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Original Research

Performance Evaluation of Medical Academic Libraries Based on DEA Approach

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Abstract

Medical academic libraries are required to exemplify and quantify the value of their services to their users and parent organizations. Using the Data Envelopment Approach (DEA) technique, this study reports and discusses the efficiency measurement of the 77 academic libraries in Type1 medical sciences universities in Iran. Eleven (11) input and outputs variables were selected to measure the efficiency and performance of the libraries. The selected variables were: Total volumes held, net volumes added during the research period, number of professional staff, and number of supporting staff (service, security, etc.). The total number of full-time students enrollment, full-time instructional faculties, total personal expenditures (professional and supporting staff), area of the libraries, library spaces, computers, and seating capacities. As representative variables of the services libraries provide to their users, we have selected as outputs opening hours per week, the number of registered readers/members (students, faculty, etc.), circulation transactions, and the number of reader visits or attendance. The input-oriented BCC model analyzed libraries' efficiency and benchmarked each inefficient unit by determining and introducing similar efficient units in terms of services and multiple parameters. Out of the 77 libraries analyzed, 30 libraries were efficient, and 47 were ranked as inefficient. By addressing the performance details of each of the introduced units as a benchmark, the finding of this study can help the gatekeeper of these universities to plan and modify their library work plans to improve performance and achieve full efficiency.

Keywords: Academic Libraries, Performance Evaluation, Library Evaluation, Data Envelopment Analysis, Technical Performance, Super Efficiency.

Introduction

Having quick and timely access to the updated information in medical sciences is critical, which can inform the health professional's practices. Considering that information resources in medical sciences usually have a short life span than other disciplines, academic medical libraries play a key role in providing timely and accurate information to health professionals. In other words, academic medical libraries "are established to provide services and information resources to support and advance the mission to patient care, research and biomedical education for health institutions" (Adio, Akewukereke & Ibitoye, 2007). Medical academic libraries need to exemplify and quantify the value of their services to their stakeholders. Evaluating the preference of the libraries can exemplify how and to what extent these libraries contribute to medical science universities' educational and research activities.

There are 68 universities of medical sciences and independent medical schools in Iran, and at least an academic library is attached to these medical universities. Further, each medical university faculty usually has a specialized library affiliated with a specific faculty or department. These medical libraries offer various related services to twenty thousand medical sciences teachers and more than two hundred and fifty thousand students. Medical libraries in these medical universities are responsible for supporting education and research activities. The increasing access and use of information and communication technology (ICT) have created great opportunities to provide value-added information services. These ICT-based services have significantly changed the medical libraries' inputs, processes, and outputs in the last twenty years. However, medical academic libraries' budgets did not keep pace with this radical shift, and many Iranian medical libraries experienced budget cuts (Entezari, 2010).

Medical libraries' quality and performance assessments provide library gatekeepers with useful quantitative and qualitative data to restructure and improve their services. Hamburg (1974), addressing the economic shortfall and accountability issues, underlined the importance of optimal allocating libraries limited resources to achieve maximum profit, and in the case of academic libraries, he believed that libraries should act according to the needs and requirements of staff, who work in the educational and research affairs of each university (ibid). Government budgets are increasingly declining, and the gatekeepers are reluctant to accept the mere goodness of the libraries without providing comprehensible evidence (Tavares, Geisa, Lidia & Mirian, 2018; De Prospo, Altman & Beasley, 1973).

The first study on measuring the performance of production units was conducted by Farrell (1957). This study has been seen as a groundstone for many studies addressing models for evaluating the performance of those units. The concept of efficiency suggests comparing what is produced with a certain amount of resources and the maximum amount produced concerning the same amount of resources (de Mello, Gomes, Meza, Neto & Sant Anna, 2005). Such a concept can be used in academic libraries, providing key services to society, spreading knowledge, and nurturing new talent in the academic environment, especially in the so-called information, digitalization, and intellectual age (Kuang Wu, Zhao, Wang & Luo, 2010). Due to the dominant accountability movement (Shahwan & Kaba, 2013), which puts great pressure on more services using fewer resources (Shim & Kantor, 1999), as well as rapid technological changes (Noh, 2011), there is an increasing call for continuous evaluation. Efficiency in those institutions as Shim (2003).

Various researchers over the past years have studied academic libraries in Iran. These studies are usually limited to a medical university library (Najafi, 2020). There is a known

assumption that more inputs and resources can make the libraries more efficient. It is necessary to evaluate the performance of the medical university libraries considering the methodological problems in the studies conducted and the lack of continuous evaluations among medical university libraries. Despite the availability of vast opportunities offered to equip and manage medical libraries in Iran, there is no systematic evaluation to measure their performance and quality of services in these libraries. In this study, the performance and efficiency of medical university libraries are evaluated using Data Envelopment Analysis Technique (DEA). The following research questions are particularly addressed:

1- Which libraries are among the efficient libraries and which are among the inefficient libraries?
2- Based on the super-efficiency analysis, what is the ranking status of efficient libraries?
3- What are the factors that influenced the inefficiency of inefficient libraries? And
4- Which libraries are recommended for benchmarking by inefficient units?

