

Ranking Iranian biomedical research centers according to H-variants (G, M, A, R) in Scopus and Web of Science

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Received: 27 July 2014

Accepted: 8 March 2015

Published: 7 June 2015

Abstract

Background: We conducted a comprehensive bibliometrics analysis to calculate the H, G, M, A and R indicators for all Iranian biomedical research centers (IBRCs) from the output of ISI Web of Science (WoS) and Scopus between 1991 and 2010. We compared the research performance of the research centers according to these indicators.

Methods: This was a cross-sectional and descriptive-analytical study, conducted on 104 Iranian biomedical research centers between August and September 2011. We collected our data through Scopus and WoS. Pearson correlation coefficient between the scientometrics indicators was calculated using SPSS, version 16.

Results: The mean values of all indicators were higher in Scopus than in WoS. Drug Applied Research Center of Tabriz University of Medical Sciences had the highest number of publications in both WoS and Scopus databases. This research center along with Royan Institute received the highest number of citations in both Scopus and WoS, respectively. The highest correlation was seen between G and R (.998) in WoS and between G and R (.990) in Scopus. Furthermore, the highest overlap of the 10 top IBRCs was between G and H in WoS (100%) and between G-R (90%) and H-R (90%) in Scopus.

Conclusion: Research centers affiliated to the top ranked Iranian medical universities obtained a better position with respect to the studied scientometrics indicators. All aforementioned indicators are important for ranking bibliometrics studies as they refer to different attributes of scientific output and citation aspects.

Keywords: Scientometrics, H-index, G-index, A-index, R-index, M-index, Biomedical Centers, Research Centers, Iran.

Cite this article as: Mahmudi Z, Tahamtan I, Sedghi Sh, Roudbari M. Ranking Iranian biomedical research centers according to H-variants (G, M, A, R) in Scopus and Web of Science. *Med J Islam Repub Iran* 2015 (7 June). Vol. 29:217.

Introduction

The distribution of funding across universities, research areas and research fields is challenging. Although there are many allocating funding models for research, many countries tend to allocate research funds based on the scientific productivity of researchers or academic institutions (1). Accordingly, a number of indicators (e.g., to-

tal number of publications, total number of citations, H-index) are used to measure researchers, research centers, academic institutions and universities (2). H-index (h), is defined as follows: "A scientist has index h if h of his/her N_p papers have at least h citations each, and the other ($N_p - h$) papers have no more than h citations each"(3). Hirsch (2005) described H-index as an ef-

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fective index to assess the scientific output and impact of a scientist (3); however, this was later applied to evaluate institutions, departments, universities and countries (4). Although H-index has been used in many scientometrics studies, its limitations and disadvantages have been pointed out in different studies (5). One disadvantage is that H-index is influenced by self-citations which makes its value more than what it really is and gives a false belief that the scientific work is greatly accepted by the other researchers. Due to the limitations of the H-index, a number of variants such as G, M, A, R deployed by the researchers are aimed to compensate for the weaknesses (5).

Nowadays, scientometrics has become an important field of study to follow up the scientific products of a research group, a university, etc. Scientometrics studies are useful methods for managing financial and human resources and have been used many times in medical sciences during the recent years (6). A number of scientometrics studies have been conducted on Iranian scientific production in the recent years (7). Osareh and Wilson (2000) investigated the scientific output of Iran in Science Citation Index during 1985–1989 and 1990–1994 and also during 2000–2006 (8, 9). Moin et al. (2005) studied the scientific output of Iran at the threshold of the 21st century (10). Sotudeh (2010) has compared Iran's impact to global norms in different sub-fields of Science Citation Index during 2002–2005 (11). Hayati and Ebrahimi (2009) have also studied the number of articles and citations for Iranian universities, research institutes and other organizations (12). Siamian et al. (2013) studied the scientific production of Northern Iran Medical Sciences Universities in Scopus from 2005 through 2010 (13). Nourmohammadi and Hodaei (2013) investigated Iranian women's scientific production in high priority fields of science and technology according to the records of Web of Science (WoS) during 2000–2010 (14). Scientometric analysis of the major Iranian medical uni-

versities has been done by Abolghassemi-Fakhree and Jouyban (2011) (7). As previous studies indicated, extensive literature exists on scientometrics studies in Iranian context. However, there is no comparison between Iranian Biomedical Research Centers (IBRCs) based on scientometrics indicators.

In recent years, Iran has had an increasing growth in the number of publications in science and even in biomedical research. However, due to the lack of funding, it is important to increase the quality of biomedical research and conduct practical research according to the country's research priorities. This urged the policy-makers in Iran Ministry of Health to examine the strengths and weaknesses of biomedical research centers when allocating funding. Thus, we decided to evaluate Iranian biomedical research centers according to quantitative and qualitative scientometrics indicators. These indicators allow us to observe whether the performance of a research institute/group or institute is high or not. This was the first bibliometrics study in Iran covering a 20-year period from 1991 to 2010 for all 104 biomedical research centers. It is noteworthy to mention that counting the number of citations and calculating the scientometrics indicators using data from different databases, namely Scopus and WoS, are relatively laborious (15). Considering the growing popularity of Scopus and WoS as citation analysis tools, we decided to compare the scientometrics indicators for the subjects of the studies derived from these databases. We conducted a comprehensive bibliometrics analysis to calculate the H, G, M, A and R indicators for all biomedical research centers and compare these indicators to illustrate the research performance of research centers in two decades. The aims of this study were calculating the H-index, G-index, M-index, A-index and R-index of IBRCs with the output of WoS and Scopus, ranking IBRCs publications according to scientometrics indicators, identifying Pearson Correlation Coefficient between the scientometrics indicators and

calculating the overlap of the 10 top IBRCs in WoS and Scopus with respect to the studied scientometrics indicators.

Methods

This was a descriptive-analytical study, conducted on 104 Iranian biomedical research centers (IBRCs) which were approved by Iran Ministry of Health. In this cross-sectional study, we used the following steps to collect data from Scopus and WoS databases.

First, the names and affiliations of biomedical research centers were collected through the records of Iran Ministry of Health. Then, we contacted each center and visited their websites for further assurance of their affiliation names. This helped us to conduct comprehensive search and generate precise citation calculations. Because some names or transliteration of institutions (from Persian to English) were not entered consistently in Scopus, we manually standardized all such instances. In cases that the names were altered, we merged the citations under their most recent respective name.

In WoS, we searched the name of country (Iran), name of the medical university and name of the biomedical research center in the advance search of the database. Data were extracted in the "text" format and imported into Microsoft Excel for data analysis. In Scopus, the name of country (Iran), name of the medical university and name of the biomedical research center were searched in "Affiliation Search" search field to retrieve documents published by each Iranian biomedical research center.

