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A Scientometric Assessment of the Medical Universities Performance: Two Decades Analysis from 1998 to 2018

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Abstract

Introduction: Given the key role of universities and higher education institutes in the social and economic development of countries, it is necessary to evaluate their performance regularly with appropriate methods and measures. Since research and science production are among the essential functions of universities, measurement of scientific outputs is an important part of university performance evaluation. The aim of this study was to rank the Iranian medical universities by scientometric indicators.

Methods: One way to evaluate the scientific outputs is to use one of many scientometric indicators defined over the years for quantitative and qualitative evaluation of the researchers. This approach can also be expanded for evaluation at the university level. In the descriptive survey presented in this paper, 152597 scientific articles published by the authors affiliated with 50 Iranian medical universities were investigated. The scientific output data extracted from the Scopus database of each university were analyzed separately using the cumulative number of scientific papers, number of citations, citation impact, *h*-index, *m*-parameter, and *g*-index. The universities were then ranked according to each indicator. This study is an applied research based on the results. The sample number in this study was all scientific output of the universities studied.

Results: Among the studied universities, Tehran University of Medical Science ranked first in terms of cumulative number of scientific papers, citations, *h*-index, and *g*-index, Alborz University of Medical Science ranked the first in terms of *m*-parameter, and Arak University of Medical Sciences ranked the first in terms of citation impact.

Conclusion: The obtained rankings were compared with the results of Islamic World Science Citation Database (ISC) ranking system. This comparison showed that the rankings of Iranian medical universities based on cumulative number of papers, number of citations, and *h*-index were strongly correlated with the results of ISC ranking system.

Keywords: Scientific Performance, Medical University Ranking, Scientometric, Scientific Output.

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Introduction

The scientific output of universities can be conveniently evaluated by the use of scientometric indicators (1). There are a number of quantitative and qualitative indicators for assessing the scientific production of universities (2). Scientometrics is the science of evaluating the scientific output with the help of quantitative, content, and citation analyses (3, 4). Published articles are among the primary research outputs of universities and institutes of higher education. Many faculty members believe that publishing articles in high rank academic journals is a good indicator of the quality of their research (5). Studies on the evaluation of research output of universities have also shown that the emergence and growing acceptance of integrated databases have led to greater intentions to evaluate scientific articles on this basis. Hence, the number of scientific articles indexed in internationally recognized scientific databases and the number of citations are currently the most important objective indicators of scientific output. The number of indexed articles represents the quantitative growth of scientific output, while the number of citations reflects the impact of published articles and thus their quality (6).

Scientometric studies often use four groups of indicators for their quantitative and qualitative evaluations (7):

i Productivity indicators, including the number of articles cited, the annual number of articles, and the number of articles of a specific author;

ii Impact indicators, including the total number of citations, the annual number of citations, and the number of citations of a specific author;

iii Composite indicators, like the average number of citations per article;

iv *h*-index which shows the quality and impact of scientific outputs.

Scientometric indicators have also been used in several studies to rank the universities in terms of research output. For example, in a study by Garfield on Taiwan's scientific output, it was found that the most cited institutions of this country indeed have the most scientific output, but reported that ranking the universities based on the citation impact yields different results from ranking based on productivity or citation (8). Velloso and Lannes used scientometric indicators to evaluate the scientific output of Brazilian universities and reported a growth in the scientific output of state universities in this country (9). In a research by Harzing, the patterns of research in the field of economics and business in Australia were examined, and a significant difference was found between the ranking of universities based on the number of articles and citation impact in these fields as compared to other fields (10). Moreover, Ponce and Lozano evaluated the impact of articles published by the American and Canadian neurology departments in the ISI database and stated that because of its balanced nature, *h*-index may cause new issues when used at different levels (11). In another study, Lazaridis used the h index to rank the departments of Greek universities (12). In a scientometric analysis conducted by Abolghassemi Fakhree and Jouyban, they evaluated seven Iranian medical universities based on scientific outputs registered in Scopus (1). They compared the universities in terms of annual number of published articles, annual number of citations, and annual number of citations per article, *h*-index, top ten authors, and top ten journals. Also, Molinari and Molinari used a new method based on *h*-index and the scientific output of the institutions, which measures the quality and quantity of their research, to rank the top-rated universities (13). In this regard, Lukman and Krajnc presented a university ranking model based on three dimensions of research, education and environment (14). Alasehir et al. provided a national rating system called URAP-TR for ranking Turkish universities based on their scientific performance. In this model, which is an extension of the international ranking model URAP for Turkey, the data from the Thomson Reuters (WOC) and the Turkish Higher Education Association (YOK) were used to rate the research output of the institutions (15). Daraio et al. presented a ranking model for European universities, in which several criteria were used to evaluate the research output of institutions (16).

The most popular of scientometric indicator is the h-index introduced by Hirsch as a quantitative and qualitative measure of research (17). According to Hirsch, *h*-index is a good measure of the strength of scientific institutions as it can represent both productivity and impact simultaneously. Later, h-index was expanded for better content validity and measurement power, and supplemented with two other indicators called m- parameter and *g*-index. These indicators can be used for evaluation at both author and institutional levels. The internationally recognized databases that archive the scientific outputs of authors and institutions provide a variety of indicators for quantitative and qualitative evaluation of the stored documents.

Many researchers have used h-index and its supplementary indicators to evaluate the scientific output of universities (7, 12, 13, 18-20). Waltman and van Eck criticized the new Crown index used at the CWTS Leiden Ranking for normalizing the citation rates and introduced a new index called field-normalized citation impact score for this purpose (21). In a study conducted by Torres-Salinas et al., they presented a two-dimensional index for institution-field ranking based on the net production and the quality (22). Their goal in developing this indicator was to provide a comprehensive and objective means for comparing the research output of institutions in a specific field. They used this index to rank the Spanish universities in the fields of chemistry and computer science from 2000 to 2009. Dorta-González and Dorta-González measured the citation potential of different fields based on the ratios between the number of scientific outputs, citations, and resources (23). Mitra suggested that *h*-index could be used to evaluate the efficiency of research at institutional level (24). He also introduced an alternative version of h-index called h2, which equals the number of authors in an institution who have an h-index of at least h. After this proposal, Prathap conducted more research on the measurement of scientific performance of organizations and institutions with the help of *h*-index. In a study by Da Luz and Marques-Portella, the institutional *h*-index of Brazilian psychiatric postgraduate programs was calculated and it was found that this *h*-index significantly correlated with the number of citations and the number of articles among top 10% mostly cited papers (25).

