Efficiency of Red Crescent Society Units in Gilan Province and Their Ranking using Data Envelopment Analysis

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Original Article

Abstract

INTRODUCTION: Efficiency is one of the basic measures of organizational performance, and in general, refers to the degree or quality of the achievement of the desired goals. This study aimed to investigate the efficiency of Red Crescent population branches in Gilan province and rank them based on the data envelopment analysis model.

METHODS: This research was applied in terms of purpose and documentary in terms of implementation. For the purposes of the study, 16 branches of the Red Crescent Society in Gilan province were analyzed with GAMS software (version 24) in 2018. In this research, the input-oriented Banker, Charnes, and Cooper model was used as one of the basic models of data envelopment analysis to measure the relative efficiency of 16 branches of the Red Crescent Society in Gilan province. Afterward, the Anderson-Peterson super-efficiency model was used to rank the efficient units.

FINDINGS: Based on the findings, six branches, namely Astara, Rasht, Bandar Anzali, Tallish, Lahijan, and Sowme'eh Sara, had an efficiency score of one. In other words, they were recognized as efficient branches and could provide solutions and models as reference branches for inefficient branches to help them reach the efficiency limit. Afterward, the Anderson-Peterson super-efficiency model was used to rank the efficient units. According to this model, the efficiency scores of the studied units were more than one and the Rasht branch had the highest efficiency.

CONCLUSION: The results provide researchers as well as branch managers and staff with suggestions that can help them make better decisions. An important point to keep in mind is that in order to increase the efficiency of a branch, it is necessary to reduce input costs and increase outputs based on reference branches. Due to the fact that this research uses an input-oriented approach, its purpose is to increase the indicators that enhance the efficiency of branches.

Keywords: Data Envelopment Analysis; Efficiency; Organization; Ranking; Red Crescent Society.

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Introduction

Efficiency in its general sense refers to the degree or quality of the achievement of the desired goals. Efficiency has also been defined as the ratio of outputs to inputs (1). Efficiency is the ratio of the utilization of an organization of its resources in production to its best performance at a point in time. Regarding the difference between efficiency and productivity, the following points should be considered: a) efficiency is expressed as a measure within the range of 0-1, or in percentage, 0-100%, while productivity can be greater than one; b) productivity is calculated in terms of various

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factors, such as workforce or capital productivity, while efficiency is a general measure that must be obtained from the combination of inputs and outputs (2).

Efficiency is one of the basic factors for the evaluation of organizational performance and simply shows the ratio of the output of an organization to its input. However, as the number of inputs and outputs increases, it becomes very difficult to measure the efficiency with this method. Accordingly, it is necessary to develop other methods for the assessment of efficiency (3).

Since the relationships between inputs and outputs and therefore the output function are unknown, we must estimate the relationships between them by an estimator to evaluate the performance of Decision-Making Units (DMUs). One of the estimators that can estimate the production function is Data Envelopment Analysis (DEA). The DEA is a non-parametric method based on mathematical programming. Data envelopment analysis divides homogeneous DMUs into two categories, namely efficient and inefficient units. Afterward, it considers efficient units as a reference for the improvement of the performance of inefficient units and makes a proposal to improve the inefficient units. This method was proposed in 1978 by Cooper, Charles, and Rhodes (4).

Goal of DEA is to identify the units that produce the most output from the least amount of inputs. In general, the purpose of DEA is to determine the limit of efficiency by which efficient and inefficient organizations can be distinguished from and compared with each other (5).

Nowadays, management experts emphasize the importance of performance evaluation models as one of the most valid indicators of organizational development. Therefore, currently, one of the main concerns of organizations is to achieve an efficient and flexible evaluation method that can examine all their functional aspects (6).

According to its international responsibilities (the International Committee of the Red Cross), the Red Crescent Society must provide assistance inside and outside the borders in times of crises, such as floods, earthquakes, and wars. Moreover, it has to raise awareness about crisis relief and management This Society, like other organizations, has specific establishments, articles of association, programs, and goals. Recently, a lot of research has been conducted on the nature and method of the evaluation of the performance of organizations. Results of this research are valuable since they allow us to understand the current state of organizations and examine future challenges in performance assessment.

