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ORIGINAL ARTICLE

Assessment of the Therapeutic Performance of a Selected Medical University Based On Driving Indices Using the AHP-TOPSIS Approach

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A B S T R A C T

Background: The assessment of the performance of medical universities as one of the main organizations providing healthcare services is of utmost significance. In this regard, the indices of treatment domain play a fundamental role in promoting health indices and affect the overall performance of the medical university. The present study evaluated the performance of a selected university of medical sciences in Iran based on treatment driving indices with the AHP-TOPSIS approach.

Methods: This research applied a combination of qualitative and quantitative methods. In this study, first the driving indices were identified and weighted, and then the performance was analyzed according to the indices. The statistical population of the research consisted of key experts in the validation and weighting phase and of nine years of information pertaining to one of the medical universities of Iran in the final phase. The instrument used in the study was the Index Collection Form. Prioritization of indices was done by AHP method using Expert Choice and Excel. TOPSIS model were used to evaluate performance.

Results: In the first step, using a review study, 111 indices were identified, and in the validation stage, 10 indices of treatment domain were selected. Then, based on hierarchical analysis and pairwise comparisons in the weighted indices, the highest weight or priority pertained to the index of the ratio of the total nursing staff to the available beds with a weight of 0.161 and the lowest weight or priority related to the index of natural delivery to all deliveries with a weight of 0.049. According to the TOPSIS method, the selected university showed the highest performance (0.228) in 2014 and the lowest performance (0.006) in 2017.

Conclusion: Considering strategic measures in the deputy of treatment simultaneously to improve and manage research indices over time can improve the performance of universities. Thus, it is appropriate to monitor the indices periodically and in the order of priority, so that in addition to maintaining the efficiency, especially in the indices related to human resources, the effectiveness of the measures, including the improvement of the functional indices of the treatment domain, can also be improved.

Keywords: University of Medical Sciences, Treatment Index, TOPSIS, AHP, Performance Assessment

Introduction

Over the last decades, the success of any organization has depended on the reforms resulting from the weak points identified in the assessment stage, in such a way that every organization uses

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valid measurement tools in assessment to recognize the level of desirability, improve the activities of the employees, eliminate the deficiencies, and plan for strengthening and progress. One of the tools of efficient management is to have an accurate, impartial, and consistent monitoring and assessment system, which can be used to lead and direct the organization in the best possible way to achieve maximum efficiency (1). University performance assessment is a continuous process that requires continuous monitoring to maintain the performance of the organization at a high level (2). Top managers of organizations can take steps to achieve the top goals of the organization when they have appropriate, up-to-date, and comprehensive information about the functioning of their organization and make correct and timely decisions for the continuous improvement of their organization in accordance with daily progress. To this end, scientific management requires that the senior managers and planners of the organization consider the category of evaluating the overall performance of the organization based on scientific, accurate, and effective indices (3). The health and treatment sector is one of the sectors wherein prioritization is necessary to meet its needs due to limited resources (4). The existence of inequality and its dimensions is one of the important signs of underdevelopment, because only countries are actually rendered as developed that not only have high economic and social indices, but also enjoy a relatively fair distribution of income and facilities. Nonetheless, in underdeveloped countries, not only the values of these indices are low, but also their distribution is very unfair (5). Several indices are considered to measure the level of development in a time and place, and health is one of these indices (6). Among the various development indices, the health and treatment index is one of the most important indices of the progress of any country due to its great role in ensuring the health of people in the community; the success rate of national development programs depends to a large extent on achieving the goals of this sector. The more the amount and quality of health indices in a community and the more balanced and appropriate the distribution of these indices, the more relative prosperity and health there will be in that community (7). A brief glance at the health indices in the country in the last decade shows, on the one hand, the rapid improvement of the indices, and on the other hand, the existence of inequality in some indices in different regions and provinces of the country (8). In any case, it is necessary for Iran, like any developing country, to pay special attention to the development in the health and treatment sector to improve its development position among the countries of the world, because the development in this sector is the prerequisite for development in other sectors of the community. Without a healthy community and people with physical, mental and social health, development in other sectors is futile. To plan development in the health and treatment sector of a community, it is first necessary to examine the status of that community in terms of the amount of health and treatment indices (9). In recent years, the use of quantitative methods to investigate the current situation has become common because knowing the state of universities qualitatively may be associated with a lot of discretion and personal bias. Mathematical models, if compiled in simple formats and with a limited number of variables, can provide a clearer understanding of urban phenomena. AHP-TOPSIS hybrid approach was used in this study. The combined method is used in cases where if one method is used alone, it will take a lot of time and many calculations, which will result in incorrect results. The AHP-TOPSIS hybrid method reduces the amount of calculations and pairwise comparisons to at least half in almost all decision-making problems, which in addition to causing accuracy in calculations and results, is also an acceptable and logical solution. In hierarchical analysis, the decision-maker starts his/her work by providing a hierarchical decision tree. This tree shows indices and decision options that perform a series of pairwise comparisons. This comparison shows the weight of each of the factors compared to the competing options. Finally, the AHP logic combines the matrices resulting from pairwise

