59.0.38.0.48.0.38) = 0.38$$

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In this step, the distance between each alternative and the positive and negative ideal points is calculated. The distance from the positive ideal for option 1 (supplier A1) is equal to: (Table 5).

$$d_1^+\{(0.43-0.43)^2.(0.56-0.56)^2.(0.59-0.59)^2\} = (0.0.0)$$

The distance from the negative ideal is equal to: (Table 2).

$$d_1^+\{(0..9-0.43)^2.(0.16-0.56)^2.(0.38-0.59)^2\} \cong (0.1204.0.1631.0.0461)$$

Fourth step: normalizing the decision matrix

At this stage, we should convert the fuzzy decision matrix of people's opinions into a fuzzy descaled matrix. To obtain the matrix, if the components are positive, the first relationship, and if the components are negative, (Table 7).

At this step, we calculated the weighted matrix using the weight of the criteria obtained by three experts utilizing the expert method. The results of the overall weights of the criteria are presented in Table 8.

At this stage, the weighted fuzzy decision matrix was determined, the results of which are tabulated in Table 9.

Sixth step. Determining the fuzzy positive ideal (A+) and negative ideal (A-) alternatives for the components

At this stage, the fuzzy positive (A+) and the negative (A-) ideal points were determined for the components. The information about the positive and negative ideals for each criterion is presented in Table 10

Seventh step. Calculation of the total distances of each component from the fuzzy positive ideal and the fuzzy negative ideal.

This step involved the calculation of the distance between the positive and negative ideals. Table 11 summarizes the distance from the positive ideal alternative.

Table 11 shows the distance of the alternatives from the positive ideal.

Table 8. Weight of criteria

C_1	C_1	C_5	C_4	C_3	C_2	C_1	Criterion
0.11, 0.23, 0.41	0.11, 0.2, 0.39	0.48, 0.66, 0.84	0.41, 0.59, 0.77	0.57, 0.75, 0.93	0.55, 0.73, 0.91	0.59, 0.77, 0.95	**Weight of criteria**

Table 9. Fuzzy decision matrix

d+	Easy to use the product			Technical ability			After sales services			Price product			Timely delivery			Product quality		
0.59	0.58	0.43	0.59	0.56	0.43	0.59	0.58	0.43	0.48	0.37	0.26	0.59	0.61	0.43	0.59	0.56	0.43	A1
0.59	0.58	0.43	0.59	0.56	0.43	0.59	0.47	0.26	0.48	0.39	0.26	0.59	0.63	0.61	0.48	0.44	0.26	A2
0.59	0.56	0.43	0.59	0.56	0.43	0.59	0.47	0.26	0.38	0.26	0.09	0.59	0.63	0.61	0.59	0.42	0.26	A3
0.48	0.46	0.26	0.59	0.53	0.43	0.38	0.30	0.09	0.38	0.28	0.09	0.59	0.61	0.43	0.38	0.23	0.09	A4
0.38	021	0.09	0.27	0.19	0.19	0.38	0.33	0.09	0.38	0.26	0.09	0.48	0.40	0.09	0.48	0.40	0.26	A5
0.59	0.42	0.26	0.48	0.39	0.39	0.48	0.40	0.26	0.38	0.32	0.09	0.59	0.58	0.43	0.38	0.16	0.09	A6

Table 10. Positive and negative ideals

d+	Easy to use the product			Technical ability			After sales services			Price product			Timely delivery			Product quality		
0.59	0.63	0.61	0.59	0.58	0.43	0.59	0.58	0.43	0.48	0.39	0.26	0.59	0.63	0.61	0.59	0.56	0.43	**Positive ideals**
0.38	0.30	0.09	0.38	0.21	0.09	0.27	0.30	0.09	0.38	0.26	0.09	0.48	0.40	0.09	0.48	0.16	0.09	**Negative ideals**

Final step: ranking the alternatives

The information regarding ranking suppliers is presented in Table 12. The five supplier companies, here called A1 to A6, were ranked using the fuzzy TOPSIS method.

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Table 11. Results of distance between positive ideal

Easy to use the product		Technical ability	After sales services	Price product	Timely delivery	Product quality	
0.0000	0.0000	0.0000	0.0000	0.0003	0.0304	0.0000	A1
0.0314	0.0000	0.0000	0.0412	0.0000	0.0000	0.0568	A2
0.0329	0.0003	0.0000	0.0412	0.0568	0.0000	0.0499	A3
0.0314	0.0568	0.0012	0.2456	0.0528	0.0304	0.2780	A4
0.4286	0.3027	03604	0.2271	0.0568	0.3348	0.0666	A5
0.1570	0.0551	0.0725	0.0725	0.0466	0.0329	0.3298	A6

Table 12. Ranking suppliers

Rank	CCi	suppliers
1	0.9154	A1
2	0.9114	A2
3	0.8939	A3
4	0.7523	A4
5	0.4470	A5
6	0.7098	A6

Discussion and Conclusion

Taking into account the vital role of the healthcare sector, which includes hospitals and Red Crescent centers constitute its components, as well as the growing trend of technology and increasing the variety of medical equipment, selecting the right supplier has become increasingly important. Moreover, finding the fuzzy ideal and anti-ideal alternatives is important; in this step, the positive ideal was equal to the largest entry of each criterion column and the negative ideal was equal to the smallest entry of each criterion column.

According to the results obtained by the fuzzy Delphi method, the criterion of product quality with a score of 0.88 was chosen as the most important criterion, whereas the ease-to-use product index with a score of 0.7 was determined as the least important criterion. The selection and evaluation of suppliers were conducted through several different quantitative and qualitative indicators, such as cost, quality, timely delivery, and after-sales service. As a result, companies must choose key indicators and suitable suppliers since the right supplier leads to a reduction in purchase costs as well as an increase in the quality of the products, and ultimately the success of the organization in reaching its goals.

Manivel and Ranganathan in 2017 investigated the importance of supplier selection in hospital pharmacy using fuzzy TOPSIS and FAHP methods. They selected five criteria by interviewing the manager of the hospital pharmacy and analyzed them. The decision-makers determined the weights of the criteria and sub-criteria, evaluated the alternatives, and ranked them using the FAHP and FTOPSIS methods. Finally, similar to the current research, they compared the results using FAHP and FTOPSIS methods and selected the appropriate supplier.

In 2017, Bahadori et al. studied the selection of hospital suppliers using Fuzzy VIKOR methods and artificial neural networks. They conducted their study in a military hospital. The obtained results showed that the quality with the highest weight was the most effective criterion in the selection of the supplier, followed by the criteria of price, timely delivery, packaging and quality of transportation, the background of the supplier, and payment terms. These results were similar to those of the current research process.

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Conflict of Interests

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