University ranking systems are typically more focused on the research output of universities than on other domains, and this is reflected in the weights they assign to the criteria that represent this aspect of

academic performance. The reason behind this focus of ranking systems is the convenience of objective data measurement (26). This has resulted in an increased demand for quantitative and qualitative analyses of research outputs in recent years (27). These analyses and comparisons of research outputs aim at identifying authors or institutions that play an influential role in different fields of science. Some of the global rankings are essentially focused on the results and impact of research, a focus that amplifies the importance of research evaluation indices. Some of the ranking systems that can be used to compare the research outcomes of universities include Academic Ranking of World Universities (ARWU), SCImago Institutions Rankings, Leiden University Rankings, QS World University Rankings, and Ranking of Islamic Countries Universities and Research Institutions (ISC).

The mentioned researches and ranking systems have failed to pay due attention to all scientometric indicators as they have mostly focused on the use of *h*-index, the number of articles or citations. Given the importance of evaluating the scientific outputs of universities for identifying their weaknesses, it is essential to rank the universities by the indicators that are also normalized for the impact of age and size of the institution.

Evaluation of scientific performance of universities in terms of indicators such as cumulative number of scientific outputs and citations, citation impact, scientific production per capita, *h*-index, *m*-parameter, and *g*-index is of significant importance. Since research in the field of medical science is often based on clinical and laboratory findings, quantitative and qualitative evaluation of these works requires even more attention. In the present study, the scientific papers published by the Iranian state-funded medical universities (affiliated to the Ministry of Health and Medical Education of Iran) in scientific databases are studied in order to rank these universities in terms of their research performance. The aim of this study was to rank the Iranian medical universities in terms of research performance by Scientometric indicators.

Methods

The data of this study consist of all articles published in the Scopus database by any author who has organizational affiliation with Iranian state-funded universities. Since the goal of this research was to rank the Iranian medical universities based on the scientific outputs registered on the scientific databases, a search was conducted by typing the word "Iran" in the affiliation field and then extracting the names of Iranian state-funded medical universities to form a list of eligible universities with scientific papers in the database from 1980 to 2018. To avoid possible confusion in the English names of non-English universities, Scopus database has standardized most of the names. For any remaining case, however, it was assumed that the name with the most scientific papers is the standard form. All of the articles found were stored in a database separated by university. This search found 152597 articles written in Iranian state-funded medical universities until March 2018.

In the data analysis step, seven indicators, namely the number of scientific papers, scientific papers per capita, cumulative number of citations, citation impact, *h*-index, *m*-parameter, and *g*-index of each university were calculated. Then, the studied universities were ranked according to each index. Finally, Spearman's rank correlation analysis was used to validate the results and compare them with those of another system. In this study, analysis of data and correlations was performed using Excel and SPSS software. The research framework is shown in Figure 1.

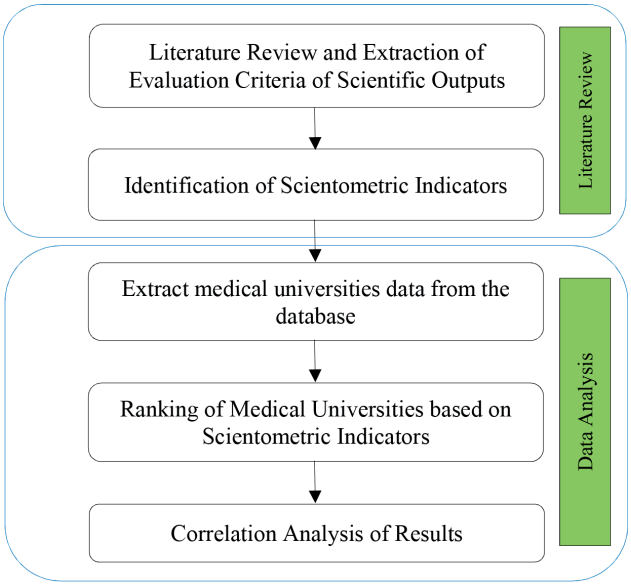

Figure 1: Research framework

Results

The database formed and organized in Excel was used to calculate each index for each university and then universities were ranked according to each index. The results obtained in this stage of work are presented below.

Ranking the Iranian Universities based on the Number of Scientific Publications

First, an investigation was performed based on the number of articles published by the Iranian

universities and education or research institutions. The Scopus statistics of articles published by these institutions are illustrated in Figure 2.

As shown in Figure 2, the scientific production of Iranian universities over the past two decades exhibits a generally increasing trend with major jumps at several occasions. It can be seen that nearly 98% of the scientific output under analysis has been produced in the last 20 years. Figure 3 shows the number of Iranian articles published over the past two decades.

The data presented in Figure 3 shows that nearly 86% of Iranian articles have been published in the last decade and nearly 52% of the total articles belong to the last 5 years. This trend can be attributed to the qualitative and quantitative development of postgraduate programs, more attention to international cooperation between universities, improvement of communication and information infrastructures in universities, and efforts to make research funds more transparent. Given the wide variety of scientific fields in which Iranian universities conduct research, the trend of scientific production by the field is also important. The fields in which Iranian authors have had scientific output are illustrated in Figure 4. This trend was obtained using the subject classification tool of Scopus database.

As shown in Figure 4, Iranian universities have higher scientific production in engineering, medicine and chemistry fields than in other branches of science. Given the second place of medical fields in this ranking, it is important to analyze and rank the universities that have contributed to the publication of these articles. According to the data presented in Figure 4, the scientific production of Iranian universities in the medical fields has been mostly published at an international level, whereas scientific output in other fields has had higher domestic publication. This may suggest that Iran has a better infrastructure for publishing scientific papers in non-medical fields, and the other reason is that medical science topics are more basic and internationally published worldwide, an issue that can be considered by policy-makers in the field of research.