The first biomedical research center in Iran was established in 1991 (Medical Ethics Researches); thus, all documents published since 1991 were included in the study. We considered all types of documents including articles, reviews, letters, conference papers, notes, editorials, short surveys, erratum, etc. which were indexed in Scopus and WoS.

When searching Scopus and WoS databases, the number of citations to documents

of each research center was retrieved until the date that the search was conducted. Since the study population was very large, we were not able to search all research centers in the same date. Thus, the citations to the publications of each research center were limited to December 2010 to ensure consistency. To do this, the citations to publications from 2011 were discarded and the remained citations were sorted based on the date of publication.

Study Variables and Data Analysis

We calculated the following indicators for 104 Iranian biomedical research centers: The total number of publications (all types) and citations (self-citations were not excluded) were identified for each research center between 1991 and 2010.

Hirsch index, also known as the H-index: Based on the definition, a researcher or research center has index H if H of its' N documents received at least H citations for each document. Publications of each research center were ranked according to the number of citations received. H-index was defined as the highest rank such that the first H publications each received h or more citations (16).

G-index is an index that illustrates the citation growth of the most cited documents over time. G-index gives more weight to highly cited papers than H-index (5). For calculating G-index, documents were ranked in a decreasing order of number of received citations. G-index was the highest rank such that the cumulative sum of the number of citations received was larger than or equal to the square of this rank (16).

A-index is defined as the mean number of citations received by documents in the Hirsch core. H-core is defined as all citations received by the first "H" ranked articles which is calculated by dividing H core citations by H-index (5, 16).

Another index is M-index which is computed by dividing the H-index of a person or an institution by the number of years since its first document was published (H/n). In fact, this index takes into account

Article's number	Citaions untill 2010	citations untill 2010 on rank	Cumulative number of citations	H	H-core	G	A	R	M
1	0	13	13						0/75
2	0	6	19						
3	0	5	24	3	24		8	4.89	
4	1	3	27						
5	0	3	30			5			
6	0	1	31						
7	0	0	31						
8	0	0	31						
9	0	0	31						
10	13	0	31						
11	3	0	31						
12	0	0	31						
13	3	0	31						
14	5	0	31						
15	6	0	31						

Fig. 1. Identifying H, G, A, R and M indicators for “Cellular and Molecular Research Center” of Zahedan UMSs in Scopus

“the time” as a weighting factor (5). M-index and G-index reach the same goal that is correcting the fact that the original H-index does not take into account the exact number of citations of articles in the Hirsch core (17). The problems related to the M-index (“the better scientist is ‘punished’ for having a higher H-index, as the A-index involves a division by h”) are overcome by another index called the R-index which is calculated using a square root. R is defined as the square-root of the sum of citations in the h-core. R-index was suggested by Jin et al. (2007) and takes into account the citation intensity in the Hirsch core. The R-index is calculated as $R = \sqrt{A.H}$ (17).

The following figure indicates how those five indicators were calculated for “Cellular and Molecular Research Center” of Zahedan UMSs in an Excel sheet using Scopus data.

We used SPSS 16 to calculate the Pearson correlation coefficient between the scientometrics indicators. P value less than 0.01 was considered as significant.

Results

We combined two lists of documents re-

trieved from Scopus and WoS and removed the duplicate items with regards to the title of documents and the names of biomedical research centers. This allowed us to keep documents authored by researchers from two or more research centers. Researchers of Iranian biomedical research centers produced 6035 documents between 1999 and 2010. The majority of IRBCs (87.5 %) published 5469 documents in Scopus (MA=60.09 publications per center) and these documents received 16996 citations (MA=186.76 citation per center) between 1991 and 2010. Forty nine research centers published 2366 documents in journals indexed in WoS (MA= 48.28 publications per each center) and these items received 6923 citations (MA=141.28) until 2010 (As stated earlier, we did not exclude the self-citations). Fifty five research centers had no publications in WoS and 13 had no publications in Scopus through the studied years. Moreover, some research centers with some publications in these databases had received no citations. The total number of publications of IBRCs indexed in Scopus was twice more than that of publications indexed in WoS. The mean numbers of ci-

Table 1. Top 5 Iranian Biomedical Research Centers according to number of publications and citations in Scopus between 1991 and 2010

IBRCs	Number of publications	%	IBRCs	Number of citations	%
Drug Applied Research Center of Tabriz UMSs	369	7.24	Drug Applied Research Center of Tabriz UMSs	1322	7.78
Royan Institute	314	5.74	Royan Institute	1300	7.65
Biotechnology Research Center of Tehran UMSs	286	5.23	Biotechnology Research Center of Tehran UMSs	1005	5.91
Biotechnology Research Center of Pasteur Institute of Iran	195	3.57	Pharmaceutical Research Center of Mashhad	830	3.27
Pharmaceutical Research Center of Mashhad	175	3.20	Molecular Immunology Research Center of Tehran UMSs	669	4.88

Table 2. Top 5 Iranian Biomedical Research Centers according to number of publications and citations in WoS between 1991 and 2010

IBRCs	Number of publications	%	IBRCs	Number of citations	%
Drug Applied Research Center of Tabriz UMSs	408	17.24	Royan Institute	1197	16.70
Royan Institute	362	15.30	Drug Applied Research Center of Tabriz UMSs	1156	17.29
Iranian Blood Transfusion Organization	180	7.61	Pharmaceutical Research Center of Mashhad UMSs	1142	5.08
Biotechnology Research Center of Tabriz UMSs	125	5.28	Medical Nanotechnology Research Center of Terhan UMSs	480	4.04
Pharmaceutical Research Center of Mashhad UMSs	113	4.78	Medical Biology Research Center of Kermanshah UMSs	362	10.72

tations to publications in Scopus and WoS were 2.5 and 2.1, respectively.

The ranking of IBRCs according to the number of papers indicated that Drug Applied Research Center of Tabriz UMSs had the highest number of publications in both WoS (408 [17.24]) and Scopus (369 [7.24%]), followed by Royan Institute with 362 publications [15.30%] in WoS and 314 [5.74%] in Scopus. Drug Applied Research Center of Tabriz UMSs received the highest number of citations in Scopus (1322 [7.78%]) and Royan Institute had the highest number of citations indexed in WoS (1197 [16.70%]). Table 1 and 2 demonstrate the number of publications and citations for the 5 top IBRCs in WoS and Scopus, respectively. A complete list of IBRCs and scientometrics indicators is presented in appendix 1 and 2.