Evaluating the Performance of Medical Academic Libraries

The efficiency and effectiveness of activities, processes, resources, systems, and organizations are concerned with quantifying performance measurement (Neely, Gregory, & Platts, 1995). Quantifying efficiency and effectiveness is a key issue in evaluating performances that address decisions about measurements, methods, and information systems to support the whole process. (Celere, Miller, Ganga & Martins, 2019). Library performance evaluation researches date back to the 1960s, and researchers and colleagues made the first serious attempt on objective evaluation methods at the National Library of Medicine (Hariri, 2013). Since the 1960s, the evaluation of libraries has always been an important issue in library and information science studies, and different types of libraries, including academic, public, specialized, and school libraries, have been evaluated from different aspects.

Lancaster (1995) conducted a comprehensive study of various aspects of library evaluation. In his study, he outlined four types of assessments/evaluations:

• Collection evaluation, including the comparison of collections with bibliographies, collection analysis in terms of resources available in different subject categories, resource circulation analysis, review of collection used in the reading room and the library, evaluation of periodicals, collection weeding studies, reviews Use of library space and studies on resource availability

• Evaluate reference services, including answering questions, searching databases, user education studies

• Cost-effectiveness studies and

• Study other aspects such as the range of library services and user satisfaction surveys

Library and university administrators may use objective criteria to identify strengths and weaknesses and determine costs associated with supporting education and research. In his research, Pritchard (1996) found that a small number of libraries are self-evaluated and often considered part of a larger evaluation. Addressing the budget constraints and increasing technological advances, he argues that the main goal of university libraries should be aligned with the higher education institution’s structures and criteria.

Library performance evaluation has two broad aspects: "effectiveness" and "efficiency". Effectiveness refers to the number of library services provided to meet the expectations or goals set by the parent institution. The increasing number of initiatives aimed to measure

effectiveness in terms of the impact of library services on their users. The second aspect of measuring library performance is focused on "efficiency", i.e., how well a library can convert its inputs (resources) into outputs (services) or produce a certain level of output with a minimum amount of input. Measuring library performance has received less attention, while it is an important criterion for decision-makers for parents of institutions. (Shim, 2003). Efficiency has often been confused with productivity and used interchangeably (Sinclair & Miller, 1984). However, efficiency includes productivity Achabal, Heineke & McIntyre, 1984); productivity integrates efficiency (Siegel, 1980), and thus it is challenging to be used interchangeably. Efficiency is often used when an organization is assessed according to the given standards(Klassen, Russell & Chrisman, 1998).

A comprehensive survey result shows that the existing library performance efficiency measurement mainly adopts data envelopment analysis (Najafi, Emamgholipour Sefiddashti, Sheikhshoaei, Razavi Hajiagha & Masoumi, 2020). Library efficiency means the ability of a library to transform its inputs (resources) into outputs (products or services). It refers to the input-output efficiency of the library. As a public cultural service institution, efficiency means how many products and services can be provided based on existing resources.

The first work in the literature that used the DEA technique to measure the efficiency of libraries is by Easun (1994), who applied this method in a group of school libraries in California. Subsequently, this technique has been used in different types of libraries: Chen (1997) applied the DEA in 23 Taiwan school, and university libraries; Sharma, Leung & Zane (1999) in 47 public libraries in Hawaii (USA); Vitaliano (1998) applied the DEA in 184 public libraries in New York; Worthington (1999) analyzed 168 public libraries in New South Wales (Australia) with the novelty that he related and measures efficiency as existing performance measures in the public library management methods. Hammond (2002) used the DEA to examine the relative efficiency of 99 UK public libraries, taking into account their structural differences; Shim (2003) evaluated 95 libraries belonging to the ARL (Association of Research Libraries) of the United States to measure its efficiency by providing the novelty on the use of a rescaling of the data, to avoid the comparison between variables of small and large magnitude (for example, the number of library volumes versus full-time staff). More recent results are due to Reichmann (2004) and Reichmann and Sommersguter-Reichmann (2006), who have measured the efficiency of 118 libraries in Australia, Austria, Canada, Germany, Switzerland, and the United States. Shahwan and Kaba (2013) focused on measuring efficiency in 11 academic libraries in some countries.

