ORIGINAL ARTICLE

The Efficiency of Health Performance in Universities of Medical Sciences in Iran: Data Envelopment Analysis

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Abstract

Background: Technical efficiency, which is measured by calculating the ratio of products to resources, is the most important factor in assessing the efficiency status of organizations. Data envelopment analysis is useful to measure the efficiency score of all the units which have homogeneous input resources and output products and to rank them. The aim of this study was to measure and compare the efficiency of health performance in medical universities in Iran.

Methods: The present research is a cross-sectional study to measure the efficiency of health performance using the national information of the health system of Iran. Input data include hospital beds, specialists, general physicians, dentists, pharmacists, nurses, midwives, computerised topography scan and magnetic resonance imagination devices, and Gini Index; also, the output data include pregnancy care coverage, infant mortality rate, low birth weight, and in-patient days. These data were attained from the annual Ministry of Health and Medical Education report in 2017 for 46 medical universities. To estimate the efficiency of health performance of each medical university using data envelopment analysis, we designed an input-oriented model with Variable Returns to Scale in GAMS 28.2.0. The effect of contextual factors on the efficiency score was calculated using the Tobit Regression model.

Results: Results showed that only 19 (41%) medical universities were on the efficiency frontier. The highest mean of efficiency score was attributed to eastern areas, followed by the western and northern areas, and the worst status was related to southern parts of the country. The efficiency scores of universities located in northern areas were closer, while there was more difference among the efficiency scores of the universities of central areas of the country. Tobit regression shows that significant factors in efficiency include life expectancy and medical university class.

Conclusion: The results of this study emphasized the differences in the performance efficiency of medical universities. Considering the inefficiency of smaller universities, we need to make careful decisions in establishing new universities in small cities.

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Introduction

In recent years, factors such as constant advancements in new and expensive health technologies, increase in the expectations of societies from health systems, and growth of hard and chronic disease among people have led to an increase in health expenses.[1] In the Disease Control Priority report of the national bank, it was emphasized that inefficiency and defects in resource management are bigger threats to the health department of developing countries than the shortage of budget.[2]

Various studies have shown that in most underdeveloped countries the limited resources of the health sector are used inefficiently, and the government budget is spent on providing services that are not effective enough.[3] Inefficient utilization of the resources in the health sector leads to a situation in which even increasing the share of the health sector in the country public resources would not create a significant impact on improving the outcomes of health system. Therefore, efficient use of limited resources in the health sector is one of the main concerns of managers and policymakers.[4]

Evidence shows that, like other countries, Iran is facing an extreme increase in health expenses.[5] In 2000, nearly 4.7% of the Gross Domestic Product (GDP) of Iran was allocated to the health sector, while in 2016 it was 8.1%.[6] The growth of expenses occurred in a situation in which the economic growth of the country in recent years has been lower than the growth of health expenses. This issue has created difficulties in covering health expenses.[7]

Improving efficiency in providing health services is a long-term strategic goal. Efficiency means using the minimum resources to produce a certain number of products or services or producing the maximum amount of product using a certain number of resources. In other words, efficiency means not wasting the resource.[8] In the health sector, 4 forms of efficiency are defined, consisting of technical efficiency, technological efficiency, economic efficiency, and allocative efficiency. Technical efficiency, which is measured by calculating the ratio of products to resources, is the most important factor in assessing the efficiency status of organizations.

Technical efficiency is measurable through various techniques such as non-parametric data envelopment analysis (DEA) and parametric stochastic frontier analysis (SFA).[9] In the parametric method, the production function is estimated. This method provides a frontier function which envelopes all data which is why it is called data envelopment analysis.[10]

Therefore, by employing this method, we can measure the efficiency score of all the units which have homogeneous input resources and output products and grade them. In this technique, the units which produce a certain number of products using the minimum resources are demonstrated with a similar function, and their efficiency is 100%. Other units which produce the same amount of products using more resources will attain a lower efficiency score.[11] Since healthcare structures always benefit from a combination of resources to achieve a combination of products, services, and health outcomes and usually these combinations are homogeneous, in most cases, DEA is used to measure efficiency in the health sector. Besides identifying the best performance, DEA enables the managers of organizations to identify the ways of achieving the best performance.[12]

To date, numerous efforts have been made to measure the efficiency of the health sector using DEA. In most studies, efficiency has been assessed on the level of service provided by institutes such as hospitals or healthcare centres.[13, 14] Only in a few studies in China,[15, 16] Spai,[17] Slovak Republic,[18] Italy,[19] and Canada,[20] efficiency has been assessed on the level of the health system. Also, in some studies, health performance efficiency is assessed in Organization for Economic Co-operation and Development (OECD) countries[21, 22] and World Health Organization (WHO) Eastern Mediterranean region countries.[23] No study has ever assessed the heath performance efficiency on the national level.