The best performance in terms of H-index in WoS was shown by Royan Institute (19) followed by Mashhad Pharmaceutical Research Center (17) and Drug Applied Research Center of Tabriz UMSs (15). Furthermore, Royan Institute had the best performance in terms of H-index in Scopus,

(19) followed by Drug Applied Research Center of Tabriz UMSs (16) and Mashhad Pharmaceutical Research Center (16). The mean value of H-index for all IBRCs was 4.4 in WoS and 5.25 in Scopus (Table 3).

The G values in WoS ranged between 0 and 26 with a mean value of 6.36. Royan Institute (26) had the highest G value in WoS followed by Mashhad Pharmaceutical Research Center (21) and Drug Applied Research Center of Tabriz UMSs (20). Given a mean of 7.58, the G-index values ranged between 0 and 28 in Scopus. Royan Institute had the best performance in terms of G-index (28) followed by Molecular Immunology Research Center of Tehran (25) and Biotechnology Research Center of Tehran (25). Table 3 demonstrates the G-index values for top 10 IBRCs in WoS and Scopus (Table 4).

The mean R value was 6.14 in WoS and the best results with respect to this index were achieved by Royan Institute (24.39) followed by Mashhad Pharmaceutical Research Center (20.42) and Drug Applied Research Center of Tabriz UMSs (18.17). Given a mean value of 7.54, Royan Insti-

Table 3. H-index of top 10 Iranian Biomedical Research Centers in Scopus and WoS between 1991 and 2010

IBRCs in Scopus	H-index	IBRCs in WOS	H-index
Royan Institute	19	Royan Institute	19
Drug Applied Research Center of Tabriz UMSs	16	Pharmaceutical Research Center of Mashhad UMSs	17
Pharmaceutical Research Center of Mashhad UMSs	16	Drug Applied Research Center of Tabriz UMSs	15
Biotechnology Research Center of Tehran UMSs	15	Medical Nanotechnology Research Center of Tehran UMSs	12
Genetics Research Center of University of Social Welfare and Rehabilitation Sciences	14	Iranian Blood Transfusion Organization	10
Biotechnology Research Center of Pasteur Institute of Iran	13	Medical Biology Research Center of Kermanshah UMSs	10
Medical Biology Research Center of Kermanshah UMSs	12	Research Center for pharmaceutical nanotechnology of Tabriz UMSs	9
Medical Nanotechnology Research Center of Tehran UMSs	12	Immunology Research Center of Mashhad UMSs	9
Immunology Research Center of Mashhad UMSs	12	Mums Biotechnology Research Center of Mashhad UMSs	9
Medicinal Plants Research Center of Tehran	11	Biotechnology Research Center of Tabriz UMSs	8

Table 4. G-index of top 10 Iranian Biomedical Research Centers in Scopus and WoS between 1991 and 2010

IBRCs in Scopus	G-index	IBRCs in WOS	G-index
Royan Institute	28	Royan Institute	26
Molecular Immunology Research Center of Tehran UMSs	25	Pharmaceutical Research Center of Mashhad UMSs	21
Biotechnology Research Center of Tehran UMSs	25	Drug Applied Research Center of Tabriz UMSs	20
Genetics Research Center of University of Social Welfare and Rehabilitation Sciences	22	Medical Nanotechnology Research Center of Tehran UMSs	19
Drug Applied Research Center of Tabriz UMSs	21	Iranian Blood Transfusion Organization	16
Pharmaceutical Research Center of Mashhad UMSs	21	Research Center for pharmaceutical nanotechnology of Tabriz UMSs	14
Medicinal Plants Research Center of Tehran UMSs	18	Medical Biology Research Center of Kermanshah UMSs	14
Institute for Environmental Research of Tehran UMSs	18	Immunology Research Center of Mashhad UMSs	13
Medical Nanotechnology Research Center of Tehran UMSs	17	Mums Biotechnology Research Center of Mashhad UMSs	13
Biotechnology Research Center of Pasteur Institute of Iran	17	Biotechnology Research Center of Tabriz UMSs	11

tute (25.87) had the highest value for R-index in Scopus, followed by Molecular Immunology Research Center of Tehran (23.9) and Tehran biotechnology (22.1) as shown in Table 5.

The mean value of A-index was 8.80 in WoS and 12.4 in Scopus. The highest A values were obtained by Royan Institute (31.32), Medical Nanotechnology Research Center of Tehran (27.25) and Drug Applied Research Center (24.59). Genetics research center of Social Welfare and Rehabilitation Sciences University (104.25), Molecular Immunology Research Center of Tehran (57.20) and Molecular Medicine Research center of Hamadan (42.20) had the highest A values in Scopus, respectively (Table 6).

The mean M value was 0.73 in WoS and 0.8 in Scopus. Medical Nanotechnology Research Center of Tehran (2.4), Pharmaceutical Research Center of Mashhad (1.89) and Research Center for pharmaceutical nanotechnology of Tabriz (1.8) had the highest values in WoS. The best results on the M-index were obtained by Nuclear Medicine Research Center of Tehran UMSs (2.5), Medical Nanotechnology Research Center of Tehran (2.4) and Food and Drug Laboratory Research Center of Iran Ministry of Health (2) as presented in Table 7.

As Tables 8 and 9 demonstrate, there was a significant Pearson relationship between the number of publications and citations in both Scopus (0.917) and WoS (0.941). In

Table 5. R-index of top 10 Iranian Biomedical Research Centers in Scopus and WoS between 1991 and 2010

IBRCs in Scopus	R-index	IBRCs in WOS	R-index2
Royan Institute	25.87	Royan Institute	24.39
Molecular Immunology Research Center of Tehran UMSs	23.92	Pharmaceutical Research Center of Mashhad UMSs	20.42
Biotechnology Research Center of Tehran UMSs	22.18	Drug Applied Research Center of Tabriz UMSs	18.17
Genetics Research Center of University of Social Welfare and Rehabilitation Sciences	20.42	Medical Nanotechnology Research Center of Tehran UMSs	18.08
Pharmaceutical Research Center of Mashhad UMSs	19.67	Iranian Blood Transfusion Organization	15.39
Drug Applied Research Center of Tabriz UMSs	19.21	Research Center for pharmaceutical nanotechnology of Tabriz UMSs	13.19
Institute for Environmental Research of Tehran UMSs	16.88	Medical Biology Research Center of Kermanshah UMSs	12.73
Immunology Research Center of Mashhad	16.49	Immunology Research Center of Mashhad	12.61
Medicinal Plants Research Center of Tehran UMSs	16.28	Mums Biotechnology Research Center of Mashhad UMSs	12.61
Medical Nanotechnology Research Center of Tehran UMSs	16.06	Institute for Environmental Research of Tehran UMSs	10.20