Red Crescent Organization is responsible for the provision of relief; hence, attention should be paid to its promotion and development. Therefore, the present study aimed to increase the efficiency of the units of this organization in Gilan province. In studies based on statistical analysis, since the entire statistical population is not available, the data is mainly collected through sampling which is usually done by questionnaires. Afterward, the obtained data are analyzed using statistical methods. However, in the DEA method, the data are obtained through observation of the performance of the DMU and used along with mathematically proven models to estimate the production technology.

The estimated technology is always a subset of real technology; consequently, a unit that is inefficient in the estimated technology will always be inefficient in real technology as well. In the obtained technology, the units that are on the border of technology are considered efficient units, while the other ones are supposed to be inefficient. In Figure 1, units A, B, and C are efficient and unit D is inefficient.

Based on the built technology, efficient units can be considered as a reference for inefficient units. Therefore, inefficient units can be made efficient by reducing the inputs, increasing the outputs, or both, and moving the selected unit towards the technology border and obtaining an image point for it on the border. This image point is actually a suggestion to make the inefficient unit efficient. In Figure 1, by reducing the input of unit D to the image point, D* is obtained on the

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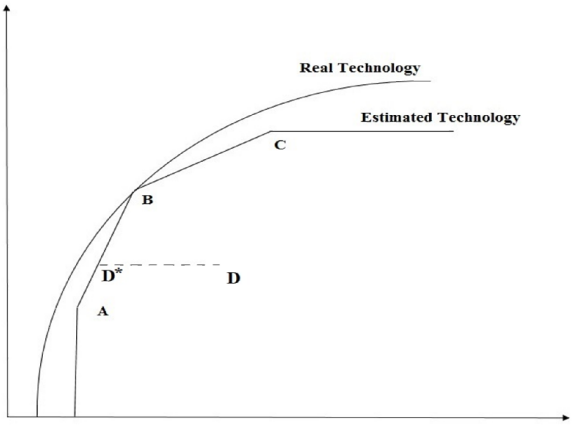


Figure 1. Real and estimated technologies in 2D mode

border of the estimated technology which is efficient in this technology. Therefore, it can be considered as a proposal to make unit D efficient.

According to the above-mentioned factors and given the raised issues and extensive studies about performance evaluation, it was decided to use the non-parametric DEA technique to assess the efficiency of units. In this research, first, the inputs and outputs of the model were determined; afterward, one of the main DEA models was used to identify the efficient and inefficient units and find the cause. Subsequently, the units were ranked using the Anderson-Peterson (AP) super-efficiency ranking methods. The main goal of the present study was to evaluate the efficiency of the Red Crescent branches in Gilan province and rank them accordingly.

Researchers have always used the DEA model to measure efficiency in many units and organizations. Consequently, several studies have been carried out in this regard some of the most important ones are as follows:

Guo et al. (2017) in a study entitled "Non-cooperative two-stage network DEA model: linear vs. parametric linear" concluded that linear fractional non-cooperative network DEA models for two-stage network structures often turn into parametric linear models. They also found that when the parameters change, the converted parameter linear models are solved by the calculation of a series of linear models (7).

Powers and McMullen in their study conducted in 2017 used the DEA method with weight restrictions to differentiate strong performance criteria from other performance criteria in a set of securities to prevent the identification of the production units with undesirable levels that are about to achieve efficiency. They stated that the selection of securities can be an example of multi-criteria decision-making issues that basically are made according to the examination of several indicators (8).

Xie in a study performed in 2016 calculated the cost-effectiveness of 107 property-liability insurance companies during 1993-2004 using the DEA technique. He considered workforce, business services, raw materials, and financial capitals of shareholders as the input and the current value of the damages and the real assets invested as the output of the model. Eventually, he concluded that the efficiency of the listed companies in the stock exchange is not worse than the efficiency, cost, and revenue change of private companies (9).

Bazrkar et al. in their study carried out in 2014 evaluated the net technical, scale, and combined performance of 454 insurance companies in 15 Eurozone countries using the DEA technique. They considered the total operation costs, total capital, total technical reserves, and total borrowing from creditors as input and the net income insurance premium and the total investment income as output (10).

