Title: Improving the Process of Providing Medical Supplies by Designing an Optimal Model of Purchasing Expertise Based on the Delphi Technique

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Abstract

Background and Objectives: Hospitals, as the most critical and costly part of the health system of any country, are required to provide quality and cost-effective diagnostic and treatment services, and optimal resource efficiency and cost management are considered essential elements for achieving these goals. In the meantime, proper expertise in medical supplies purchasing has been considered one of the ways to maintain and improve the quality of services and control costs in hospitals. In this regard, this research aims to identify effective indicators in the expertise of medical supplies purchasing.

Methods: This research was of the applied type and was carried out in a descriptive-survey way. To implement, the indicators collected from previous related studies, with the opinion of experts and using the Delphi method, were completed, and the expertise model of medical supplies purchasing was designed and proposed.

Results: Sixteen criteria for medical supplies purchasing in five main categories, "cost", "quality and safety", "compliance with requirements", "delivery conditions" and "supplier records" were identified, categorized, and designed in the form of a conceptual model of purchasing expertise. According to the results, the criteria of "quality", "importer/producer registration in the system of the General Department of Medical Equipment" and "price" were recognized as the most critical indicators in the purchase of medical supplies.

Conclusion: Accurate identification of effective quantitative and qualitative indicators in the purchase of medical supplies and their use in health and treatment centers will lead to the supply of suitable medical supplies and, as a result, provide quality and cost-effective services along with the efficient management of resources and expenses, it will lead to the improvement of the country's health system services and increase in the satisfaction of service recipients.

Keywords: The health system, health centers, purchasing expertise, medical supplies, Delphi technique.

Background and objectives

The health and treatment sector is the largest industry in the world in terms of budget, employees, customers, etc[1]., and hospitals, as the most important and costly operating units of this industry, account for a large amount of health and treatment resources, which should be used carefully and lead to the provision of quality and cost-effective services[2]. Therefore, one of the strategic goals of the health and treatment sector of every country has always been to increase the efficiency of the facilities of these centers and reduce treatment costs[3].

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In the meantime, medical supplies and drugs, spending one-third of the annual budget of medical centers and their beneficial and vital role in treating patients have received much attention in recent years[4].The use of quality medical supplies has a direct relationship with the increase It has the health of patients and reliability in using healthcare services; On the other hand, saving in the supply chain of hospitals leads to the reduction of costs and the continuation of the services of these centers. Therefore, the need to prepare appropriate medical supplies and improve the expertise process of its purchase has made the necessity and importance of managing this sector even more visible, and policymakers and researchers in different countries have seen the role that proper purchasing can play in optimizing costs and increasing competitive advantage[2, 5-8]. The optimum supply of medical supplies has a direct effect on the realization of the goals of the health system and guaranteeing the citizens' right to health. despite the fact that providing medical equipment and supplies has become one of the main processes in hospitals, however, the medical community does not apply a systematic and documented method in the field of optimal logistics[9].

Researchers have concluded that in hospitals, purchasing medical supplies is often very complicated and is affected by several components. Its quality depends on the expertise and skill of experts in paying sufficient attention to all details. In this process, factors such as risks, costs, results, and effects must be considered. In addition to these factors, the prevailing laws and the variety of medical supplies available in the market increase the complexity and uncertainty, both internal and external, making a choice more difficult. Also, traditional decision-making, focusing on price, cost, profit, or another single economic objective defined by the procurement committee, will have adverse consequences such as harming the interests of patients and reducing the effectiveness of treatment, increasing the burden of the insurance fund and wasting medical and health resources[10,11].

Therefore, it seems that applying and paying attention to all the effective quantitative and qualitative indicators in the expertise of medical supplies purchasing can lead to the right choice and, as a result, provide convenient, quality, and cost-effective services. The review of the studies conducted in purchasing and supplying medical supplies inside and outside the country, despite the limited number, shows the upward growth of these researches and the increase in recognition and attention towards this issue and its importance in recent years. In this regard, Lari et al. (2021), in a research conducted to determine the influential factors in managing the purchase of medical supplies, considered the selection of medical supplies as very important, and they stated that the slightest mistake would have a hefty economic and social damage for the society. In this research, based on review studies and experts' opinions, the indicators of "quality" of medical supplies, its "safety" for users and patients, "observance of requirements, laws and executive regulations in line with the purchase of domestic products" and the necessity of "observance of purchasing process standards" as effective factors in Purchase management has been mentioned[10]. Davis (2012) investigated the methods of purchasing medical equipment in Ireland and the three criteria of "quality", "price" and "volume" as decision criteria for purchasing medical equipment and supplies in this country[12]. In the model proposed by Liu et al.

