Original Article
http://mjiri.iums.ac.ir
Medical Journal of the Islamic Republic of Iran (MJIRI)

Med J Islam Repub Iran. 2023 (3 Apr);37.31. https://doi.org/10.47176/mjiri.37.31

Assessing the Research Performance of the Iranian Medical Academics and Universities: A Bibliometric Analysis

Javad Khanali[1], Mohammad-Reza Malekpour[1], Ali-Asghar Kolahi[1]*

Received: 3 May 2022 Published: 3 Apr 2023

Abstract

Background: Implementing bibliometric indicators is the most prominent way to quantify the current status of research performance. This study aimed to map out the research performance of Iranian medical academics and universities in 2020 and determine its progress from 2016.

Methods: Data were extracted from the Iranian scientometric information database and universities' scientometric information database. Then, the data were analyzed to provide descriptive statistics of bibliometric indicators. Besides, the association between the research productivity of academics or universities with their background characteristics was investigated using Mann-Whitney U, Kruskal-Wallis, and chi-square tests.

Results: Iranian medical academics had extensive research productivity from 2016 to 2020, leading to 2.5-fold increase in their median number of papers. The research productivity was heterogeneous among the academics, with an H-index ranging from 0 to 98, and a median of 4. The research productivity was different by gender, academic position, general field of study, and academic degree. The class 1 universities had a higher quantity in research performance; however, there was no difference in quality-related indices comprising citations per paper ratio and high impact publication rate (SJR Q1) among different university classes. The median international collaboration rate has followed a growing trend in recent years and was 17% in 2020.

Conclusion: There is a remarkable growth in the research productivity of Iranian academics and universities. Iranian research community historically had rare international research collaborations; however, promising growth is shown in this regard. To maintain the growth in research productivity, the country should increase research and development expenditure, address gender disparities, supply universities that are lagging behind, facilitate further international collaboration, and support national journals to be indexed in the international citation databases.

Keywords: Bibliometrics, Iranian Universities, Medical Research, Research Activity, Research and Development, Scientometrics

Conflicts of Interest: *None declared*
Funding: *This study was financially supported by the Social Determinants of Health Research Center, Shahid Beheshti University of Medical Sciences under code 43002730.*

Cite this article as: Khanali J, Malekpour MR, Kolahi AA. Assessing the Research Performance of the Iranian Medical Academics and Universities: A Bibliometric Analysis. *Med J Islam Repub Iran*. 2023 (3 Apr);37:31. https://doi.org/10.47176/mjiri.37.31

Introduction

Higher education in Iran (Persia) dates back to centuries before the birth of Jesus. The first educational complex in the form of a university in Persia was founded in the third century AD in Ahvaz, the Academy of Gundishapur (1).

Corresponding author: *Dr Ali-Asghar Kolahi, a.kolahi@sbmu.ac.ir*

[1] Social Determinants of Health Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

↑What is "already known" in this topic:
Many studies have been performed on the scientific performance of the Iranian academic community. However, the studies have been primarily local or performed on samples rather than being country-wide and include the whole research community. Country-wide and regular assessment of the academic community in terms of research productivity is mandatory for decision makers to plan for the research sector.

→What this article adds:
The research productivity of the Iranian academic community exponentially grew from 2016 to 2020. There is a disparity in the research productivity of men and women, which is in line with the global gender gap in science due to underlying local and historical factors. A promising growth is shown in the international research collaborations of the Iranian research community.

Gundishapour had a medical school and one of the largest hospitals in the ancient world. In this hospital, renowned physicians and scholars of age from various nationalities were employed to teach, do research, and treat patients (2). Modern higher education was brought to Iran with the Dar ul-Funun school of higher education in Tehran in 1851. In 1934, the University of Tehran was established and became the mother university, after which some other universities were established in major cities, including Tabriz, Ahvaz, Isfahan, and Shiraz (1).

Research productivity is a generally accepted and one of the most critical factors that must be considered to assure quality in higher education institutions (3). Research drives science and technology progress and is a central component of sustainable development (4). Nowadays, Iran is following an upward trend in research productivity. The country ranks twenty-first worldwide and second in the Middle East in terms of the number of scientific publications (5). Moreover, the number of articles by Iranian researchers indexed in the Web of Science Core Collection has increased by 18 folds, from 1750 papers in 2000 to 31,619 papers in 2014 (4, 6). These accomplishments were made despite the fact that Iran's research and development budget amounts to just 0.5% of its gross domestic product (GDP) compared with 1.4% for industrialized nations (4, 7).

The scientometric analysis is the most prominent way to recognize and quantify the current status and progress of research performance of an academic, university, or country (3, 8, 9). The result of such scientometric analysis is also helpful for decision-making on research budgeting and promotion (6). The internet proliferation has contributed dramatically to the more widespread use of bibliometric indices to quantify research productivity. Several databases have also been created that index a significant percentage of the published material and categorize it by the researcher, affiliation, scientific area, and so forth. These databases allow the extraction of useful information for evaluating the research outputs rapidly (3, 10).

This study aimed to map out the research productivity of Iranian medical academics from 2016 to 2020. The study also assesses the research productivity, international collaboration, self-citation behavior, and rate of publishing in high-quality journals in Iranian medical universities. These objectives were achieved through extracting and analyzing data from 2 national scientometric information databases. The study, which is the first of its kind to our knowledge, is conducted on the entire research community rather than just a few selected members and is conducted across the entire nation. The study also covers the research productivity of both medical academics and universities in association with their individual- and institutional-level variables to elucidate and discuss heterogeneities, lagging points, strengths, and barriers. Providing such a thorough view of research quantity and quality will provide a solid basis for policy-makers to plan for the research sector.

Methods

Data Source

The data on academics was extracted from the Iranian scientometric information database (11). The study enrolled all the 20,734 permanent academic staff in 2020 and 16,165 permanent academic staff in 2016, which were registered in the database. The data on the number of academics and research indicators of Iranian medical universities were extracted from the universities' scientometric information database (12). The study only included 45 out of the 54 Iranian medical universities, which had a profile in the Scimago institution ranking. Data on the other 9 universities were excluded (13). These databases are linked to the Scopus database and regularly update their scientometric data on the scientometric performance of Iranian medical academics and universities.