The next step was the quantitative analysis of the scientific production of each Iranian university or institution with articles indexed in the database Scopus. The search of database (Search strategy was Country affiliation ("Iran") and any time) revealed 376 Iranian institutions with indexed scientific production. Since the purpose of this research was to study the scientific production of Iranian state-

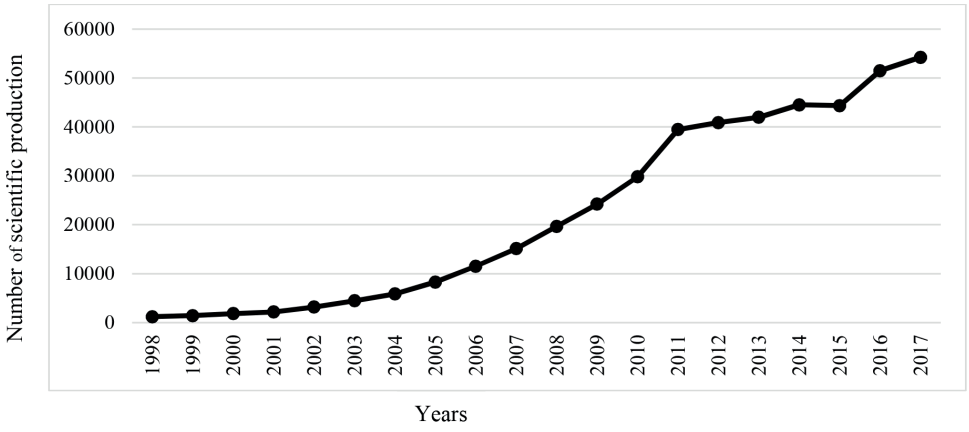

Figure 2: Trend of scientific production of Iranian universities in the last two decades

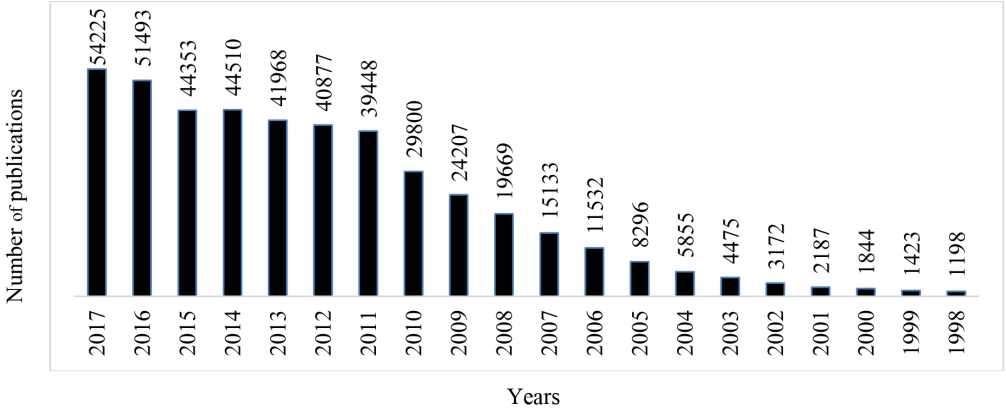

Figure 3: The number of Iranian articles published over the past two decades.

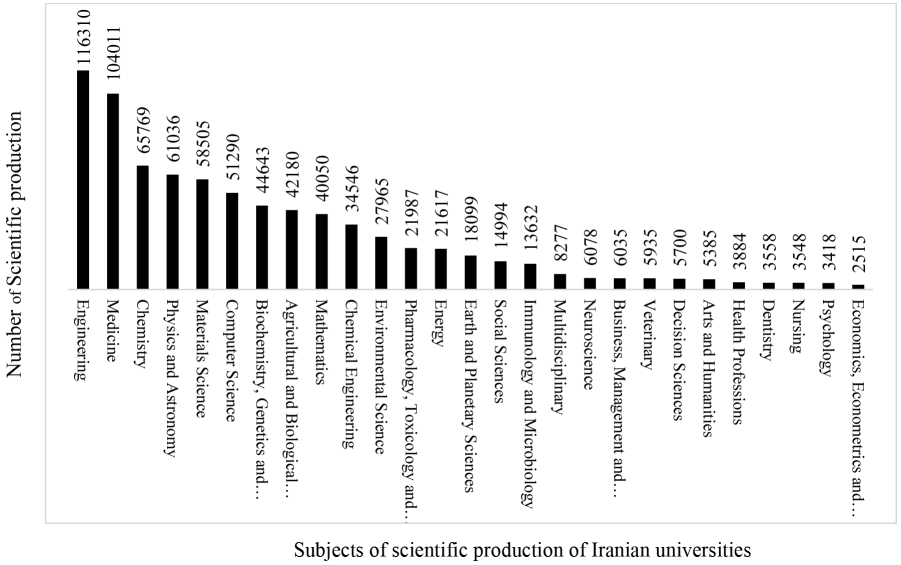

Figure 4: Field distribution of scientific production of Iranian universities

funded medical universities, the articles related to 50 Iranian state-funded medical universities were extracted. Given that nearly 86% of the scientific papers of Iranian universities have been published in the past decade, the authors chose to use the cumulative scientific production of universities in the last decade. Table 1 shows the ranking of the medical universities studied based on the number of scientific papers published in the past decade. The abbreviation for University names is presented in Appendix A.

Table 1 shows that the universities that are larger, older, and cover more scientific fields have a quantitatively better scientific output and are ranked higher in this respect. The number of scientific papers published by universities seems to be highly dependent on the age and size of their faculty. Therefore, the number of university's faculty members, as the people who play the central role in the production of science, is of significant importance. The scientific production per capita of each university was then calculated by dividing the number of published scientific papers by the number of faculty members. Table 2 shows the ranking of Iranian medical universities based on scientific output per capita.

As shown in Table 2, there are several minor and major differences between this ranking and the one provided in Table 1. It is evident that in the universities that rank higher, a greater portion of faculty members actively participate in the production of scientific papers, while in the universities that rank lower, this

Table 1: Ranking of Iranian universities based on the number of articles published in the past decade

Rank	Name of University	Total	Rank	Name of University	Total	Rank	Name of University	Total
1	TehUMS	35612	18	ZahUMS	1712	35	AjaUMS	786
2	SBUMS	15325	19	ShakUMS	1569	36	RafUMS	742
3	ShiUMS	9359	20	GuiUMS	1532	37	BirUMS	647
4	IsfUMS	9312	21	UrmUMS	1461	38	ZabUMS	646
5	TabUMS	8868	22	GolUMS	1398	39	ArdUMS	633
6	MasUMS	8224	23	ZanUMS	1395	40	YasUMS	583
7	IraUMS	7556	24	KurUMS	1370	41	SabUMS	496
8	AhvUMS	4277	25	KasUMS	1282	42	SharUMS	471
9	BaqUMS	3766	26	QazUMS	1214	43	JahUMS	451
10	MazUMS	3704	27	SemUMS	1135	44	GonUMS	451
11	KerUMS	3418	28	LorUMS	1081	45	FasUMS	430
12	KersUMS	3115	29	IlaUMS	1060	46	NKUMS	414
13	ShahedU	2966	30	AraUMS	1047	47	DezUMS	173
14	HamUMS	2816	31	HorUMS	945	48	TorUMS	101
15	SSUMS	2263	32	AlbUMS	929	49	JirUMS	90
16	USWRS	2079	33	BusUMS	814	50	BamUMS	87
17	BabUMS	1995	34	QomUMS	797			

