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Efficiency of COVID-19 Testing Centers in Iran: A Data Envelopment Analysis Approach

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Abstract

Objective: The purpose of this study is to investigate the efficiency of the Iranian Red Crescent Society (IRCS) in managing their nonmonetary resources involved in coronavirus disease 2019 (COVID-19) response.
Methods: For this purpose, the data envelopment analysis approach was used to measure the efficiency, considering the number of personnel and vehicles and screened passengers as the input and output parameters, respectively. It was examined the efficiency of 10 IRCS's branches given 17 d of screening operation. For the analysis, the DEA SolverPro software 15a version was used.
Results: The results show that only 1 branch had been fully efficient in using the resources, while 5 branches showed less than 50% efficiency. This study reveals that it is unnecessary to use a fixed number of volunteers at different stations with different passenger numbers.
Conclusions: Using resources without efficient planning can lead to direct costs such as food, transportation, and maintenance, as well as indirect costs such as burnout, fatigue, and stress when responding to the COVID-19 pandemic. This analysis should support IRCS's managers to move their valuable resources from inefficient to efficient centers to increase the screening rate and reduce the fatigue of aid workers for the next pandemic rounds.

On February 19, 2020, Iran reported its first confirmed case of coronavirus disease 2019 (COVID-19) infection.[1,2] As of August 4, 2020, Iran remained in the top 15 countries in terms of people infected with COVID-19 in the world, showing 312,035 confirmed cases and 17,405 deaths toll.[3,4] Given the huge impact of the pandemic and the lack of preparedness in the country, the Iranian government faced several challenges to deal with the situation, including a lack of human resources. As a result, the government commissioned the Iranian Red Crescent Society (IRCS)[5] for screening passengers on the country's main roads during the Iranian New Year holidays (a.k.a. Nowruz). The rationale was the IRCS's access to a large volunteer network that could help run the screening plan.[5] The IRCS has more than 25 y of experience in offering help and rescue missions. The society also has branches in all major cities of Iran, enabling access to several volunteers' capacity.[5,6]

During the pandemic response and in the screening program, several of IRCS's volunteers were assigned and equipped with vehicles for screening passengers. The screening program began on March 18, 2020, for 17 d. In the program, the IRCS volunteers, based on the situation in different provinces, worked in more than 851 temporary stations at the main entrance and exit points of cities, including roads, train stations, and airports.[5] The program's objective was to test passengers with fever kits and identify the suspected cases of COVID-19. There was at minimum 4 trained personnel (limited to 8-h shifts for everyone) consisting of IRCS's staff and volunteers in each station. This personnel was in charge of screening passengers for COVID-19 symptoms until the end of April 4, 2020.[6] All volunteers attending the plan had previously completed first aid training courses and prehospital emergency training for 22 h and 45 h, respectively. Following the program was voluntary and unpaid, but IRCS2 covered the operations costs.[5]

Background and Motivation

The IRCS is a nongovernmental organization and has access to limited monetary and nonmonetary resources. Moreover, it has a decentralized structure with branches in different cities with distinct capacities regarding human resources and vehicles (e.g., ambulances).[7] As such, performance appraisal in measuring the efficiency was of great importance for IRCS headquarters for the program.[5] Following the worldwide movement toward improving efficiency and addressing funding gaps, IRCS's decision-makers seek to find actionable ways to limit costs and increase efficiency.

Poor resource management leads to the waste of resources, including money, human resources, buildings, and equipment.[8] Such a loss means that a particular share of outcome could potentially be achieved by using fewer resources. By preventing the loss of financial and human resources, such resources can provide high-quality and cost-effective services.[9] To this end, the financial, economic analysis provides a logical and systematic framework for analyzing essential issues in the health sector.[10] However, making decisions regarding the optimal provision of health care is a complex task and requires information about system performance for decision-makers.[11]

Efficiency has been introduced as a criterion for measuring performance. It refers to comparing the input value (ie, what is being used) by the output (ie, what is obtained).[12] Efficiency is a broad concept, and it has been discussed in a variety of areas, such as engineering, management, economics, and health.[13] That said, several definitions of efficiency can be found in the literature and practice.[14] Farrell defines a firm's efficiency as "to produce an output to a sufficiently large extent than a given input value," and it specifies the technical allocation and economic performance of its type.[15] The definition has been used in the health sector; however, it was adapted the definition in this study for the pandemic response context.