Study Design

The research performance of Iranian medical academics was investigated in December 2020 and 2016 through a scientometric approach. The variables were categorized as individual-level background characteristics and bibliometric indicators indicating the research performance of the academics. The background variables comprised name, gender, general field of study, academic position, and academic degree. First, the descriptive statistics of the study population were presented by the background variables. Then, bibliometric indicators such as the number of published papers, number of citations, citations per paper ratio, self-citation rate, G-index, and H-index were investigated in all academics and each of the defined subgroups. The relationship between background characteristics and bibliometric indicators and the correlation between the bibliometric indicators were analyzed. In order to examine for progressions, the 2016 data were handled, examined, and analyzed similarly to the 2020 data.

The research productivity of Iranian medical universities was investigated in 2020. The universities were categorized into 3 university classes according to the categorization of the developing, monitoring, and evaluation council in the Ministry of Health and Medical Education based on the organizational structure of the universities. The number of academics, number of published papers, number of citations, citations per paper ratio, self-citation rate, H-index, H5-index, international collaboration rate, and Scimago Journal Ranking quartile 1 (SJR Q1) were investigated and presented for each university. Then, the relationship between university classes and bibliometric indicators, and the correlation between the bibliometric indicators were analyzed. The definition of the key bibliographic indicators assessed in the study is presented in Table 1.

Statistical Analysis

Shapiro-Wilk W and Kolmogorov-Smirnov tests showed that none of the bibliographic indicators follow a normal distribution among academics and universities. Descriptive statistics were used to present the scientometric indicators, including median and quartiles. Mann-Whitney U and Kruskal-Wallis nonparametric tests were

Table 1. Definitions of research indicators used in the study

N	Indicators	Definition
1	Published papers	The number of Scopus-indexed published articles in scientific journals by individuals or universities
2	Citations	The number of Scopus-indexed citations to published papers by individuals or universities
3	Citations per paper	The number of citations to the total number of published papers
4	Self-citation rate	The share of citations of individuals or universities done by the researchers or universities themselves
5	G-index	The largest number g such that the top g articles by citation received (together) at least g^2 citations
6	H-index	The largest number h such that h publications have at least h citations
7	H5-index	The largest number h such that h publications have at least h new citations in the last 5 years
8	International collaboration rate (IC)	The contribution of articles with international cooperation to total published articles
9	Scimago journal rank quartile 1 articles (SJR Q1)	The share of published article in 25% of the top journals in each subdiscipline classified by SJR

used to study the relationship between academic background characteristics or university classes and scientometric indicators. The Pearson's correlation test was implemented to test the correlation between bibliographic indices. Chi-square analysis was used to test whether academic's background characteristics changed from 2016 to 2020. Data were presented as median (Q1; Q3). IBM SPSS statistics Version 22 software package was used for data analysis. Data visualization was performed using Tableau Desktop (Version 2020).

Results

Bibliometric Indicators in 2020

Of the 20,734 academics, about 58% were men. In terms of academic degrees, most academics (57%) were assistant professors, and only 12% of academics were professors. About 42% of the academics were in the field of medicine, and the Doctor of Medicine (MD) degree was the most frequent academic degree (37% of academics). The research performance of Iranian academics was highly heterogeneous. The number of published papers by Iranian academics ranged from 0 to 1298, with a median of 10. The citation number had a median of 50, a minimum of 0, and a maximum of 87,687. The H-index also ranged from 0 to 98, with a median of 4. The median (Q1; Q3) self-citation ratio was 1.4 (0; 6.3) and more than 95% of academics had a ratio lower than 20% (Table 2).

Research productivity was not similar among different groups regarding gender, academic position, general field of study, and academic degree. Men had a higher number of published papers, citations, citations per paper, self-citation rate, G-index, and H-index than women ($P < 0.001$) (Table 2). Approximately 11 % of women and 22% of men had an H-index of 10 or higher. In higher academic positions, the number of published papers, citations, citations per paper, self-citation rate, G-index, and H-index were higher (all the pairwise comparisons were statistically significant, $P < 0.001$). About 67% of professors had an H-index of 10 or higher; however, only 2% of instructors had such H-index. Academics in different fields of study and different academic degrees had a different number of published papers, citations, citations per paper, self-citation rate, G-index, and H-index ($P < 0.001$) (Table 2). However, pairwise comparisons showed similarities between some groups. For instance, medicine, paramedicine, and "other fields related to medical sciences" groups were similar in the number of papers, citations, citations per paper, G-index, and H-index. As another example, nursing and dentistry groups were similar in terms of citations, H-index and G-index. Among academic degrees, PhD by research group was similar to the PhD pharmacy group in all assessed indices.

Examining correlations between the number of published papers, citations, citations per paper, self-citation rate, G-index, and H-index revealed that each pair had a significant positive correlation, except the citations per paper and self-citation rate, which showed a nonsignificant correlation. The most remarkable correlation was between the H-index and G-index ($r = 0.931$; $P < 0.001$). The index with the strongest correlation with the number of published papers was H-index ($r = 0.848$; $P < 0.001$). In contrast, the number of citations had the strongest correlation with the G-index ($r = 0.76$; $P < 0.001$).

After removing articles with more than 100 authors (kilo-author articles), none of the 6 indices assessed in academics changed significantly ($P > 0.3$ for all comparisons). Besides, the median of academics' number of papers, H-index, and G-index did not change, and other medians changed minimally (eg, the median of the number of citations changed from 50 to 49). Conversely, when the data were restricted to the top 10% of academics by H-index, all indices except the number of papers decreased significantly ($P < 0.05$).

The Change in Bibliometric Indicators From 2016 to 2020

The number of academics increased by more than 4000 people from 2016 to 2020. The proportion of female academic increased in the 2016-2020 period from 39.8% to 42%, χ^2 (1, N = 36,899) = 18.3; $P < 0.001$. The proportion of professors also increased from 7.5% to 11.8%, χ^2 (1, N = 36,899) = 183.5; $P < 0.001$. From 2016 to 2020, the median number of published papers increased from 4 to 10, the median citations per paper increased from 1.5 to 4.8, and the median H-index increased from 1 to 4. A similar increase was observed in all gender, academic positions, the field of study, and academic degree subgroups (Table 3).