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comparisons to make optimal decisions. Additionally, the nature of consensus in collective decision-making improves the consistency of the judgments and improves the reliability of the model as a decision-making tool (10). The TOPSIS model was also developed by Huang and Yun (1981) as one of the classic compensation methods in multi-criteria decision-making to solve prioritization problems based on similarity with the positive ideal solution. The TOPSIS algorithm is a very technical and strong decision-making method for prioritizing options by simulating the ideal solution. Among the advantages of this method compared to other ranking methods, we can mention the simultaneous involvement of quantitative and qualitative criteria in the assessment, taking into account a significant number of criteria, the desirable and acceptable performance of the system, and its simplicity (11). Based on the surveys, few studies have investigated the indices of the treatment domain in universities and most of the studies have only reported the performance indices in a certain period of time. In this study, performance assessment has been investigated based on the available information in a 9-year period. Less research has been done on this aspect of the issue. Based on what was mentioned above, the present study, while identifying and prioritizing the indices of the treatment domain, evaluated the performance of a selected university of medical sciences in Iran based on the indices of the treatment drivers with the AHP-TOPSIS approach.

Materials and Methods

This mixed qualitative-quantitative research was descriptive in terms of goals, application, and nature. It was conducted with the aim of comparing the nine-year performance status (2013-2021) of one of the country's selected medical sciences universities based on therapeutic indices. At first, indices related to treatment in medical sciences universities were identified through library research and documents review. In the next stage, using the Delphi method (consensus based on two factors of importance and measurability), 10 indices agreed by experts in the treatment domain were selected for performance assessment as described in Table 1. Knowledgeable experts were used to select the most important indices. At this stage, the opinions of 18 experts were used. The criteria for selecting experts was to have an executive experience in the statistical units of the deputy of treatment in universities or hospitals and to have at least a master's degree related to health information technology. Purposive sampling method was used at this stage that selected the known cases.

Table 1. Selected indices of the treatment domain based on Delphi method

Symbol	Index	Symbol	Index
I1	Average patient hospital stay	I6	The percentage of triaged patients within 6 hours in hospital emergency rooms
I2	Bed occupancy index	I7	Population ratio to the number of psychiatric beds
I3	Per capita manpower to the active bed	I8	Ratio of total nursing staff to available beds
I4	Per capita paramedical manpower to the active bed	I9	Nurse to bed ratio in intensive care units
I5	Ratio of natural delivery to all deliveries	I10	Ratio of nurses per ten thousand people of the covered population

In the next step, the indices were weighted using the hierarchical analysis. The sample size for weighting the indices included 12 of the mentioned experts in the Delphi phase. Since the aim was to compare and determine the importance of the studied indices in relation to each other from the point of view of experts, the items were designed in such a way that each index was compared to other indices based on the numbers 9, 7, 5, 3, 1 indicating the following scales: completely more

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important, highly more important, more important, slightly more important, and the same. Based on this, the first index was compared with the next 9 indices, the second index was compared with the next 7 indices, and so on. Then, in the next step, the performance of the selected university of medical sciences during a nine-year period was investigated using the TOPSIS method and based on weighted indices. The analysis of questionnaires related to the Delphi method was done with $SPSS_{21}$ using descriptive statistics of frequency, percentage, mean, and standard deviation. The investigation of the performance of the university was also carried out with AHP-TOPSIS hybrid method.

TOPSIS Technique

TOPSIS is based on the concept that the selected option should have the smallest distance from the positive ideal solution and the largest distance from the negative ideal solution. In this study, 9 options were evaluated by 10 indices. This method entails 6 steps:

Step Zero (Obtaining the decision matrix): In this method, the decision matrix is evaluated, which includes 9 options and 10 indices.

