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Ranking Healthcare Centers Using Fuzzy Analytic Hierarchy Process and TOPSIS: Iranian Experience

F. Amini, J. Rezaeenour*

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Abstract Establishing justice in healthcare services is currently a major challenge for public healthcare systems, especially in developing countries. Inadequate distribution of resources and facilities is among the root causes of unfair access to healthcare. Using ranking mechanisms, healthcare managers are able to compare different areas in terms of the services they receive, which will help achieve balanced allocation of services. Ranking allows fair dispersion of financial resources as well as human workforce. It also helps monitor and evaluate plans so that the strengths and weaknesses can be identified and improved. Furthermore, incentive policies can be devised for healthcare managers and providers throughout the country. This paper aims to present rank healthcare centers in the Province of Golestan in Iran with regards to the execution of the Family Health Program. A multi-criteria decision-making approach is taken: using a Fuzzy Analytic Hierarchy Process (FAHP) for determining the weights of the criteria and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) for ranking the cities of the province. In order to confirm the results, they are compared to those obtained from the Elimination Et Choice Translating Reality (ELECTRE) method. The outcome of this study can significantly aid in improving managerial practices including resource planning, so that the overall performance of healthcare centers can be promoted.

Keywords: Ranking Performance Analysis, Fuzzy Analytic Hierarchy Pprocess, Topsis, Electre, Family Health Program.

1 Introduction

Worldwide, health systems are moving towards "justice in health" for all human beings. Despite overall improvements in global health, health services are being distributed unfairly. Therefore, it is essential that justice in health services, especially in third-world countries, receive more attention [1,2]. Over the course of the past century, many health programs were built on the foundation of improving the health of the general population [3]. Inadequate distribution of health related resources and facilities in different regions are among the causes

***Corresponding Author.** (✉)
E-mail: j.rezaee@qom.ac.ir (J. Rezaeenour)

F. Amini,
Department of Information Technology, Faculty of Technology and Engineering, University of Qom, Qom, Iran.

J. Rezaeenour
Department of Industrial Engineering, Faculty of Technology and Engineering, University of Qom, Qom, Iran.

of healthcare injustice [4,5]. Past experience has shown that in every country, several regions tend to standout in terms of performance and achieve superior development.

Competition is a natural phenomenon in which several alternatives receive different shares of finite resources. However, since health is not a commodity, there should be no competition for resources in healthcare. This forces officials to make very tough decisions, which may not always be correct [6]. Under such circumstances, the transparency, structure, and comprehensiveness of these decisions are scrutinized to meet patient needs as well as societal and moral values. Healthcare decisions impact both individuals and the society, which increases their complexity and places a burden of responsibility on the decision-makers (DMs). Thus, the need for a systematic approach to evaluating alternative according to various criteria in the decision-making process is clear [7].

A ranking mechanism, which allows the comparison of regions according to various criteria, can help managers at various levels realize healthcare justice. Identifying factors that influence performance in different regions allows decision-makers to both take advantage regional managers' experiences and allocate budget efficiently. Overall, ranking decision criteria plays a significant role in fair allocation of resources and facilities; helps assess and monitor plans to pinpoint strength and weaknesses; improves quality of service; and allows the application of more effective rewards and punishments. Similar to any real-world problem, large number criteria, with various degrees of importance, exist in healthcare. Combining and ranking these criteria for the purpose of resource allocation is not an easy task.

A multitude of techniques have been devised to support decision-makers, which are known collectively as Multi-Criteria Decision Analysis (MCDA). Using MCDA it is possible to make decisions according to several criteria in a transparent manner, which may be the reason for the increase in their popularity in many disciplines. Compared to their traditional counterparts, MCDA methods allow more effective decisions [8]. The concept has received a great deal of attention in decision sciences, both in theory and practice. Organizations, including private companies and state-run offices, are increasingly adopting MCDA. The concept can be used under varying degrees of uncertainty as well as risk, which is among its strengths.

The public is generally interested in improved level of health. However, healthcare systems need to achieve this goal within strictly pre-defined budget frames. Therefore, resource allocation becomes a primary task in all healthcare delivery systems. Both resource allocation and priority setting aim to optimize their use of resources for achieving the highest health benefits.

Multi-Criteria Decision Making (MCDM) methods are suitable candidates for ranking and prioritizing resource allocation. This paper aims to present a model for ranking healthcare centers in the Province of Golestan in terms of performance on the Family Health Program (FHP). Weights are determined for the criteria of the program using Fuzzy Analytic Hierarchy Process (FAHP). TOPSIS is employed to rank the cities in the province. Furthermore, in order to ensure accuracy, a second set of ranks are obtained using ELECTRE and compared to those of TOPSIS.

The remainder of this paper is organized as follows. Section 2 provides a brief review of the literature on the application of MCDM approaches in the healthcare domain. In Section 3, the problem and the proposed solution are given. Section 4 presents the results of the paper. Finally, in Section 5, we conclude the paper with a discussion of the results.