Table 2: Ranking of Iranian medical universities based on scientific production per capita

Rank	Name of University	Scale	Rank	Name of University	Scale	Rank	Name of University	Scale
1	ShahedU	21.97	18	SSUMS	5.97	35	LorUMS	4.11
2	TehUMS	17.79	19	KasUMS	5.96	36	BusUMS	3.97
3	USWRS	13.08	20	AjaUMS	5.78	37	ZanUMS	3.91
4	BaqUMS	12.03	21	BabUMS	5.67	38	QomUMS	3.80
5	SBUMS	10.73	22	AlbUMS	5.60	39	JahUMS	3.73
6	IsfUMS	10.63	23	KurUMS	5.50	40	GuiUMS	3.40
7	TabUMS	10.22	24	SemUMS	5.40	41	HorUMS	3.32
8	ShiUMS	10.11	25	ZahUMS	5.16	42	YasUMS	3.17
9	MasUMS	10.03	26	ZabUMS	4.86	43	SabUMS	3.01
10	MazUMS	8.78	27	GonUMS	4.80	44	ArdUMS	2.80
11	IraUMS	8.47	28	FasUMS	4.78	45	BirUMS	2.59
12	KersUMS	7.49	29	GolUMS	4.57	46	NKUMS	2.45
13	KerUMS	7.03	30	RafUMS	4.29	47	DezUMS	2.28
14	IlaUMS	6.75	31	AraUMS	4.24	48	TorUMS	1.87
15	AhvUMS	6.65	32	QazUMS	4.22	49	JirUMS	1.67
16	ShakUMS	6.54	33	UrmUMS	4.19	50	BamUMS	1.43
17	HamUMS	6.43	34	SharUMS	4.17			

Table 3: Ranking of Iranian medical universities based on the total number of citations in the past decade

Rank	Name of University	Cite	Rank	Name of University	Cite	Rank	Name of University	Cite
1	TehUMS	275157	18	GolUMS	10299	35	HorUMS	3970
2	SBUMS	92319	19	SSUMS	10190	36	AjaUMS	3478
3	IsfUMS	58865	20	USWRS	10163	37	ArdUMS	3215
4	TabUMS	58442	21	ZahUMS	8903	38	BirUMS	2939
5	MasUMS	57046	22	ZanUMS	8509	39	YasUMS	2899
6	ShiUMS	54629	23	BabUMS	7902	40	SharUMS	2368
7	IraUMS	35277	24	LorUMS	7728	41	FasUMS	2305
8	MazUMS	24519	25	UrmUMS	7265	42	ZabUMS	2133
9	BaqUMS	22879	26	AlbUMS	6865	43	NKUMS	1752
10	KerUMS	22392	27	GuiUMS	6859	44	GonUMS	1563
11	AhvUMS	21359	28	QazUMS	6831	45	SabUMS	1555
12	ShahedU	18270	29	KasUMS	6185	46	JahUMS	1487
13	KersUMS	16267	30	QomUMS	5637	47	DezUMS	400
14	HamUMS	13706	31	IlaUMS	5577	48	jirUMS	313
15	KurUMS	13477	32	SemUMS	4805	49	TorUMS	281
16	AraUMS	13017	33	RafUMS	4416	50	BamUMS	213
17	ShakUMS	12446	34	BusUMS	4412			

portion is smaller. Since it takes a long time to form and develop a scientific production and publication chain, younger universities are not ranked well in this index. Also, the universities that rank better in this table show that the majority of faculty members of that institute have been involved in the dissemination of scientific output.

Ranking the Iranian universities based on Scientometric Indicators

In this part of the research, the gathered data waere analyzed to compare the universities in terms of scientometric indicators that reflect the quantity and quality of scientific outputs. The first indicator used for this purpose was the cumulative number of citations per paper, which provides a qualitative assessment of researches. For this qualitative evaluation, the cumulative number of citations for each university in the past decade was calculated. Table 3 shows the ranking of the studied universities based on the total number of citations in the past decade.

Table 3 shows that older and larger universities with more faculty members are more likely to refer to their articles and thus have a top rank. Also, comparison of Tables 1 and 3 shows only minor

changes in the top ten ranks, which means that those universities that have a higher number of published papers have more citations as well. However, there are some discrepancies in lower ranks, which indicate that some universities pay more attention to the quality of papers. It seems more reasonable to rank the universities based on the number of citations rather than the number of papers themselves. However, this ranking method has its own bias, as large and old universities, which cover a greater variety of fields and produce a higher number of papers, get more citations, and rank higher in this respect. There are two ways to neutralize the bias of cumulative number of scientific papers and citations.

The first way is to determine the share of highly cited articles of each university from all articles published by that university. For this purpose, the cumulative number of citations of each university in a certain period can be divided by its cumulative number of papers in the same period. This constitutes the definition of an index called citation impact or the ratio of citations to scientific publications, which is calculated by the following equation.

$$\text{Citation Impact (CI)} = \frac{\text{number of citations from university papers in the past ten years}}{\text{number of university papers in the past ten years}} \quad (1)$$

The result of the analysis conducted based on this index is shown in Table 4. The results presented in this Table are different from the rankings performed. Table 4 shows that some relatively young universities ranked higher than older universities, which is indicative of the relatively better quality of their scientific products. In spite of being large and old and covering many disciplines, some universities rank lower in this Table than in Tables 1 and 3. This suggests that high scientific publication or high cumulative citation rate alone cannot properly reflect the quality of scientific production of a university. The citation impact combines the quantitative and qualitative criteria in a way that the share of highly cited articles from all articles plays a more effective role in the evaluation, thus providing a more realistic assessment of the ranking of each institution. Therefore, university rankings based on the citation impact index provide a normalized ranking. The second method is to rank universities by the combined use of multiple scientometric indictors, which is described below.