Alikhani conducted a study in 2016 to determine the indicators that affected strategic performance management in the Red Crescent Society of Alborz province. For this purpose, he identified and evaluated the indicators that influenced the optimal performance of strategic management. He examined the current status of the system with a comprehensive look based on a balanced scorecard. He found that the mean of the components, namely learning and growth, internal processes and businesses, and finance and customer had significant effects on the strategic performance management, in that order (11).

Seddighi and Morovatti performed a study in 2014 entitled “Efficiency evaluation of road relief bases of Yazd province red crescent society in new year plan”. They concluded that currently, due to the significant development of roads and the increase in the number of vehicles, it is necessary to provide road relief bases with better performance. Therefore, it is important to evaluate the performance of the road relief bases. For this purpose, they reviewed the performance of 13 road relief bases with the input-oriented Charnes, Cooper, and Rhodes model and ranked the bases accordingly (12).

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Methods

This research was applied in terms of purpose and documentary in terms of implementation since it describes a phenomenon. This research aimed to evaluate the efficiency of Red Crescent branches in Gilan province and rank them accordingly. Therefore, the DEA method was used which is a practical technique and is one of the most used methods in operations research. Through this method, the efficiency and performance of each unit can be evaluated by mathematical planning using forms and reports. In the following, we will first deal with the mathematical concepts and preliminaries of this matter:

Suppose we have n DMUs with m inputs and s outputs. In DEA, production technology is defined as follows:

Model 1: $T = \{(x, y) \in R_{+}^{m} \times R_{+}^{n} | \, x \text{ can produce } y\}$

In model 1, x is the input and y is the output of the DMUs. Main idea of achievement of efficiency in DEA is to compare DMUs with production technology. However, since the set of production possibilities is unknown to us the technology set is estimated using the collected observations. The set of production technology, or technology for short, is also called the set of production possibilities (4).

Suppose DMU_o is the evaluated unit. In 1984, Banker, Charnes, and Cooper (BCC) introduced the BCC enveloping input-oriented model which is as follows (13):

Model 2:

$$\begin{aligned} &\min \theta \\ &s.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{io} \qquad i = 1, \ldots, m \\ &\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{ro} \qquad r = 1, \ldots, s \\ &\sum_{j=1}^{n} \lambda_j = 1 \\ &\lambda_j \ge 0 \qquad j = 1, \ldots, n \end{aligned}$$

In model $\theta \le 1$ is always true. In this model, DMU_o is efficient if and only if θ*=1 and all auxiliary variables also equal 0. The dual model of this model, known as the input-oriented BCC multiple-axis model, is as follows:

Model 3:

$$\begin{aligned} &\max \sum_{r=1}^{s} u_r y_{ro} + w \\ &s.t. \quad \sum_{i=1}^{m} v_i x_{io} = 1 \\ &\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + w \le 0 \qquad j = 1, \ldots, n \\ &u_r, v_i \ge 0 \qquad r = 1, \ldots, s \quad , i = 1, \ldots, m \\ &w \quad free \end{aligned}$$

In model 3, if the optimal answer is 1 and $u^* > 0$, $v^* > 0$, the DMU_o is called strongly efficient (4) (14).

The Anderson-Peterson or super-efficiency model that makes it possible to determine the most efficient unit was proposed in 1993 by Anderson and Peterson for ranking the efficient units. This method is used to rank efficient units whose efficiency score is equal to one. In this method, the score of efficient units can be more than one, and thereby efficient units can be ranked similarly to inefficient units. The procedure is to remove the DMU_o from the production possibility set and run the model for other DMUs. The higher the super-efficiency score of the unit, the more efficient that unit will be (4) (14). The super-efficiency model for the DMU_o is as follows:

Model 4:

$$\begin{aligned} &\min \theta \\ &s.t. \quad \sum_{j=1, j \ne o}^{n} \lambda_j x_{ij} \le \theta x_{io} \qquad i = 1, \ldots, m \\ &\sum_{j=1, j \ne o}^{n} \lambda_j y_{rj} \ge y_{ro} \qquad r = 1, \ldots, s \\ &\sum_{j=1}^{n} \lambda_j = 1 \\ &\lambda_j \ge 0 \qquad j = 1, \ldots, n \end{aligned}$$

In this research, since the used model is input-oriented, the goal is to help the inefficient units reach the efficiency limit through the maintenance of the output at a constant level and reduction of the input. Therefore, here, the type of the used function is MIN.