2 Literature Review

Various disciplines including management, marketing, engineering, and operational research have contributed to the development of MCDM. In practice, many methods fall under MCDM approaches, all of which share a common performance matrix. The rows of the matrix represent the alternatives while the criteria are shown in the columns. The values in each column are compared to select a particular alternative [9]. AHP is a useful method in making decisions, which has been well-received by both scholars and practitioners. Russo et al. studied different aspects of AHP and its application in different fields. The process of selecting effective criteria followed by the calculation of priority weights of the criteria are among the topics they discuss in their paper [10]. Integrating current methods with fuzzy techniques may represent a practical solution to handling uncertainty in the decision-making process. For instance, an interdepartmental study on the criteria of performance applied the AHP method to determine the weight of each criterion. This was followed by the application of the Fuzzy TOPSIS approach to assess the performance of executive managers [11]. Identifying the factors involved in using a software component as well as the selection of a suitable developer and evaluating the associated cost-benefit are among the reasons that choosing a software component can be considered an MCDM problem. A study employed the FAHP approach along with fuzzy TOPSIS to facilitate decision-making in this area [12].

Healthcare decision-makers can utilize a number of methods and tools to increase their effectiveness. Evaluating and selecting software packages that can meet organizational requirements is always a challenging task. Choosing the wrong open-source Electronic Medical Record (EMR) software may result in damages to the organization's reputation and have serious financial consequences. In one study, an MCDM technique is proposed for selecting open-source EMR software. Pertinent criteria are analyzed using AHP and TOPSIS. The procedure is able to suggest a suitable EMR with adequate effectiveness [13].

A large number of individuals are concerned with selecting appropriate insurance coverage. The fact that many firms and organizations, with varying options and attributes, compete in this area adds to the complexity of the situation. Another study aimed to use FAHP and TOPSIS in the process of selecting healthcare insurance providers according to various criteria [14]. Furthermore, AHP has been used to prioritize different factors influencing nursing staff's satisfaction with the information system at their workplace [15]. Service quality, safety, and health are among the issues in healthcare which not only benefit the patients but also other stakeholders including physicians, hospitals, and the community as a whole. Taiwanese hospitals have utilized FAHP and TOPSIS to prioritize factors influencing quality of service and evaluate their impact on quality of safety services provided by the hospitals [16]. Accordingly, FAHP is used to assign weights to the criteria and the hospitals are ranked based on their levels of quality, using Fuzzy TOPSIS. A similar case study in Turkey determined service quality indices, developed in order to present a scientific basis for classification of hospitals using multiple criteria decision making tools. The AHP was employed to analyze the importance of each index in terms of service providers and patients [17].

3. Methods and Materials

3.1 Methodology

This study has four major phases. First, the main criteria for assessing four operational plans of the FHP were defined and used as the basis for ranking the cities participating in the program. A survey of extant literature and interviews with FHP experts led to the identification of the criteria. In the second phase, program experts decided on the relative weight of each criterion. Relying on the advantages of the FAHP approach for solving MCDM problems, a version of the method developed by Chang was used for pairwise comparisons to obtain the final weight of each criterion. The third phase involved the application of the simple yet efficient TOPSIS method for ranking the cities. Finally, in order to ensure the validity of the results, the cities were once again ranked using the ELECTRE method and Spearman's correlation was conducted to analyze the two sets.