Ranking the Universities based on h-Index

The *h*-index, also known by the name of its inventor, Hirsch, is an indicator that represents both quality and quantity of scientific papers. To calculate this index, we must first sort the scientific papers in descending order of citations per article. Then, starting from the top, we must move down the sorted list in search of the row where the number of citations is equal to the number of rows. This number is *h*. This definition can be expanded for colleges, universities and countries. This index was calculated for the universities in the database, with the articles belonging to each university considered separately in the calculations. After analyzing the universities based on this index, the ranking provided in Table 5 was obtained.

As shown in Table 5, the high rank university in

Table 4: Ranking of Iranian medical universities based on the citation impact in the past decade

Rank	Name of University	CI	Rank	Name of University	CI	Rank	Name of University	CI
1	AraUMS	12.43	18	RafUMS	5.95	35	BirUMS	4.54
2	KurUMS	9.84	19	ShiUMS	5.84	36	SSUMS	4.50
3	ShakUMS	7.93	20	QazUMS	5.63	37	GuiUMS	4.48
4	TehUMS	7.73	21	BusUMS	5.42	38	AjaUMS	4.42
5	AlbUMS	7.39	22	FasUMS	5.36	39	SemUMS	4.23
6	GolUMS	7.37	23	IlaUMS	5.26	40	NKUMS	4.23
7	LorUMS	7.15	24	KersUMS	5.22	41	HorUMS	4.20
8	QomUMS	7.07	25	ZahUMS	5.20	42	BabUMS	3.96
9	MasUMS	6.94	26	ArdUMS	5.08	43	JirUMS	3.48
10	MazUMS	6.62	27	SharUMS	5.03	44	GonUMS	3.47
11	TabUMS	6.59	28	AhvUMS	4.99	45	ZabUMS	3.30
12	KerUMS	6.55	29	UrmUMS	4.97	46	JahUMS	3.30
13	IsfUMS	6.32	30	YasUMS	4.97	47	SabUMS	3.14
14	ShahedU	6.16	31	USWRS	4.89	48	TorUMS	2.78
15	ZanUMS	6.10	32	HamUMS	4.87	49	BamUMS	2.45
16	BaqUMS	6.08	33	KasUMS	4.82	50	DezUMS	2.31
17	SBUMS	6.02	34	IraUMS	4.67			

Table 5: Ranking of Iranian medical universities based on *h*-index

Rank	Name of University	*h*-index	Rank	Name of University	*h*-index	Rank	Name of University	*h*-index
1	TehUMS	140	18	USWRS	41	35	ArdUMS	29
2	SBUMS	95	19	LorUMS	39	36	HorUMS	27
3	IsfUMS	86	20	SSUMS	38	37	AjaUMS	25
4	MasUMS	76	21	BabUMS	38	38	BirUMS	23
5	ShiUMS	74	22	ZahUMS	37	39	YasUMS	23
6	TabUMS	74	23	ZanUMS	37	40	SharUMS	22
7	IraUMS	65	24	GuiUMS	36	41	FasUMS	22
8	ShakUMS	60	25	KurUMS	36	42	ZabUMS	21
9	ShahedU	58	26	UrmUMS	34	43	JahUMS	20
10	MazUMS	57	27	KasUMS	32	44	NKUMS	19
11	KerUMS	57	28	SemUMS	31	45	SabUMS	18
12	BaqUMS	55	29	QazUMS	31	46	GonUMS	17
13	AhvUMS	46	30	AlbUMS	31	47	BamUMS	9
14	KersUMS	45	31	IlaUMS	30	48	TorUMS	9
15	GolUMS	43	32	RafUMS	30	49	DezUMS	8
16	AraUMS	43	33	BusUMS	29	50	JirUMS	8
17	HamUMS	41	34	QomUMS	29			

Table 6: Ranking of Iranian medical universities based on *m*-parameter

Rank	Name of University	*m*-parameter	Rank	Name of University	*m*-parameter	Rank	Name of University	*m*-parameter
1	AlbUMS	4.43	18	IsfUMS	2.00	35	BirUMS	1.53
2	ShahedU	3.22	19	RafUMS	2.00	36	ZabUMS	1.50
3	ShakUMS	3.00	20	YasUMS	1.92	37	SemUMS	1.48
4	QomUMS	2.90	21	KurUMS	1.89	38	QazUMS	1.48
5	GolUMS	2.87	22	IlaUMS	1.88	39	HorUMS	1.42
6	MazUMS	2.85	23	AraUMS	1.87	40	SharUMS	1.38
7	TabUMS	2.74	24	SSUMS	1.81	41	ZahUMS	1.37
8	TehUMS	2.69	25	BabUMS	1.81	42	DezUMS	1.33
9	BaqUMS	2.62	26	GuiUMS	1.80	43	JirUMS	1.33
10	ZanUMS	2.47	27	TorUMS	1.80	44	SabUMS	1.29
11	LorUMS	2.29	28	BusUMS	1.71	45	ShiUMS	1.28
12	BamUMS	2.25	29	HamUMS	1.64	46	JahUMS	1.18
13	UrmUMS	2.13	30	IraUMS	1.63	47	AhvUMS	1.07
14	AjaUMS	2.08	31	MasUMS	1.62	48	USWRS	1.03
15	ArdUMS	2.07	32	KasUMS	1.60	49	NKUMS	1.00
16	KersUMS	2.05	33	FasUMS	1.57	50	SBUMS	0.72
17	KerUMS	2.04	34	GonUMS	1.55			

terms of *h*-index was found to be TehUMS (TUMS), and SBUMS (SBUMS) and IsfUMS (IUMS) ranked second and third in this respect. The citation index is highly dependent on the passage of time, as older articles typically receive more citations and are, therefore, generalizable to universities. This Table indicates that older and larger universities rank higher in terms of this index. There is a high similarity between the ranking of Table 5 and those of Tables 1 and 3, with only a minor difference in one or two ranks. From this Table, we can conclude that since large and old universities are at the top of the list, this index is very much affected by the university's age, size, and range of fields.

Ranking the Universities based on m-Parameter

One of the problems of h-index is its high dependence on the history of research activity. For example, the *h*-index of younger authors (universities) is not comparable to the h-index of older ones as the number of articles and citations increases with time. To resolve this issue, Hirsch introduced a supplementary indicator called *m*-parameter, by adjusting the *h*-index for the history of research

activity of the author (university). The *h*-index is calculated by dividing the *h*-index by the research lifetime (the time between the publication of the first and last papers). In line with Hirsch's definition of this index, first, the research lifetime of the studied universities was obtained and then the *m*-parameter was calculated accordingly. The ranking of Iranian medical universities based on this indicator is displayed in Table 6.