A combination of methods to measure the efficiency of local public libraries in Flanders was proposed in the study by Stroobants and Bouckaert (2014). Vrabková and Friedrich (2017) measured the efficiency of 33 Czech city libraries using decomposition of technical efficiency to pure technical efficiency and scale efficiency. Guccio et al. (2018) used a network two-stage Data Envelopment Analysis (DEA) approach to examine the relationship between the Italian public libraries' basic inputs, intermediate outputs, and final outputs. Moreover, Bayat (2018) studied 47 central academic higher education libraries in Iran by DEA and CSW.

Data Envelopment Analysis

One of the appropriate and efficient tools in productivity measurement and evaluation is data envelopment analysis, which is used as a non-parametric method to calculate the efficiency of decision-making units. It is used to experimentally measure the decision-making units'

production efficiency (DMUs). The analyzed organizations, teams, or units are called decision units or DMUs.

Data Envelopment Analysis (DEA) measures the relative performance of organizations with multiple inputs and multiple outputs. (Charnes, Cooper & Rhodes, 1978). It is a data-driven method for evaluating the performance of a set of peer entities that generates multiple outputs using multiple inputs. However, this definition of DMU is vague. In recent years, we have seen many applications of DEA for use in evaluating the performance of different types of organizations in different areas across the globe. (Gökşen, Doğan & Özkarabacak, 2015) .The DEA bibliography compiled by Emrouznejad and Yang (2017) reports more than 1,000 applications of the DEA technique. DEA allows the weight of the individual inputs and outputs of each DMU to vary as long as it creates the best possible combination for the desired library. The key to DEA is the identification of so-called efficient boundaries in some DMU comparison sets. It is said that all the units in this border work with 100% efficiency. The results of the DEA analysis can be used to measure the performance of libraries, especially for benchmark purposes(Shim, 2003).

This technique has been developed in response to the need to measure the relative efficiency of decision-making units with multiple inputs and outputs. The term decision-making units imply that the technique can be applied at any unit level in a managed organization, from all libraries in the country to the libraries of a university and even in an operational unit such as a cataloging unit in a library.

Data envelopment analysis has several advantages over traditional evaluation methods such as ranking, ratios, or regression analysis in library evaluation. Chen (1997) outlines three advantages of using data envelopment analysis in evaluating the performance of nonprofit organizations, especially academic libraries, as follows:

- Data Envelopment Analysis technique can extract individual aggregated scores that indicate the performance status of each library relative to its peer group.
- Data Envelopment Analysis technique can determine any deficiencies in the given input or output. It also provides insight to promote the quality and quantity of the outputs or decrease the excess inefficient library input to become an efficient library.
- This technique can also maintain parity in performance evaluation to examine multiple heterogeneous outputs and inputs in a mathematical programming pattern to create a set of common weights for each input and output.

Efficient libraries in terms of data envelopment analysis techniques are those libraries that use the least input for a given level of service (input-driven) or produce the most output with the same input level. This indicates the relative efficiency of all the libraries understudy and shows that an efficient library is a benchmark for inefficient libraries (Reichmann, 2004).

While none of the current evaluation methods, including data envelopment analysis, can describe the full nature of library performance, data envelopment analysis seems to have more advantages than traditional approaches because it provides information to library administrators that present their library status compared to other peer libraries. In addition, with the results of using this technique in performance evaluation, libraries can respond to the parent organization's requests for performance appraisal quantitatively and comprehensively (Shim & Kantor, 1999).

The DEA technique can be an alternative to "ratio" and regression models to work with multiple inputs and output variables (Ozcan, 2014). Moreover, it does not require that the model

variables meet special statistical characteristics since this technique measures the efficiency of each library concerning the other libraries in the sample and allows great flexibility in the selection of variables according to the different types of measurement (costs, spaces, number of people, number of books, etc.).

Context of the study

Sixty-six medical universities and higher education institutions in Iran provide medical education to students. These higher education institutions are affiliated with the Ministry of Health in Iran. Medical higher education institutions are classified into three types, i.e., Type 1, Type 2, and Type 3, based on their facilities, equipment, number of teachers and students, and the volume of education and research activities. Type 1 is considered the main higher education institution with the most resources in this classification, including teachers, students, budgets, and physical resources. The same units use the data envelopment analysis technique to compare the performance efficiency of these three types of medical higher education institutions. All medical higher education institutions libraries regarded as type 1 were selected in this study.

The main universities of medical sciences are reflected in this group. Each of these universities has several faculties (some universities have more than 10 faculties). Apart from the central library in these universities, each faculty has its specialized faculty library.

Materials and Methods

The DEA (Data Envelopment Analysis) method is used to measure the relative efficiency of organizational units that have the same goals and objectives. This is a non-parametric method in operational research and economics to estimate production frontiers. (Charnes et al., 1978). Each library represents a separate DMU to experimentally measure the production efficiency of decision units (DMUs) in this study. Although the DEA is strongly associated with production theory in economics, it is also used to benchmark operations management, where a set of measures is selected to benchmark production and service performance (ibid). The basic idea of the DEA is the construction of a model library made up of the combination of the inputs and outputs of all the libraries analyzed and the identification of the so-called efficiency frontier. All the libraries on the border will be those working at one hundred percent efficiency for the selected input and output variables. Libraries outside the efficiency frontier will be inefficient libraries, and the relative value of this inefficiency can be calculated. In benchmarking, efficient DMUs, as defined by the DEA, may not necessarily be "a production frontier" but lead to "the best performance frontier".”(ibid).