Universities of medical sciences are stewards of public health in Iran. In the Health Transformation Plan, considerable financial resources were assigned to universities of medical sciences to be used according to uniform national guidelines. The use of government budgets to provide a wide range of health services and differences in health performance in various areas of the country highlights the significance of performance efficiency assessment in these universities.

Since the nature of the input and output indicators of medical universities is similar, data envelopment analysis is a suitable approach to compare their health performance status. The present study aimed to assess the performance efficiency of universities of medical sciences.

Methods

In this study, the efficiency of health performance of 46 universities of medical sciences in Iran was measured. Each of the 46 universities of medical sciences is considered as a decision-making unit for the implementation of DEA. Data analysis was done in two phases using DEA techniques and Tobit regression. The key advantage of DEA is that the efficiency of each unit is measured against that of other similar units.

Input and Output Data

Selecting variables of the model for analysing efficiency is crucial. Therefore, proper input and output variables which have been widely used in previous studies were selected for the analysis.[21, 23] Among the indicators used in various studies, we selected those that were a good indicator for university performance in the field of health. In addition, the other criterion for choosing the input and output indicators included access to their data for all medical universities across the country. The input variables include the number of specialists, general physicians, nurses, midwives, dentists, pharmacists, hospital beds, CT scan and MRI devices, and Gini Index (2017); also, output variables include pregnancy care coverage (at least 6 times in each pregnancy), infant mortality rate (in one thousand births), In-patient Days and low birth weight (under 2500 g).

Data Source

The data are related to the year 2017. The sources of the data include MOHME resources data banks such as Hospital Statistics and Information System, hospital information management systems of universities of medical sciences, MOHME license issuance and medical equipment information system and national health index system (SIB). All data related to inputs and outputs of different universities that were collected from various sources were validated by authorities of the related university of medical sciences and then entered into the model. Table 1 presents definition and explanation of input and output variables.

Data Analysis

In the first stage, data envelopment analysis (DEA) was used as a non-parametric method to assess the efficiency of health performance of medical sciences universities in Iran. As Singh et al. describe: "To compute the relative efficiency of a DMU, the DEA assigns weights to a set of inputs and outputs to maximize the efficiency score of each DMU. Efficiency in data envelopment analysis (DEA) is defined as the ratio of weighted sum of outputs divided by the weighted sum of inputs.[13] Given that the outputs of the health system are influenced by many socio-economic factors and are not under the control of health policymakers in universities of medical sciences, the input-oriented approach with the variable returns to scale model (VRS) was used. We used GAMS 28.2.0 to calculate the efficiency score. Efficiency of different universities was measured using the input-oriented model with Variable Returns to Scale, and the universities were graded.

VRS DEA Model – Input orientation

$$\theta^* = \min \theta$$

$$\sum_{j=1}^{n} \lambda_j \, x_{ij} \leq \theta_{xi0} \qquad (i=1,\ldots, m).$$

$$\sum_{j=1}^{n} \lambda_j \, y_{rj} \geq y_{r0} \qquad (r=1,\ldots, s).$$

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

$$\lambda_j \geq 0 \quad (j=1,\ldots, n).$$

where:
θ is the efficiency score;
x is the input vector and y is the output vector
xi and yi are the observed input and output values;
λ is the DMU's non-negative weights defining frontier points.[30]

Tobit Regression

In the second stage, DEA efficiency scores calculated in the previous stage were regressed against some contextual factors to determine their control over the efficiency score. In Tobit regression equation, regions are used as explanatory variables. These factors are presented in Figure 1. Since efficiency score is a number between 0 and 1, we used Tobit Regression