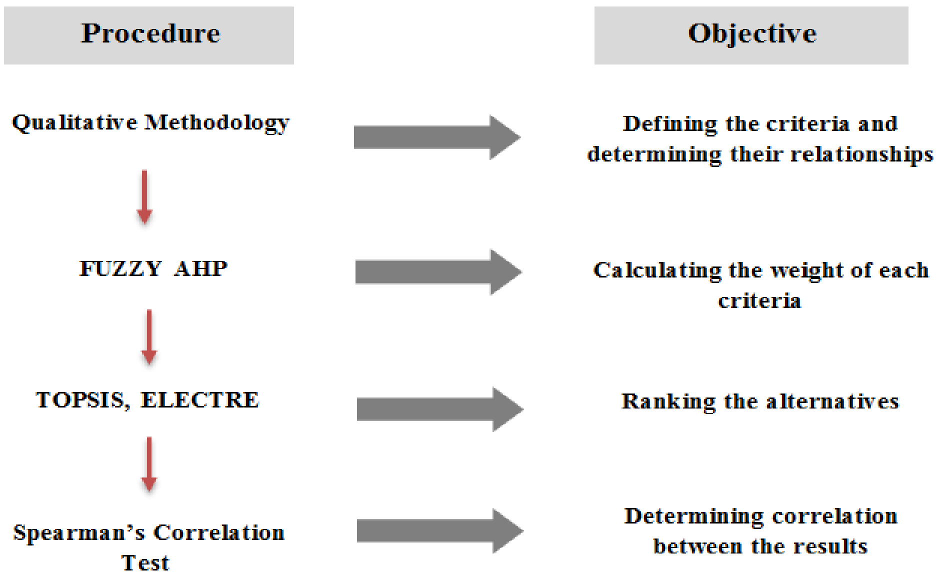

Fig. 1 Proposed process for ranking cities participating in the FHP

Fuzzy Analytic Hierarchy Process

Fuzzy set theory was introduced by Zadeh in 1965 [18]. Bellman and Zadeh were the first to use the theory for handling vague, imprecise, and uncertain decision-making [19]. Developed by Saaty, the Analytic Hierarchy Process (AHP) is among the most efficient methods of MCDM [20].The basic AHP creates a matrix of pairwise comparisons between the factors so that the impact of items in each level on the items in the next level can be determined. Incorporation of uncertainty into the AHP forms the basis for an approach known as the fuzzy AHP (FAHP). Numerous authors including Buckley [21], Chang [22], Mikhailov and Tsvetinov [23], and Van Laarhoven and Pedrcyz [24] suggest different methods of implementing the fuzzy AHP. Chang's fuzzy AHP is a systematic method of choosing alternatives and solving problems using fuzzy set theory and the AHP, which employs triangular fuzzy numbers. The purpose of these numbers is to determine the priority of different decision variables, while the final priority of weights is determined through the application of the extended AHP method based on triangular fuzzy numbers.

The weights in the FAHP algorithm, proposed by Chang, are calculated in seven steps as follows.

Step 1. Determining the hierarchy of criteria impacting the decision.
Step 2. Defining fuzzy numbers for pairwise comparisons.
Step 3. Creating the pairwise comparison matrix:

The values in this matrix are fuzzy numbers , where j and i represent the column and the row index of alternatives, respectively. In cases where multiple decision-makers are involved, each entry of the matrix is a triangular number whose points are the minimum, average, and maximum values according to questionnaires, respectively.

Step 4. Calculating S_i for each row of the pairwise comparison matrix using Eq. (1):

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} \tag{1}$$

The values of $\sum_{j=1}^{m} M_{gi}^{j}$ and $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$ can be obtained by Eq.s (2) and (3):

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_i, \sum_{j=1}^{m} m_i, \sum_{j=1}^{m} u_i \right), \tag{2}$$

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} = \left(1 \Big/ \sum_{j=1}^{n} u_i, 1 \Big/ \sum_{j=1}^{n} m_i, 1 \Big/ \sum_{j=1}^{n} l_i \right) \tag{3}$$

Step 5. Calculating the degree of possibility for each S_i; the value for the rectangular numbers $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ is defined by Eq. (4):

$$V(M \geq M_1, M_2, ..., M_n) = hgt(M_1 \cap M_2) = \mu_{M2}(d),$$
$$= \begin{cases} 1, & m_2 \geq m_1 \\ 0, & l_1 \geq u_2 \\ l_1 - u_2 / (m_2 - u_2) - (m_1 - l_1), & Otherwise \end{cases} \tag{4}$$

Step 6. Obtaining the weight for each criteria using Eq. (5):

$$V(M \geq M_1, M_2, ..., M_n) = MinV(M \geq M_i) \quad i = 1, 2, ..., n. \tag{5}$$

Assuming Eq. (6) holds, the weight vector is obtained by Eq. (7):

$$d'(A_i) = MinV(S_i \geq S_k) \quad k = 1, 2, ..., n. \qquad k \neq I \tag{6}$$

$$W' = (d'(A_1), d'(A_2), ..., d'(A_n))^T \quad A_i (i = 1, 2, ..., n). \tag{7}$$

Step 7. Finally, the normalized weight vector can be obtained by Eq. (8):

$$W = (d(A_1), d(A_2), ..., d(A_n))^T \tag{8}$$

TOPSIS (Technique for Order Performance by Similarity to Ideal Solution)

TOPSIS is a simple yet very efficient MCDM algorithm. It sorts alternatives according to their distance from the positive and negative ideal solutions. The Positive Ideal Solution (PIS) represents the point with maximal and minimal attainable values for benefits and costs criteria, respectively. Conversely, the Negative Ideal Solution (NIS) maximizes the cost criteria while minimizing the benefit criteria [25, 26]. In TOPSIS, the alternative farthest from NIS and closest to PIS achieves first rank. The details of the ranking procedure in TOPSIS are as follows [25].