According to Table 6, one of the factors that affect the quality and quantity of research output of universities is their research lifetime. It is obvious that older academic institutions have a greater scientific output and better quality indicators. As stated earlier, to reduce the effect of this factor, it is preferred to incorporate the research lifetime into the quality indicators of scientific production. In Table 6, it can be seen that universities with shorter research lifetime and higher quality scientific products are at the top of the ranking, while many of the larger and older universities have ranked lower than in previous table and some have even moved to the bottom of the list. There are also some small new universities at the top of the list. With this index, the universities whose research history has a lower impact on their current output rank higer.

Ranking of the Universities based on g-Index

Another weakness of the *h*-index is that it ignores the importance of highly cited articles. For example, an author who has 5 articles with 5 or slightly more citations will have the same *h*-index (5) as another author who has 5 articles with 1000 citations. The *h*-index cannot reflect this disparity, while in reality there should be a significant difference between the ranks of these authors. To resolve this issue, Egghe developed an extended version of Hirsch index called the *g*-index (28). Contrary to *h*-index, *g*-index assigns a higher weight to the articles that are cited more frequently. The *g*-index is the largest number of articles that have g^2 or more citations. A set of papers has a *g*-index *g* if *g* is the highest rank such that the top g papers have, together, at least g^2 citations. The higher the number of citations, the higher will be the *g*-index. To obtain this index, articles must be sorted in descending order of citations, then, starting from the top and moving downward, one must find the row *g* where corresponding article has g^2 citations. Because of its formula, *g*-index will never be lower than *h*-index. Like *h*-index and *m*-parameter, *g*-index can be expanded for universities. Based on this definition, the *g*-index of each studied university was calculated separately using the gathered database. The ranking obtained based on this index is presented in Table 7.

Comparison of Top-10 universities in the rankings based on *h*-index and *g*-index shows that TehUMS (TUMS) has maintained its top position in both rankings. In this Table, SBUMS (BUMS) and MasUMS (MUMS) have risen to ranks three and four respectively, while IsfUMS, ShiUMS, TabUMS, ShahedU, and ShakUMS each have lost rank compared to *h*-index table. IraUMS and MazUMS have also fallen in rank. Overall, the universities that rank higher based on *g*-index have a higher share of highly cited scientific papers. Universities ranked by

Table 7: Ranking of Iranian medical universities based on *g*-index

Rank	Name of University	*g*-index	Rank	Name of University	*g*-index	Rank	Name of University	*g*-index
1	TehUMS	254	18	USWRS	67	35	HorUMS	39
2	SBUMS	144	19	AlbUMS	66	36	BusUMS	37
3	MasUMS	133	20	ZanUMS	62	37	AjaUMS	35
4	IsfUMS	129	21	ZahUMS	60	38	BirUMS	33
5	IraUMS	122	22	QomUMS	59	39	YasUMS	31
6	MazUMS	115	23	HamUMS	58	40	SharUMS	31
7	ShiUMS	112	24	BabUMS	57	41	FasUMS	30
8	AraUMS	105	25	LorUMS	57	42	NKUMS	28
9	TabUMS	104	26	QazUMS	55	43	JahUMS	27
10	KurUMS	99	27	SemUMS	52	44	ZabUMS	26
11	KerUMS	94	28	GuiUMS	51	45	SabUMS	25
12	BaqUMS	87	29	SSUMS	49	46	GonUMS	21
13	ShahedU	83	30	UrmUMS	49	47	JirUMS	16
14	ShakUMS	78	31	ArdUMS	47	48	DezUMS	13
15	GolUMS	75	32	KasUMS	44	49	TorUMS	12
16	KersUMS	74	33	RafUMS	44	50	BamUMS	10
17	AhvUMS	70	34	IlaUMS	42			

Table 8: ISC Ranking of Iranian medical universities

Rank	Name of University	Rank	Name of University	Rank	Name Of University
1	TehUMS	14	SemUMS	27	ArdUMS
2	SBUMS	15	AraUMS	28	BirUMS
3	IsfUMS	16	HamUMS	29	BabUMS
4	ShiUMS	17	ZahUMS	30	UrmUMS
5	MasUMS	18	NKUMS	31	FasUMS
6	TabUMS	19	AlbUMS	32	IlaUMS
7	USWRS	20	QazUMS	33	QomUMS
8	MazUMS	21	SharUMS	34	JahUMS
9	KerUMS	22	KurUMS	35	YasUMS
10	IraUMS	23	GolUMS	36	SabUMS
11	AhvUMS	24	ShakUMS	37	GonUMS
12	SSUMS	25	BusUMS	38	DezUMS
13	ZanUMS	26	GuiUMS	39	TorUMS

Table 9: Spearman's coefficient of correlation between ISC ranking and the rankings based on scientometric indicators

		Total	Citions	*h*-indx	*m*-parameter	*g*-index	CI
ISC Ranking	Pearson Correlation	0.837**	0.820**	0.816**	0.303	0.286	0.484**
	P value	0.000	0.000	0.000	0.061	0.078	0.002
	N	39	39	39	39	39	39

** Correlation is significant at the 0.01 level (2-tailed).

the *g*-index are more comprehensive than the *h*-index.

Analysis of Correlation with ISC Ranking System

The Islamic World Science Citation Center (ISC) was founded in 2010 by Iran's Ministry of Science, Research and Technology to rank the universities and institutes of higher education in Iran and the wider Islamic world. The main criteria of this system are research, education, international image, facilities and socio-economic activities, with the highest weight assigned to research. Hence, ranking of this system tends to be focused on research. Therefore, the ISC ranking of universities and institutes of higher education can be compared with the rankings obtained in this study. Table 8 shows the ISC ranking of 39 universities studied in this paper.

Next, the correlation of the ranking provided in the table above with the previous rankings was investigated. Since these data were of rank type, this correlation was investigated using the Spearman's rank correlation analysis, which was performed in SPSS version 21. Table 9 shows the Spearman's coefficient of correlation between ISC ranking and the rankings obtained in this study.

As shown in Table 9, ISC ranking of Iranian medical universities has a significant correlation with the rankings obtained based on cumulative number of papers, cumulative number of citations, and *h*-index, but not with the rankings obtained based on *m*-parameter, *g*-index, and citation impact.