In this study, the data were collected from 16 branches of the Red Crescent Society in Gilan province with two inputs:

Training budget: x_1

Operation budget: x_2

And three outputs:

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Number of volunteers recruited: y_1
Income of units: y_2
Number of training courses: y_3

Which were collected in 2018 and have continued to operate continuously in the last four years (Table 1).

The raw data required for this research were extracted by referring to the deputies of the Red Crescent Society of Gilan province. As mentioned earlier, each of these units is introduced as a DMU with two inputs and three outputs (Figure 2).

First, to determine the efficient and inefficient units and calculate the efficiency score of each DMU, the data was put in model 2. Results of the performance of this model are summarized in Table 2. Subsequently, model 4 (super-efficiency model) was used to rank the efficient units. Results of the performance of this model are tabulated in Table 3. Furthermore, the data were analyzed in GAMS software (version 24). This software is able to perform optimization models in operations research.

Table 1. Data on inputs and outputs of the Data Envelopment Analysis model

DMU	Branch	Income		Outcome		
		Training budget (Rial)	Operation budget (Rial)	Recruited volunteers	Income of units	Training course
DMU1	Astara	97900000	625200000	796	1024726000	38
DMU2	Bandar Anzali	81700000	731447000	1195	321300000	37
DMU3	Talish	65000000	480200000	714	22050000	39
DMU4	Rasht	163400000	691700000	828	1470308000	44
DMU5	Sowme'eh Sara	105600000	719000000	1057	47970000	36
DMU6	Lahijan	247500000	686250000	1817	2420500000	140
DMU7	Fuman	55000000	468700000	510	50100000	18
DMU8	Langerud	92000000	705500000	874	571580000	27
DMU9	Rudsar	86400000	591200000	536	315160000	22
DMU10	Astaneh-ye Ashrafiyeh	62500000	429700000	273	19900000	24
DMU11	Shaft	7900000	322500000	470	17250000	32
DMU12	Rezvanshahr	126500000	649200000	612	208519850	47
DMU13	Rudbar	79200000	480200000	376	192919766	28
DMU14	Siahkal	143600000	645500000	612	602550000	38
DMU15	Masal	116000000	525200000	571	75935000	34
DMU16	Amlash	95000000	383680000	523	8500000	30

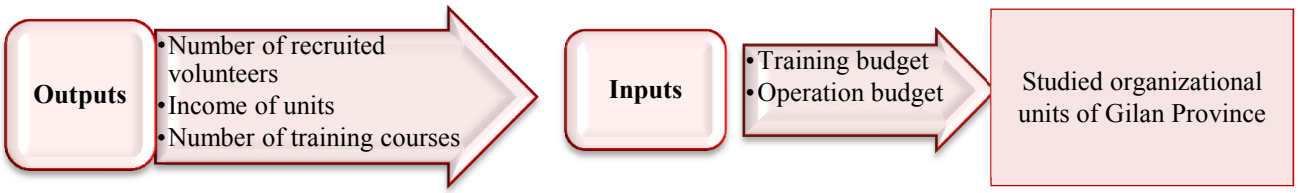


Figure 2. Decision-making units

Table 2. Results of the efficiency of Red Crescent decision making units or branches based on input-oriented Banker, Charnes, and Cooper model

DMU	Branch	Efficiency score	DMU	Branch	Efficiency score
1	Astara	1	9	Rudsar	0.8404
2	Bandar Anzali	1	10	Astaneh-ye Ashrafiyeh	0.8174
3	Talish	1	11	Shaft	0.7993
4	Rasht	1	12	Rezvanshahr	0.7580
5	Sowme'eh Sara	1	13	Rudbar	0.7210
6	Lahijan	1	14	Siahkal	0.6611
7	Fuman	0.9634	15	Masal	0.5761
8	Langerud	0.8802	16	Amlash	0.5622

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Findings

Results of using Model 2 on the data are shown in the second and fifth columns in Table 2. Given the efficiency score column in Table 2, it can be seen that out of the 16 evaluated branches, six branches, namely Astara, Rasht, Bandar Anzali, Talish, Lahijan, and Sowme'eh Sara have an efficiency score of one. Moreover, 10 other branches with an efficiency score of less than one are considered inefficient.