Table 6. A-index of 10 top Iranian Biomedical Research Centers in Scopus and WoS between 1991 and 2010

IBRCs in Scopus	M-index	IBRCs in WOS	M-index
Genetics Research Center of University of Social Welfare and Rehabilitation Sciences	104.25	Royan Institute	31.32
Molecular Immunology Research Center of Tehran UMSs	57.20	Medical Nanotechnology Research Center of Tehran UMSs	27.25
Molecular Medicine Research center of Hamadan UMSs	42.20	Pharmaceutical Research Center of Mashhad UMSs	24.59
Razi Drug Research Center	35.33	Iranian Blood Transfusion Organization	23.7
Royan Institute	35.21	Drug Applied Research Center of Tabriz UMSs	22
Biotechnology Research Center of Tehran UMSs	32.80	Medicinal Plants Research Center of JahanDaneshgahi	21.33
Medicinal Plants Research Center of JahanDaneshgahi	32.00	Research Center for pharmaceutical nanotechnology of Tabriz UMSs	19.33
Institute for Environmental Research of Tehran UMSs	31.67	Immunology Research Center of Mashhad	17
Pharmaceutical Research Center of Mashhad UMSs	24.19	Mums Biotechnology Research Center of Mashhad UMSs	16.78
Medicinal Plants Research Center of Tehran UMSs	24.09	Medical Biology Research Center of Kermanshah UMSs	16.2

WoS, G and R (.998) had the highest correlation, followed by G and H (.987), R and H (.985), R and A (.970) and G and A (.966). In Scopus, the highest correlation was seen between G and R (.990), followed by H and G (.961), H and R (.948), C and P (.917) and C and H (.901). The least correlation was between P and M (.517), C and M (.624) and P and A (.694) in WoS and between A and M (.415), A and P (.464), and M and P (.513) in Scopus. P value less than 0.01 was considered as significant.

We calculated the overlap of the 10 top IBRCs in WoS and Scopus with regards to the studied scientometrics indicators. The highest overlap of the 10 top IBRCs was

between G and H in WoS (100%) and between G-R (90%) and H-R (90%) in Scopus. The least overlap was between M-A (60%) and M-R (60%) in WoS and between M-A (20%) and M-G (20%) in Scopus. Moreover, we calculated the mean value for the overlap of each indicator with other indicators for the top 10 IBRCs. For instance, the mean value for the overlap of H and other indicators (G, A, M and R) in WoS was calculated as follows: (overlap of H and G + overlap of H and A + overlap of H and R + overlap of H and M) divided by 4 = 87.5. It was indicated that the mean values were higher in WoS compared to Scopus (79% vs. 56%) for all indicators.

Table 7. M-index of the 10 top Iranian Biomedical Research Centers in Scopus and WoS between 1991 and 2010

IBRCs in Scopus	M-index	IBRCs in WOS	M-index
Nuclear Medicine Research Center of Tehran UMSs	2.50	Medical Nanotechnology Research Center of Tehran UMSs	2.40
Medical Nanotechnology Research Center of Tehran UMSs	2.40	Pharmaceutical Research Center of Mashhad UMSs	1.89
Food and Drug Laboratory Research Center of Iran Ministry of Health	2.00	Research Center for pharmaceutical nanotechnology of Tabriz UMSs	1.80
Pharmaceutical Research Center of Mashhad UMSs	1.78	Biotechnology Research Center of Tabriz UMSs	1.60
Medical Biology Research Center of Kermanshah UMSs	1.71	Drug Applied Research Center of Tabriz UMSs	1.50
Research Center for pharmaceutical nanotechnology of Tabriz UMSs	1.67	Medical Biology Research Center of Kermanshah	1.43
Biotechnology Research Center of Tabriz UMSs	1.60	Royan Institute	1.36
Medicinal and natural Products Chemistry Research Center of Shiraz UMSs	1.57	Cellular and molecular biology research center (cell biology research center) of Shahid Beheshti UMSs	1.33
Pharmaceutical Research Center of Isfahan UMSs	1.50	Institute for Environmental Research of Tehran UMSs	1.33
Institute for Environmental Research of Tehran UMSs	1.50	Molecular Immunology Research Center of Tehran UMSs	1.25

The mean values for the overlap of each indicator with other indicators were as follows: H (87.5) > G (85) > R (80) > A (77.5) > M (65) in WoS and in Scopus it was as follows: H and R (67.5) > G (65) > A (55) > M (25).

The studied indicators had higher mean values in Scopus compared to WoS. The difference between the mean values of each indicator in both databases was also calculated. The least difference between the mean values of indicators in WoS and Scopus was for M-index (the mean value of M was 0.80 and 0.74 in Scopus and WoS, respectively). The following relationship could be observed in both databases: A-index > G-index > R-index > H-index > M-

index.

Discussion

This was the first study to be carried out on the scientific production within the Iranian biomedical research centers according to the scientometrics indicators including H, G, A, M and R. Drug Applied Research Center of Tabriz UMSs and Royan Institute had the highest number of publications and citations in both WoS and Scopus databases. The highest correlation was between G and R (0.998) in WOS and Between G and R (0.990) in Scopus. The mean values of all indicators were higher in Scopus compared to WoS. The least difference of the mean values of indicators in WoS and

Table 8. Pearson Correlation Coefficient between scientometrics variables in WoS

	G	A	R	M	P	C
H	.987**	.918**	.985**	.811**	.803**	.884**
G		.966**	.998**	.807**	.782**	.854**
A			.970**	.752**	.694**	.766**
R				.806**	.769**	.846**
M					.517**	.624**
P						.941**

** . Correlation is significant at the 0.01 level.

Table 9. Pearson Correlation Coefficient between scientometrics variables in Scopus

	G	A	R	M	P	C
H	.961**	.675**	.948**	.614**	.868**	.901**
G		.779**	.990**	.585**	.819**	.898**
A			.802**	.415**	.464**	.657**
R				.606**	.805**	.893**
M					.513**	.518**
P						.917**