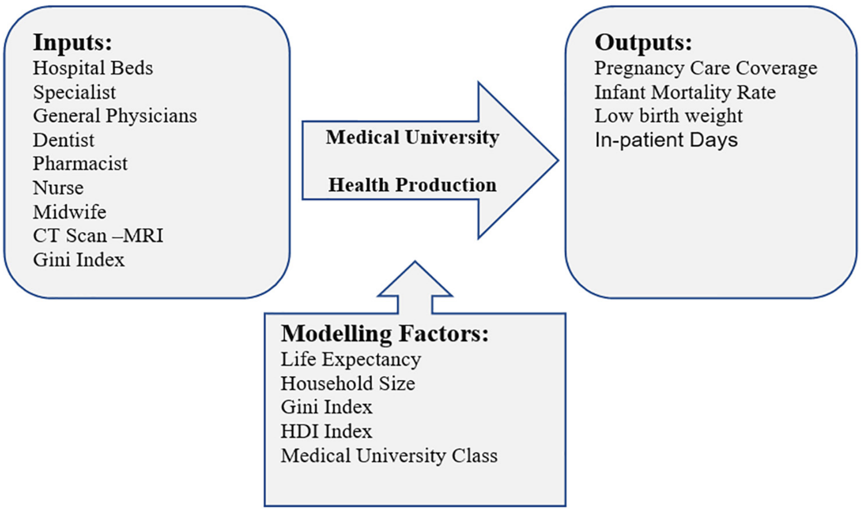

Figure 1: Iranian medical universities inputs, outputs and influencing factors

which is suitable for analyzing the censored dependent variables. Tobit Regression model is used as follows:
Tobit (Yi) = a0 + a1xj1 + a2xj2 + a3xj3 + a4xj4 + …. + εj
Where:
Yi: is the variable return to scale efficiency score for the jth Medical University,
xj: are the independent variables,
εj: are the disturbance term assumed to be normally distributed with mean μ and standard deviation σ
a: are the Tobit coefficients which indicate how a one-unit change in an independent variable xi alters the latent dependent variable yi

The general estimated model was as follows:
$$\text{Efficiency Score} = a + \beta_1 LE + \beta_2 HS + \beta_3 MUC + + \beta_3 D + \beta_3 P + \varepsilon_j$$

In this formula, β stands for unknown coefficients and ε_j is random error. Tobit regression was carried out with the Stata.12 software to clarify the predictors of efficiency. Our aim was to estimate the most parsimonious Tobit model which can explain the efficiency values. Therefore, we created and ran numerous models of various combinations of contextual factors. Finally, the selected experimental model was as follows:
$$\text{Efficiency Score} = a + \beta_1 LE + \beta_2 HS + \beta_3 MUC + \varepsilon_j$$

Tobit coefficients show how changes in a unit in independent variables (LE, HS, MUC) will lead to changes in dependent variables (Efficiency score).

Ethical Consideration

One of the ethical concerns in quantitative analysis is selection bias. To avoid this, we reported

Table 1: Definition and explanation of variables

Variable	Abbreviation	Definition and explanation	Data source
Input			
Hospital beds	HB	The total number of active hospital beds district	The Iran Health Roadmap project data which were collected as a survey of the curative deputies of medical universities across the country. To collect this data, a portal was designed and implemented, and medical universities uploaded the data of human resources, hospital beds and medical capital equipment available in 2017.
Specialist	Spe	The total number of specialists, general physicians, dentists, pharmacists, nurses and midwives who are working in health sector in the district, including public and private sectors.	
General Physicians	GP		
Dentist	Den		
Pharmacist	Phar		
Nurse	Nurs		
Midwife	Mid		
CT Scan -MRI	CTMRI	The total number of CT Scan and MRI within the district (public and private)	
Gini Index	GI	Gini Index measures income distribution across a population[25]	Revenue Distribution Report in Iran 2020[24]
Output			
Pregnancy Care Coverage	PCC	The percentage of pregnant women who received at least 6 times of pregnancy care in the governmental health centres in each district	Data of health indicators in the integrated health system (SIB) of the Ministry of Health and Medical Education
Infant Mortality Rate	IMR	The number of deaths under one year of age occurring among the live births in the district per 1,000 live births during the year of 2016	
Low birth weight	LBW	The percentage of new-borns whose birth weight is less than 2500 g	
In-patient Days	IPD	The total number of days for all patients who were admitted in hospitals affiliated to each medical university.	The Iran Health Roadmap project data
Contextual/environmental factors			
Life Expectancy	LE	The average period that a person may expect to live.	Survey of Iran's human capital development index[26]
Household size	HS	The number of persons for whom a person is financially responsible.	Data of health indicators in the integrated health system (SIB) of the Ministry of Health and Medical Education
Medical University Class	MUC	Iran's Medical Sciences Universities 3 classes: a. Major Medical Sciences Universities b. Provincial Medical Sciences Universities c. Local Medical Sciences Universities	Spatial planning of higher education of health in republic of Islamic of Iran[27]
Population density	PD	The number of people living in a square kilometre	Population and Housing Census Data of 2016[28]
Population	P	The population of each Medical Sciences University's catchment area	
Variation coefficients of distributed resources	CV	CV is a standardized measure of dispersion of a frequency distribution, and is defined as the ratio of the standard deviation to the mean.[29]	-

all indicators addressed in primary research protocol which included descriptive analysis, efficiency score and Tobit regression (IR.KMU.REC.1401.282).

Results

The findings of the present study show that the distribution of resources and the status of health indices in the areas under the coverage of the 46 universities of medical sciences and their efficiency scores are different (Table 2).