In the simplest case, in which there is a single input and a single output, the efficiency value is defined as:

$$\text{Efficiency} = E_0 = \frac{\text{output}}{\text{input}}$$

In case of having more than one input or output variable, the efficiency value is calculated as a ratio of the weighted sum of the output variables and the weighted sum of the input variables, that is:

$$\text{Efficiency} = E_0 = \frac{\text{Weighted sum of output variables}}{\text{Weighted sum of input variables}}$$

The purpose of the DEA is to make the efficiency value for each DMU in the sample the maximum it can achieve; for this, the weights of the combination of input and output

variables are adjusted according to the rest of the DMUs in the sample.

to formalize the model, we consider the objective function of the problem:

Given the DMU, the goal is:

$$\max = \frac{\sum_i u_i\, y_{ik} + u_0}{\sum_j v_j\, x_{jk}}$$

S.t.

$$\frac{\sum_i u_i\, y_{il} + u_0}{\sum_j v_j\, x_{jl}} \leq 1\ \forall l$$

$u_i \geq 0$ $v_j \geq 0$ u_0= free

As indicated previously, the objective is to maximize the weights u and v so that the resulting efficiency value for that unit of analysis is the highest possible.

The restrictions to this model are the following: The efficiency values are bounded between 0 and 1 (since they are relative numbers) and, therefore:

$$0 \leq \frac{\sum_r u_r\, y_{rj}}{\sum_i v_r\, x_{ij}} \leq 1\ \forall j = 1, \dots n$$

The weights used must be non-negative values and, therefore:

$$u_r, v_i > 0$$
$$r = 1, \dots s; i = 1, \dots m$$

Consequently, the efficiency value of the DMUj can be obtained by solving the following linear programming model:

$$\text{S.a.}[0 \leq \frac{\sum_r u_r Y_{RJ}}{\sum_I V_I X_{IJ}} \leq 1 \forall \text{J} = 1, \dots \text{N}$$
$$u_r, v_i > 0 \qquad \forall \text{r} = 1, \dots \text{s}, \text{i} = 1, \dots \text{m}$$

The DMUs with the maximum efficiency value will be those whose Ej reaches the value of 1 and are called efficient units, which will constitute the reference set for inefficient units.

Data Envelopment Analysis model comparing the values of the inefficient unit's input and output variables with the efficient units' values act as a reference. Such comparison allows us to identify the variables and the intensity of work to convert inefficient units into efficient units. In the reports of the basic data envelopment analysis models, the units evaluated with a score lower than one are scored and ranked in more detail, but the efficient units with a score of one are shown in the same way. While the optimal performance of efficient units is not the same, and there are differences, the Anderson-Pearson super-efficiency model was used for this purpose.

$$\theta^* = Min\ \theta - \varepsilon \sum_{i-1}^{m} s_i^- - \varepsilon \sum_{r=1}^{s} s_r^+$$

Subject to:

$$\sum_{i=1}^{m} \gamma_j x_{ij} + S_i^- = \theta_{xio} \quad i = (1,2, \dots, m)$$

$$\sum_{r=1}^{s} \gamma_j x_{rj} + S_r^+ = y_{ro} \quad r = (1,2,\dots,s)$$
$$\gamma_{j,} s_r^+, s_i^- \geq 0 \qquad j = (1,2,\dots,n)$$

Our analysis used data from 77 academic libraries of Iranian type1 medical universities from 2018 to 2019. Moreover, the libraries of hospitals and medical centers were not included in this study.

Data Collection

No sampling was used in selecting the statistical population, and all libraries of Type I universities were selected for this study. A checklist for collecting performance data was sent to all libraries. Moreover, after several follow-ups, the desired information was collected from libraries within three months.

One of the important steps in conducting this type of research is to determine the input and output variables for collecting data related to the performance of the evaluated units. The variables used in previous studies were extracted and organized with the participation of faculty members of the Departments of Library and Information Sciences. Finally, 18 variables in five dimensions were selected for this purpose, and a checklist was prepared with the obtained variables to collect performance information of the libraries. This checklist was created online, including the obtained criteria and background information for identification in terms of academic affiliation and contact details, as described in the category below in five dimensions.