Furthermore, according to the second and fifth columns of Table 2, the rank of inefficient units according to their efficiency score are as follows: Fuman, Langerud, Rudsar, Astaneh-ye Ashrafieh, Shaft, Rezvanshahr, Rudbar, Siahkal, Masal, and Amlash. As can be seen, Fuman has the highest score among the inefficient units and is very close to the efficiency limit, while Amlash has the lowest efficiency score and is ranked last.

Table 3. Super efficiency scores of efficient units

DMU	Branch	BCC* efficiency score	Super-efficiency score
4	Rasht	1	1.8966
1	Astara	1	1.5609
2	Bandar Anzali	1	1.4196
6	Lahijan	1	1.3992
3	Talish	1	1.3653
5	Sowme'eh Sara	1	1.1024

* Banker, Charnes, and Cooper

Table 4. Ranking of Red Crescent branches in Gilan province

DMU	Branch	Rank	DMU	Branch	Rank
4	Rasht	1	9	Rudsar	9
1	Astara	2	10	Astaneh-ye Ashrafiyeh	10
2	Bandar Anzali	3	11	Shaft	11
6	Lahijan	4	12	Rezvanshahr	12
3	Talish	5	13	Rudbar	13
5	Sowme'eh Sara	6	14	Siahkal	14
7	Fuman	7	15	Masal	15
8	Langerud	8	16	Amlash	16

Based on the results, efficient branches are equal in terms of efficiency score. For this reason, to rank these units, it is necessary to use the super-efficiency ranking technique in DEA that can rank efficient units (Table 2).

The AP super-efficiency model was used to rank the efficient units. The result of using Model 3 on the efficient units is shown in Table 3.

Efficiency score of efficient units based on the input-oriented BCC model is shown in the third column of this table. Moreover, the super-efficiency score of these units is shown in the fourth column. Based on these results, it can be concluded that the Rasht branch with a score of 1.8966 gained the first rank followed by the branches of Astara, Bandar Anzali, Lahijan, Talish, and Sowme'eh Sara. In other words, the efficient units with an efficiency score of one became distinguished from each other with the AP method. Based on this ranking, it is possible to compare the efficiency of the Red Crescent branches in Gilan province and evaluate them. The general results of this ranking are shown in Table 4.

Table 5 shows the reference units of each unit and it can be seen that the reference units of efficient units are themselves. However, the reference units of inefficient ones are efficient units. For example, for the inefficient unit of Shaft, the reference units are the Astara and Sowme'eh Sara branches.

Table 5. Reference units

Column	Branch	Reference units	Column	Branch	Reference units
1	Astara	Astara	9	Rudsar	Talish
2	Bandar Anzali	Bandar Anzali	10	Astaneh-ye Ashrafiyeh	Sowme'eh Sara

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3	Talish	Talish	11	Shaft	Sowme'eh Sara, Astara
4	Rasht	Rasht	12	Rezvanshahr	Lahijan
5	Sowme'eh Sara	Sowme'eh Sara	13	Rudbar	Bandar Anzali, Rasht
6	Lahijan	Lahijan	14	Siahkal	Bandar Anzali, Rasht, Lahijan
7	Fuman	Bandar Anzali, Astara	15	Masal	Rasht, Talish, Astara
8	Langerud	Rasht	16	Amlash	Bandar Anzali, Sowme'eh Sara