Research Performance of Iranian Universities up to 2020

A total of 45 universities in 3 classes participated in the study (Table 4). The median (Q1; Q3) number of academics was 281 (209; 483). The median (Q1; Q3) of the H-

Table 2. The research indicators of Iranian academics in 2020

Academics' characteristics	N	Published papers (n)	Citations (n)	Citations per paper	Self-citation rate (%)	G-index	H-index
		Median (Q1; Q3)	Median (Q1; Q3)	Median (Q1; Q3)	Median (Q1; Q3)	Median (Q1; Q3)	Median (Q1; Q3)
All Academics	20734	10 (3, 26)	50 (7, 190)	4.8 (2, 8.8)	1.4 (0, 6.3)	6 (2, 12)	4 (1, 8)
Gender							
Female	8717	8 (2, 19)	32 (4, 124)	4 (1.4, 7.8)	0.5 (0, 5.8)	5 (1, 10)	3 (1, 6)
Male	12017	13 (4, 32)	70 (12, 252)	5.4 (2.3, 9.4)	1.9 (0, 6.8)	7 (2, 14)	4 (2, 9)
Academic position							
Professor	2458	52 (31, 91)	465 (218, 1045)	9.1 (6.4, 12.7)	4.9 (2.4, 9.1)	19 (13, 28)	12 (8, 17)
Associate professor	4379	23 (14, 37)	133 (66, 295)	6.1 (3.9, 9.6)	3.4 (0.9, 7.8)	10 (7, 16)	6 (4, 10)
Assistant professor	11866	6 (2, 14)	23 (3, 85)	3.7 (1, 7.6)	0 (0, 5.4)	4 (1, 8)	2 (1, 5)
Instructor	2031	2 (1, 5)	5 (0, 22)	1.6 (0, 4.6)	0 (0, 0)	1 (0, 4)	1 (0, 2)
General field of study †							
Public health & Epidemiology	1855	19 (7, 45)	106 (26, 395)	5.7 (3, 10.2)	3.8 (0, 9.4)	9 (4, 17)	6 (3, 11)
Nursing	1418	4 (1, 10)	11 (1, 42)	2.4 (0.5, 5)	0 (0, 4.1)	2 (1, 5)	2 (1,3)
Paramedical	1420	9 (3, 22)	38 (7, 144)	4.2 (1.7, 7.7)	2.5 (0, 8.6)	5 (2, 11)	3 (1, 6.7)
Medicine	8706	9 (2, 22)	35 (5, 128)	4 (1.4, 7.2)	0 (0, 3.1)	5 (1, 10)	3 (1, 6)
Dentistry	1734	3 (1, 9)	10 (0, 45)	3 (0, 6)	0 (0, 1.8)	2 (0, 6)	1 (0, 4)
Pharmacy	780	25 (11, 58)	279 (82, 803)	10.9 (6.7, 15.8)	5.7 (2.4, 11)	15 (8, 26)	9 (5, 15)
Basic Sciences	3973	21 (10, 44)	173 (62, 448)	8.1 (5, 12)	6.1 (2.3, 12.2)	12 (7, 19)	7 (4, 12)
Other fields related to medical sciences	491	8 (3, 20)	33 (7, 110)	3.7 (1.6, 7.5)	2.5 (0, 9)	5 (2, 9)	3 (1, 6)
Unrelated fields to medical sciences	357	1 (0, 5)	0 (0, 14)	0 (0, 3.1)	0 (0, 0)	0 (0, 3)	0 (0, 2)
Academic degree ‡							
Doctor of Philosophy (Ph.D.)	7187	18 (8, 39)	120 (35, 349)	6.6 (3.6, 10.6)	5.3 (1.5, 11.2)	10 (5, 17)	6 (3, 10)
Doctor of Pharmacy	794	25 (11, 56)	278 (79, 799)	11.1 (6.7, 16.1)	5.7 (2.5, 10.9)	15 (8, 25)	9 (5, 15)
MD Specialty Degree	7728	8 (2, 21)	33 (4, 125)	4 (1.3, 7.2)	0 (0, 3)	5 (1, 10)	3 (1, 6)
Doctor of Dental Medicine	1820	3 (1, 9)	10 (0, 47)	3 (0, 6.7)	0 (0, 1.9)	2 (0, 6)	1 (0, 4)
MD (GP)	20	10 (2.2, 23)	119 (8, 489)	10.9 (3.6, 16.1)	1.2 (0, 4.1)	9.5 (2.2, 19.5)	7 (2, 10.2)
M.Sc.	2043	2 (1, 5)	5 (0, 22)	1.6 (0, 4.6)	0 (0, 0)	1 (0, 2)	1 (0, 4)
Ph.D. by Research	230	29 (16, 57)	264 (107, 667)	8.6 (5.7, 13.9)	7.7 (3.2, 15.2)	15 (10, 23)	9 (6, 14)
Postdoctoral Fellowship	910	14 (6, 33)	66 (17, 203)	4.7 (2.2, 7.8)	1.1 (0, 3.7)	1 (0, 4)	4 (2, 8)

† The paramedical study field indicates healthcare workers who provide clinical services to patients under the supervision of a physician. The field includes areas such as obstetrics, occupational therapy, physical therapy, nutrition, Radiotherapy, and so forth. The other fields related to medical sciences include health IT, medical education, food industry engineering, library and information science, and so forth that are related to medical science field; however, they cannot be categorized in the defined field. The unrelated fields include language teaching, Islamic studies, computer science, physical education, and so forth, which are unrelated to life science.

‡ The MD Specialty Degree refers to academic members with specialty or sub-specialty in medicine. The postdoctoral fellowship refers to academics graduated in MD that continued their training as a postdoctoral fellow. Two of the academics whose degrees were Doctor of Veterinary Medicine were excluded from this part.

index and H5-index was 55 (42; 76) and 37 (32.5; 54.5), respectively. Tehran (H-index = 188), Shahid Beheshti (H-index= 137), and Isfahan (H-index= 117) universities of medical sciences (UMSs) were the 3 highest universities by H-index (Table 4). However, the highest universities by H5-index were Tehran (H5-index = 105), Mashhad (H5-index = 82), and Iran (H5-index = 77) UMSs. Both H-index and H5-index were significantly higher in class 1 universities, while they were similar between the class 2 and 3 universities. The median H-index was 105 for class 1 universities, 55.5 for class 2 universities, and 41 for class 3 universities. The median H5-index was 65 for the class 1 universities, 36.5 for the class 2 universities, and 34 for the class 3 universities.