Variables used are listed below:

1- Information resources in 2 variables
   a. Total volumes held
   B. Net volumes added during the period
2- Human resources in 4 variables
   a. Number of professional staff
   B. Number of support staff (service, security, etc.)
   d. Total full-time student enrollment
   e. Full-time instructional faculty
3- Financial resources in 2 variables
   a. Total personal expenditures (professional staff)
   B. Total personal expenditures (support staff)
4- Dimensions of physical resources in 3 variables
   a. Area of library space
   B. computers
   J. Seating capacity
5- Services in 4 variables
   a. Opening hours per week
   b. The number of registered members (students, faculty, etc.)
   c. circulation transactions
   d. number of Reader visits or attendance

Table 1

Statistical summary of the variables used in the study

Variables	Minimum value	Maximum value	Mean	S. deviation
Books	501	147713	16323.06494	22834.11051
Added books	10	2700	456.0649351	453.3468921
Prof. staff	1	21	4.181818182	3.652821645
support staff	0	7	0.753246753	1.230023991
Student	30	17736	1333.727273	3075.530031
faculty members	3	1400	153.7012987	304.2824573
p. personal cost	300000000	6300000000	1284155844	1099132247
s. personal cost	0	1428000000	133792207.8	246562359.8
Space	40	5700	578.974026	967.6620132
Computers	1	85	14.1038961	19.07061801
Seating	6	500	95.76623377	95.7083243
Opening hours	30	110	51.0974026	16.36152884
members	50	19000	1637.662338	3961.416821
Circulation	166	33000	4117.727273	5366.013531
Attendance	240	90000	5153.025974	14247.62805

As indicated in Table 1, statistical characteristics (minimum and maximum values, mean and standard deviation) of data collected from studied university libraries are presented under input and output indicators.

Results

In this part, the study's findings addressing the efficiency performance and ranking of libraries of Iranian Type1 medical universities were provided. Initially, efficient and inefficient libraries were identified. Then by mapping the score of super-efficiency, efficient libraries were accordingly ranked. Further, benchmark libraries were introduced among inefficient libraries to follow their performance to improve their performance.

In terms of data envelopment analysis techniques, efficient libraries use the least input for a given level of service (input-oriented) or produce the most output with the same input level (output-oriented). This indicates the relative efficiency of all the libraries understudy and shows that an efficient library is a benchmark for inefficient libraries (Reichmann, 2004).

Efficient libraries:

The table below shows the efficient libraries on the optimal use of facilities in providing services in 2019.

Table 2

Libraries with full performance score (one)

Row	University-library	Row	University-library
1.	Isfahan - Faculty of Medicine, Pharmacy	2.	Shahid Beheshti - Faculty of Traditional Medicine
3.	Isfahan - Faculty of Rehabilitation	4.	Shahid Beheshti - Central library
5.	Ahvaz - School of Pharmacy	6.	Shahid Beheshti - School of Medicine
7.	Ahvaz - School of Dentistry	8.	Shahid Beheshti - School of Nursing and Midwifery

Row	University-library	Row	University-library
9.	Ahvaz - Central library	10.	Shiraz - School of Nursing and Midwifery
11.	Iran - School of Medicine	12.	Shiraz - School of Medicine
13.	Iran - School of Iranian Medicine	14.	Shiraz - School of Rehabilitation
15.	Iran - Faculty of Behavioral Sciences and Mental Health	16.	Shiraz - Faculty of Dentistry
17.	Tabriz - School of Rehabilitation	18.	Kerman - School of Nursing and Midwifery
19.	Tabriz- School of Dentistry	20.	Kerman - School of Dentistry
21.	Tabriz - Faculty of Management and Information	22.	Kerman - Faculty of Iranian Medicine
23.	Tabriz - School of Nursing and Midwifery Sciences	24.	Kerman - Zarand School of Medical
25.	Tabriz – central library	26.	Mazandaran - Behshahr School of Nursing
27.	Tehran - Paramedical School	28.	Mazandaran - Amol School of Nursing and Midwifery
29.	Tehran - Faculty of Nutrition and Dietetics	30.	Mashhad - Faculty of Nursing and Midwifery

According to the table above, it was determined that 30 libraries have a full efficiency score (one). In other words, 39% of the libraries surveyed located in Type I universities were efficient. In other words, these libraries have better performance than the other evaluated libraries and have more output than the available facilities. When it is possible to reduce one input without increasing other inputs or increase the number of outputs without decreasing other outputs, it is concluded that the DMU is inefficient. So, libraries with an efficiency score of less than one were included in this inefficient ones category. These libraries have not made optimal use of their resources to produce services compared to libraries with good performance. Of the 77 libraries evaluated, 47 have less than one performance score. They are considered inefficient. These libraries comprised about 61% of the libraries of Type I universities and are as follows:

Table 3

Inefficient libraries with a score of less than one

Row	University-library	efficiency Score	Row	University-library	efficiency Score
1.	Mashhad - School of Paramedical Sciences.	0.9787	25.	Shahid Beheshti - School of Rehabilitation	0.6477
2.	Mazandaran - Sari School of Paramedical Sciences	0.9432	26.	Kerman - School of Pharmacy	0.6397
3.	Mashhad - School of Dentistry	0.9173	27.	Mazandaran - School of Pharmacy	0.6363
4.	Mazandaran - Nasibeh School of Nursing Sari	0.9054	28.	Tabriz - School of Health and Nutrition	0.6080
5.	Mazandaran - School of Dentistry (Sari)	0.8973	29.	Mazandaran - Sari School of Medicine	0.6021
6.	Shahid Beheshti- School of Dentistry	0.8870	30.	Ahvaz- School of Medicine	0.5916
7.	Tabriz - School of	0.8732	31.	Isfahan - School of Health	0.5791

Row	University-library	efficiency Score	Row	University-library	efficiency Score
	Pharmacy				
8.	Mashhad - School of Medicine	0.8674	32.	Kerman - School of Management and Information	0.5726
9.	Ahvaz - School of Rehabilitation	0.8559	33.	Tehran - School of Nursing and Midwifery	0.5635
10.	Tabriz - School of Paramedical Sciences	0.8295	34.	Shahid Beheshti - School of Health and Safety	0.5531
11.	Ahvaz - School of Health	0.8281	35.	Shahid Beheshti - School of Pharmacy	0.5531
12.	Isfahan - School of Management and Medical Information	0.8033	36.	Mashhad - School of Pharmacy	0.5477
13.	Isfahan - School of Nursing and Midwifery	0.8021	37.	Tehran - School of Health	0.5406
14.	Ahvaz - School of Paramedical Sciences	0.7923	38.	Tabriz - School of Medicine	0.5376
15.	Shiraz - School of Management and Information	0.7669	39.	Shahid Beheshti - School of Paramedical	0.5242
16.	Tehran - School of Medicine	0.7664	40.	Kerman - School of Health	0.5000
17.	Tehran - School of Dentistry	0.7647	41.	Shiraz - School of Health	0.4971
18.	Ahvaz - School of Nursing and Midwifery	0.7383	42.	Tehran - School of Rehabilitation	0.4942
	19. Tehran - Faculty of Pharmacy	0.7056	43.	Iran - Faculty of Rehabilitation Sciences,	0.4817
20.	Shiraz - School of Paramedical Sciences	0.6922	44.	Mazandaran - School of Health	0.4523
21.	Shiraz - School of Pharmacy	0.6888	45.	Iran - School of Health	0.4324
22.	Iran - Faculty of Management and Information	0.6788	46.	Shahid Beheshti - Library of the Faculty of Nutrition Sciences and Food Industry	0.4249
23.	Iran - School of Nursing and Midwifery	0.6542	47.	Mashhad - School of Health	0.3710
24.	Kerman-Central (School of Medicine)	0.6493			

In the libraries listed in Table 3, each in all or part of the variables has (slack) input surplus or shortage in output. In this evaluation, they have not used their resources optimally compared to other examined libraries. As mentioned earlier, this technique assesses the quality of performance of each library compared to the other libraries and is based on the fact that the efficiency score obtained is relative.

High-performance libraries are introduced as benchmarks for use as models by inefficient libraries as a performance analysis in performance evaluation using the data envelopment

analysis technique. Therefore, several units with completed performance scores are often cited as criteria for inefficient libraries regarding the similarity of inputs to targeted libraries. The model libraries resulting from the evaluation output are selected based on the frequency and set as a benchmark library in Table 4.

Table 4
Benchmark Libraries for inefficient units based on the frequency

University-Library	Number	University-Library	Number
Shahid Beheshti - School of Nursing and Midwifery	41	Mazandaran - School of Nursing and Midwifery Amol	4
Kerman - School of Iranian Medicine	38	Iran - School of Medicine	3
Kerman - School of Nursing and Midwifery	34	Iran - School of Iranian Medicine	3
Kerman - Zarand School of Medical Sciences	29	Shiraz - School of Medicine	3
Tabriz - Faculty of Management and Information Science	15	Iran - Faculty of Behavioral Sciences and Mental Health	2
Shiraz - School of Dentistry	12	Shahid Beheshti - Central and Documents	2
Ahvaz - School of Dentistry	10	Ahvaz - School of Pharmacy	1
Shiraz - School of Nursing and Midwifery	10	Ahvaz - Central	1
Isfahan - Faculty of Rehabilitation	9	Tabriz - School of Nursing and Midwifery	1
Tehran - Faculty of Nutrition and Dietetics	8	Tabriz - Central	1
Mazandaran- Behshahr	8	School of Nursing Tehran- Paramedical School	1
Tabriz - Faculty of Rehabilitation	7	Shahid Beheshti - School of Medicine	1
Kerman - School of Dentistry	6	Shiraz - School of Rehabilitation	1
Isfahan - School of Medicine, Pharmacy	5	Mashhad - School of Nursing and Midwifery	1
Tabriz - School of Dentistry	5		

The table above shows that the libraries of the School of Nursing and Midwifery of Shahid Beheshti University of Medical Sciences have been introduced 41 times, and the Schools of Iranian traditional medicine and Nursing and Midwifery of Kerman University of Medical Sciences 38 and 34 times, respectively, have been introduced as benchmarks for inefficient libraries.