Step 1. Normalizing the decision matrix using Eq. (9):

$$r_{ij} = W_{ij} \Big/ \sqrt{\sum_{j=1}^{m} Wij^2}, \quad j = 1, 2, ..., m; \quad i = 1, 2, ..., n. \tag{9}$$

Step 2. Creating the weighted decision matrix using the vector of criteria weights multiply by the normalized decision matrix.

$$V_{ij} = W_i * r_{ij}, \qquad j = 1,2,...,m; \quad i = 1,2,...,n. \tag{10}$$

Step 3. Determining PIS and NIS through the application of Eq.s (11) and (12):

$$PIS = \left\{V_1^{\max}, V_2^{\max}, ..., V_n^{\max}\right\} \tag{11}$$

$$NIS = \left\{V_1^{\min}, V_2^{\min}, ..., V_n^{\min}\right\} \tag{12}$$

Step 4. Calculating the distance of each alternative from PIS and NIS by Eq.s (13) and (14):

$$d_i^+ = \sqrt{\sum_{j=1}^{m}\left(V_{ij} - V_j^{\max}\right)^2}, \ i = 1,2,...,n. \tag{13}$$

$$d_i^- = \sqrt{\sum_{j=1}^{m}\left(V_{ij} - V_j^{\min}\right)^2}, \ i = 1,2,...,n. \tag{14}$$

Step 5. Calculating the closeness coefficient for each alternative using Eq. (15):

$$CC_i = d_i^- \Big/ \left(d_i^+ + d_i^-\right) \tag{15}$$

Step 6. Ranking alternatives by comparing their CC_i values.

ELECTRE (Elimination Et Choice Translating Reality)

Proposed by[27] and later extended by other authors [28], ELECTRE refers to a category of preference aggregation based methods which are applied to pairwise comparisons of alternatives [6]. ELECTRE are known as outranking approaches because they aim to ascertain whether one option is at least as good as (i.e. outranks) another [29,30].

The purpose of ELECTRE is threefold: to aggregate heterogeneous criteria which are not commonly considered in one common scale, to avoid compensation behavior, and to account for preference differences, which results in the introduction of thresholds [31].

There are four elementary binary relations in ELECTRE: indifference, preference, weak preference and incomparability [29,32]. MCDM relies on dominance analysis of relationships among alternatives. Similar to TOPSIS, the weights of the criteria are obtained as the main input. However, instead of using tabular data directly, the algorithm only needs them for comparison purposes. Let i and j be the number alternatives and criteria, respectively. Then, the algorithm will execute in the following manner.

Step 1. Constructing the normalized decision matrix V using Eq.s (16) and (17):

$$r_{ij} = X_{ij} \Bigg/ \sqrt{\sum_{j=1}^{m} X_{ij}^2}, \qquad j = 1,2,...,m; \quad i = 1,2,...,n. \tag{16}$$

$$V_{ij} = W_i * r_{ij}, \quad j = 1,2,...,m; \quad i = 1,2,...,n. \tag{17}$$

Step 2. Constructing the concordance and discordance sets of criteria for pairs of alternatives. As a result, for each pair K and L of alternatives, Eq. (18) is true:

$$J = J_{CK_j} \cup J_{DL_j} \tag{18}$$

Where J_{CK_j} denotes alternatives in which K outranks L and J_{DL_j} represents instances where K is outranked by L.

Step 3. Calculating the sets and constructing the related matrices:

$$\overline{c} = \sum_{k=1}^{m}\sum_{l=1}^{m} c_{kl} \Big/ m\left(m-1\right), \tag{19}$$

$$\bar{d} = \sum_{l=1}^{m}\sum_{k=1}^{m} d_{kl} / m(m-1), \qquad (20)$$

Step 4. Constructing the effective concordance and discordance matrices by the application of Eq.s (21) through (24):

$$c_{kl} = \sum_{j=1}^{m} W_j \qquad (21)$$

$$F = \begin{cases} f_{kl} = 1 & if \quad c_{kl} \geq \bar{c} \\ f_{kl} = 0 & if \quad c_{kl} \prec \bar{c} \end{cases} \qquad (22)$$

$$d_{kl} = \max_{j \in D_{kl}} \left|V_{kj} - V_{lj}\right| / \max_{j \in J} \left|V_{kj} - V_{lj}\right| \qquad (23)$$

$$G = \begin{cases} g_{kl} & if \quad d_{kl} \leq \bar{d} \\ g_{kl} & if \quad d_{kl} \succ \bar{d} \end{cases} \qquad (24)$$

Step 5. Constructing the overall effective matrix and determining the priorities using Eq. (25):

$$E = F.G \rightarrow \begin{cases} if \quad e_{kl} = 1 & K \gg L \\ if \quad e_{kl} = 0 & Otherwise \end{cases} \qquad (25)$$

3.2 Case Study: Ranking Cities in the Province of Golestan (Iran) according to their Performance in the Family Health Program

This paper aims to rank fourteen cities in the Province of Golestan according to their performance on the FHP as a means to aid managers with decision-making. The FHP is divided into four operational programs: Safe Motherhood Program (SMP), Children Health Program (CHP), Reproductive Health Program (RHP), Aging Health Program (AgHP). Following the identification of decision criteria in a thorough review of literature, a hierarchy as well as a questionnaire was developed for his study. The study questionnaire was administered to employees working in various departments of the FHP. The hierarchy of the problem can be seen in Fig.2.