** . Correlation is significant at the 0.01 level.

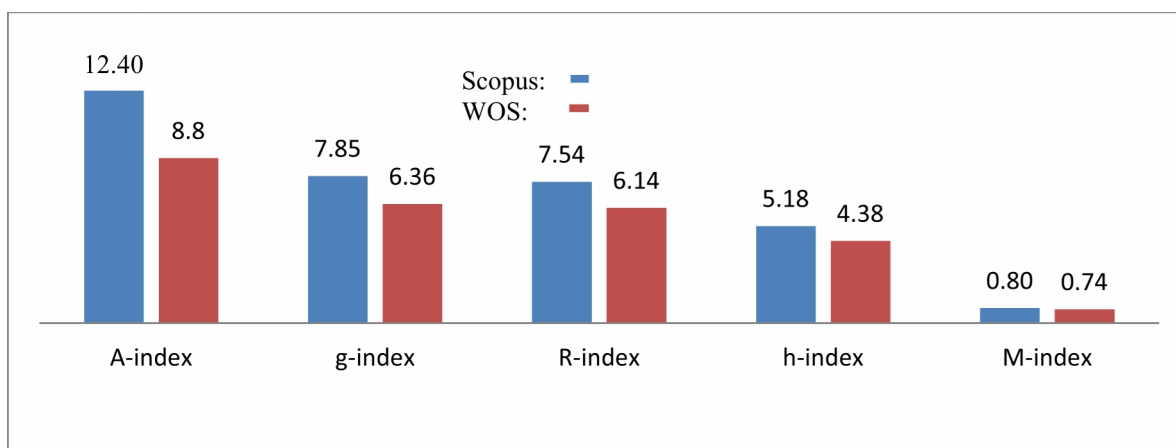


Fig. 2. Comparison of the mean values of A, G, R, H and M indicators of Iranian biomedical research centers in Scopus and WOS

Scopus was obtained in M-index (the mean value of M was 0.80 and 0.74 in Scopus and WoS, respectively). The highest overlap of the top 10 IBRCs was seen between G and H indicators in WoS (100%), and between pairs G- R and H -R with the value of 90% in Scopus.

A number of studies indicated that Scopus covered more publications and received more citations in different fields of studies (15), and this was consistent with our results. Number of publications in Scopus was 2.31 higher than WoS in the current study. The values of 5 indicators in the study were also higher in Scopus than WoS. Oliveira et al. (2012) also reached similar findings. They indicated that H-index and M-index of Brazilian researchers in clinical medicine was higher in Scopus than in WoS (18). One main reason is that Scopus covers more journals (English and other languages including Persian) and even more conference proceedings than WoS. Furthermore, more Iranian English and Persian journals were indexed in Scopus, which influenced the total number of publications and citations.

We could not find a relevant literature on the scientific output of biomedical research centers considering H, G, A, R and M indicators. Thus, we could not compare our findings with the literature to find whether the scientific status of IBRCs was ideal or not in comparison with the biomedical re-

search centers in other countries. However, when we observed some recent studies, we found that the indicator values of some IBRCs were very low in comparison with a Chinese biology center's value (Apoptosis institute had G-index=587 and R-index 414.01) (17). The biggest G and R indicators were 28 and 25.87 in our study, respectively. One study showed that the highest M-index among economics centers was 5 in Ireland (19). This might be due to the fact that the scientometrics indicators are dependent to many variables including fields and sub-fields of the study.

Most of the highly ranked research centers were affiliated to top ranked universities in Iran such as Tehran, Iran, Tabriz and Mashhad UMSs. With an increase in the number of journals published by Iranian universities indexed in Scopus in particular, it is much easier for large universities to publish their own papers in their own journals. Thus, research centers affiliated to the universities that published journals indexed in Scopus and WoS are able to publish their own papers in their own journals. As Pone et al. (2010) suggested, "Significant correlations were found between the citation indices and faculty size, number of publications and the types of degrees held by the faculty, and funding by the US NIH" (4). International and national collaboration, number of faculty members and post-graduate students, ranks of faculty mem-

bers, age of research center, domain of activity, university budget and funds secured from resources outside of the research center and the affiliation status of the research center (affiliated to a university or a non-university institution) might influence the research output of the research centers.

The Pearson correlation coefficient between the majority of pair indicators was high and the values were in a range of 0.415 and 0.998. The Pearson correlation coefficient between G and R was very high (0.998) in WOS, followed by G and H (0.987) and R and H (0.985). In Scopus, the Pearson correlation coefficient between G and R (0.990) was higher than other indicators followed by H and G (0.961), and H and R (0.948). Moreover, in WOS, P and M (0.517) and in Scopus A and M (0.415) had the least correlation. Jin et al. (2007) mentioned that the correlation between R and G was more than the correlation between R and H or G and H (17). Another study confirmed Jin's findings and indicated that the correlation between these two indicators was 0.998 (20).

Some research centers, which were among the top 10 research centers for all indicators, were not ranked in the top 10 for M-index in both databases (e.g., Royan Institute). This may be due to the fact that M-index takes into account "the time" as a weighting factor (the number of years since the first document is published by a research center). Thus, it may be argued that M-index is just suitable for the comparison of research centers when the H, A, R and G indicators of research centers are the same. Some indicators relate to the number of papers (namely, the H-index or G-index) and the others relate to the impact of the papers (namely, the A-index or M-index) in a researcher's or research center's productive core (5). Thus, it is suggested to use a combination of all scientometrics indicators for evaluation purposes (M-index and R-index, or of the M-index and the AR index) (17). Another study also suggested using M-index with other H-type variants such as G and R indicators for scientometric studies

(21). Furthermore, many research centers were just ranked in the M-index category. The mean value of the overlap of M with other indicators was also lower than the values of other indicators in both databases. This confirms our suggestion that this index should be used with other indicators for scientometrics purposes.

The ranks of IBRCs were more stable in WoS compared to Scopus. In Scopus, when we ranked research centers according to different indicators, considerable changes were observed in the ranking of some research centers. For instance, Medical Biology Research Center of Kermanshah UMSs (ranked 6th with the value of 12 for M-index) moved down on the basis of R-index (ranked 19th) while Institute for Environmental Research of Tehran UMSs (ranked 9th with the value of 12 for M-index) moved up on the basis of other four indicators and ranked among the top 10 research centers. Although the same situation was seen in WOS, the ranks of IBRCs were more stable in WoS compared to Scopus. For instance, the overlap between the top 10 research centers in A and G was 90% in WOS, while this was 30% in Scopus. It may be argued that the ranking of research centers in WoS is more reliable than Scopus, as journals index in Scopus is influenced by many variables including more indexed Iranian journals (both in Persian and English). Moreover, this may be due to the fact that WoS is a more established and accepted citation database than Scopus and the fact that WOS does not index Persian journals.