(2016), the hospital should evaluate all suppliers of essentials with the indicators of "quality" and "on-time delivery" and select suppliers with high scores to maintain long-term cooperation to improve procurement and achieve relatively centralized management and reduce of complexity and workload of procurement and management[13]. In a research conducted in 2019 by Khumpang & Arunyanart in a hospital in northeastern Thailand to discover the appropriate criteria for selecting suppliers of medical supplies from previous studies, the criteria of "quality", "price", "reliability", "agility", "compliance", "Services", "Benefits/Bargaining", "Transportation/Delivery" have been introduced to select the optimal supplier[14] Tavana, Nazari, and Farzaneh (2020) have used the method of literature review and structural equation modeling and data envelopment analysis to identify and select the criteria of "flexibility", "compliance with standards", "redundancy", "cost", "quality certificates" and "delivery time" criteria as effective factors on suppliers' performance[15]. Bahadori et al. (2020), in descriptive research using existing studies and the opinion of experts without mentioning the method, collect the criteria of "quality", "price", "delivery on time", "quality of packaging and transportation", "supplier background" and "payment conditions" to select suppliers of medical equipment[16].

According to the above studies, it can be found that little research have been done regarding the identification of expertise criteria for purchasing medical supplies. In many of them, the indicators of medical supplies purchasing have been marginally mentioned. At the same time, the accurate identification and use of effective indicators in the correct selection of medical supplies and transparency in purchasing supplies are among the main factors in providing high-quality and sustainable services in health and treatment centers. Therefore, the purpose of this research is to identify the practical and valuable criteria for the correct expertise in the purchase of medical supplies using library studies and correcting and completing them with the Delphi method to extract knowledge and exploit the expertise and experience of a group of experts.

Methods

This research is qualitative, applied in terms of purpose and descriptive survey from the point of view of data collection, and was conducted in two parts, theoretical and field. The theoretical dimension of the research was based on library studies that led to the initial collection of expertise criteria for purchasing medical supplies. In the following, it was necessary to review these criteria and make amendments. For this purpose, the Delphi method was used to extract the knowledge of experts and to correct and complete the quantitative and qualitative criteria of expertise in the purchase of medical supplies. Diagram 1 shows the process of conducting this research.

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│    Definition of research   │
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Selection of Delphi panel members
• Determining the required characteristics and expertise
• Identification and selection of members
• Talking with the candidates and determining the final
  members by announcing their readiness

Review of previous studies
• Identification of the conducted researches
• Extraction of research criteria and methods

Designing the first round of questionnaires

The first round of Delphi
• Receiving experts' opinions regarding the findings of previous studies
• Identification of new criteria desired by experts

Qualitative analysis of first round questionnaires
• Combining similar comments and removing repetitive and marginal topics
• Categorizing the criteria and designing the second round questionnaire

The second round of Delphi
• Providing all the obtained criteria to the members
• Receiving members' opinions regarding agreement or disagreement with each criterion
• Receiving members' opinions regarding the classification of criteria

