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Efficiency of Clinical Laboratories Affiliated Shiraz University of Medical Sciences in 2015: an Application of Data Envelopment Analysis

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Abstract

Background: *Nowadays, healthcare systems are considered as important service sectors, and they are social development and welfare standards; hence the performance of this sector is highly important. Evaluating performance is the first step of various departments to determine the efficiency of the healthcare system. In the meantime, diagnostic laboratories of hospitals play important roles as specialized and technical units with a cost nature. So, far, the effectiveness of diagnostic laboratories has not been assessed in Iran, therefore, in this study, for the first time in Iran, the technical efficiency of laboratories covered by the Shiraz University of Medical Sciences (SUMS) was assessed in 2015.*

Methods: *This cross-sectional study aimed to assess 10 selected laboratories from diagnostic laboratories in hospitals affiliated with SUMS. In this paper, data envelopment analysis (DEA), one of the most widely utilized methods, was used in determining performance.*

Results: *Among the 10 examined laboratories affiliated by SUMS, 4 (40%) laboratories had increasing yield to the scale, and 6 (60%) laboratories had technical, managerial, and scale efficiency equal to one. Mean±SD of technical efficiency, managerial efficiency, and scale efficiency of examined laboratories were 92.4±16, 95.9±9, and 95.5±10, respectively.*

Conclusions: *Studying the efficiency of the diagnostic laboratories affiliated with SUMS using DEA showed that most laboratories had a high level efficiency.*

Keywords: Efficiency, Data envelopment analysis, Laboratories, Hospital.
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Introduction

Performance evaluation is the first step in evaluating the performance of different parts of a single service provider, such as a hospital or laboratory.[1] Performance measurement and evaluation can be used to provide a logical framework for the distribution of human and financial resources among various departments. Successful managers have always tried to obtain the maximum results through the use of the available facilities and specific input gains; this tendency can be termed as achieving higher performance.[2]

In fact, efficiency represents the ability of a unit such as hospitals, laboratories etc., to maximize the outputs according to the specific inputs. Various aspects of performance can be outlined, so that the ability to turn inputs into outputs is measured by technical efficiency in comparison with the best performance. The scale efficiency is the ability of a unit to avoid wasting resources through getting closer to the best and most profitable scale.[1] Finally management efficiency means hard work, effort and resourcefulness of managers, the efforts of staff, and the correct combination of productive factors, thereby providing increasing efficiency and productivity in the unit.[3]

Today, the healthcare system is considered one of the important service sectors and also the foundation for social development and welfare; hence the performance of this sector is very important.[4] Complete evaluation of a patient is an appropriate part of health system services in order to understand the signs and symptoms of disease, and it usually requires physical tests and taking a patient profile with diagnostic tests. The proper use of diagnostic tests can be followed by a confirmation or rejection of a disease. The costs of care can also improve treatment of individuals in a society. Hence, the importance of diagnostic laboratories plays an important role in the treatment procedure of patients and disease prevention. On the other hand, the role of diagnostic laboratories of hospitals as a specialized technical units has a costly nature, though is strongly important. Therefore, reducing human and system errors in order to prevent a recurrence of laboratory testing is important in improving performance.[5]

In particular, efficiency is influenced by factors such as weak management capabilities, a lack of scientific and appropriate methods, non-continuous assessments, and the lack of necessary information for effective decision-making in laboratories. In addition, long periods of time or performing additional and unnecessary treatments are mentioned as other reasons for the lack of efficiency in laboratories. A lack of technical efficiency in laboratories can lead to the loss of multiple resources, including money, manpower, materials, and equipment. A reduction of the waste of resources in this area is associated with the provision of better services and an improvement in the quality of laboratory services, therefore actions to correct the function of management becomes necessary through studying the performance of laboratories. Such research helps administrators have a correct analysis of inputs and outputs, and in this regard, take steps forward by using a scientific model and the correct methods to increase efficiency.[6]

Given the widespread application of data envelopment analysis in evaluating health sector performance, this technique has been used in this article as the basis of the analysis. DEA is

a mathematical technique for evaluating the efficiency of decision-making. Numerous analysis features leads to professionals using it in their proposed performance evaluations. These features include: 1. realistic analysis and assessment of this method compared to other assessment methods; 2. a combination of factors evaluated; 3. the compensation type of its models; 4. the possibility to enter inputs and outputs with different measurement units.[7]

The infrastructure of DEA returns is linked to the article by Farrell in 1975, where the performance of a unit has been defined as "production of an output at enough level and more than an assumed amount." About twenty years later Charnz and associates expanded Farrell's ideas, and developed DEA techniques. Accordingly DEA is based on a linear programming model which calculates the efficiency of decision-making units by calculating the ratio of weighted sum of outputs rather than the weighted sum of inputs.[8] By solving a DEA model, patterns of units can be determined for inefficient units which represents an increase of necessary inputs and/or a required reduction of the outputs for the considered unit to be efficient.[9] DEA is a management method that measures the relative efficiency of each unit and present management practices. In this technique, the template unit is defined for inefficient units so that, accordingly, the inefficient units can increase their efficiency through benchmarking and reach toward the efficiency border.[10] The units (DMUs) mean an organizational unit or a separate organization that is independently operated.