Step 1 (Normalizing the decision matrix): In this step, we descale the values in the decision matrix. In this way, each of the values is divided by the size of the vector corresponding to the same index. As a result, each directory RIJ is obtained from the following relationship:

Step 2 (Weighting the normalized matrix): The decision matrix is actually parametric and needs to be quantified; for this purpose, the decision-maker determines a weight for each index. The set of weights (W) is multiplied by the normalized matrix (R).

$$W = \left(w_1 و w_2 و \ldots و w_j و \ldots و w_n \right)$$

$$\sum_{j=1}^{n} w_j = 1$$

Step 3 (Determining positive and negative ideal solution): we define two virtual options A* and A– as follows:

$$A^{*} = \left\{ \left(\max_i v_{ij} \middle| j \in J \right) و \left(\min_i v_{ij} \middle| j \in J' \right) \middle| i = 1 و 2 و \ldots و m \right\} = \left\{ v_1^{*} و v_2^{*} و \ldots و v_j^{*} و \ldots و v_n^{*} \right\}$$

$$A^{-} = \left\{ \left(\min_i v_{ij} \middle| j \in J \right) و \left(\max_i v_{ij} \middle| j \in J' \right) \middle| i = 1 و 2 و \ldots و m \right\} = \left\{ v_1^{-} و v_2^{-} و \ldots و v_j^{-} و \ldots و v_n^{-} \right\}$$

The two virtual options created are actually the worst and best solutions.

Step 4 (Obtaining the size of the distances): We measure the distance between each next *n* option using the Euclidean method. That is, we find the distance of option *i* from positive and negative ideal options.

$$S_{i*} = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^{*} \right)^2} \qquad i = 1,2,3,\cdots,m$$

$$S_{i-} = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^{-} \right)^2} \qquad i = 1,2,3,\cdots,m$$

Step 5 (Calculating the relative closeness to the ideal solution): This criterion is obtained through the following formula:

$$C_{i*} = \frac{S_{i-}}{S_{i*} + S_{i-}}$$

$$0 \prec C_{i*} \prec 1$$

Step 6 (Ranking the options): Finally, we rank the options based on their order (12).

All the study procedures were approved by the Research Ethics Committee affiliated with Yazd Shahid Sadoughi University of Medical Sciences with the ID of: IR.SSU.SPH.REC.1396.91

Results

In the stage of identification of indices, 111 indices were extracted based on review studies; these indices were included in the first round of Delphi. In the Delphi round, the indices were validated in terms of importance as well as the existence of their information for a period of nine years. Finally, 10 indices were selected. Based on hierarchical analysis and pairwise comparisons in the weighted indices, the highest priority was

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related to the index "ratio of total nursing staff to available beds" with a weight of 0.161 and the lowest priority was related to the index "ratio of natural deliveries to total deliveries" with a weight of 0.049. Besides, the inconsistency rate for these indices was 0.03. Given that the inconsistency rate should be less than 0.1 (13), the obtained weights and priorities were acceptable and there was an acceptable consistency between the opinions of the samples (Figure 1).