Discussion

Consodering the aim of this study which was to rank the Iranian medical universities by Scientometric indicators using index and ranking, the results of this study can be compared with a number of previous researches in this field. One way of ranking universities is to compare strength and productivity of the research. Productivity indicators include the number of articles cited, and the number of articles; strength indicators include the total number of citations, and the average number of citations per article. To compare the research strength and productivity, Rasolabadi and Ghadimi (7) and Torres-Salinas and Moreno-Torres (22) used the number of articles, number of articles cited and the average number of citations per article, which were also used in this study to compare the productivity of scientific production of universities of interest. Another influential indicator of university research quality is the *h*-index, which has a key role in ranking universities. The impact of the research and its measurement is often observed and described by using quality indicators such as citations and *h*-Index. Like the studies conducted by Rasolabadi and Ghadimi (7), Dorta-González and Dorta-González (23), and Mitra (24), where scientific products were evaluated by the h-index and its supplementary indices, this study also used these indicators to compare and rank the universities. In addition, there is good agreement between the rankings of the studied university with the results of the work of Abolghassemi Fakhree and

Jouyban (1), in such a way that part of the findings of this study that was considered in their research was confirmed. In comparing medical universities, the results of their study based on the number of articles, citations, *h*-index and *g*-index show that TehUMS, SBUMS, ShiUMS, IsfUMS, IranUMS, TabUMS, MasUMS were the highest ranked medical universities. Similar results were obtained in this study (see Tables 1 and 3). These findings suggest that the universities that are larger, older, and cover more scientific fields have better quantitative and qualitative research and rank higher in this respect. Another part of the results presented in this study was significantly different from the ranking based on the citation impact (Table 4); this difference is discussed in Garfield (8). Also, the reports obtained in this study are in terms of the difference observed between the ranking based on the number of papers and the ranking based on citation impact (Tables 1 and 4) The study of Harzing has been confirmed (10).

Conclusion

Given the importance of purposeful, structured and precise performance evaluation as the only way to achieve continuous quality improvement, there is a wide acceptance that ranking of universities and educational institutions is an essential requirement for progress in higher education systems. One of the functions of universities, as defined by their mission, is the production of academic and scientific outputs. Therefore, due attention to the quantity and quality of scientific production of universities with an international approach is of significant importance. One way to measure and evaluate scientific products is the use of scientometric indicators that are capable of measuring and evaluating the quantity and quality of outputs of universities and research institutions.

Scientometrics indicators were used to rank the Iranian medical universities. The scientific outputs of 50 Iranian medical universities were analyzed in terms of cumulative number of scientific papers, number of citations, citation impact, *h*-index, *m*-parameter, and *g*-index. According to the results, TehUMS ranked first in terms of the cumulative number of scientific papers, citations, *h*-index, and *g*-index, AlbUMS ranked first in terms of *m*-parameter, and AraUMS ranked first in terms of citation impact. The highest *h*-index obtained for TehUMS was 140. The average of *h*-index of the studied universities was approximately 40. For 18 out of 50 studied universities (approximately 36%), *h*-value was higher than the average. The highest *g*-index, 254, was obtained for TehUMS. The average *g*-index for the studied universities was 64.22. An interesting point in the ranking of universities with these indices was the consistency of rankings, which was reflected in the similarity of the ranks obtained based on these indices. To validate the results, they were compared with the results of ISC ranking system. This comparison showed that the rankings of Iranian medical universities based on cumulative numbers of papers, number of citations, and *h*-index have a strong correlation with the results of ISC ranking system. Another interesting result was the lack of correlation between the ISC ranking and the rankings obtained based on *m*-parameter, *g*-index, and citation impact. Considering the correlation of this system with some indicators, rather than with others, it appears that the indicators influenced by research history and per capita publication quality of institutions are somewhat overlooked in ISC and require a revision.

According to the results of the present study, universities rank differently based on their scientific outputs based on different indices. University ranking on the basis of scientometric indicators, which is the quality measurement of scientific products, is possible through citation indices, citation impact, *h*-index, m-parameter, and *g*-index. The proper use of scientometric indicators at the author and institution level is of particular importance for accurate measurement of the participation of researchers in the process of science production. The analyses of these indicators are either independent of time or consider time in a minimal fashion. Therefore, the results of university rankings are influenced by time and it is advisable to use normalized indexes in this regard.

It is recommended that the future research should incorporate the growth index into some of these indicators. Another worthwhile effort would be to rank the Iranian universities according to the index of participation in scientific production (ψ-index). In addition, one can formulate a hypothesis to test the collinearity of the introduced indices with the ranking of universities. Given that ranking the universities in terms of scientific production by the field can lead to effective growth of universities in particular areas, it is recommended that the methods employed in this study should be used to rank the universities separately for each field of research. The finding of such study would allow the university administrators and higher education officials to identify the strengths and weaknesses and chart the future course accordingly. Also, applicable suggestions for this research are ranking of Iranian universities based on the indices presented in this study for each of the medical subjects in order to

identify the top ones. Besides, it is recommended that policymakers should plan for higher education system to develop indicators that are independent of time and show some normalized ranks, such as parameter and citation impact.