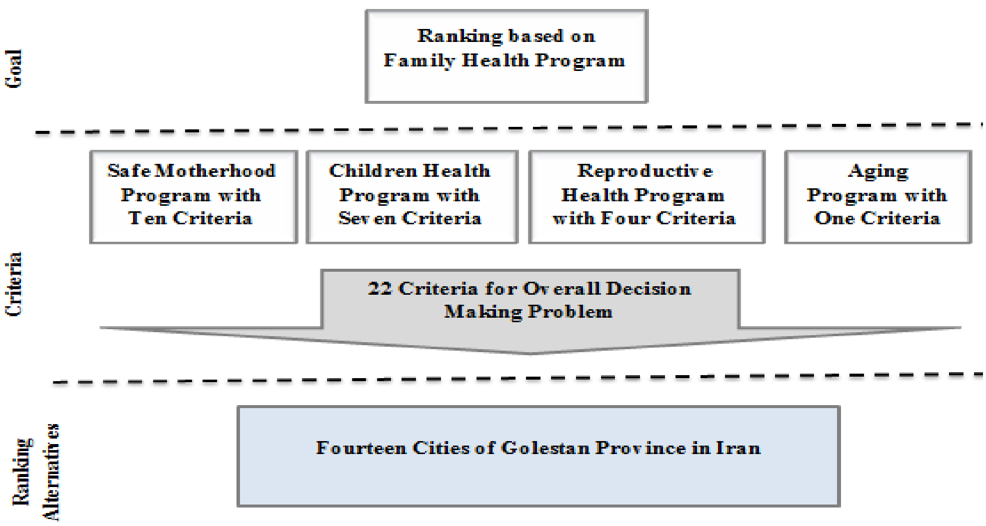

Fig. 2 The hierarchy of framework of decision making for Family Health Program

Tables 1 through 4 present the identified criteria for each of the operational programs in the FHP as well as their method of evaluation.

Table 1 Criteria for monitoring and assessment of the Aging Health Program

Criteria	Description	Assessment strategy
One	The percentage of the elderly people trained about nutrition	- 67% and more(3) - 40-66%(2) - Less than 40%(1)

Table 2 Criteria for monitoring and assessment of the Reproductive Health Program.

Criteria	Description	Assessment strategy
One	Activities done in national population day	Holding a conference (2) Any advertising activity (1) Holding extra-sectorial training classes(0)
Two	Reporting activities done after provincial monitoring	Reporting up to two weeks after monitoring visit (3) Reporting from 2 weeks to one month after monitoring visit (2) Reporting after one month or no report(0)
Three	Conducting extra-sectorial activities	For KOK, BGZ, MTP, GGN districts more than four activities in each season and for other districts more than two activities in each season (4) For KOK, BGZ, MDT, GGN districts more than two activities in each season and for other districts more than one activity in each season (3) No activity(0)
Four	Visiting and monitoring marriage training classes	One visit in the first season and filling in the checklist (2) One visit in the second season and filling in the checklist (1) No visits(0)

Table 3 Criteria for monitoring and assessment of the Children Health Program.

Criteria	Description	Assessment strategy
One	Conducting extra-sectorial activities	Holding a meeting with the city hall (2) Communicating with city hall (1) Holding a meeting with midwives and physician of private sectors (1)
Two	Reporting activities done after provincial monitoring	Reporting up to two weeks after monitoring visit (3) Reporting from 2 weeks to one month after monitoring visit (2) Reporting after one month or no report(0)
Three	Establish children`s mortality committees	Holding at least one committee in first four months (1) attending gynecologist (1) and pediatrician(1) / sending records to portal up to one month after committee(1)
Four	Holding “breastfeeding and children`s health” committees	Holding one committee in first six months according to delivered reports (1)
Five	Coverage of developmental screening for infants at the age of 12 months (urban areas)	Less than 30%(0) Between 30-50%(1) More than 50%(2)
Six	Coverage of developmental screening for infants at the age of 12 months (rural areas)	90% and more(2) 80-89%(1) Less than 80%(0)
Seven	Activities done in universal breastfeeding week/national children`s week.	Diversity of activities/ extra-sectorial and in-sectorial activities/holding campaign

Table 4 Criteria for monitoring and assessment of the Safe Motherhood Program.