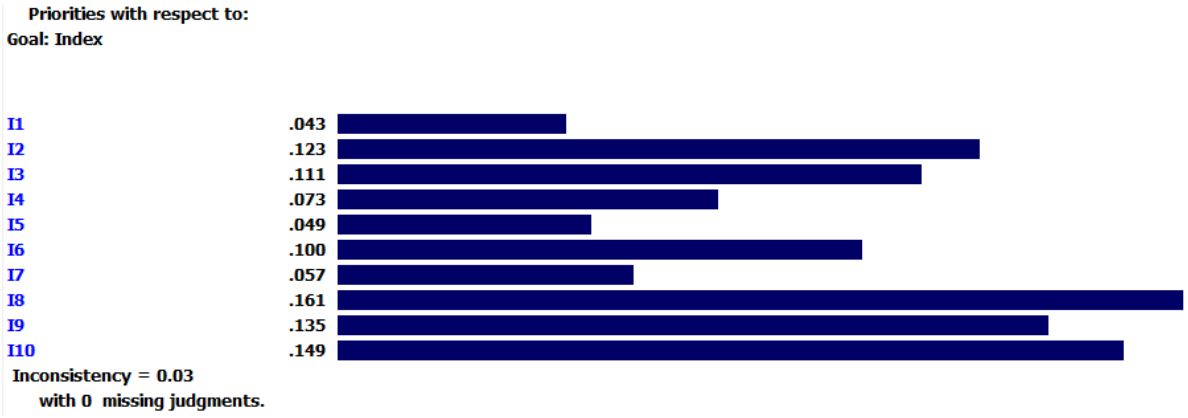

Figure 1. Displaying the weight and priority of treatment driving indices

After extracting the values of the indices, the performance of the selected university was ranked according to the year by TOPSIS method. In the TOPSIS method, a decision matrix was first formed for annual performance ranking, which included nine options or years and 10 indices. Subsequently, the formed matrix was normalized in such a way that each of the values was divided by the root of the sum of squares of each of the index vectors. Table 2 presents the descaled matrix of indices in terms of years.

The next step, after multiplying the weights obtained from AHP, was to calculate the positive and negative ideal solution, as shown in Table 3.

Table 2. Descaled matrix of indices by year

Year	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
2013	11.16	4225.00	7.67	0.23	2304.00	6773.29	78854400.00	0.77	3.28	246.49
2014	9.99	5184.00	7.73	0.20	2809.00	7569.00	81613156.00	1.61	3.84	320.41
2015	9.71	5625.00	11.78	0.57	2735.29	7744.00	79077658.63	1.35	3.65	346.70
2016	8.47	5329.00	12.04	0.50	2601.00	8436.42	55308969.00	1.23	4.24	362.14
2017	8.18	4900.00	10.43	0.35	2601.00	8100.00	54361129.00	1.12	3.65	460.10
2018	8.18	4761.00	10.62	0.35	3025.00	9604.00	59171597.63	1.03	5.11	215.11
2019	8.13	4489.00	11.58	0.24	2704.00	8464.00	58939633.07	0.97	3.55	382.71
2020	8.16	2601.00	11.98	0.29	2500.00	8649.00	62775147.93	1.11	4.15	403.89
2021	7.65	4225.00	14.00	0.37	2304.00	8464.00	76319637.35	1.22	4.49	474.05

Table 3. Determining positive and negative ideal solutions

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
A^+	0.054	3.403	0.157	0.024	0.965	3.535	188.907	0.080	0.115	1.246
A^-	0.037	1.573	0.086	0.008	0.735	2.493	125.828	0.039	0.074	0.566

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After determining the positive and negative ideal solution, the distance from the positive and negative ideal solution was obtained, which is specified for each of the performance years in Table 4.

Table 4. Determining the size of the distance from the positive and negative ideal solution

Year	D^+	D^-
2013	6.56	56.70
2014	0.90	63.10
2015	5.92	57.24
2016	60.89	2.84
2017	63.08	1.61
2018	51.95	11.26
2019	52.49	10.69
2020	43.64	19.49
2021	12.29	50.84

In the final step, the similarity index that represents each of the performance years and their rank was determined. According to the TOPSIS method, the selected university showed the highest performance in 2014 and the lowest performance in 2017(Table 5). The performance coefficient of the university can also be seen in Figure 2.

Table 5. Ranking and performance coefficient of the university in the time interval examined by the TOPSIS method

Year	coefficient	Rank
0.228	2014	1
0.210	2015	2
0.208	2013	3
0.186	2021	4
0.071	2020	5
0.041	2018	6
0.039	2019	7
0.010	2016	8
0.006	2017	9

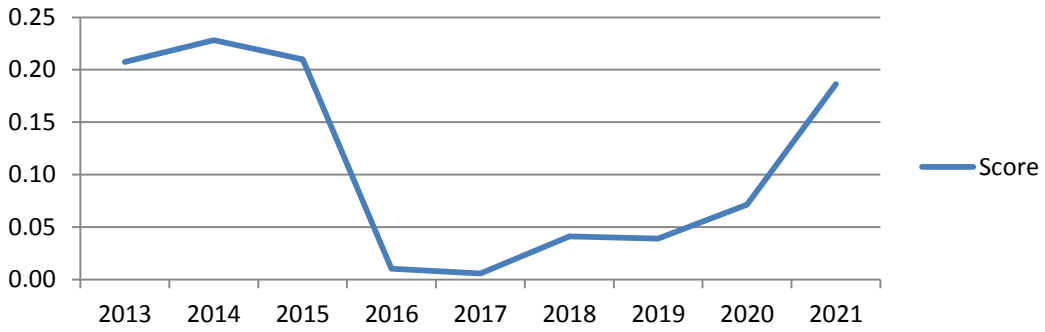

Figure 2. Performance coefficient of the selected university in the studied years