Ranking of efficient libraries in the output of the super-efficiency model

In basic data envelopment analysis models, decision-making units are divided into two main categories: efficient and inefficient. Inefficient units are ranked based on their scores (zero and one) (see Table 3). The efficient libraries listed in Table 2 all have full performance scores and are ranked based on performance scores. However, the performance of all of them is not on the same level, and despite being on the borderline, the efficiency varies depending on the effective use of resources in the production of services. For this purpose and to show the distances between efficient units, the super-efficiency scores of the units were extracted using the Peterson-Anderson technique, and the efficient units were ranked based on their efficiency

over the super-efficiency score. The following tables present the super-efficiency scores of the introduced efficient libraries separately:

Table 5

Efficient libraries ranked on super-efficiency score

Row	University- Library	S-efficiency score	Row	University- Library	S-efficiency score
1.	Shahid Beheshti - School of Nursing and Midwifery	11.307	25.	Mashhad - School of Dentistry	0.985
2.	Shiraz - School of Dentistry	3.853	26.	Mashhad - School of Medicine	0.96
3.	Isfahan- School of Medicine, Pharmacy	3.6	27.	Shahid Beheshti- School of Dentistry	0.953
4.	Tabriz- central library	2.914	28.	Mazandaran- Sari Paramedical School	0.933
5.	Iran - School of Medicine	2.288	29.	Shahid Beheshti - School of Traditional Medicine	0.931
6.	Kerman - School of Nursing and Midwifery	2.036	30.	Tabriz - School of Paramedical Medicine	0.926
7.	Tabriz - School of Rehabilitation	1.73	31.	Tabriz - School of Pharmacy	0.91
8.	Tabriz- School of Dentistry	1.696	32	Tehran- School of Pharmacy.	0.895
9.	Shahid Beheshti - Central and Documents	1.672	33.	Tehran - School of Dentistry	0.895
10.	Shiraz - School of Nursing and Midwifery	1.521	34.	Shiraz - School of Management and Information	0.89
11.	Ahvaz - School of Pharmacy	1.502	35.	Tehran - School of Medicine	0.889
12.	Shiraz - School of Medicine	1.396	36.	Ahvaz - School of Nursing and Midwifery	0.887
13.	Tehran - School of Paramedical	1.343	37.	Isfahan - School of Management and Medical Information	0.871
14.	Iran - Faculty of Behavioral Sciences and Psychiatry	1.33	38.	Ahvaz - Faculty of Rehabilitation	0.86
15.	Tabriz - Faculty of Management and Information	1.314	39.	Isfahan - Faculty of Nursing and Midwifery	0.858
16.	Isfahan - School of Rehabilitation	1.304	40.	Mazandaran - Nasibeh Sari School of Nursing	0.858
17.	Mazandaran - School of Nursing and Midwifery	1.25	41.	Mazandaran - School of Dentistry (Sari)	0.852
18.	Kerman - School of Dentistry	1.181	42.	Ahvaz - School of Health	0.844

Row	University- Library	S-efficiency score	Row	University- Library	S-efficiency score
19.	Shiraz - School of Rehabilitation	1.175	43.	Tabriz - School of Health and Nutrition	0.833
20.	Shahid Beheshti - School of Medicine	1.09	44.	Iran - School of Nursing and Midwifery	0.827
21.	Mashhad - School of Nursing and Midwifery	1.073	45.	Ahvaz - School of Medicine	0.811
22.	Tabriz- School of Nursing and Midwifery	1.018	46.	Tehran- School of Health	0.811
23.	Ahvaz – Central library	1.012	47.	Isfahan - School of Health	0.798
24.	Mashhad - School of Paramedical	0.993			

Among the efficient libraries of Type I universities, the libraries of the School of Nursing and Midwifery of Shahid Beheshti University of Medical Sciences, Dentistry of Shiraz University of Medical Sciences, Medicine and Pharmacy of Isfahan University of Medical Sciences, the Central Library of Tabriz University of Medical Sciences and the Library of Iran University of Medical Sciences Top libraries have been reported. According to Table 5, the rest of the efficient libraries in this category are sorted by performance score.