Quantitative analysis of second round questionnaires
• Calculation of the sum, average, median and standard deviation of the scores of each criterion
• Calculation of Kendall's coordination coefficient
• Verification and screening of the criteria with the threshold value and preparation of the final model
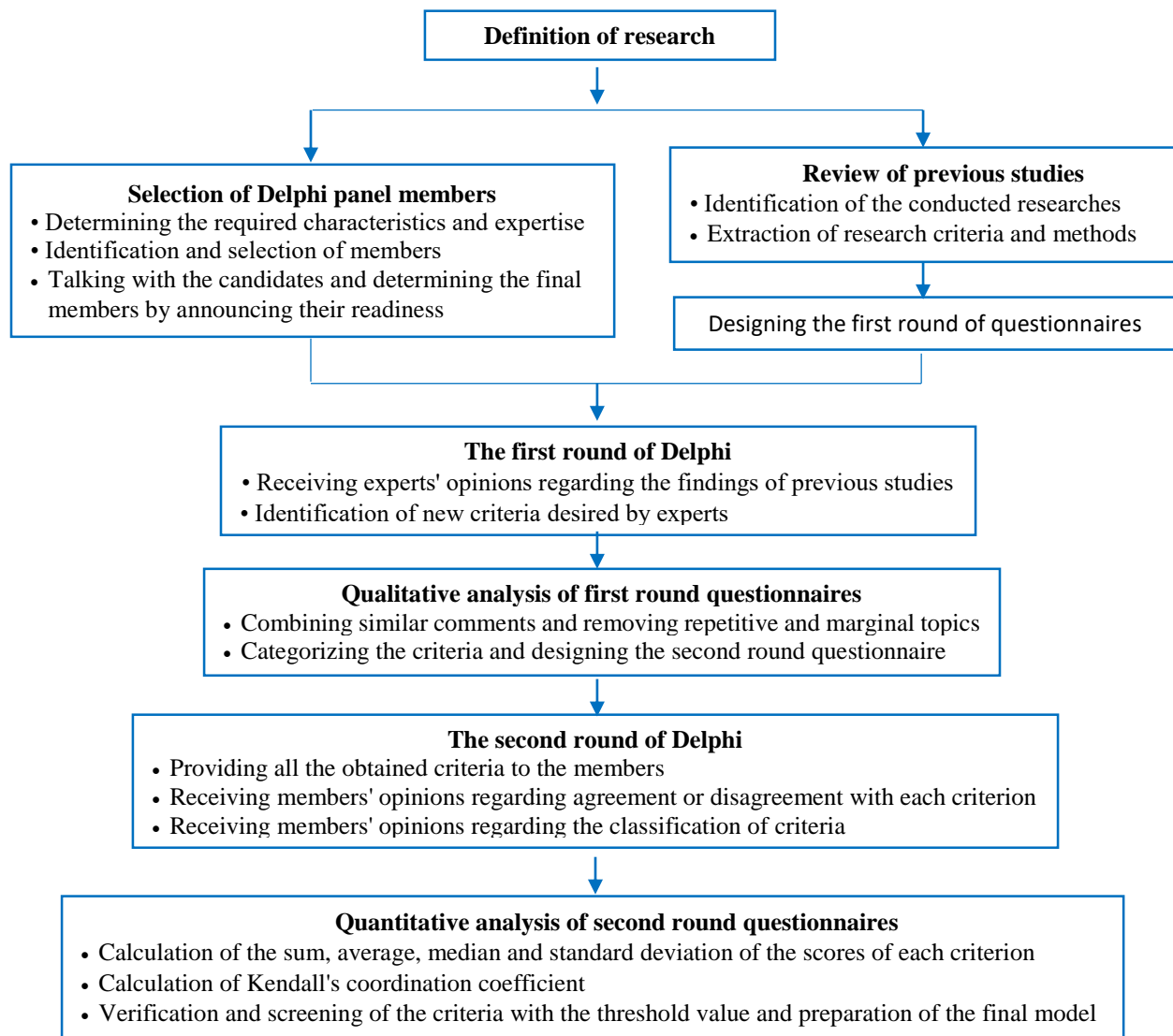
Diagram 1: The process of conducting research and implementing the Delphi method

The selection of panel members in the Delphi method is an important issue that should be considered. The number of these people has been mentioned differently in the research, but when there is a similarity between them, usually 10 to 20 experts are enough[17]. The experts participating in research must have knowledge and expertise in the subject of the research. Therefore, from the community of experts in the field of medical equipment and supplies of the country, including university faculty members, researchers and doctoral students and staff and hospital managers, and experts in the field of medical supplies in universities of medical sciences and affiliated organizations, 15 people were selected by the method of "non-probability sampling and a combination of targeted and judgmental methods", of which 12 people declared their readiness, and They cooperated with researchers. The judgment method is based on the assumption that the researcher's

knowledge about society is used to select the sample. This sample includes specialists, managers, and experts of medical equipment in the country who have academic, research, executive, and experimental records related to medical equipment and supplies. The

demographic characteristics of these people are presented in Table 1. The participation of these people was used to acquire knowledge and answer the questionnaires of this research.