Due to the high number of DMUs and to have a better comparison of the health performance of these areas, 46 universities of medical sciences were divided into 5 geographical areas of north, south, east, west, and centre of the country (Figure 1) and the descriptive statistics of input and output variables of each area in 2017 were reported (Table 2).

Given that the number of universities of medical sciences, number of cities and population in the 5 areas are different, instead of the number of each available resource, the ratio of resources to one thousand people

Table 2: Descriptive statistics of the variables

Universities (DMUs)	Efficiency Score	Input									Output			
		Gini	CTMRI	HB	Phar	Den	Mid	Nurs	GP	Spe	IPD	PCC	LBW	IMR
Ahvaz	1.00	0.25	4	811	64	123	291	1240	176	166	1601325	90%	0.18	0.10
Arak	0.71	0.34	8	2054	184	406	362	1692	661	505	506838	88%	0.15	0.13
Ardebil	1.00	0.29	5	1994	153	236	583	661	725	426	469200	76%	0.18	0.12
babel	0.85	0.27	9	2084	98	308	278	2560	648	419	303970	80%	0.11	0.10
Bam	0.77	0.31	4	1337	124	258	429	2091	482	424	87534	78%	0.15	0.13
Birjand	0.97	0.24	15	5856	811	1115	1382	8327	2772	1935	284547	62%	0.16	0.22
Bushehr	0.90	0.29	2	1008	33	73	181	1154	233	228	303351	73%	0.10	0.13
Dezful	1.00	0.25	2	1154	34	41	131	566	51	80	184944	77%	0.10	0.11
Esfahan	0.83	0.31	22	6293	1197	1454	1021	10690	3101	2816	1705541	73%	0.12	0.14
Fasa	0.73	0.31	30	6903	922	1591	1799	11762	3075	2212	140877	80%	0.13	0.09
Gilan	0.84	0.28	6	2375	277	377	396	3107	1055	679	862964	87%	0.15	0.14
Golestan	0.85	0.31	8	2876	269	343	749	3473	774	560	737430	93%	0.14	0.08
Gonabad	1.00	0.30	5	2125	598	985	314	3069	2422	163	42464	93%	0.19	0.19
Hamedan	0.76	0.31	5	2660	234	255	773	3521	770	495	705313	75%	0.16	0.10
Hormozgan	0.77	0.34	21	7816	1142	1608	1779	10471	4141	2519	541721	92%	0.15	0.12
Ilam	0.87	0.30	3	1008	121	120	346	1588	408	233	172074	80%	0.16	0.12
Iran	1.00	0.30	3	1122	109	253	324	1429	430	361	2770825	80%	0.17	0.11
Jahrom	0.79	0.31	23	6404	508	983	1313	9177	1320	2408	102132	44%	0.18	0.15
Jiroft	0.73	0.31	57	9538	1466	364	880	13611	937	5423	143190	64%	0.17	0.17
Karaj	0.78	0.31	21	6482	157	177	1477	7108	963	1288	644952	69%	0.17	0.09
Kashan	0.76	0.31	7	1675	180	196	580	2333	450	477	310373	69%	0.16	0.19
Kerman	0.95	0.31	4	1048	86	98	57	1053	116	176	758349	36%	0.14	0.13
Kermanshah	0.81	0.29	10	2990	333	580	679	4973	1659	800	715760	72%	0.10	0.07
Kurdistan	1.00	0.27	2	635	84	76	179	1060	177	161	562198	86%	0.15	0.13
Lorestan	1.00	0.29	1	353	15	16	57	244	50	67	595981	96%	0.11	0.14
Mashhad	1.00	0.30	14	3670	520	637	1190	5398	1767	1343	2111386	68%	0.19	0.16
Mazandaran	0.87	0.27	14	3322	481	740	971	3572	2443	1143	1036560	74%	0.17	0.12
North Khorasan	1.00	0.29	1	380	40	45	171	595	114	89	268908	81%	0.13	0.10
Orumieh	1.00	0.27	10	4120	386	476	639	4294	977	920	1043850	85%	0.18	0.24
Qazvin	1.00	0.30	1	402	26	33	39	437	106	108	466055	80%	0.14	0.64
Qom	0.83	0.28	5	1799	181	313	463	2563	721	480	460882	83%	0.16	0.19
Rafsanjan	1.00	0.31	9	2165	222	286	673	2693	546	467	107446	92%	0.19	0.11
Sabzevar	0.80	0.30	3	1862	190	239	480	2972	498	349	157316	43%	0.08	0.07
Semnan	0.87	0.31	4	1545	153	211	265	1913	285	394	183526	93%	0.13	0.12
Shahid Beheshti	1.00	0.30	1	808	45	67	106	694	189	117	2366200	71%	0.17	0.13
ShahreKord	0.84	0.28	7	2102	173	300	627	3180	373	492	440204	83%	0.16	0.12
Shahrud	0.85	0.31	3	726	63	86	207	908	238	241	167006	67%	0.13	0.12
Shiraz	1.00	0.31	3	1442	98	168	406	1893	468	269	1846298	89%	0.13	0.12
Tabriz	1.00	0.33	2	327	31	34	129	395	96	64	1676632	89%	0.09	0.13
Tehran	0.83	0.30	76	9559	901	1292	1806	13882	3547	3398	1576739	70%	0.13	0.12
Torbat Heydarieh	1.00	0.30	1	273	47	36	63	499	137	88	87319	97%	0.13	0.11
Yasuj	1.00	0.23	4	862	103	195	167	1505	432	223	253144	87%	0.17	0.15
Yazd	0.72	0.33	9	2538	233	368	279	2894	1020	543	688134	83%	0.11	0.17
Zabul	1.00	0.30	6	668	85	137	270	843	300	207	127361	88%	0.16	0.12
Zahedan	0.94	0.30	2	479	47	92	185	638	255	98	518550	95%	0.11	0.14
Zanjan	1.00	0.26	1	507	45	50	100	567	101	79	431207	72%	0.09	0.07