Limitations

Although there were many international ranking systems, this study considered scientometrics indicators because we aimed to concentrate only on the scientific production of the studied research centers via the output of the two mentioned citation databases. Moreover, we could consider effective factors including budget, number of staff/researchers, rank of faculties, policies, international collaboration and external

grants on the studied indicators. However, due to the lack of enough information in research centers, the high workload and time limitations, we were not able to study those factors. In future studies, it is suggested to categorize the research centers into top, middle and low ranked categories and analyse the findings according to these categories. Further investigation is required to explore the relationship between the citation patterns and areas of research in biomedical research centers.

Conclusion

Most of the highly ranked research centers were affiliated to top ranked universities in Iran such as Tehran, Iran, Tabriz and Mashhad UMSs. All aforementioned indicators are important for ranking bibliometrics studies as they refer to different attributes of scientific output and citation aspects. However, we suggest using the M-index for the comparison of research centers with the equal G, A, R and H values.

Ranks of IBRCs according to scientometrics indicators were more stable in WoS compared to Scopus. The mean values of all indicators were higher in Scopus compared to WoS. Scientometrics is usually used for ranking universities and research institutes according to their research outputs. Other scientometrics indicators should also be considered in ranking research centers. Furthermore, more indicators for the qualitative and quantitative evaluation of researches are needed to rank researchers and research centers with outstanding scientific output.

Acknowledgments

This study was supported by School of Health and Information Science, Iran University of Medical Sciences in 2012.

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Appendix 1

Table 10. Number of publications, citations and the values of scientometrics indicators for Iranian Biomedical Research Centers in Scopus, between 1991-2010

No	IBRCs	Medical University or institution name	Publications	percent	Citations	percent	Scientometrics indicators				
							H	G	A	R	M
1	Drug Applied Research Center	Tabriz	396	7.24	1322	7.78	16	21	23.06	19.21	1.23
2	Royan Institute	JahadDaneshgahi	314	5.74	1300	7.65	19	28	35.21	25.87	1.36
3	Biotechnology Research Center	Tehran	286	5.23	1005	5.91	15	25	32.80	22.18	1.50
4	Biotechnology Research Center	Pasteur Institute of Iran	195	3.57	555	3.27	13	17	19.69	16.00	1.08
5	Pharmaceutical Research Center	Mashhad	175	3.20	830	4.88	16	21	24.19	19.67	1.78
6	Medicinal and natural Products Chemistry Research center	Shiraz	169	3.09	589	3.47	11	17	22.72	15.81	1.57
7	Iranian Blood Transfusion Organization	-	162	2.96	400	2.35	10	15	20.30	14.25	1.11
8	Neuro Sciences Research Center	Shahid Beheshti	149	2.72	669	3.94	11	17	20.82	15.13	1.22
9	Biotechnology Research Center	Tabriz	138	2.52	236	1.39	8	9	10.63	9.22	1.60
10	Mums Biotechnology Research Center	Mashhad	136	2.49	414	2.44	11	15	18.82	14.39	1.38
11	Razi Vaccine and Serum Research Institute	JahadDaneshgahi	135	2.47	247	1.45	7	12	16.43	10.72	0.15
12	Medicinal Plants Research Center	Tehran	133	2.43	412	2.42	11	18	24.09	16.28	1.10
13	Medical Biology Research Center	Kermanshah	130	2.38	506	2.98	12	15	17.25	14.39	1.71
14	Shiraz Institute For Cancer Research Center	Shiraz	129	2.36	515	3.03	11	17	21.54	15.39	1.10
15	Research Center for Science AND Technology in Medicine	Tehran	127	2.32	139	0.82	6	8	11.33	8.25	1.00
16	Health Research Center	Baqiyatallah	121	2.21	236	1.39	7	11	13.86	9.85	0.78
17	Physiology Research Center	Kerman	120	2.19	181	1.06	5	9	13.00	8.06	0.45
18	Immunology Research Center	Mashhad	114	2.08	395	2.32	12	17	22.67	16.49	1.50
19	Nuclear Medicine Research Center	Tehran	111	2.03	122	0.72	5	7	8.00	6.32	2.50
20	Research Center for pharmaceutical nanotechnology	Tabriz	109	1.99	359	2.11	10	16	21.60	14.70	1.67
21	Pharmaceutical Research Center	Isfahan	105	1.92	227	1.34	9	11	13.00	10.82	1.50
22	Food and Drug Laboratory Research Center	Iran Health Ministry	101	1.85	335	1.97	10	16	22.00	14.83	2.00
23	Molecular biology Research Center (Research Center for Molecular Biology)	Baqiyatallah	98	1.79	155	0.91	6	8	10.33	7.87	0.86
24	Medical Nanotechnology Research Center	Tehran	96	1.76	447	2.63	12	17	21.50	16.06	2.40
25	Genetics Research Center	Social Welfare and Rehabilitation Sciences	90	1.65	661	3.89	14	22	104.25	20.42	1.40
26	Center For Environment Research Center	Tehran	88	1.61	411	2.42	9	18	31.67	16.88	1.50
27	Sbmu pharmaceutical sciences research center	Shahid Beheshti	86	1.57	272	1.60	10	13	15.90	12.61	0.91
	Nuclear Medicine Research center	Tehran	83	1.52	157	0.92	5	10	16.40	9.06	0.45
29	Molecular Immunology Research Center	Tehran	74	1.35	689	4.05	10	25	57.20	23.92	1.00
30	Physiology Research Center	Ahvaz	72	1.32	102	0.60	5	6	7.20	6.00	1.00