Table 1: Characteristics of the experts participating in the research

Education	length of experience	type of experience	age	gender
6 PhD	9 people over 15 years	5 scientific-research and executive people	9 people over 40 years old	7 men
6 masters	3 people less than 15 years old	٧ executive people	3 people under 40 years old	5 women

The Delphi technique is a structured process for extracting and classifying the knowledge of a group of experts, which is done through the distribution of questionnaires among these people and controlled feedback on the opinions received[18]. This technique can be used for "identification" and "screening" of the most critical decision-making indicators. According to Helmer (1977), Delphi is a useful communication tool between a numbers of experts that facilitates summarizing the opinions of group members[19]. According to Linston and Trof (1975), the Delphi technique is used in situations where the problem cannot be investigated through analytical techniques, but the abstract judgments of experts can be used for it, people who have to participate in the investigation of a problem, do not have enough communication or have various specialized and experimental fields, the number of people required is more than they can have face-to-face interaction, holding periodic group meetings is not justified in terms of time and cost, or to ensure the

validity of the results, it is necessary to preserve the inhomogeneity of people[19].

To implement this method, in the first step, according to the criteria extracted from the literature review and with the consensus of several experts, questions were raised in the form of an open questionnaire. Its face and content validity was confirmed using the opinions of specialists and professors and then presented to the experts for their response. The purpose of this stage was to collect and classify the opinions of the experts participating in the study by using the questions in the questionnaire and to identify the effective indicators in the expertise of medical supplies purchasing from the eyes of specialists and experts. At this stage, each of the experts participating in the study was asked to present their ideas and express their opinions regarding the findings of the previous studies and finally return their desired content. After collecting the questionnaires, the responses were organized without any attempt to evaluate or judge; in this way, similar comments were combined and repetitive and marginal topics were removed. Then, with the qualitative analysis

and content analysis of the answers, a foundation was provided for making the next questionnaire.

In the second stage, a questionnaire based on the answers of the first stage was prepared and given to the same participants again. The purpose of this round was to determine the importance of the criteria obtained from the first questionnaire, along with the reasons. At this stage, the members of the Delphi panel ranked and quantified each criterion using linguistic variables and a 5-point Likert scale. To analyze the results of this questionnaire and to perform calculations, a score of 5 means very high importance and a score of 1 means the very low significance of each criterion was considered by each expert. Then, the data was analyzed using SPSS 24 software, and to find the level of experts' agreement with each index, the sum, average, and median scores were used. And finally, the standard deviation of the scores of each index was calculated. An index called the threshold value was also used to confirm and screen the criteria, and in this research, due to the use of a 5-option Likert scale, the number 3 was considered for it. In other words, if the average score of each criterion was less than 3, that criterion was removed.

In the Delphi method, consensus or unanimity does not mean finding the correct answer but simply the participants' agreement at a certain level on the subject in question[20]. In this research, Kendall's coefficient of coordination was used to determine the consensus scale between the members of the Delphi committee. Kendall's coordination coefficient is a scale to assess the degree of coordination and agreement between several rank categories related to N objects or individuals and is calculated as follows[21]:

$$W = \frac{s}{\frac{1}{12}k^2(N^3-N)} \qquad \text{(Eq 1)}$$

Where **N** is the number of rated criteria, **k** is the number of sets of ratings (number of judges), **s** is the sum of the squared deviations of **R$_j$** from the mean of **R$_j$** and **R$_j$** is the total number of ratings related to a criterion.

$$s = \sum\left(R_j - \frac{\sum R_j}{N}\right)^2 \qquad \text{(Eq 2)}$$

The value of this scale is equal to one when there is complete coordination or agreement and zero when there is no coordination. Many discussions have been raised regarding the validity and reliability of the Delphi method. The researchers believe that controlling the validity and reliability of this method is not an easy task. Still, the use of consecutive questionnaires and the presence of expert participants increases the content validity of Delphi and, finally, the validity of the results obtained from the Delphi method is improved by increasing their response rate[22].

Results:

The results of the review of previous studies and content analysis of the first round of Delphi questionnaires regarding the essential criteria for the expertise of purchasing medical supplies are shown in Table 2.