Examination of improvements in the technical and management efficiency of laboratories is severely needed. According to obtained information, no study has been published in this field in Iran so far. Hence, this study examines, for the first time, the technical performance of laboratories in Shiraz University of Medical Sciences (SUMS) in 2015 by a DEA approach.

Materials and Methods

This cross-sectional study is implemented based on obtaining information and descriptions of the available conditions and comparison of types of efficiencies that includes technical, managerial, scale efficiencies, and a determination of the types of return to scale of the labs in hospitals affiliated with SUMS. The study population consists of 10 selected laboratories in hospitals affiliated with SUMS, which includes the hospital laboratories of Shahid Chamran, Shahid Rajai, Shahid Dastgheib, Ibn Sina, Khalili, AliAsghar, Shushtari, Zainabiyyeh, Amir, and the heart hospital of Al- Zahra. The data collection tool of this study for the history and literature was the scientific and documentary resources of the Hospital Information System, and the data of input and output indicators for the assessment of performance were obtained and used from the laboratories in coordination with the administration of laboratories at SUMS. Our data were gathered during the summer 2016.

In this study, considering the necessity of meaningful indicators in assessing the performance of laboratories, the indicators were defined and used with the use of comments from experts and professors (including the head of the administration of laboratories and two lecturers of health management) in the field of health as the inputs of the model. These include: the number microscopes, the number of consumed kits, consumed hematology substances, the number of instruments, and the number of personnel including, technicians and experts. On the other hand, due to the large numbers and diversity of performance indicators in assessing the performance of laboratories, indicators of outputs had been selected using the scientific documentations and comments of the experts in the field of health. While the outputs include five common laboratory tests, including hematology tests, thyroid function tests, microbiology tests, stool tests, and U/A tests, which were carried out in 2015 for each laboratory. It is worth noting that in determining inputs and outputs, the criteria of data availability, laboratory activities, and also information and access to data have been considered; this means that indicators have been selected as inputs and outputs that include important and effective parts of the results of input and output sources that have been proportional to the activity of all laboratories. Based on these inputs and outputs, and results of DEA model, the efficiency of each studied laboratory can be found and therefore, a rating is provided in the investigated laboratories. So far, many models have been introduced, and two basic models widely used in DEA are Charnes-Cooper-Rohdes(CCR) and BCC models. In the CCR model, a mathematical optimization method for determining the efficiency is applied through converting multiple inputs and outputs of a single unit to a virtual input and a virtual output, and the BCC model is a model of blind analysis of data that assess the relative efficiency of variable yields to scale deals. After obtaining the opinions of experts and specialists and the assumption of variable yield to the scale, in this study the BCC model was selected to achieve a proper management strategy. Obviously, the assumption of a constant return to scale for a system means that by increasing the inputs, the output level is also correspondingly increased, while the assumption of increasing return to scale means that by increasing the level of the input, the output increases with a higher ratio; conversely, reducing the return to scale for a system means that by increasing the inputs, there is a smaller ratio of increase for the output levels. The nature and the context of the DEA model for optimal allocation of resources allows for more and better monitoring the laboratory system inputs and outputs

Permission and ethical approval for the study was obtained from the Vice Chancellery of clinical affairs of SUMS. Due to ethical considerations, we concealed the names of laboratories in the results.

Quantitative and qualitative data were described by mean±standard deviation and frequency (percentage), respectively. Microsoft excel 2010 was employed to clean the data and obtain descriptive statistics. Efficiency scores were computed using the DEA Program, version 2.1 (DEAP 2.1).

Results

The highest and lowest scores of human resources belonged to the 10th (49 persons) laboratory and the 4th Laboratory (6 persons). The lowest number of microscopes (1 microscope) was found in the 5th hospital and the largest

Table 1. The model's inputs of laboratories in 2015

Laboratory ID	Microscope	Consumed kits	Consumed hematology substances	Number of instruments			Number of personnel		
				Elysa	Auto Analyzer	Cell Counter	Technicians	Experts	Doctors
1	4	34	L:50 IS:550	1	3	2	7	10	1
2	3	43	L:112 IS:180	1	2	2	3	22	2
3	3	4	L:103 IS:617	1	1	2	1	9	1
4	3	12	L:12 IS:25	1	2	1	-	5	1
5	1	24	L:20 IS:144	-	1	2	1	5	1
6	4	43	L:50 IS:600	1	2	2	4	11	2
7	2	24	L:18 IS:60	1	1	1	2	7	1
8	3	84	L:61 IS:720	1	2	2	5	14	1
9	6	20	L:120 IS:480	1	2	2	5	10	1
10	4	228	L:120 IS:450	-	5	5	12	36	1