The median (Q1; Q3) number of papers was 2500 (1482; 6393), and the median (Q1; Q3) number of citations was 25,340 (14,148; 71,124). The median (Q1; Q3) of the citations per paper number was 9.55 (8.51; 11.49). Tehran (papers = 54,263; citations = 687,375) and Shahid Beheshti (papers = 30,500; citations = 311,718) UMSs were the 2 highest in the number of papers and citations among universities. Iran UMSs was the third university in the number of papers (papers = 18,155), and Mashhad UMS was the third in citations (citations = 179,246). In citations per paper ratio, Maragheh (citation/paper = 27.33), Alborz (citation/paper = 24.69), and Qom (citation/paper = 23.53) UMSs, all of which are class 3 universities, were the highest (Table 4). The number of papers was significantly higher in higher classes (median of 16,344 in class 1; 2828 in class 2; and 1828 in class 3).

Table 3. The comparison of research indicators among Iranian academics between 2016 and 2020

Academics' characteristics	Published papers (n) Median (Q1; Q3)		Citations per paper Median (Q1; Q3)		H-index Median (Q1; Q3)	
	2016	2020	2016	2020	2016	2020
All Academics	4 (1, 11)	10 (3, 26)	1.5 (0, 4.2)	4.8 (2, 8.8)	1 (0, 3)	4 (1, 8)
Gender						
Female	3 (0, 8)	8 (2, 19)	1 (0, 3.5)	4 (1.4, 7.8)	1 (0, 3)	3 (1, 6)
Male	4 (1, 13)	13 (4, 32)	1.8 (0, 4.7)	5.4 (2.3, 9.4)	2 (0, 4)	4 (2, 9)
Academic Position						
Professor	24 (12, 51)	52 (31, 91)	7.1 (3, 10.3)	9.1 (6.4, 12.7)	6 (4, 12)	12 (8, 17)
Associate professor	12 (6, 19)	23 (14, 37)	3.2 (1.7, 6.5)	6.1 (3.9, 9.6)	3 (2, 5)	6 (4, 10)
Assistant professor	3 (0, 7)	6 (2, 14)	1 (0, 3.3)	3.7 (1, 7.6)	1 (0, 2)	2 (1, 5)
Instructor	1 (0, 3)	2 (1, 5)	0 (0, 1.3)	1.6 (0, 4.6)	0 (0, 1)	1 (0, 2)
General Field of Study†						
Public health & Epidemiology	5 (1, 12)	19 (7, 45)	1.7 (0, 3.5)	5.7 (3, 10.2)	2 (0, 3)	6 (3, 11)
Nursing	1 (0, 3)	4 (1, 10)	0 (0, 1.2)	2.4 (0.5, 5)	0 (0, 1)	2 (1,3)
Paramedical	2 (0, 7)	9 (3, 22)	1 (0, 3)	4.2 (1.7, 7.7)	1 (0, 2)	3 (1, 6.7)
Medicine	4 (1, 11)	9 (2, 22)	1.5 (0, 4)	4 (1.4, 7.2)	1 (0, 3)	3 (1, 6)
Dentistry	1 (0, 4)	3 (1, 9)	0 (0, 2.5)	3 (0, 6)	0 (0, 2)	1 (0, 4)
Pharmacy	13 (5, 34)	25 (11, 58)	7.2 (3.3, 10.9)	10.9 (6.7, 15.8)	5 (2, 10)	9 (5, 15)
Basic Sciences	8 (3, 17)	21 (10, 44)	3.5 (1.1, 7.7)	8.1 (5, 12)	3 (1, 5)	7 (4, 12)
Other fields related to medical sciences	3 (0, 8)	8 (3, 20)	0.7 (0, 2.8)	3.7 (1.6, 7.5)	1 (0, 3)	3 (1, 6)
Unrelated fields to medical sciences	0 (0, 2)	1 (0, 5)	0 (0, 0.7)	0 (0, 3.1)	0 (0, 1)	0 (0, 2)
Academic Degree‡						
Doctor of Philosophy (Ph.D.)	8 (3, 16)	18 (8, 39)	2.7 (0.9, 6.2)	6.6 (3.6, 10.6)	3 (1, 5)	6 (3, 10)
Doctor of Pharmacy	13 (5, 33)	25 (11, 56)	7.1 (3.3, 11)	11.1 (6.7, 16.1)	4.5 (2, 10)	9 (5, 15)
MD Specialty Degree	4 (1, 11)	8 (2, 21)	1.5 (0, 3.9)	4 (1.3, 7.2)	1 (0, 3)	3 (1, 6)
Doctor of Dentistry Medicine	1 (0, 4)	3 (1, 9)	0 (0, 2.5)	3 (0, 6.7)	0 (0, 2)	1(0, 4)
M.Sc.	1 (0, 3)	2 (1, 5)	0 (0, 1.3)	1.6 (0, 4.6)	0 (0, 1)	1 (0, 4)
Postdoctoral Fellowship	7 (2, 16)	14 (6, 33)	2 (0.7, 4.2)	4.7 (2.2, 7.8)	2 (1, 4)	4 (2, 8)

† The paramedical study field indicates healthcare workers who provide clinical services to patients under the supervision of a physician. The field includes areas such as obstetrics, occupational therapy, physical therapy, nutrition, Radiotherapy, and so forth. The other related fields include health IT, medical education, food industry engineering, library and information science, and so forth that are related science field or medical science field; however, they cannot be categorized in the defined field. The unrelated fields include language teaching, Islamic studies, computer science, physical education, and so forth, which are unrelated to life science.
‡ The MD Speciality Degree refers to academic members with specialty or sub-specialty in medicine. The postdoctoral fellowship refers to academics graduated in MD that continued their training as a postdoctoral fellow. Ph.D. by Research and MD (GP) groups were omitted from the table due to the low number of cases in 2016.
For all defined subgroups, differences between the years 2016 and 2020 were statistically significant with a P value of <0.001

The number of citations was also higher in class 1; however, it was similar between class 2 and 3 universities. In contrast, there was no difference between university classes in the citations per paper index (median of 10.66 in class 1; 9.26 in class 2; and 9.11 in class 3).