Table 2: Criteria extracted from the first stage Delphi questionnaires

Titles of criteria extracted from previous studies and identified by experts		
Criteria extracted from	Price [10, 12, 14, 15, 16]	Compliance [14]
	Quality [10, 12, 13, 14, 16]	Services [14]
	Safety [10]	Advantages/redundancy/bargaining [14,15]

Titles of criteria extracted from previous studies and identified by experts		
previous studies	Compliance with the requirements, laws and executive regulations in order to buy from domestic products [10]	Compliance with the standards of the purchase process [10,15]
	Transportation [14, 16]	Flexibility [15]
	Volume [12]	Quality certificates [15]
	Delivery on time [13, 15, 16]	Packaging quality [16]
	Reliability [14]	Background of the supplier [16]
	Agility [14]	Terms of payment [16]
criteria identified by experts	Quality of medical supplies	Price
	The satisfaction of the treatment staff with the performance of medical supplies	Complying with financial and transaction regulations of universities
	Complying with the pricing regulations of the General Administration of Medical Equipment	Registration of requirements in the system of the General Department of Medical Equipment
	Safety and reliability	Purchase of domestic products
	Compliance of goods with proforma and invoice	Purchase through bidding
	Ease of use	Having international approvals
	Having the approval of the General Department of Medical Equipment	The possibility of concluding a contract or memorandum of understanding
	Registration of the importing or producing company in the system of the General Administration	Registration of the representative of the distributor company in the system of the General Administration
	Discounts and benefits from purchases	Abundance and availability of goods
	The possibility of returning goods	Call history
	Seller support	History of accidents
	Delivery time	History of the seller company
	Availability and responsiveness of the seller	Seller's financial ability and payment terms
	Delivery location	transport cost

The qualitative analysis of the responses of the first stage of Delphi and the extraction of the indicators desired by the experts showed a lot of overlap in the indicators extracted from the texts. The combination of these two categories of indicators obtained was the basis of the second questionnaire. Therefore, in the second round, a questionnaire, according to Table 3, was prepared and given to the same participants again. Also, in this round, the calculated indicators were coded and categorized using the opinions of professors, researchers and existing literature, and those that were related were placed in a group, and the experts were asked to give their final idea and agree or disagree with Announce the classification is done, and finally, the group of experts of this research approved the classification with ten positive votes and two abstentions.

Table 3: Findings from the analysis of the questionnaires of the second stage of Delphi using SPSS software

Category	Indicator	Total	Average	Middle	standard

				deviation
Cost	Price	56	4.7	5	0.5
	Discounts and benefits from purchases	47	3.9	4	1.1
	transport cost	41	3.4	3	0.7
Quality and safety	Quality	60	5	5	0
	Ease of use	48	4	4	0.6
	Having international certificates and approvals	47	3.9	4	0.9
	History of accidents and recalls	56	4.7	5	0.5
Compliance with requirements	Having the approval of the General Administration and registration in the relevant system	56	4.7	5	0.5
	Purchase of domestic products	55	4.6	5	0.7
	Complying with the pricing regulations of the General Administration	56	4.7	5	0.5
	Importer/producer registration in the General Administration system	57	4.8	5	0.5
	Registration of distributor agency in the system of the General Administration	46	3.8	4	0.9
	Complying with the financial and transaction regulations of the university	23	1.9	2	0.5
	Compliance of goods with proforma and invoice	18	1.5	1	0.7
Delivery conditions	Delivery time	51	4.3	4	0.5
	Delivery location	44	3.7	4	0.8
	Packaging quality	30	2.5	2	0.8
	The possibility of returning goods	32	2.7	3	0.5
Supplier's records	History of the seller company	38	3.2	3	0.6
	Production capacity and ability to supply by the seller	33	2.8	3	0.6
	Seller's financial ability and payment terms	35	2.9	3	1
	Flexibility of the seller and the possibility of bargaining	28	2.3	2	0.5
	seller's response and support	52	4.3	4	0.5
	Geographical location of the seller	14	1.2	1	0.4
	Abundance and availability of goods	28	2.3	2	0.7
	The possibility of concluding a contract or memorandum of understanding	25	2.1	2	0.7
	The possibility of buying through bidding	21	1.8	2	0.6

The results obtained from the calculation of the Kendall coefficient to determine the consensus scale between the members of the Delphi committee, based on the information from the second round of Delphi questionnaires, by the SPSS 24 software, are given in Table 4.