Criteria	Description	Assessment strategy
One	programming and performing the annual action plan	- Preparing modified version timely /consideration frames and goals announced by provincial level / performing activities according to Gantt Chart (3) - Preparing modified version with delay / relative consideration of frames and goals announced by provincial level / performing activities not according to Gantt Chart (2) - Delay in preparing final version/not considering frames and goals announced by provincial level (1)
Two	Monitoring by head of Family Health unit	- Monitoring twice in -month(2) - Monitoring once in month(1) - No monitoring(0)
Three	The quality of monitoring visits	- Considering monitoring standards in more than 90% according to feedback records(3) - Considering monitoring standards in 70-90% according to feedback records(2) - Considering monitoring standards in 50-70% according to feedback records(1) - Considering monitoring standards in less than 50% according to feedback records(0)
Four	Follow up and conducting resolutions of health sector maternal health committees	- Follow up and conducting 70-100% of resolutions (3) - Follow up and conducting 50-70% of resolutions (2) - Follow up and conducting less than 50% of resolutions (1)
Five	Follow up and replying to correspondences receiving from provincial level	- Replying up to one week after deadline (2) - Replying more than one week after deadline (1) - No reply (0)
Six	Coverage of pre-pregnancy care in rural areas	- Less than 70% (0) - Between 70-80% (1) - More than 80% (2)
Seven	Coverage of prenatal care at least 6 times in rural areas	Less than 90% (0) Between 90-98% (1) More than 98% (2)
Eight	Coverage of post-delivery care at least 2 times in rural areas	Less than 90% (0) Between 90-98% (1) More than 98% (2)
Nine	Sending data and statistics timely	Up to the tenth to fifteenth of the first month in next season , considering the number of health centers (3) From fifteenth to twentieth of the first month in next season , considering the number of health centers (2) From twentieth to the end of the first month in next season , considering the number of health centers (1) Sending after one month(0)
Ten	Reporting "saving mothers` life" scenarios to provincial level	Up to the tenth to fifteenth of the first month in next season , considering the number of health centers (2) From fifteenth to twentieth of the first month in next season , considering the number of health centers (1) Sending after 2 months(0)

4 Results

After constructing the hierarchy of criteria in the FHP, the first step was to apply the FAHP algorithm in order to obtain the weights of the criteria in each level. The final weight of each criterion in each level equals the weight of the base program multiplied by the weight criterion in that particular level. Due to the large number of pairwise comparisons, in the following, only an instance of the comparisons is presented and followed by the normalized weights.

Table 5 Fuzzy comparison matrix of the four basic criteria in relation to the goal and their priority vectors.

	SMP	CHP	RHP	AgHP	S_i	Weight
SMP	(1.5,1.85,2.25)	(1.28,1.28,1.28)	(1,1.08,1.12)	(1,1,1)	(0.26,0.31,0.4)	0.5129
CHP	(1.5,1.7,2)	(1.14,1.18,1.28)	(1,1,1)	(0.89,0.93,1)	(0.24,0.3,0.34)	0.3730
RHP	(1.17,1.4,1.75)	(1,1,1)	(0.78,0.84,0.87)	(0.78,0.78,0.78)	(0.2,0.24,0.28)	0.1139
AgHP	(1,1,1)	(0.57,0.71,0.86)	(0.5,0.62,0.67)	(0.44,0.55,0.66)	(0.13,0.17,0.2)	0

Table 6 Weight vector of Safe motherhood program criteria

Criteria	S_i	Local Weight	Overall Weight
One	(0.104,0.11,0.13)	0.152	0.078
Two	(0.1,0.11,0.13)	0.152	0.078
Three	(0.11,0.11,0.14)	0.152	0.078
Four	(0.09,0.1,0.123)	0.086	0.044
Five	(0.07,0.07,0.083)	0	0
Six	(0.104,0.11,0.13)	0.152	0.078
Seven	(0.104,0.11,0.13)	0.152	0.078
Eight	(0.11,0.11,0.14)	0.152	0.078
Nine	(0.05,0.06,0.07)	0	0
Ten	(0.05,0.06,0.08)	0	0

Table 7 Weight vector of Children health program criteria

Criteria	S_i	Local Weight	Overall Weight
One	(0.1,0.13,0.14)	0	0
Two	(0.05,0.06,0.09)	0	0
Three	(0.16,0.2,0.24)	0.448	0.067
Four	(0.11,0.14,0.18)	0.112	0.038
Five	(0.12,0.15,0.18)	0.128	0
Six	(0.14,0.17,0.2)	0.256	0.067
Seven	(0.11,0.13,0.17)	0.056	0.067

Table 8 Weight vector of Reproductive health program criteria

Criteria	S_i	Local Weight	Overall Weight
One	(0.27,0.33,0.39)	0.524	0.06
Two	(0.2,0.24,0.29)	0.095	0.011
Three	(0.26,0.3,0.35)	0.381	0.043
Four	(0.1,0.12,0.14)	0	0

Since the Elderly Health Program has been executed to a very limited extent, it was assigned a final weight of zero, compared to the other subprograms of the FHP. Consequently, its only criterion (as shown in Table 5) was also assigned a weight of zero, effectively eliminating the program.

Subsequent to the weighting of the criteria, the cities were ranked using TOPSIS. For this purpose, the columns of the matrices holding the values of the criteria for the cities were normalized (as shown in Appendix) and the elements were multiplied by the weights of the criteria. Since the cities are not equally developed, a deprivation coefficient, developed by the Health Organization of Golestan, was applied in order to balance the values. Finally, the similarity index for each alternative was obtained by calculating the distances to PIS and NIS. The calculated parameters together with their ranks and the final are shown in Tables 9 through 13.