Table 6. Image points of inputs and outputs

Column	Branch	Image points of the input with a decreasing tendency				Image points of the output with an increasing tendency					
		Training budget (Rial)		Operation budget (Rial)		Number of recruited volunteers		Income of branches (thousand Rials)		Number of training courses	
		Current value	Target value	Current value	Target value	Current value	Target value	Current value	Target value	Current value	Target value
1	Astara	97900	97900	625200	625200	796	796	1024726	1024726	38	38
2	Astaneh-ye Ashrafiyeh	81700	62600	731447	645500	1195	1302	321300	411100	37	45
3	Amlash	65000	52900	480200	452311	714	900	22050	31170	39	49
4	Bandar Anzali	163400	163400	691700	691700	828	828	1470308	1470308	44	44
5	Talesh	105600	105600	719000	719000	1057	1057	47970	47970	36	36
6	Rasht	247500	247500	686250	686200	1817	1817	2420500	2420500	140	140
7	Rezvanshahr	55000	39250	468700	433200	510	816	50100	595710	18	31
8	Rudbar	92000	84500	705500	599500	874	1002	571580	611720	27	39
9	Rudsar	86400	59200	591200	507400	536	634	315160	426360	22	31
10	Siahkal	62500	50100	429700	332000	273	550	19900	30900	24	41
11	Shaft	79000	75800	322500	221500	470	800	17250	24410	32	50
12	Sowme'eh Sara	126500	126500	649200	649200	612	612	208519.58	208519.58	47	47
13	Fuman	79200	60540	480200	469600	376	421	192919.766	236000	28	34
14	Lahijan	143600	143600	645500	645500	612	612	602550	601550	38	38
15	Langerud	116000	93000	525200	460000	571	805	75935	99517	34	59
16	Masala	95000	75500	383680	360000	523	960	8500	28650	30	46

Table 6 summarizes the image points of inefficient units. In fact, these points indicate how much each of the inefficient units must change their inputs and outputs to become efficient. For example, in order to be efficient, the Rudbar unit must reduce its training cost from 92000 to 84500 thousand Rials and the operation costs from 705500 to 599500 thousand Rials. Besides, this unit should increase its recruited volunteers from 874 to 1002, the branch income from 571580 to 611720 thousand Rials, and the training courses from 27 to 39.

Discussion and Conclusion

The present study aimed to assess the efficiency and rank the Red Crescent branches in Gilan province and calculate the efficiency score of the branches which led to the identification of efficient units. In addition, it was found that each efficient branch could be introduced as a DMU for other inefficient branches. Therefore, one of the objectives of this study was to define values that can increase outputs, as shown in Table 6, in order to determine the image points of inputs and outputs to finally, increase efficiency.

The model inputs, namely training and operation costs are considered as debts in the financial statements of the branches; therefore, their reduction can increase the efficiency of the units. Accordingly, DEA can be used to find the numerical amount of the reduction of inputs through the determination of the image points. Based on the results of the method and formula of image points, it can be stated that inefficient branches should reduce their inputs and increase their outputs to achieve better efficiency.

According to the results obtained from the analysis of input and output data in GAMS software (version 24) and the DEA techniques, out of the 16 branches of the Red Crescent Society, six branches are efficient, and thereby can be DMUs for inefficient units. Moreover, image points provided solutions for each branch to improve their performance and increase their efficiency.

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Currently, awareness of the efficiency of the organization in order to achieve the goals and desired position of the organization is very important for managers. Role and importance of the Red Crescent Society as a service provider and relief organization are obvious. Therefore, the Red Crescent Society must always evaluate itself to increase its efficiency. Usage of the DEA model in this study made it possible to compare and rank the branches of the Red Crescent Society and provided solutions for the improvement of their efficiency and performance. In addition, relative efficiency, the cause of inefficiency of each branch, and the decisions needed to help inefficient units reach the limits of efficiency were determined. Moreover, it was clarified that each branch should use which unit as a reference.

Hence, due to the importance of the relief services, it is necessary to make an accurate and appropriate assessment of the efficiency of the Red Crescent Society branches to improve their performance and increase their efficiency. Besides, the assessment results can provide essential information for managers to develop their planning processes and achieve optimal resource allocation.

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Conflict of Interests

Authors have no conflict of interests.

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