The median of the self-citation rate, international collaboration rate, and SJR Q1 article rate were 10%, 17%, and 24%, respectively. The highest universities in terms of self-citation rate was Shahrekord (rate = 32%), Tabriz (rate = 18%), and Mashhad (rate = 16%) UMSs. The self-citation rate was significantly higher in class 1 universities than in other classes. In international collaboration rate, the University of Social Welfare and Rehabilitation Sciences (rate = 31%), Marragheh UMS (27%), and Zabol UMS (27%) were the highest. The median international collaboration rate was the highest in class 3 universities (median, 19.5%); however, the differences between the 3 classes were not significant. Maragheh (rate = 47%), Tabriz (rate = 32%), Tehran (rate = 28%), and Shiraz (rate = 28%) UMSs were the highest in SJR Q1 rate index. In terms of SJR Q1 rate, class 1 universities were higher than class 2 universities, but other pairwise comparisons were not significant.

The number of academics in each medical university had strong positive correlations with the number of papers (r = 0.954; $P < 0.001$) and H-index (r = 0.948; $P < 0.001$). However, there are outliers for the rule, which is shown in Figure 1. The number of papers, citations, H-index, and H5-index had also strong positive correlations with each other (r >0.85; $P < 0.001$).

The horizontal axis shows the number of academics, the vertical axis shows the H-index, and the size of the bubbles is in proportion to the number of published papers of each university. The figure shows a strong correlation between the number of academics, number of papers, and H-index among Iranian universities of medical sciences (r > 0.9; $P < 0.001$ for each pairwise correlation). The bold gray line is the regression line, and the bounds of the regression confidence interval are shown in pale gray lines. Numbering is according to the order of universities in Table 4. Due to the low H-index, number 44, Torbat Heydarieh UMS, was left out of the analysis in order to reduce the plot's blank space and improve the contrast between the spots.

Discussion

The study revealed that the scientific performance of academics was remarkably diverse among different groups in terms of gender, academic position, general field of study, and academic degree (Table 2). Regarding gender, we showed men had more papers, citations, and citations per paper, H-index, and G-index than women, which is in accordance with a previous study (6).

Table 4. The research indicators of Iranian medical universities in 2020

	Name of University	Class†	No. of Academics (n)	Papers (n)	Citations (n)	H-index	H5-index	Citation per Paper	Self-Citation Rate (%)	IC‡ Rate (%)	SJR Q1‡ articles Rate (%)
1	Tehran University of Medical Sciences	1	1873	54263	687375	188	105	12.67	15	20	28
2	Shahid Beheshti University of Medical Sciences	1	1399	30500	311718	137	76	10.22	14	18	25
3	Mashhad University of Medical Sciences	1	948	14955	179246	115	82	11.99	16	23	25
4	Isfahan University of Medical Sciences	1	946	16344	167963	117	65	11.36	11	15	26
5	Iran University of Medical Sciences	1	992	18155	169169	103	77	9.32	9	20	25
6	Shiraz University of Medical Sciences	1	941	17865	173796	105	57	9.73	13	16	28
7	Tabriz University of Medical Sciences	1	867	15091	160937	104	62	10.66	18	24	32
8	Baqiyatallah Medical Sciences University	2	308	6836	90521	90	67	13.24	11	16	22
9	Mazandaran University of Medical Sciences	2	485	6360	81427	84	53	12.80	9	15	19
10	Ahvaz Jundishapur University of Medical Sciences	1	723	7764	74188	76	57	9.56	11	13	20
11	Kermanshah University of Medical Sciences	2	521	6675	71197	76	56	10.67	12	23	27
12	Medical University of Kerman	1	578	6426	71051	77	46	11.06	11	17	27
13	Alborz University of Medical Sciences	3	272	2089	51573	71	59	24.69	4	25	25
14	Shahrekord University of Medical Sciences	3	261	2632	25345	69	37	9.63	32	12	19
15	Arak University of Medical Sciences	2	271	2160	49104	63	40	22.73	4	15	22
16	Hamadan University of Medical Sciences	2	481	5421	51338	64	40	9.47	10	13	19
17	Kurdistan University of Medical Sciences	3	281	2500	43606	60	44	17.44	4	19	24
18	Babol University of Medical Sciences	2	348	3587	31627	57	36	8.82	9	13	17
19	Zahedan University of Medical Sciences	2	392	3137	32470	58	38	10.35	10	15	18
20	Lorestan University of Medical Sciences	2	302	2204	25077	58	41	11.38	15	15	20
21	Kashan University of Medical Sciences	2	246	2623	24808	55	42	9.46	13	18	26
22	Guilan University of Medical Sciences	2	450	3072	27132	54	36	8.83	7	15	21
23	Zanjan University of Medical Sciences	2	427	2639	23453	54	37	8.89	8	15	26
24	University of Social Welfare and Rehabilitation Sciences	2	158	3382	30675	56	28	9.07	10	31	24
25	Shahid Sadoughi University of Medical Sciences	2	429	4120	29701	56	36	7.21	10	14	20
26	Qom University of Medical Sciences	3	247	1606	37795	52	43	23.53	2	13	21
27	Urmia University of Medical Sciences	2	364	3017	24960	51	38	8.27	8	16	27
28	Qazvin University of Medical Sciences	2	263	2189	23103	47	32	10.55	6	21	21
29	Bushehr University of Medical Sciences	3	225	1459	15320	46	35	10.50	10	21	26
30	Ilam University of Medical Sciences	3	200	2042	16466	45	32	8.06	13	17	19
31	Semnan University of Medical Sciences	2	235	2308	15736	44	32	6.82	10	16	20
32	Birjand University of Medical Sciences	2	305	1728	13255	43	35	7.67	10	24	24
33	Ardabil University of Medical Sciences	2	300	1540	13494	42	31	8.76	10	18	23
34	Zabol University of Medical Sciences	3	130	1200	10752	44	40	8.96	14	25	24
35	Shahroud University of Medical Sciences	3	156	1143	13278	41	33	11.62	7	17	24
36	Maragheh University of Medical Sciences	3	57	780	21321	36	36	27.33	3	27	47
37	Hormozgan University of Medical Sciences	2	279	1649	14802	43	34	8.98	6	16	23
38	Yasuj University of Medical Sciences	3	197	1257	10123	41	32	8.05	10	22	26
39	Rafsanjan University of Medical Sciences	2	203	1285	15587	39	27	12.13	10	16	22
40	Gonabad University of Medical Sciences	3	114	944	8751	38	37	9.27	11	15	20
41	Sabzevar University of Medical Sciences	3	151	1072	7890	36	33	7.36	9	27	25
42	Aja University of Medical Sciences	3	215	1506	7985	35	22	5.30	6	11	19
43	Fasa University of Medical Sciences	3	97	869	6834	34	25	7.86	11	17	25
44	Torbat Heydarieh University of Medical Sciences	3	72	555	2720	22	21	4.90	11	21	22
45	North Khorasan University of Medical Sciences	3	215	825	5964	32	24	7.23	6	20	23

Universities were sorted from the highest in H-index to the lowest one.