in each area is reported. As shown in Table 2, northern universities and the central ones have access to more resources per 100000 people, and fewer resources are available to southern and western areas of the country. The descriptive data of each university is presented in Appendix 1.

Regarding the health production status (output indices), the universities in northern areas followed by those in western areas had better conditions compared to other areas, while the universities in southern areas had a lower performance (Table 2).

From Table 2, it is apparent that among the 46 universities, only 19 (41%) medical universities were on the efficiency frontier. Universities that attained a 100% efficiency score included Zabul, Ahvaz, Ardebil, Dezful, Gonabad, Kurdistan, Lorestan, Mashhad, North Khorasan, Orumieh, Qazvin, Rafsanjan, Shahid Beheshti, Shiraz, Tabriz, Torbat, Heydarieh, Yasuj, Zanjan, and Iran Universities of Medical Sciences. Conversely, Arak, Yazd, Jiroft, and Fasa Universities of Medical Sciences had the lowest efficiency scores, respectively.

Technical Efficiency

Table 3 represents the mean, maximum, and minimum values of efficiency scores for northern, southern, eastern, western, and central areas and the whole country. The highest mean of efficiency score was attributed to eastern areas, followed by the western and northern areas, and the worst status was related to southern parts of the country. The standard deviation shows that efficiency scores of universities located in northern areas are closer, while there are more differences among the efficiency scores of the universities of central areas of the country. Figure 2 presents 10 countries' areas and the figure 3 demonstrates the efficiency score of universities of medical sciences in the country.

Tobit Regression

To explain the health performance efficiency model, we used Tobit Regression. Table 4 represents the results of Tobit Regression model. In this model, the probability value of chi2 was almost zero which means that the H0 hypothesis, which is the relationship between contextual factors and efficiency score, is accepted with a 99.9% confidence level. Also, the value of Pseudo R2 of the regression model was 0.3545 which means that this model can explain about 35% of the determining factors of the efficiency score.

Medical sciences universities in Iran are categorized into three types based on their location and focus. Major medical sciences universities are located in large cities and offer comprehensive medical programs with access to large teaching hospitals and research facilities, providing the students with extensive clinical and research opportunities. Provincial medical sciences universities situated in provincial capitals focus on addressing regional healthcare needs and work closely with educational hospitals to train healthcare professionals. Local medical sciences universities in smaller cities emphasize basic medical education to produce healthcare professionals who can serve the primary healthcare needs of their local communities. Each category of university plays a distinct role in training medical professionals and contributes to the healthcare system in Iran.

Table 3: Descriptive statistics of technical efficiency score in each geographical area

	Max	Min	Average	SD	CV
North	1	0.84	0.90	0.07	0.08
South	1	0.73	0.80	0.10	0.13
West	1	0.76	0.93	0.09	0.09
East	1	0.77	0.94	0.08	0.09
Centre	1	0.71	0.86	0.11	0.13
Iran	1	0.71	0.90	0.10	0.11