Discussion

This study is the first attempt to evaluate the medical university library's performance in Iran at a national level using the DEA technique. The top and low-efficiency libraries indicate the Iranian academic medical libraries' performance among Type 1 medical universities. The study's findings show that the services of the University Library of Medical Sciences at all Iranian universities are relatively efficient overall, although there is still little room for improvement. As indicated in the study findings, 39% of the Medical Sciences University Libraries of the studied universities were fully efficient. This finding is aligned with the previous studies addressing that the efficiency of the library needs to be enhanced. In a study about the efficiency evaluation of 184 public libraries in New York, Vitaliano (1998) found that 12.5% of the studied libraries were considered efficient. In another study, Sharma et al. (1999) evaluated the efficiency of 47 public libraries in Hawaii and found that 29% of libraries were rated fully efficient. In other studies (Worthington, 1999; Hammond, 2002; Dehghan-Nayeri, Mohaghar & Afkhami, 2017), the efficiency ratios were 10.1%, 34.6%, 28.8%, and 34%, respectively, not more than half. To sum up, there are some drawbacks in the utilization of library resources, and the overall efficiency level needs to be improved.

Further, DEA analysis helps each libraries determine whether, in what areas, and to what extent their performance can and should be improved. According to the findings, 47 libraries are rated as inefficient. These libraries seem that could not to use their resources effectively. On the other hand, a number of the libraries - including Libraries of the Schools of Nursing and Midwifery of Shahid Beheshti University of Medical Sciences, Dentistry of Shiraz University of Medical Sciences, Medicine and Pharmacy of Isfahan University of Medical Sciences, Central Library of Tabriz University of Medical Sciences and University of Medical Sciences Library Iranian medical sciences - are rated as supper efficient which indicate that these libraries use their input effectively to provide great services to their users.

In specific situations reducing inputs or increasing outputs alone is not enough. For instance, if a library reduces its inputs from 4 to 2 units, its output is less than its peer library. Such differences or gaps between these libraries with their peers are called "slack". It refers to extra input or missing outputs that exist even after a significant change in input or output.(Najafi et al., 2020). According to the reported slack of 47 inefficient university libraries in this study, the following factors mainly define the inefficacy among Medical Sciences University Libraries. These factors are seat capacity, the library space number of the library collection, and the staff member. Other studies have further indicated some different slacks (Guajardo, 2018), operating costs (Srakar, Kodrič-Dačić, Koman & Kavaš, 2017), Loans (Vrabková & Friedrich, 2017). The number of employees and cultural and educational events has been reported as slack.

Traditionally, bigger well-equipped libraries - i.e., large reading rooms, many information resources, and more staff - function more and are often considered more efficient libraries. However, according to the evaluation models, including DEA, the library's productivity and efficiency depend on using its resources to make value. Therefore, libraries much smaller than the libraries in the main universities may have a higher efficiency score indicated in the study's findings. In this study, the library of the school of medicine at Tehran University of Medical Sciences, as the biggest medical school in Iran, with an efficiency score of 0.706368, is one of the inefficient libraries in the model output. The lack of optimal use of inputs and the low output rate related to resource circulation statistics is why this university library is identified as inefficient.

On the other hand, the library of Zarand medical school in Kerman University of medical science has been introduced as one of the libraries with full efficiency (100%). These phenomena, interestingly, were underlined in other studies. For instance, in Shojaeian, Afifian and Ziaeian (2020) study, small libraries such as Arsanjan and Khorram Bid were considered efficient among 29 studied libraries in Fars province in Iran. The largest and most advanced public library in Shiraz was indicated to be inefficient. Although the amount of (inputs) in the public library of Shiraz was more than in other cities in Fars province, the number of outputs was not commensurate with the distributed facilities.

Conclusion

In an information society where generating, finding, implementing, distributing, manipulating, and integrating information is vital, the Medical libraries' continuous performance assessment is an urgent and necessary requirement. It is suggested to evaluate measure libraries' performance quality of services using cost-effectiveness, cost-benefit analyses, and benchmarks for making decisions. However, having more or new equipment, instruments, space, and staff cannot ensure library service quality. As highlighted in the findings, the service quality of the library of the medical school of Tehran University - despite access to more equipment, space and staff – was significantly lower than the other libraries of type 1 universities studied in this study. On the contrary, the School of Nursing and Midwifery of Shahid Beheshti University of Medical Sciences library made the best use of the very few available resources. Thus, the academic libraries' librarians and gatekeepers must systematically analyze and decide how to utilize the available resources best to create the best service quality for their users.

Suggestions for future research

• To accurately measure new library services such as digital resources and library service's effect on the client's education and research, a survey with combined data envelopment analysis and regression analysis is suggested to conduct a comparative performance evaluation of academic libraries.

• Considering that only the performance efficiency of libraries was studied in this study, it is suggested to combine this tool with quality tools such as LibQual and Kano to obtain a complete qualitative and quantitative review of the performance status of this type of library.

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