†The three presented university classes in the study are defined by Developing, Monitoring and Evaluation council in the Ministry of Health and Medical Education, and is a categorization based on organizational structure of universities.

‡ abbreviations: IC, International collaboration; SJR, Scimago Journal Rank

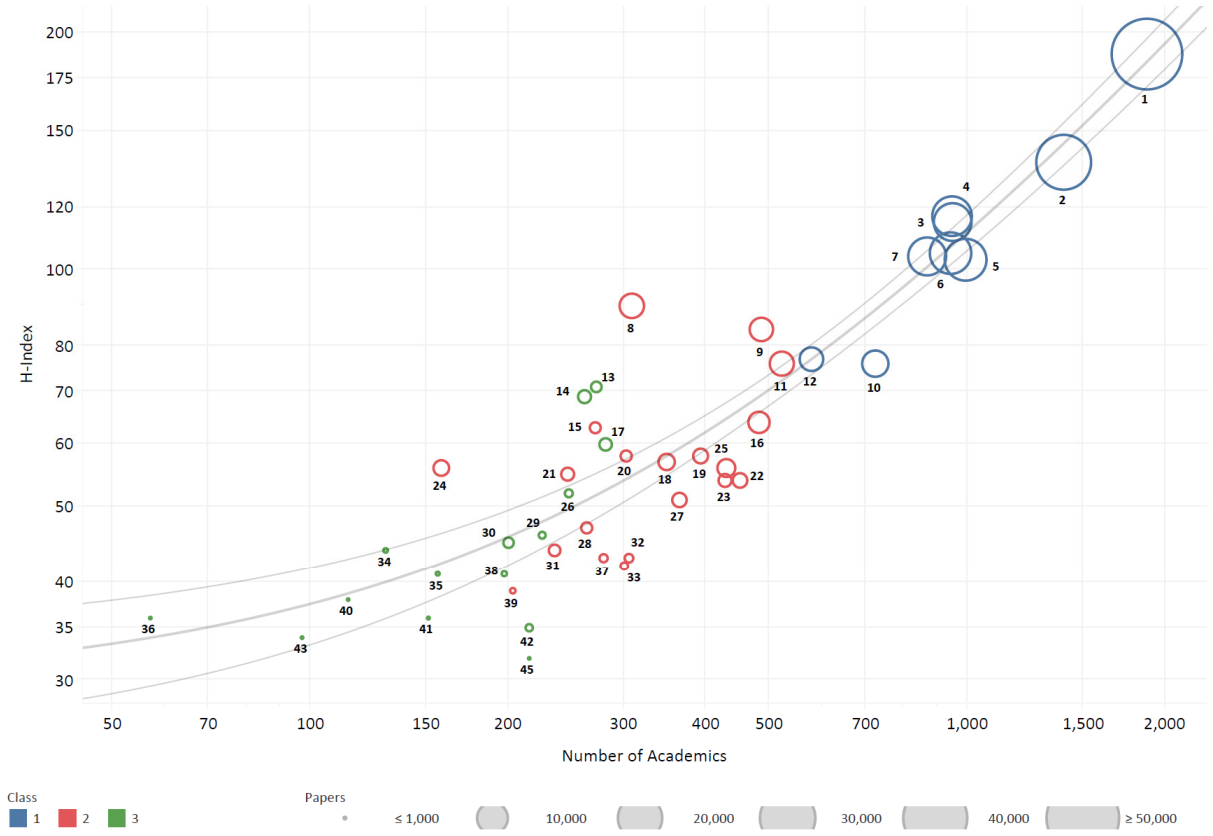

Figure 1. H-index, number of academics, and number of published papers in Iranian Medical Universities

This gender disparity could be due to the fact that the share of female faculty members is increasing in recent years; therefore, female academics may have lower work experience (4). Furthermore, the disparity between men and women could be partly explained by a global gender gap in science, which has underlying local and historical factors that subtly hinder women's access and advancement in science (14, 15). Among academic positions, professors had higher quality- and quantity-related scientometric indices. This outcome was anticipated since researchers at higher levels of the hierarchy have more significant responsibilities for supervision and leadership than do academics at lower ranks. Consequently, as the number of research projects an academic supervises increases, the number of published research papers bearing their name increases (3).

In terms of fields of study, academics in pharmacy had higher citations, citations per paper, H-index, and G-index than other fields; however, they were similar to academics in basic science in the number of papers. Besides, academics with doctor of pharmacy and PhD by research degrees were higher than others in the number of papers, citations, citations per paper, H-index, and G-index. Previous studies also reported the highest share of pharmacy field in the PubMed-indexed papers with Iran's affiliation and better quality-related research indicators for these papers (3, 7, 16). This difference could be due to the vast capacity of the field for research through laboratories. In contrast, some other fields take more time to conduct research and publish the results because they deal with the complexity of social networks. The result approves the essential role of field-weighted indices to compare the research outputs of 2 researchers with different fields of study.

The study showed a strong correlation between H-index and G-index among Iranian academics. H-index also had the strongest correlation with the number of papers; whereas, G-index had such correlation with the number of citations. This result indicates that these indexes do not replace each other but that they are complementary. We should also consider that these indicators are still immature, and further modifications and developments are still going on (17).