Table 9 PIS, NIS, CC and the ranking of healthcare centers Based on Safe Motherhood Program

City	D^*	D^-	CC	Rank
ASH	0.042	0.028	0.400	13
AGH	0.029	0.036	0.549	9
BGZ	0.0408	0.029	0.419	12
BTK	0.034	0.032	0.487	11
RAM	0.027	0.038	0.589	6
AAB	0.039	0.024	0.382	14
KOK	0.025907	0.036	0.580	7
KAL	0.015245	0.045	0.748	3
GAL	0.020484	0.040	0.664	4
GGN	0.014336	0.047	0.768	2
GMN	0.025761	0.040	0.610	5
GND	0.00674	0.057	0.894	1
MTP	0.032785	0.038	0.541	10
MDT	0.029663	0.038	0.560	8

Table 10 Ranking of healthcare centers based on Aging health program

City	Score	Rank
MTP	0.433	First
KAL-GMN	0.404	Second
ASH- AGH- RAM- AAB- GAL- MDT	0.375	Third
BTK-KOK	0.346	Four[th]
GND	0.327	Fift[hs]
GGN	0.289	Six[th]
BGZ	0.115	Seven[th]

As mentioned earlier, Aging health program, included one criterion, therefore, the normalized values were merely sorted in decreasing order.

Table 11 PIS, NIS, CC and the ranking of healthcare centers Based on Children Health Program

City	D^*	D^-	CC	Rank
ASH	0.0446	0.023483	0.344914	11
AGH	0.050853	0.019656	0.278771	13
BGZ	0.043558	0.029838	0.406533	10
BTK	0.034517	0.03689	0.51662	7
RAM	0.032292	0.040515	0.556476	5
AAB	0.041503	0.032353	0.438054	9
KOK	0.054366	0.026083	0.324217	12
KAL	0.019941	0.050086	0.715238	2
GAL	0.034605	0.039081	0.530374	6
GGN	0.037697	0.037519	0.498818	8
GMN	0.032221	0.04215	0.566752	4
GND	0.014744	0.057736	0.796583	1
MTP	0.03071	0.040805	0.570579	3
MDT	0.032292	0.040515	0.556476	5

Table 12 PIS, NIS, CC and the ranking of healthcare Centers based on Reproductive Health Program

City	D^*	D^-	CC	Rank
ASH	0.011113	0.013654	0.5513	8
AGH	0.011113	0.013654	0.5513	8
BGZ	0.02185	0	0	11
BTK	0.02083	0.004173	0.166888	9
RAM	0.021017	0.001632	0.072041	10
AAB	0.008394	0.015244	0.644908	5
KOK	0.02083	0.004173	0.166888	9

City	D^*	D^-	CC	Rank
KAL	0.006283	0.016911	0.729112	2
GAL	0.008394	0.015244	0.644908	4
GGN	0.008418	0.016962	0.668336	3
GMN	0.009633	0.015254	0.61294	7
GND	0.007301	0.020594	0.738256	1
MTP	0.008418	0.016962	0.668336	3
MDT	0.008827	0.014383	0.619683	6

Table 13 PIS, NIS, CC and the overall ranking of healthcare Centers based on Family Health Program

City	D^*	D^-	CC	Rank
GND	0.01778	0.083659	0.824725	1
KAL	0.025875	0.069624	0.729052	2
GGN	0.0412	0.06278	0.603772	3
GMN	0.042363	0.060335	0.587503	4
GAL	0.04108	0.05828	0.586557	4
MTP	0.045703	0.058665	0.562096	5
MDT	0.044727	0.057261	0.561448	5
RAM	0.046892	0.05582	0.543463	6
BTK	0.052866	0.049302	0.482558	7
AAB	0.057855	0.043292	0.428008	8
AGH	0.059994	0.043447	0.42002	8
KOK	0.063724	0.04453	0.41135	9
BGZ	0.063584	0.0419	0.397217	10
ASH	0.062391	0.039148	0.385542	11

In order to verify the results obtained from TOPSIS, the ranking procedure was repeated using ELECTRE. The calculated concordance ($\bar{c}$) and discordance ($\bar{d}$) indices for this method are as below:

Table 14 The overall ranking of healthcare centers based on ELECTRE method

City	Win	Loss	Difference	Rank
ASH	0	2	-2	7
AGH	0	5	-5	8
BGZ	0	6	-6	9
BTK	1	1	0	5
RAM	1	1	0	5
AAB	0	2	-2	7
KOK	0	1	-1	6
KAL	10	0	10	1
GAL	4	1	3	2
GGN	2	0	2	3
GMN	2	1	1	4
GND	1	0	1	4
MTP	0	0	0	5
MDT	0	1	-1	6

Aiming to compare TOPSIS and ELECTRE rankings, we calculate Spearman's rank correlation coefficient. The values, in conjunction with significance test results for each city obtained using TOPSIS and ELECTRE, serve as non-parametric inputs. Table 15 presents the parameters of the test.