Figure 2: Country Areas

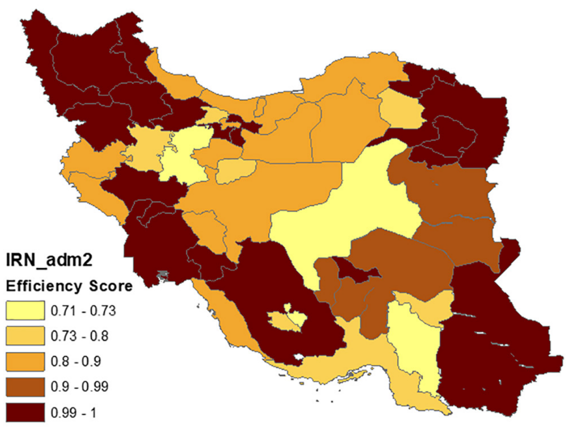

Figure 3: Efficiency Scores

Table 4: Results of Tobit regression model

Variable	Coefficient	t	P>|t|
Life Expectancy	0.0493	1.09	0.28
Medical University Class	0.427	4.79	0.000**
Cons	-3.946	-1.16	0.251
Observations Summary			
Number of observations			46
LR chi2(3)			27.25
Prob>chi2			0.0000
Pseudo R2			0.3545

*P<0.05, **P<0.01

Our results showed that among the independent contextual factors affecting efficiency scores the classification of medical universities has a significant impact. Our analysis revealed that the medical university rank significantly influenced efficiency scores at a significance level of 0.05. This finding indicates that a higher university rank correlates with increased efficiency scores. Specifically, a one-unit increase in university rank is associated with a 0.42 increase in the efficiency score, assuming that other variables remain constant. This suggests that larger medical sciences universities located in provincial capitals tend to exhibit higher efficiency compared to smaller universities in other cities, highlighting the importance of university classification in understanding and improving healthcare system performance. Also, increasing the amount of life expectancy indices will have a direct effect on the efficiency scores of universities. However, the coefficient for this variable was not significant.

Discussion

Universities of medical sciences and health care services are the main factors in providing health services for Iranians. These universities are financially supported by government resources and are managed based on the same MOHME instructions. Assessment of the status of human resource distribution, hospital beds, and capital equipment in Iran showed that these resources were not equally distributed among universities. Inhabitants of developed northern and central areas have access to more resources and eastern areas have better conditions than western areas of the country. The tendency of specialized workforce to serve in different areas determines the distribution of other resources of the health system.[31] Due to better climatic conditions and better social and urbanization infrastructures in the northern half of the country, population density is higher in these parts and specialized workforce is more interested in working there,[32] perhaps, that is why accessibility of resources in the northern, central, and eastern areas of the country is better.

Most of the health output, except for the pregnancy care coverage, had better conditions in northern and central areas. Since pregnancy care coverage is only defined in the public sector, its low rate in northern and central areas can be due to the better welfare and higher income of the inhabitants and, consequently, their tendency to receive these services from gynaecologists and midwives in the private sector. Therefore, the government should pay attention to the necessity of differences among health service packages in different areas of the country and avoid allocating many resources to services which are not desirable in urban areas.[15]

Difference in available resources can be the reason for the difference in health output in universities of medical sciences. Our results show that only 41% of medical universities, mainly in the north and centre of the country, use their resources optimally, which shows a significant difference in health performance of universities of medical sciences. The findings of a study which was published in 2014 show that most of the universities of medical sciences in Iran do not have a high financial performance, and this can be due to issues in financial resources management, especially in combining the assets. The results of another study showed that the universities of Gilan, Ardabil and Bojnourd (in northern Iran) had the highest performance among the top 15 universities, while the universities of Rafsanjan, Ahvaz, Kerman, and Jiroft showed poor performance.[33]

Some studies which were conducted in China showed a significant difference in the efficiency of different provinces, and only 30% of the provinces were efficient. Also, the health performance of more developed eastern provinces in China was more efficient than the western ones.

Returns to scale analysis showed that there are increasing returns to scale only in 3 universities. In other words, in most parts of the country, adding new resources to the health service provision system will not lead to improvement in efficiency, and there is a need for improving the technology of service provision including strategies, processes, contents of service packages (benefit packages), service provision places, management strategies, and service quality.

In the secondary DEA analyses, slack values were also calculated. The highest value of surplus resource exists in the south. Extreme inefficiency of small universities like Fasa and Jahrom has led to a decrease in the efficiency score of southern universities. In southern parts of Iran, there are many small universities with a small under-coverage population, and it seems that this form of resource allocation is preventing them from optimally using the health system resources.

The present study showed that the efficiency of health performance in universities located in northern, western, and eastern areas of Iran was higher than the central and southern universities. We may explain the inefficiency of central universities which include developed cities such as Tehran, Isfahan, and Yazd, based on their position in the reference system for providing subspecialty services to inhabitants of all areas of the country. Providing subspecialty services requires more capital equipment and manpower for fewer patients. Therefore, in these areas the number of in-patient days is lower than expected, while the subspecialty prices are high, and it seems that if the costs of health input and output is defined and economic efficiency is measured based on these costs, the relative efficiency score of these universities will change.