The research indicators of Iranian medical academics have remarkably increased from 2016 to 2020. This result is in accordance with previous reports on the exponential growth of Iranian research productivity in recent decades (4, 18, 19). Despite economic hardship and sanctions, Iran has been the first country in both the number of papers and citations since 2012 (4, 5). It is known that having a large number of universities, scientific indexed journals, and research publications, high GDP, and spending on research and development is substantial to research productivity. On the other side, this high research productivity will result in patents, high technology exports, and ultimately GDP (20, 21). However, almost 0.5% of Iran's GDP is allocated to research and development compared

with the world average of higher than 1.5%, and during the past 2 decades, research and development expenditure has increased only 0.1%. Therefore, it seems that increasing the expenditure on research and development is necessary to maintain previous achievements and growth (4).

The self-citation rate of more than 75% of Iranian academics was less than 6.3%. Self-citation in scientific work is logical and acceptable at a percentage of 10% to 20% (22). As a logical action, self-citation has some rationales, such as presenting previous research findings, improving the visibility of published works, making a work dynamic within the citation cycle, and validating and providing evidence for the research at hand. A self-citation may also result from the cumulative nature of individual studies, the need for personal gratification, or the value of self-citation as a rhetorical or tactical tool to pursue scientific authority and visibility. Considering that more than 95% of Iranian academics have a self-citation of lower than 20%, it could be concluded that Iranian academics use self-citation in a rational way. A previous study estimated a self-citation rate of 36.57% for Iran, which is higher than the global level, and concluded that Iranian academics use self-citation at a high level. However, the estimation was based on the SJR database, which presents self-citations for countries, not academics. This indicates that the database displays the number of publications that cite papers with a similar affiliation country, as opposed to citing papers with a similar author. Another notable result was the significant decrease in the number of citations, citations per paper, H-index, and G-index after removing kilo-author articles from the research profile of the first decile of academics by H-index. In contrast, removing kilo-author articles did not change scientometric indices in all academics. This difference indicates higher dependence of the research profile of top researchers on kilo-author articles. These articles are mostly collaborative articles conducted by international organizations such as the Institute for health metrics and evaluation, which conducts the GBD studies (23).

Among university classes, class 1 universities were higher in the number of papers, citations, H-index, H5-index, and self-citation rate than the other 2 classes. This is in accordance with a previous report on the research performance of Iranian universities (24). However, some quality-related indices—such as citations per paper and SJR Q1—did not show any meaningful difference among university classes, and even the highest universities in citations per paper were class 3 universities. The similarity of citations per paper among university classes was not declared by previous national studies and they did not compare citations per paper among the classes (6, 18, 24). One previous study, in contrast to our result, showed that SJR Q1 is higher in class 1 universities since they compared the number of SJR Q1 papers not the share of these papers to total documents (24). Class 3 universities, including Maragheh, Alborz, and Qom UMSs, are all small universities with fewer than 2100 articles in Scopus. However, each of these universities had 1 or 2 academic staff with a high number of papers in high-impact journals and a citations per paper ratio higher than 40, which has increased the average citations per paper and SJR Q1 of these universities. The high citations per paper and SJR Q1 in these academic staff can be partially due to their collaboration with GBD studies.

The median SJR Q1 article rate in Iranian medical universities was 24% in 2020, and all class 1 universities had an SJR Q1 rate higher than 25%. Therefore, it could be concluded that the share of SJR Q1 articles to the total number of articles is high. This SJR Q1 rate is much higher than previous reports of a 17% SJR Q1 rate in 2015 (24), which indicates an improvement in the quality of publications in recent years. The same increase from 2015 was also observed in the international collaboration. Only 5 universities had a lower international collaboration rate than 13.5%, which is the average calculated in 2015 for the international collaboration rate in Iranian research outputs (24). However, a recent article estimated that only 2.5% of published articled resulted from international collaboration, which is much lower than the 13.5% estimated in 2015 and 17% estimated by our study (6). The difference could be due to sampling bias since they chose 744 academics as a proxy of 19,023 academic stuff. Historically, the low rate of international research collaborations in medical universities has been a national challenge. The increase in international collaborations shown in the study is prospering, since collaborations benefit not only the researchers but also organizations, besides increasing research quality (25-27).

Conclusion

In conclusion, the study showed the growing trend of research productivity of Iranian academic staff and universities either by quantity or quality. However, barriers are shown to be gender disparity in favor of men staff, limited success or interest for research in some fields of study, some structurally disorganized universities for research, and low albeit increasing international collaboration. In order to achieve sustainable growth in research productivity, the country should increase research and development expenditure, support frontiers researchers and institutions, supply research institutions that are lagged behind, facilitate further international collaboration, and support national journals to be indexed in international citation databases.

List of Abbreviations

GDP: Gross Domestic Product
IC: International Collaboration
ISID: Iranian Scientometric Information Database
R & D: Research and Development
SJR Q1: Scimago Journal Rank quartile 1
UMS: University of Medical Science
USID: Universities' Scientometric Information Database

Authors' Contributions

J.K. analyzed data and wrote the manuscript. M.R.M. cleaned data, draw the figure, and revised the manuscript. A-A.K. proposed the idea, extracted the data, supervised the study, and revised the manuscript. All authors read and

approved the final manuscript.

Acknowledgment

Authors wish to express their gratitude to everyone who helped in the study.

Availability of Data and Material

The datasets used and analyzed during the present study are available from the corresponding author on reasonable request. These data are also available at https://isid.research.ac.ir/ and https://usid.research.ac.ir/.

Conflict of Interests

The authors declare that they have no competing interests.