Table 4: Calculation of Kendall's correlation coefficient using SPSS software

Test Statistics

N	12
Kendall's W[a]	.907
Chi-Square	283.882
df	26
Asymp. Sig.	.000
a. Kendall's Coefficient of Concordance	

As can be seen from the results, the probability value is smaller than the test level (0.05), and the chi-square statistic means rejecting the null hypothesis based on randomness and inconsistency of experts' opinions. [23] Also, the statistical value higher than 0.9 for the Kendall coefficient means a firm agreement of the experts in determining the importance of the criteria and the adequacy of the discussion and no need to carry out the next rounds of Delphi to achieve greater coordination between the experts. [17] Usually, two statistical criteria are used to decide whether to stop or continue the Delphi rounds. The first criterion is the strong consensus among the panel members, calculated based on the Kendall coefficient. In the absence of such an agreement, the stability of this coefficient or its slight growth in two consecutive rounds shows that there has not been an increase in the members' agreement, and the polling process should be stopped. [21] Therefore, this round was considered the last stage of the Delphi process. In the following, a threshold value of 3 was used to confirm and screen the criteria. The final criteria categorized in diagram 2 are presented in the form of the expertise model for purchasing medical supplies which can be used in healthcare centers.
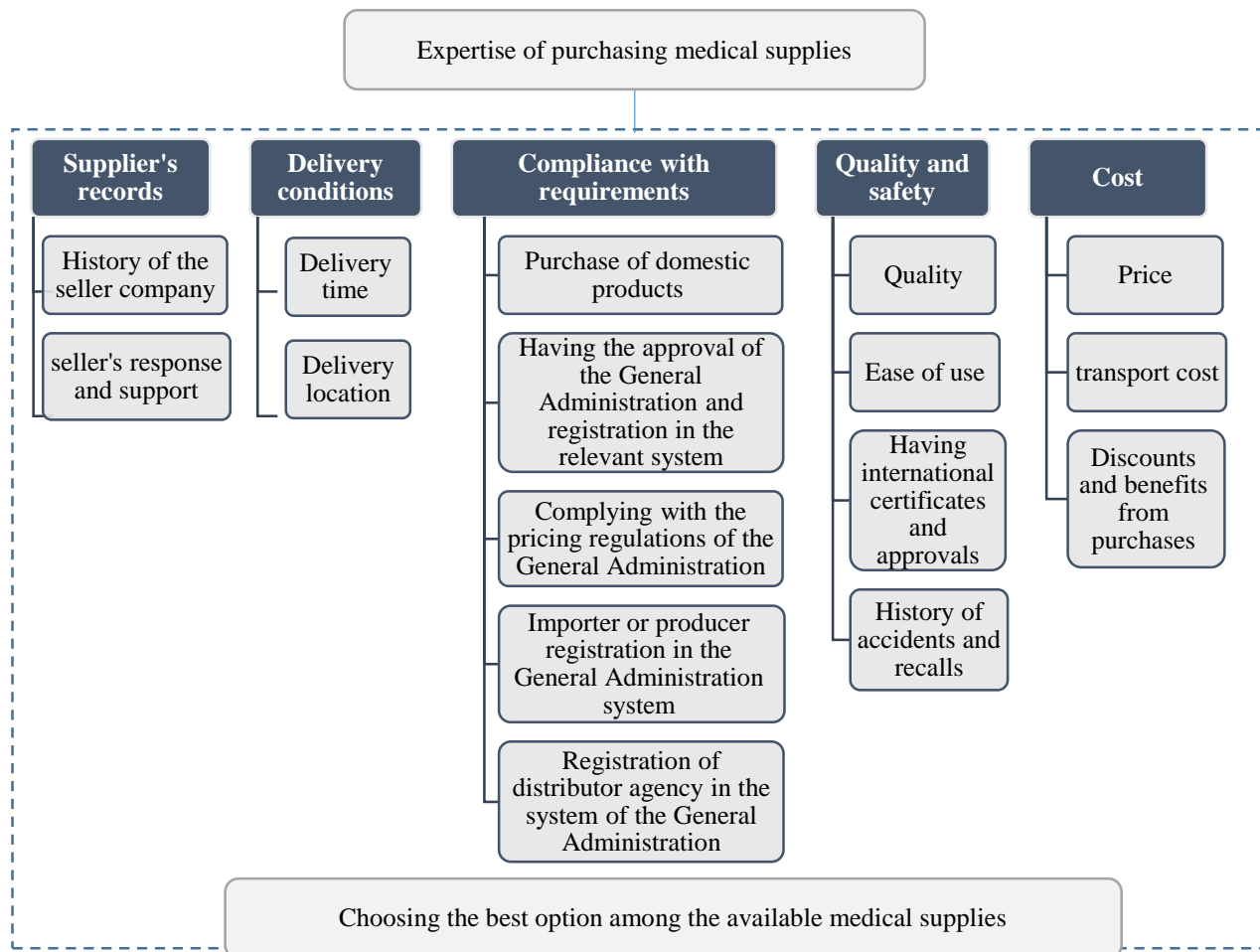
Diagram 2: The final model of expertise criteria for purchasing medical supplies

Discussion

Expertise in the purchase of medical supplies in the healthcare system is a complex and specialized decision, and it can be defined as a multi-criteria decision-making problem that includes several qualitative and quantitative factors, and its purpose is to choose the best option among Options available. Studies show that the indicators of selection and purchase of medical supplies have exceeded the traditional set of price and quality over the past years, and new criteria for an optimal purchase have been gradually presented.