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References

1. Abolghassemi Fakhree MA, Jouyban A. Scientometric analysis of the major Iranian medical universities. Scientometrics. 2011;87(1):205-20.
2. Aldieri L, Kotsemir M, Vinci CP. The impact of research collaboration on academic performance: An empirical analysis for some European countries. Socio-Economic Planning Sciences. 2018;62:13-30.
3. Ali H, Kumari A. Biodiversity: a scientometric analysis of publications output from India during 2003–2012. Journal of Advancements in Library Sciences. 2018;2(2):41-7.
4. García JA, Rodriguez-Sánchez R, Fdez-Valdivia J, Martinez-Baena J. On first quartile journals which are not of highest impact. Scientometrics. 2011;90(3):925-43.
5. Dusansky R, Vernon CJ. Rankings of US economics departments. Journal of economic perspectives. 1998;12(1):157-70.
6. Rogers DW, Hendee WR, Orton CG. Scientific citation indices are useful in evaluating medical physicists for promotion and tenure. Medical physics. 2006;33(1):1-3.
7. Rasolabadi M, Ghadimi T, Haidari A, Khezri A, Gharibi F. Scientific output of the universities in Sanandaj according to Scopus database. Scientific Journal of Kurdistan University of Medical Sciences. 2014;19(4).
8. Garfield E. A Citationist Perspective On Science In Taiwan-Most Cited Papers, Institutions, And Authors, 1981-1992. Current Contents. 1993;17: 3-12.
9. Velloso A, Lannes D, De Meis L. Concentration of science in Brazilian governmental universities. Scientometrics. 2004;61(2):207-20.
10. Harzing A-W. Australian research output in economics and business: high volume, low impact? Australian Journal of Management. 2005;30(2):183-200.
11. Ponce FA, Lozano AM. Academic impact and rankings of American and Canadian neurosurgical departments as assessed using the h index. Journal of neurosurgery. 2010;113(3):447-57.
12. Lazaridis T. Ranking university departments using the mean h-index. Scientometrics. 2010;82(2):211-6.
13. Molinari J-F, Molinari A. A new methodology for ranking scientific institutions. Scientometrics. 2008;75(1):163-74.
14. Lukman R, Krajnc D, Glavič P. University ranking using research, educational and environmental indicators. Journal of Cleaner Production. 2010;18(7):619-28.
15. Alaşehir O, Çakır MP, Acartürk C, Baykal N, Akbulut U. URAP-TR: a national ranking for Turkish universities based on academic performance. Scientometrics. 2014;101(1):159-78.
16. Daraio C, Bonaccorsi A, Simar L. Rankings and university performance: A conditional multidimensional approach. European Journal of Operational Research. 2015;244(3):918-30.
17. Hirsch JE. An index to quantify an individual's scientific research output. Proceedings of the National academy of Sciences. 2005;102(46): 16569-72.
18. Meho LI, Rogers Y. Citation counting, citation ranking, and h-index of human-computer interaction researchers: a comparison of Scopus and Web of Science. Journal of the American Society for Information Science and Technology. 2008;59(11):1711-26.
19. Huang Mh, Lin CS. Counting methods & university ranking by H-index. Proceedings of the American Society for Information Science and Technology. 2011;48(1):1-6.
20. Mryglod O, Kenna R, Holovatch Y, Berche B. Predicting results of the research excellence framework using departmental h-index: revisited. Scientometrics. 2015;104(3):1013-7.
21. Waltman L, van Eck NJ, van Leeuwen TN, Visser MS, van Raan AF. Towards a new crown indicator: Some theoretical considerations. Journal of informetrics. 2011;5(1):37-47.
22. Torres-Salinas D, Moreno-Torres JG, Delgado-López-Cózar E, Herrera F. A methodology for Institution-Field ranking based on a bidimensional analysis: the IFQ 2 A index. Scientometrics. 2011;88(3):771-86.
23. Dorta-González P, Dorta-González MI, Suárez-Vega R. An approach to the author citation potential: Measures of scientific performance which are invariant across scientific fields. Scientometrics. 2015;102(2):1467-96.
24. Mitra P. Hirsch-type indices for ranking institutions scientific research output. Current Science. 2006;91(11):1439.

25. Da Luz MP, Marques-Portella C, Mendlowicz M, Gleiser S, Coutinho ESF, Figueira I. Institutional h-index: The performance of a new metric in the evaluation of Brazilian Psychiatric Post-graduation Programs. Scientometrics. 2008;77(2):361-8.
26. Dridi C, Adamowicz WL, Weersink A. Ranking of research output of agricultural economics departments in Canada and selected US universities. Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie. 2010;58(3):273-82.
27. Buela-Casal G, Gutiérrez-Martínez O, Bermúdez-Sánchez MP, Vadillo-Muñoz O. Comparative study of international academic rankings of universities. Scientometrics. 2007;71(3):349-65.
28. Egghe L. Theory and practise of the g-index. Scientometrics. 2006;69(1):131-52.

Appendix A: The abbreviation of the university names

Name of University	Abbreviation	Name of University	Abbreviation
Tehran University of Medical Sciences	TehUMS	Qazvin University of Medical Sciences	QazUMS
Shahid Beheshti University of Medical Sciences	SBUMS	Semnan University of Medical Sciences	SemUMS
Shiraz University of Medical Sciences	ShiUMS	Lorestan University of Medical Sciences	LorUMS
Isfahan University of Medical Sciences	IsfUMS	Ilam University of Medical Sciences	IlaUMS
Tabriz University of Medical Sciences	TabUMS	Arak University of Medical Sciences	AraUMS
Mashhad University of Medical Sciences	MasUMS	Hormozgan University of Medical Sciences	HorUMS
Iran University of Medical Sciences	IraUMS	Alborz University of Medical Sciences	AlbUMS
Ahvaz, Jundishapur University of Medical Sciences	AhvUMS	Bushehr University of Medical Sciences	BusUMS
Baqiyatallah Medical Sciences University	BaqUMS	Qom University of Medical Sciences	QomUMS
Mazandaran University of Medical Sciences	MazUMS	Aja University of Medical Sciences	AjaUMS
Kerman University of Medical Sciences	KerUMS	Rafsanjan University of Medical Sciences	RafUMS
Kermanshah University of Medical Sciences	KSUMS	Birjand University of Medical Sciences	BirUMS
Shahed University	ShahedU	Zabol University of Medical Sciences	ZabUMS
Hamedan University of Medical Sciences and Health Services	HamUMS	Ardabil University of Medical Sciences	ArdUMS
Shahid Sadoughi University of Medical Sciences	SSUMS	Yasuj University of Medical Sciences	YasUMS
University of Social Welfare and Rehabilitation Sciences	USWRS	Sabzevar University of Medical Sciences	SabUMS
Babol University of Medical Sciences	BabUMS	Shahroud University of Medical Sciences	SharUMS
Zahedan University of Medical Sciences	ZahUMS	Jahrom University of Medical Science	JahUMS
Shahrekord University of Medical Sciences	ShakUMS	Gonabad University of Medical Sciences	GonUMS
Guilan University of Medical Sciences	GuiUMS	Fasa University of Medical Sciences	FasUMS
Urmia University of Medical Sciences	UrmUMS	North Khorasan University of Medical Sciences	NKUMS
Golestan University of Medical Sciences	GolUMS	Dezful University of Medical Sciences	DezUMS
Zanjan University of Medical Sciences	ZanUMS	Torbat Heydariyeh University of Medical Sciences	THUMS
Kurdistan University of Medical Sciences	KurUMS	jiroft University of Medical Sciences	JirUMS
Kashan University of Medical Sciences and Health Services	KasUMS	Bam University of Medical Sciences	BamUMS