Lei (2008) notes that the efficiency of the emergency response can be assessed using the data envelopment analysis (DEA) method under the constraints of total resources.[16] Previously, the DEA method has often been used for locating emergency logistics, which could successfully increase the reliability of suggested locations while reducing the complexity of the decision-making process.[17] The method has been used for evaluating disaster resilience capacity in Istanbul to determine the efficient number of units for disaster response in this city.[18] That said, the application of this method for measuring performance is not rare. For instance, the DEA method was used to evaluate the Turkish disaster relief management system to identify inefficient units.[18] Moreover, the method has been applied to measure the efficiency of humanitarian aid across 106 countries between 2010 and 2016. The study indicated that the efficiency of aid expenditure could be improved between 20 and 50%.[19]

However, a few researches has been conducted in Iran to measure the efficiency of COVID-19 response. Given the limited resources available in the IRCS's branches, this study could contribute to more efficient use of resources. The purpose of this study will be to evaluate the efficiency of the IRCS's branches in the passengers' screening program and to provide suggestions to increase the operation's efficiency.

Methods

This research is a cross-sectional and descriptive-mathematical study using the DEA method. This study seeks to use a suitable model to evaluate the efficiency of the COVID-19 screening program in the Yazd Province of Iran with 10 counties as similar decision-making units (DMU).

Data have been collected from IRCS's branches in 10 counties of the Yazd Province, Iran. The information about screening passengers in each station was primarily sent to the province's emergency operations center (EOC) from March 17 to April 4, 2020.

The first author retrieved the data from the IRCS's Deputy for Relief and Rescue. As explained earlier, screening stations, with the help of aid workers as well as rescue vehicles and ambulances, provide testing services to the passengers. Here, volunteers and staff are considered as first input (aid-workers), while the second input is vehicles (ambulance, rescue vehicle, and regular light cars), and screened passengers represent the output. Due to the lack of vehicles for transporting facilities and human resources, the full capacity of vehicles was used. Therefore, the Red Crescent Society used passenger cars as well as ambulances to carry out its missions. Furthermore, in some branches, passenger cars needed repairs, so other vehicles, such as ambulances and rescue vehicles, were used for the mission. Under normal circumstances, it was possible to borrow a car from other organizations, but at the beginning of the pandemic, all organizations were on standby and it was not possible to borrow a car. It is possible to add the station's financial cost as another input; however, the financial cost of every station depended mainly on the number of aid workers. As such, the cost is hidden in the aid workers' input. Moreover, for an optimized result, it was recommended that the following formula should be considered[20,21]:

Number of DMUs (10 in this study) $\geq 3*(\text{input}\ (2) + \text{output}\ (1))$

Because of the above formula, with 10 DMUs in this study, data were summarized to 2 inputs and 1 output, and adding other inputs and outputs will decrease the quality of results. For analysis, the DEA SolverPro software 15a version was used. The collected data that are shown in Table 1 were used in the software.