Although in these studies, efforts have been made to calculate the effective indicators in the purchase of medical supplies, a comprehensive method for identifying these factors has not been used, and all the indicators in previous studies and the criteria desired by the experts have not been taken into consideration[10, 12-16].

In this research, the most important quantitative and qualitative indicators of expertise in the purchase of medical supplies, which was the result of a comprehensive review of the conducted research and the expertise and experience of specialists in this

field, were identified in the form of 16 sub-criteria and were classified into 5 main criteria groups by re-surveying the experts and the obtained results were presented in the framework of the expertise criteria model for the purchase of medical supplies. None of the aforementioned studies have focused on the classification of indicators and the design of a comprehensive model[10, 12-16].

In this structure, as shown in Table 3, "quality" and then "importer/producer registration in the General Administration system" are known as the most important indicators. "Price", "Having the approval of the General Administration and registration in the relevant system" and "Complying with the pricing rules of the General Administration" are all ranked next after the first two indicators, with equal points. This issue shows that, except for "quality" and "price", compliance with the requirements of the General Department of Medical Equipment as a reference and trustee for monitoring the production, import, distribution and consumption of medical equipment and supplies is considered an essential dimension in an optimal purchase. In most previous studies, price and quality have been mentioned as the leading indicators in purchasing essentials[12,14,16]. Along with the previous three indicators, the criterion of "history of accidents and recalls" can be seen in the table. "Accident" refers to an event that leads to death or serious injury to the patient, the user of the device, or other people, and its occurrence is usually caused by the defect of the device, improper performance of the device, user error, improper design, problems related to the production of the device or problems related to device labeling. "Recall" also occurs when goods are collected due to the possibility of injury or even death[24].

After the above criteria, as the research of Lari et al. (2018), experts have considered the "Purchase of domestic products "[10]. Buying domestic products, supporting domestic industries and the country's economy and following the guidelines, implies receiving available after-sales services[25]. The criterion in the form of "seller's response and support" is given in the next step, and the row of "goods delivery time" has been given a score. "Ease of use" or user-friendliness, which leads to better user performance with the device, has received an average score of 4 from the eyes of experts. "Discounts and benefits from purchases" are also considered in the next row.

"International approvals" such as FDA, CE, ISO 13485, etc., each express the compliance of the medical equipment and supplies with international standards and show a suitable level of quality in competition with other similar products. Tavana, Nazari and Farzaneh (2020) also mentioned this criterion as "quality certificates" in their research[15].

"Registration of the distributor's agency in the system of the General Administration" is also one of the prerequisites for purchasing and a "suitable place for delivery of goods" that accelerates the receipt of goods by the centers. "Transportation cost" and "Seller's company record" are also fundamental but less important than the previous indicators. Undoubtedly, a company that has been operating for a long time in selling goods has more experienced and trained personnel than a company that is doing this for the first time. From the 27 initially collected indicators, 11 were considered unimportant according to the experts and were removed. Among these 11 indicators, "geographical location of the seller" was recognized as the least essential indicator in the matter of purchase expertise and selection of supplies by experts. Finally, these results led to the preparation of the expertise model of medical supplies purchasing from the eyes of experts.

Conclusion

The use of this model and the use of valuable and effective indicators in the expertise of medical supplies purchasing and not paying attention and spending time on less important indicators, in addition to saving time and personnel power, leads to a suitable and optimal purchase and guarantees quality in providing services and reducing costs. In addition, it brings the satisfaction of the doctor, user and patient and makes purchasing medical supplies clear and straightforward. The practical implementation of the above model and the evaluation of its consequences in comparison with past purchases and the last criteria is an issue that can be interesting for researchers and future research, and its results will be helpful in the healthcare system.

Competing Interests
The authors declare no competing interests.

Authors' contributions
The authors are the same.

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Conflict of interest
The authors declare that there is no conflict of interest.

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