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31	Pharmaceutical Research Center	Shiraz	70	1.28	220	1.29	7	11	15.42	10.39	1.00
32	Cellular and molecular biology research center (cell biology research center)	Shahid Beheshti	69	1.26	214	1.26	7	11	15.14	10.30	1.17
33	Cellular and Molecular Research Center	Iran	64	1.17	178	1.05	7	11	15.71	10.49	0.78
34	Medical Education Research Center	Isfahan	59	1.08	155	0.91	7	11	15.14	10.30	1.40
35	National public health management Center	Tabriz	57	1.04	99	0.58	5	6	7.60	6.16	0.83
36	Janbazan Medical and Engineering Research center	Bonyadshahid and omoorlsargaran	56	1.02	140	0.82	6	9	11.33	8.25	1.20
37	Microbiology Research Center	Pasteur Institute of Iran	56	1.02	164	0.96	8	9	10.37	9.11	0.67
38	Pharmaceutical Research Center	Tehran	56	1.02	198	1.16	9	12	13.33	10.95	1.50
39	Reproductive Research Center	JahadDanesghahi	55	1.01	42	0.25	3	4	5.00	3.87	0.75
40	Physiology Research Center	Isfahan	53	0.97	113	0.66	6	8	10.83	8.06	1.00
41	Physiology Research Center	Semnan	50	0.91	104	0.61	6	8	10.00	7.75	0.75
42	Immunology Research Center	Iran	50	0.91	108	0.64	6	8	8.83	7.28	1.00
43	Razi Pharmaceutical Research Center	Iran	43	0.79	268	1.58	6	15	35.33	14.56	0.60
44	Pharmaceutics Research Center	Kerman	37	0.68	57	0.34	3	6	11.67	5.92	0.75
45	National Research Center Medical Sciences	Iran Health Ministry	34	0.62	146	0.86	6	11	17.00	10.10	0.60
46	Monoclonal Antibody Research Center	JahadDanesghahi	31	0.57	32	0.19	4	4	4.75	4.36	1.00
47	Medical Ethics and History Of Medicine Research Center	Tehran	29	0.53	23	0.14	3	3	3.67	3.32	0.60
48	Pharmacological Research Center Of medicinal plants	Mashhad	29	0.53	117	0.69	6	10	14.00	9.17	1.20
49	Health policy Research Center	Shiraz	23	0.42	63	0.37	3	7	18.00	7.34	0.75
50	Cellular and Molecular Research Center	ShahreKord	21	0.38	24	0.14	3	4	5.33	4.00	0.50
51	Drug Design AND Development Research Center	Tehran	19	0.35	8	0.05	2	2	3.50	2.65	1.00
52	Behavioral Sciences Research Center	Shahid Beheshti	19	0.35	56	0.33	5	6	6.20	5.57	0.71
53	Virology Research Center	Shahid Beheshti	17	0.31	55	0.32	5	7	8.60	6.55	0.83
54	Nutrition Research Center	Tabriz	16	0.29	21	0.12	2	4	8.00	4.00	0.33
55	Traditional medicine and material medica research Center	Shahid Beheshti	15	0.27	7	0.04	2	2	2.50	2.24	0.40
56	Cellular and Molecular Research Center	Zahedan	15	0.27	31	0.18	3	5	8.00	4.90	0.75
57	Medical Nanotechnology Research Center	Shahid Beheshti	14	0.26	7	0.04	7	7	2.50	2.24	0.67
58	Medicinal Plants Research Center	JahadDanesghahi	13	0.24	100	0.59	3	10	32.00	9.80	0.38
59	Traditional and Complementary Medicine Research Center	Mazandaran	11	0.20	1	0.01	1	1	1.00	1.00	1.00
60	Reference Laboratories Of Iran Research Center	Iran Health Ministry	11	0.20	5	0.03	1	1	2.00	1.41	0.25
61	Research Center for Health Sciences	Hamadan	10	0.18	36	0.21	4	6	8.00	5.66	0.80
62	Cellular and Molecular Research Center	Kordestan	10	0.18	1	0.01	1	1	1.00	1.00	0.33
63	Proteomics Research Center	Shahid Beheshti	10	0.18	0	0.00	0	0	0.00	0.00	0.00
64	Molecular Medicine Research center	Hamadan	9	0.16	214	1.26	5	9	42.20	14.53	1.00
65	Cellular and Molecular Biology Research Center	Mazandaran	8	0.15	12	0.07	2	3	4.00	2.83	0.50

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66	Knowledge Utilization Research Center	Tehran	8	0.15	2	0.01	1	1	2.00	1.41	0.50
67	Research Center for Children Health	Tabriz	7	0.13	7	0.04	2	2	2.50	2.24	0.67
68	Cellular and Molecular Biology Research Center	Babol	7	0.13	2	0.01	1	1	2.00	1.41	0.33
69	Research Center for Health Sciences	Mazandaran	6	0.11	17	0.10	2	4	8.00	4.00	0.40
70	Cellular and Molecular Research Center	Urmia	6	0.11	0	0.00	0	0	0.00	0.00	0.00
71	Phytochemistry Research Center	Shahid Beheshti	5	0.09	1	0.01	1	1	1.00	1.00	0.50
72	Medical Image and Signal Processing Research Center	Isfahan	5	0.09	0	0.00	0	0	0.00	0.00	0.00
73	Biotechnology Research Center	Bushehr	4	0.07	0	0.00	0	0	0.00	0.00	0.00
74	Research Institute for Islamic AND Complementary Medicine	Iran	4	0.07	26	0.15	2	4	12.00	4.90	0.67
75	Histomorphometry and stereology Research Center	Shiraz	4	0.07	0	0.00	0	0	0.00	0.00	0.00
76	Center Of Basic Research Infection Disease	Shiraz	3	0.05	0	0.00	0	0	0.00	0.00	0.00
77	Zahedan Health Promotion Research Center	Zahedan	3	0.05	3	0.02	1	1	2.00	1.41	0.33
78	Cellular and Molecular Research Center	Ahvaz	3	0.05	0	0.00	0	0	0.00	0.00	0.00
79	Community-based Participatory Research (CBPR)	Tehran	3	0.05	0	0.00	0	0	0.00	0.00	0.00
80	Health Economic Research Center	Isfahan	3	0.05	0	0.00	0	0	0.00	0.00	0.00
81	Molecular Medicine Research center	Arak	3	0.05	1	0.01	1	1	1.00	1.00	0.50
82	Medicinal Plants Research Center	Ahvaz	2	0.04	3	0.02	1	1	2.00	1.41	0.20
83	Medicinal Plants Research Center	ShahreKord	2	0.04	1	0.01	1	1	1.00	1.00	0.50
84	Health Related Social and Behavioral Sciences Research Center	Shahrood	2	0.04	0	0.00	0	0	0.00	0.00	0.00
85	Reproductive Infertility Biology And biotechnology Research center	JahadDaneshgahi	2	0.04	12	0.07	2	2	6.00	3.46	0.40
86	Medicinal Plants Research Center	Yasouj	1	0.02	0	0.00	0	0	0.00	0.00	0.00
87	Pharmaceutical Research Center	Mazandaran	1	0.02	0	0.00	0	0	0.00	0.00	0.00
88	Social Determinants of Health Research Center	Social Welfare and Rehabilitation Sciences	1	0.02	0	0.00	0	0	0.00	0.00	0.00
89	Ethics Law Medicine	Shahid Beheshti	1	0.02	4	0.02	1	1	4.00	2.00	1.00
90	Sport Physiology Research Center	Baqiyatallah	1	0.02	9	0.05	1	1	9.00	3.00	0.33
91	Anti-microbial Resistance Research Center	Iran	1	0.02	1	0.01	1	1	1.00	1.00	1.00
Total			5469		16996		478	715	1128.92	685.92	73.14
Mean			60.09		186.76		5.17	7.85	12.41	7.54	0.80