Table 15 Coefficient term parameters

N	R_s	Significance
14	0.853	0.001

According to Table 15, the validity of the results can be claimed with 99 percent confidence, which guarantees the reliability of this study [33]. Therefore, the initial assumption is rejected.

5 Discussion and Conclusion

Healthcare both affects and is affected by regional development. The first step to creating any growth and advancement is gaining an understanding of the issues at hand. Thus, an understanding of the current situation is necessary for fair distribution of healthcare services. This paper first described the indicators of health in the Province of Golestan, as a representative sample of the country. The cities in the province were then ranked in terms of FHP performance using a multi-criteria decision-making process.

The obtained ranks can prove useful in determining the status quo, allocating resources, and enforcing policies. They can also be useful in identifying the strengths and weaknesses of each region and help managers assess performance in various areas. This will ultimately lead to improved health in the society. Furthermore, by assigning weights in an MCDM approach, unfair comparisons and their consequent managerial mistakes can be avoided. For instance, high performance in low-priority affairs must be adjusted with a suitable weight so that decision-makers are not misled. The following summarizes the findings of this study.

Developed cities such as KOK and BGZ, have not achieved appropriate performance. As a result, additional managerial and technical support, as well as strict monitoring is suggested. Furthermore, despite receiving adequate resources, smaller cities may require more managerial and technical support to achieve performance goals.

Reasonable performance on one of FHP's subprograms does not guarantee similar performance on the other subprograms. In extreme cases, including GGN and GND, poor performance in childcare, overshadows the cities' overall acceptable performance.

Unexpectedly, it was found that the location factor has no impact on the rank of an area. This significant finding is in contrast to the popular belief that eastern cities of the province are disadvantaged compared to those in the west. According to the ranks, there are low- and high-performance cities in both eastern (e.g. ASH and GND) and western areas (e.g. BGZ and GGN).

It can be concluded that effective management, even in extremely underprivileged areas such as GND and KA, can lead to top performance and achieve success.

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Appendix

Table 1. Normalized values of the basic criteria of Family Health Program

Criteria	ASH	AGH	BGZ	BTK	RAM	AAB	KOK	KAL	GAL	GGN	GMN	GND	MTP	MDT
SMP1	0.323	0.216	0.216	0.216	0.323	0.216	0.323	0.323	0.323	0.216	0.216	0.216	0.216	0.323
SMP 2	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
SMP 3	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
SMP 4	0.323	0.108	0.108	0.108	0.108	0.323	0.323	0.323	0.323	0.323	0.108	0.323	0.323	0.323
SMP 5	0.275	0.275	0.275	0.275	0.275	0.275	0.275	0.137	0.275	0.275	0.275	0.275	0.275	0.275
SMP 6	0.292	0.292	0.146	0.292	0.292	0.146	0.292	0.292	0.292	0.292	0.292	0.292	0.146	0.292
SMP 7	0	0.286	0.286	0.286	0.286	0.143	0.286	0.286	0.286	0.286	0.286	0.286	0.286	0.286
SMP 8	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.283	0.141	0.141
SMP 9	0.211	0.211	0.105	0.211	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.316	0.211	0.105
SMP 10	0.301	0.151	0.151	0.301	0.151	0.151	0.301	0.301	0.301	0.301	0.301	0.301	0.301	0.301
CHP1	0.122	0.366	0.244	0.244	0.244	0.122	0.244	0.244	0.366	0.244	0.122	0.366	0.366	0.244
CHP2	0	0.343	0	0.343	0.343	0.343	0.171	0.343	0.343	0.171	0	0.343	0	0.343
CHP3	0.225	0.225	0.225	0.225	0.225	0.225	0	0.337	0.337	0.225	0.337	0.45	0.225	0.225
CHP4	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
CHP5	0.164	0.164	0.329	0.329	0.329	0.329	0.329	0.329	0	0.164	0.329	0.164	0329	0.164
CHP6	0.147	0	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.295	0.147	0.295	0.295
CHP7	0.135	0.135	0.135	0.404	0.404	0.135	0.27	0.404	0.135	0.135	0.135	0.27	0.27	0.404
RHP1	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
RHP2	0	0	0	0.320	0	0.48	0.32	0.48	0.48	0	0	0	0	0.320
RHP3	0.312	0.312	0.078	0.078	0.078	0.312	0.078	0.312	0.312	0.312	0.312	0.312	0.312	0.312
RHP4	0.354	0.177	0.177	0.177	0.177	0.177	0.354	0.354	0.177	0.354	0.177	0.177	0.354	0.354
AgHP1	0.289	0.289	0.096	0.289	0.289	0.289	0.289	0.289	0.289	0.192	0.289	0.192	0.289	0.289