The results of this study emphasize the differences in the performance efficiency of medical universities. Government resources are allocated to universities with a program budgeting approach. This approach focuses on providing the inputs necessary for implementing the plans, while outputs are not assessed. Therefore, this is not a proper basis for efficient management in these universities. As performance outcomes of universities of medical sciences, such as performance indices or public health indices, have no direct effect on their budget, it seems that universities are not motivated to achieve better indices. Consequently, it is recommended that health policymakers should use the information on the status of health indices, their changes, and the health performance efficiency of universities of medical sciences as inputs for budgeting.[34]

Tobit regression indicated that universities with higher levels (in terms of medical university rankings) had a better chance of achieving efficiency. According to previous analyses, these findings do not seem unlikely. Universities located in the capital of the country and provinces benefit from higher authority and more qualified human resources to implement health programs and utilize resources efficiently.

This study has some limitations. While some indices such as human resource allocation, hospital beds, and capital equipment were properly selected and the validity of their data was checked by contacting the vice-chancellor of treatment affairs of all universities of medical sciences; due to the limitations in attaining accurate data of health performance, a limited set of output indices were included.

The fact that using a diverse range of output variables can provide a more accurate assessment of the efficiency of the health performance of universities of medical sciences, if the information on some of the service quality indices such as patient satisfaction is included in the analysis, it can affect the results, and this needs to be improved in future studies.

While health systems account for the health of society and consume a lot of resources, due to the production of intangible output, their performance evaluation is neglected in most cases. Accordingly, although in most studies, the efficiency has been assessed on the level of service-providing institutes such as hospitals or healthcare centres, the strength of this study is that this study measured the efficiency score of the health system performance at the national level of IR. Iran.

Conclusion

Average performance scores vary across universities as well as in different parts of the country, so judging the performance of universities based solely on health indicators can be misleading. In addition, budgets and resources allocated to medical universities are usually made without knowledge of the evidence of their performance in previous years, which further highlights the need for planning and budgeting to improve balance in performance of universities. Learning from the experiences of benchmark universities can also be very helpful. This study showed that medical university class index had a significant effect on the efficiency score in such a way that larger universities were more efficient. Establishing universities of medical sciences in each city is possible only through authorization by MOHME. In many cities, local authorities believe that establishing a university of medical sciences can help develop the area and improve people's access to health care services. Therefore, constant demands for establishing universities of medical sciences are sent to MOHME.[35]

Authors' Contribution

Alireza Shakibaei and Mehdi Nejati interpreted data for the work and had a substantial contribution to the conception of the work, Fatemeh Dehnavieh was in charge of data collection, data analysis, interpretation of data for the work and drafted the work, and Somayeh Noori Hekmat was in charge of final approval of the data analysis.

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Appendix 1: Descriptive statistics of the variables: Per 100000 population and CV (variation coefficients) of each item in each area

Country areas (number of universities)	Item	Input										Output			
		HB	Spe	GP	Den	Phar	Nurs	Mid	CTMRI	Gini	Literacy	PCC (%)	IMR	LBW	IPD
North (8) 13759390	per 100000	213	78	103	37	30	314	69	0.81	-	-	0.84	747	5971	0.4
	CV	0.59	0.70	0.97	0.78	0.79	0.64	0.66	0.66	0.03	0.08	0.10	0.16	0.20	0.74
Centre (12) 27241837	per 100000	94	70	107	43	26	135	14	0.22	-	-	0.77	678	6944	0.44
	CV	0.95	1.18	1.13	1.11	1.25	1.06	0.91	1.49	0.04	0.09	0.10	0.32	0.16	0.77
East (10) 13609213	per 100000	186	40	75	27	17	213	21	0.66	-	-	0.7	967	9226	0.33
	CV	0.83	1.12	1.02	0.95	0.94	0.85	0.86	0.73	0.07	0.10	0.28	0.32	0.28	1.40
West (10) 17670530	per 100000	120	26	30	15	11	150	30	0.4	-	-	0.82	888	6149	0.35
	CV	0.74	0.84	0.96	0.89	0.85	0.74	0.69	0.71	0.02	0.12	0.08	0.33	0.26	0.71
South (6) 7638729	per 100000	68	18	34	15	8	118	13	0.31	-	-	0.85	803	80000	0.38
	CV	0.42	0.64	0.70	0.64	0.58	0.43	0.43	0.65	0.02	0.12	0.24	0.22	0.14	1.20
IR. Iran (46) 79919699	per 100000	148	45	53	22	17	199	32	0.58	-	-	0.79	818	7227	0.39
	CV	0.95	1.35	1.11	1.10	1.19	1.05	0.88	1.42	0.05	0.11	0.17	0.31	0.23	0.97