Table 11. Number of publications, citations and the values of scientometrics indicators for Iranian Biomedical Research Centers in-WoS between 1991-2010

No	IBRCs	Medical University or institution name	Publications	percent	Citations	percent	Scientometrics indicators				
							H	G	A	R	M
1	Drug Applied Research Center	Tabriz	408	17.24	1156	16.70	15	20	22	18.17	1.50
2	Royan Institute	JahadDaneshgahi	362	15.30	1197	17.29	19	26	31.32	24.39	1.36
3	Iranian Blood Transfusion Organization	-	180	7.61	352	5.08	10	16	23.7	15.39	0.48
4	Biotechnology Research Center	Tabriz	125	5.28	280	4.04	8	11	12.75	10.10	1.60
5	Pharmaceutical Research Center	Mashahd	113	4.78	742	10.72	17	21	24.59	20.42	1.89
6	Research Center for pharmaceutical nanotechnology	Tabriz	110	4.65	334	4.82	9	14	19.33	13.19	1.80
7	Biotechnology Research Center	Pasteur Institute of Iran	93	3.93	146	2.11	7	10	13	9.54	1.00
8	Medical Biology Research Center	Kermanshah	86	3.63	364	5.26	10	14	16.2	12.73	1.43
9	Mums Biotechnology Research Center	Mashahd	85	3.59	319	4.61	9	13	16.78	12.61	1.13
10	Immunology Research Center	Mashhad	78	3.30	239	3.45	2	2	3	2.45	1.00
11	Center For Environment Research Center	Tehran	78	3.30	220	3.18	8	11	13	10.20	1.33
12	Physiology Research Center	Kerman	75	3.17	133	1.92	5	8	12	7.75	0.83
13	Medical Nanotechnology Research Center	Tehran	63	2.66	480	6.93	12	19	27.25	18.08	2.40
14	Cellular and molecular biology research center (cell biology research center)	Sahid Beheshti	43	1.82	153	2.21	8	11	12.625	10.05	1.33
15	Pharmaceutics Research Center	Mashahd	37	1.56	96	1.39	6	9	11.83	8.43	1.20
16	Medical Education Research Center	Isfahan	34	1.44	33	0.48	3	4	5.67	4.12	0.75
17	Molecular Immunology Research Center	Tehran	33	1.39	71	1.03	5	7	9.6	6.93	1.25
18	Biotechnology Research Center	Tehran	33	1.39	48	0.69	4	5	7.25	5.39	0.80
19	Physiology Research Center	Isfahan	33	1.39	22	0.32	2	3	3.5	2.65	0.50
20	Physiology Research Center	Semnan	30	1.27	54	0.78	4	7	10.5	6.48	0.67
21	Molecular biology Research Center (Research Cenmter for Molecular Biology)	Baqiyatallah	28	1.18	26	0.38	3	4	5	3.87	0.75
22	Sbmu pharmaceutical sciences research center	Shahid Beheshti	23	0.97	53	0.77	4	7	10.75	6.56	0.67
23	Pharmaceutics Research Center	Kerman	23	0.97	28	0.40	2	5	10.5	4.58	0.67
24	Janbazan Medical and Engineering Research center	Bonyadshahid and omoorIsargaran	20	0.85	32	0.46	3	5	9	5.20	0.60
25	Health Research Center	Baqiyatallah	19	0.80	27	0.39	4	4	4.5	4.24	0.67
26	Pharmaceutical Research Center	Isfahan	19	0.80	44	0.64	4	6	8.25	5.74	0.80
27	Razi Herbal Medicines Research Center	Lorestan	18	0.76	11	0.16	1	3	7	2.65	0.33
28	Medicinal Plants Research Center	Tehran	17	0.72	68	0.98	5	8	13	8.06	0.83
29	Pharmaceutical Research Center	Mazandaran	14	0.59	23	0.33	3	4	4.67	3.74	1.00
30	Immunology Research Center	Iran	13	0.55	9	0.13	9	13	17	12.61	1.13

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31	Behavioural Sciences Research Center	Shahid Beheshti	8	0.34	49	0.71	4	6	8.5	5.83	0.67
32	Physiology Research Center	Ahvaz	8	0.34	0	0.00	0	0	0	0.00	0.00
33	Medicinal Plants Research Center	JahadDaneshgahi	8	0.34	65	0.94	3	8	21.33	8.00	0.38
34	Virology Research Center	Shahid Beheshti	8	0.34	1	0.01	1	1	1	1.00	0.50
35	Phytochemistry Research Center	Shahid Beheshti	7	0.30	2	0.03	1	1	2	1.41	0.50
36	Medical Nanotechnology Research Center	Shahid Beheshti	6	0.25	13	0.19	2	3	4	2.83	0.67
37	Nuclear Medicine Research Center	Tehran	4	0.17	2	0.03	1	1	2	1.41	0.17
38	Biotechnology Research Center	Bushehr	4	0.17	0	0.00	0	0	0	0.00	0.00
39	National Research Center Medical Sciences	Iran Health Ministry	4	0.17	23	0.33	3	4	7.67	4.80	0.30
40	Food and Drug Laboratory Research Center	Iran Health Ministry	3	0.13	0	0.00	0	0	0	0.00	0.00
41	Medicinal Plants Research Center	ShahreKord	3	0.13	1	0.01	1	1	1	0.00	0.33
42	Center Of Basic Research Infection Disease	Shiraz	2	0.08	0	0.00	0	0	0	0.00	0.00
43	Research Center for Health Sciences	Mazandaran	2	0.08	2	0.03	1	1	2	1.41	1.00
44	Zahedan Health Promotion Research Center	Zahedan	1	0.04	3	0.04	1	1	3	1.73	0.25
45	Nutrition Research Cenetr	Tabriz	1	0.04	2	0.03	1	1	2	1.41	0.33
46	Research Center for Children Health	Tabriz	1	0.04	0	0.00	0	0	0	0.00	0.00
47	Health policy Research Center	Shiraz	1	0.04	0	0.00	0	0	0	0.00	0.00
48	Medicinal and natural Products Chemistry Research center	Shiraz	1	0.04	0	0.00	0	0	0	0.00	0.00
49	Neuro Sciences Research Center	Shahid Beheshti	1	0.04	0	0.00	0	0	0	0.00	0.00
50	Total		2366	408		1156	220	318	440.06	307.15	36.8
51	Mean		48.28	362		1197	4.38	6.36	8.80	6.14	0.73