L: number of consumer lyse bottles per year, IS: number of consumer Isotone bottles per year

Table 2. The model's outputs of laboratories in 2015

Laboratory ID	Hematology tests (CBC)	Thyroid function tests	Microbiology tests	Stool tests	U/A tests
1	22328	4629	3090	641	3577
2	65837	1366	12721	1507	7615
3	27696	41033	16317	24464	23351
4	8642	4560	1307	1101	608
5	14042	-	1560	17	49
6	40847	4203	4682	1555	6278
7	14110	4530	3414	550	6519
8	47821	6429	4947	534	14941
9	30548	665	3384	1118	2563
10	67504	20612	23673	13434	50318

Table 3. Efficiency Results of laboratories in 2015

Laboratory ID	Technical efficiency	Managerial efficiency	Scale efficiency	Return to scale
1	0.503	0.703	0.685	Increase
2	1	1	1	Constant
3	1	1	1	Constant
4	1	1	1	Constant
5	1	1	1	Constant
6	0.973	0.980	0.992	Increase
7	1	1	1	Constant
8	0.997	0.998	0.998	Increase
9	0.771	0.880	0.876	Increase
10	1	1	1	Constant

number of microscopes (6 microscopes) was available in the 9th hospital. Most hardware devices (including devices of Cell Counter and Auto Analyzer and Elysa) were in the laboratories of the 10th hospital. The highest number of hematology tests (67504 tests) and microbiology (23673 test) testes were related to hematology laboratories of the 10th hospital, and the lowest number of hematology (test 8642) and microbiology (1307 tests) tests was found in the laboratory of the 4th hospital. Additionally, the maximum number of thyroid function tests (20612 tests) was carried out in the 10th hospital, while the minimum number of thyroid function tests (665 tests) was related to the laboratories of the 9th hospital. The laboratory data of inputs and outputs are provided in Tables 1 and 2. From 10 studied laboratories affiliated with SUMS, 4 labs (40%) had increasing return to scale. The results of the calculations of laboratories' efficiency and the types of return to scale have been shown in detail in Table 3. The mean±standard deviation of technical and managerial efficiency and scale efficiency of examined laboratories were 92.40±16.00, 95.90±9.00, and 95.50±10, respectively. In six laboratories, the technical, managerial, and scale efficiency was 100%, which demonstrates the maximum efficiency of these laboratories.

Discussion

Due to the importance of being aware of the performance and efficiency of diagnostic laboratories, the conducted research aimed to examine the efficiency of diagnostic laboratories affiliated with the SUMS using the DEA technique, which demonstrated the high efficiency of most of the laboratories. In Iran, most of the studies conducted in the evaluation of efficiency using the DEA technique,[11-14] have evaluated hospitals, and the few studies related to the laboratories makes the comparison of our results with the results of other studies difficult.

Except for the laboratories of the 1st and 9th hospitals, the three dimensions of efficiency, scale, and technical and managerial efficiency, demonstrate that all 8 studied laboratories had an efficiency score higher than 97% and

reached optimum performance. The 1st and 9th hospitals are singled out due to specialties and complicated tests carried out in them that require the opinions of specialists and a senior specialist. Additionally, according to our observations in the laboratories of these hospitals, all power and capacity of morning shift staff led to the best results; however the introduction of lab issues during the evening shift and some of personnel in this shift can be considered as the other causes in the reduction of efficiency in the two mentioned hospitals.

In this study, about forty percent of laboratories had increasing returns to scale, indicating the potential of the laboratories to gain more efficiency by using more resources. Also, some studies about the efficiency of hospitals had the same results,[11,15] which means that about fifty percent of the hospitals and their diagnostic laboratories should increase their resources and inputs to achieve higher efficiency.

The laboratories with fewer human resources, in which the number of experts was more than 5 times the number of technicians, were more efficient. This indicated the important role of experts in laboratory sciences as an effective resource in improving the efficiency and performance of diagnostic laboratories. The previous research confirms that specialization of health care systems, including hospitals and laboratories, may improve performance and efficiency.[15,16]

It is worth noting that the relative number of requested tests per week is the same for all laboratories by a factor of 10%, and all laboratories had 10% of their tests repeated.

The use of multiple input and output variables can be mentioned as the advantage of this research in utilizing DEA in order to determine the efficiency and measurement of performance. However, deletion or ignorance of any factors other than the variables in the study can also be considered as disadvantages of the present study because they may cause mistakes in the estimation of efficiency and examination of performance of laboratories. Clearly, carrying out more studies in the country and using other models to analyze performance can develop a good viewpoint for senior health managers. In general, however, the performance of the studied laboratories has been at the optimal level, but the managers should always have the necessary planning to increase the efficiency and study the effects of factors, such as the quality of services and the consent of patients, about the performance of their laboratories.

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Conflict of Interest

The authors declared that they have no conflict of interest.

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