Appendix 2: Descriptive statistics of variables: The maximum and minimum number of each item in each area

Country areas (number of universities)	Item	Input										Output			
		HB	Spe	GP	Den	Phar	Nurs	Mid	CT-MRI	Gini	Literacy	PCC (%)	IMR	LBW	IPD
North (9)	Min	1008	233	408	120	109	661	324	3	0.2	82	67%	459	5376	167006
	Max	5856	1935	2772	1115	811	8327	1382	15	0.36	90.460.266	0.93	896	6560	1676632
Centre (12)	Min	726	117	116	67	45	694	57	1	0.26	81.7688887	69%	517	5157	310373
	Max	9559	5423	3547	1454	1466	13882	1806	76	0.35	87.8	0.96	836	8723	2770825
East (10)	Min	273	67	50	16	15	244	39	1	0.29	77.9790.46	36%	691	6518	42464
	Max	7816	2519	4141	1608	1142	10471	1779	21	0.35	90.46	0.97	1470	11904	2111386
West (10)	Min	668	166	176	123	64	843	265	4	0.28	71.5690.46	72%	422	5130	172074
	Max	4120	920	977	476	386	4294	773	10	0.35	90.46	0.9	1226	7504	1601325
South (5)	Min	327	64	51	34	31	395	100	1	0.27	82.2	44%	803	7675	102132
	Max	6903	2212	3075	1591	922	11762	1799	30	0.35	86.3	0.92	1091	8929	1846298
IR. Iran (46)	Min	273	64	50	16	15	244	39	1	0.2	71.5	36%	156	5130	42464
	Max	9559	5423	4141	1608	1466	13882	1806	76	0.36	90.46	0.97	1470	11904	2770825

Appendix 3: Descriptive statistics of variables: Per 100000 population and CV variation coefficients) of each item in each area

Country areas (number of universities / Population)	Item	Input										Output		
		HB	Spe	GP	Den	Phar	Nurs	Mid	CTMRI	Gini	PCC (%)	IMR	LBW	IPD
North (8) 13759390	per 100000	213	78	103	37	30	314	69	0.81	-	0.84	747	5971	0.4
	CV	0.59	0.70	0.97	0.78	0.79	0.64	0.66	0.66	0.03	0.10	0.16	0.20	0.74
Centre (12) 27241837	per 100000	94	70	107	43	26	135	14	0.22	-	0.77	678	6944	0.44
	CV	0.95	1.18	1.13	1.11	1.25	1.06	0.91	1.49	0.04	0.10	0.32	0.16	0.77
East (10) 13609213	per 100000	186	40	75	27	17	213	21	0.66	-	0.7	967	9226	0.33
	CV	0.83	1.12	1.02	0.95	0.94	0.85	0.86	0.73	0.07	0.28	0.32	0.28	1.40
West (10) 17670530	per 100000	120	26	30	15	11	150	30	0.4	-	0.82	888	6149	0.35
	CV	0.74	0.84	0.96	0.89	0.85	0.74	0.69	0.71	0.02	0.08	0.33	0.26	0.71
South (6) 7638729	per 100000	68	18	34	15	8	118	13	0.31	-	0.85	803	80000	0.38
	CV	0.42	0.64	0.70	0.64	0.58	0.43	0.43	0.65	0.02	0.24	0.22	0.14	1.20
IR. Iran (46) 79919699	per 100000	148	45	53	22	17	199	32	0.58	-	0.79	818	7227	0.39
	CV	0.95	1.35	1.11	1.10	1.19	1.05	0.88	1.42	0.05	0.17	0.31	0.23	0.97

Appendix 4: The projection percentages for input and output variables

Country areas	Spe	GP	Nurs	Mid	Den	Phar	HB	CTMRI	IMR	LBW	PCC	IPD
North	-40%	-34%	-38%	-36%	-31%	-36%	-38%	-37%	17%	2%	3%	115%
South	-64%	-66%	-65%	-63%	-68%	-57%	-59%	-58%	42%	3%	18%	322%
West	-44%	-45%	-47%	-47%	-51%	-49%	-45%	-49%	14%	6%	27%	351%
East	-48%	-42%	-47%	-49%	-47%	-48%	-44%	-44%	67%	0%	8%	111%
Central	-53%	-51%	-54%	-50%	-55%	-56%	-52%	-55%	54%	2%	14%	25%
IR. Iran	-49%	-46%	-49%	-48%	-49%	-49%	-47%	-48%	40%	3%	14%	164%