Table 1. Health system efficiency using the data envelopment analysis method

	Inputs		Output		
County	Aid workers	Vehicles	Screened passengers	Efficiency	Rank
Abarkuh	74	61	9100	26%	8
Ardakan	26	13	1061	13%	9
Ashkezar	49	44	19590	94%	2
Bafq	24	18	167	2%	10
Bahabad	91	19	8202	68%	4
Taft	127	49	13373	43%	6
Khatam	38	20	3524	28%	7
Mehriz	80	17	6267	58%	5
Meybod	18	10	5855	93%	3
Yazd	60	45	28610	100%	1

Results

Table 1 shows the ranking of branches according to their level of efficiency. As the table depicts, the IRCS's branch in the city of Yazd was found 100% efficient, followed by Ashkezar and Meybod branches with 94% and 93% efficiency, respectively. Of interest, 5 branches had less than 50% efficiency. The Bafq branch was the most inefficient branch in the Yazd Province according to the results, which can primarily be due to the low number of passengers that visited this city during the Nowruz holidays.

Discussion

One of the critical problems in any disaster response is to find the optimum allocation of scarce monetary and nonmonetary resources to operational locations.[22–24] Evidence shows that this problem was more demanding in COVID-19 response, owing to the pandemic's huge impact on different sectors, including the

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health care.[25,26] Iran struggled with this challenge specifically because of the high number of infected people, lack of financial resources, and insufficient preparedness.[4,27]

In addition, resource allocation in COVID-19 responses was considered as an ethical challenge.[2,25] Conventional performance appraisal methods often take into account the level of output resulting from the performance of the databases. However, it is easy to see that access to the output is only possible in the context of using input and using appropriate processes. Therefore, just paying attention to the output in evaluating and managing performance could be misleading.

The output indicator in this study was chosen as the number of screened passengers for COVID-19. Two options could be followed to increase efficiency. The first option is increasing the output or decreasing the input. Because the number of passengers screened in this project is considered the output, and 1 of the government's goals has been to reduce people's travel during quarantine, so it is not possible to consider increasing the output as a goal. Thus, to increase efficiency, it is needed to work on reducing the input. Reducing the input could decrease the costs of the program. Moreover, it is a significant way toward the safety of volunteers. It was reported that, in this program in Iran, at least 20 volunteers got infected with the COVID-19.

The second option could be relocating resources. It seems that to increase efficiency, especially in branches with low efficiency, moving resources can be considered as a suggestion. Due to the branches' low efficiency, the number of passengers was very few, and they were among the cities that were not in the path of passengers, so the use of personnel and cars was not necessary. It can be suggested that a low-efficiency branch such as Bafq branch could move some of its personnel and vehicles to more efficient branches such as the Yazd branch to cover more people or reduce the fatigue of aid workers in the Yazd branch. However, there are political challenges in moving resources, and reducing the input is difficult in disasters.[28,29] Sometimes, governors, attorneys, and military forces intervene in allocating human resources or vehicles.[30] The more challenging part is that the allocated items are taken and transferred to another city. In this case, there may be a lot of political resistance or unrest in the region.[31] Therefore, it is necessary to plan the optimal allocation of resources in advance.[32,33] For example, in the context of this study, the number of passengers passing through different cities can be estimated. Therefore, it was possible to plan the resource allocation (input) according to the expected output.

Conclusions

In the present study, an attempt was made to solve the resource allocation problem using 1 of the well-established research methods in operations research, such as the DEA method. In this study, screening stations' performance was evaluated using an input-driven model among different data analysis models and considering the input and output indicators. Using the data for 10 IRCS's branches, the 3 branches of Yazd, Meybod, and Ashkezar were found to be nearly 100% efficient. Yazd County gained full efficiency, and the other 2 counties were efficient with less than 10% inefficiency. Other branches were ranked according to their level of efficiency. Five branches had less than 50% efficiency. It can be suggested that low-efficiency branches provide some of their personnel and vehicles to more efficient branches to cover more passengers or reduce aid workers' fatigue. However, it could be concluded that it is unnecessary to use a fixed number of volunteers at different stations with different numbers of passengers. Also, it is better to plan the allocation of resources according to the number of beneficiaries. Using resources without optimal planning can lead to direct costs, such as food, transportation, maintenance, and indirect costs, such as burnout, fatigue, and stress when responding to disasters such as the COVID-19 pandemic.

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