Discussion

One of the main missions of any organization is the productivity and improvement of the services provided in the healthcare sector. Managers can pave the way for achieving the organizational goals and the development and progress of the country by increasing the productivity of their organizations (14). Meanwhile, indices of the treatment domain play a vital role in the success of universities of medical sciences, and their monitoring can be effective in improving the treatment domain (15). In this regard, the present study was conducted with the aim of evaluating the performance of one selected university of medical sciences based on treatment driving indices with the AHP-TOPSIS hybrid method. In the present study, 10 ratio indices were selected to rank the performance based on treatment driving indices. Consistent with the results of the present study, relatively similar indices were used in other studies. In Turkish hospitals, Sahin et al. (16) considered indices such as the number of nurses, active beds, the number of inpatients and outpatients, and the ratio of nursing indices to

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performance indices as the main indices for evaluating productivity. To measure the productivity of regional hospitals supported by the government in Gujarat State, India, Beth et al. (17) applied the indices "the number of doctors, nursing, paramedical, administrative, and technical staff, the number of beds, drug costs, physical infrastructure, the list of equipment, working hours, and inpatient services. Based on hierarchical analysis and pairwise comparisons in the weighted indices, the highest weight or priority was related to the index of the ratio of the total nursing staff to the available beds with a weight of 0.161 and the lowest weight or priority pertained to the natural delivery index to total delivery index with a weight of 0.049. Regarding other indices, the results revealed the importance of human resources indices in the treatment domain, such as ratio of per capita human resources to active beds, the ratio of total nursing staff to available beds, and the ratio of nurses to beds in intensive care units. In various studies, human resources in the field of healthcare were given high priority. In Lux's study, the employees of the treatment domain have been considered as one of the reasons for the development of health centers and organizations (18). Other studies have also mentioned factors such as manpower, advanced equipment and specialized facilities as important factors for the promotion and development of health centers (19-21). The assessment of the functional status of the treatment domain based on the TOPSIS method shows that after the health transformation plan, the status of the indices of the treatment domain has improved, so that the years 2015 to 2017 show a more appropriate performance in the treatment domain. In this regard, the results of the study by Badiee et al. (22) (2017) suggested that after the implementation of the health transformation plan, the status of indices in the treatment domain, including the percentage of bed occupancy, and bed rotation on the day of hospitalization of patients, has improved. In another study conducted by Dargahi et al. (23) (2017), the results demonstrated that the performance indices of hospitals have improved after the implementation of the health transformation plan. Although after about three years of the implementation of the health transformation plan and the problems related to the sustainability of financial resources, this plan has not continued with its original strength, and the effect of this on the performance of the treatment area of the studied university can also be seen during the years 2016-2018. Furthermore, during this period, the share of the health budget from the country's total budget also faced changes that could affect this performance. Nevertheless, in 2021, the indices of the treatment domain show a more favorable performance, which is not irrelevant to the outbreak of the Covid-19, because in this period, the indices related to human resources were highly noticed to respond to the crisis.

Conclusion

The results of the present research showed the importance of the index of bed occupancy rate and the ratio of nursing staff to beds in hospitals in the treatment domain. To strengthen the indices of the treatment domain, the authorities are required to focus on these two indices in the first place. Considering that the nurse to bed ratio index is an input index and the bed occupancy rate index is considered as an output index, thus, paying attention to the fair distribution of nursing staff in terms of beds in medical centers can be the best strategy to strengthen the performance of universities in the treatment domain. It is further recommended to pay attention to the strategies related to improving the bed occupancy rate, including the activation of government clinics, the strengthening of hospital hotels to attract patients, as well as the correct implementation of procedures to reduce the hospital stay, especially in ICUs.

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Conflict of interests

The authors declared no conflict of interests.

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Authors' contributions

Raadabadi M, Abolhosseini H and Dehghani Tafti A designed research; Raadabadi M and Khayatan M conducted research; Raadabadi M and Shayegh M analyzed data; and Mehrparvar AH, Abolhosseini H and Dehghani Tafti wrote the paper. Abolhosseini H had primary responsibility for final content. All authors read and approved the final manuscript.

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