References

1. Abolghassemi Fakhree MA, Jouyban A. Scientometric analysis of the major Iranian medical universities. Scientometrics [Internet]. 2011 Jan 1 [cited 2021 Jul 5];87(1):205–20. Available from: http://en.wikipedia.org/wiki/List_
2. Mirzaee AA, Mohammadi S. A Study of the Growth and Flourish of Gundishapur Scientific Centre in Sasanian Period. J Res Hist Med [Internet]. 2015;4(4):225–34. Available from: https://rhm.sums.ac.ir/article_42957.html
3. Kazakis NA, Diamantidis AD, Fragidis LL, Lazarides MK. Evaluating the research performance of the Greek medical schools using bibliometrics. Sci 2013 982 [Internet]. 2013 May 21 [cited 2021 Jul 5];98(2):1367–84. Available from: https://link.springer.com/article/10.1007/s11192-013-1049-x
4. Akhondzadeh S, Ebadifar A, Eftekhari MB, Falahat K. Medical science and research in Iran. Arch Iran Med [Internet]. 2017 [cited 2021 Jul 5];20(11):665–72. Available from: https://pubmed.ncbi.nlm.nih.gov/29480730/
5. SCImago Journal and Country Rank. SJR - International Science Ranking [Internet]. Vol. 25, Https://Www.Scimagojr.Com/Countryrank.Php. 2019 [cited 2021 Jul 5]. p. 2526–34. Available from: https://www.scimagojr.com/countryrank.php?order=it&ord=desc
6. Sadeghi-Bazargani H, Bakhtiary F, Golestani M, Sadeghi-Bazargani Y, Jalilzadeh N, Saadati M. The research performance of Iranian medical academics: A National Analyses. BMC Med Educ [Internet]. 2019 Dec 3 [cited 2021 Jul 5];19(1):1–6. Available from: https://pubmed.ncbi.nlm.nih.gov/31796038/
7. Abdollahi M. Perspectives of science in Iran [Internet]. Vol. 9, Iranian Journal of Pharmaceutical Research. 2010 [cited 2021 Jul 5]. p. 207–8. Available from: https://pubmed.ncbi.nlm.nih.gov/24363729/
8. Meo SA, Almasri AA, Usmani AM. Research productivity of Pakistan in medical sciences during the period 1996-2012. Eur Rev Med Pharmacol Sci [Internet]. 2013 [cited 2021 Jul 6];17(21):2839–46. Available from: https://pubmed.ncbi.nlm.nih.gov/24254549/
9. Meo SA, Hassan A, Usmani AM. Research progress and prospects of Saudi Arabia in global medical sciences. Eur Rev Med Pharmacol Sci [Internet]. 2013 [cited 2021 Jul 6];17(24):3265–71. Available from: https://pubmed.ncbi.nlm.nih.gov/24379054/
10. Khanali J, Malekpour MR, Kolahi AA. Improved dynamics of sharing research findings in the COVID-19 epidemic compared with the SARS and Ebola epidemics. BMC Public Health [Internet]. 2021 Dec 1 [cited 2021 Jul 22];21(1). Available from: https://pubmed.ncbi.nlm.nih.gov/33422049/
11. Iranian Scientometric Information Database [Internet]. [cited 2021 Jul 6]. Available from: https://isid.research.ac.ir/
12. Universities Scientometric Information Database [Internet]. [cited 2021 Jul 6]. Available from: https://usid.research.ac.ir/
13. Research Rankings - Iran 2020 [Internet]. [cited 2021 Jul 5]. https://www.scimagoir.com/rankings.php?country=IRN&ranking=Research&year=2014
14. Larivière V, Ni C, Gingras Y, Cronin B, Sugimoto CR. Bibliometrics: Global gender disparities in science. Nat 2013 5047479 [Internet]. 2013 Dec 11 [cited 2021 Jul 11];504(7479):211–3. Available from: https://www.nature.com/articles/504211a
15. Marini G, Meschitti V. The trench warfare of gender discrimination: evidence from academic promotions to full professor in Italy. Sci 2018 1152 [Internet]. 2018 Mar 9 [cited 2021 Jul 11];115(2):989–1006. Available from: https://link.springer.com/article/10.1007/s11192-018-2696-8
16. Moeini R, Gorji N, Ghods R, Mozaffarpur SA. Quantitative and Qualitative Assessment of Persian Medicine Articles Indexed in Pubmed by the End of 2015. J Babol Univ Med Sci [Internet]. 2017 [cited 2022 Aug 15];19(1):21–6. Available from: http://jbums.org/article-1-6285-en.html
17. Costas R, Bordons M. Is g-index better than h-index? An exploratory study at the individual level. Scientometrics [Internet]. 2008 Jun 19 [cited 2021 Jul 11];77(2):267–88. Available from: https://akjournals.com/view/journals/11192/77/2/article-p267.xml
18. Mohammadhassanzadeh H, Samadikuchaksaraei A, Shokraneh F, Valinejad A, Abolghasem-Gorji H, Yue C. A bibliometric overview of 30 years of medical sciences productivity in Iran. Arch Iran Med [Internet]. 2010 [cited 2021 Jul 11];13(4):313–7. Available from: https://pubmed.ncbi.nlm.nih.gov/20597565/
19. Mansoori P. 50 years of Iranian clinical, biomedical, and public health research: A bibliometric analysis of the Web of Science Core Collection (1965-2014). J Glob Health. 2018;8(2).
20. Meo SA, Usmani AM. Impact of R&D expenditures on research publications, patents and high-tech exports among european countries. Eur Rev Med Pharmacol Sci [Internet]. 2014 [cited 2021 Jul 11];18(1):1–9. https://pubmed.ncbi.nlm.nih.gov/24452936/
21. Meo SA, Masri AA Al, Usmani AM, Memon AN, Zaidi SZ. Impact of GDP, Spending on R&D, Number of Universities and Scientific Journals on Research Publications among Asian Countries. PLoS One [Internet]. 2013 Jun 20 [cited 2021 Jul 11];8(6):66449. Available from: /pmc/articles/PMC3688761/
22. Yaminfirooz M, Tirgar A. Self-citation in Iran in comparison with other countries. Acta Inform Medica [Internet]. 2019 [cited 2021 Jul 12];27(4):259–62. https://pubmed.ncbi.nlm.nih.gov/32055093/
23. Singh Chawla D. Hyperauthorship: global projects spark surge in thousand-author papers. Nature [Internet]. 2019 [cited 2021 Jul 12]; Available from: https://www.nature.com/articles/d41586-019-03862-0
24. Eftekhari MB, Sobhani Z, Eltemasi M, Ghalenoee E, Falahat K, Habibi E, et al. Research ranking of Iranian universities of medical sciences based on international indicators: An experience from I.R. of Iran. Arch Iran Med [Internet]. 2017 [cited 2021 Jul 11];20(11):673–9. Available from: https://pubmed.ncbi.nlm.nih.gov/29480731/
25. Khor KA, Yu LG. Influence of international co-authorship on the research citation impact of young universities. Scientometrics [Internet]. 2016 Jun 1 [cited 2022 May 3];107(3):1095–110. Available from: https://link.springer.com/article/10.1007/s11192-016-1905-6
26. Van Den Besselaar P, Hemlin S, Van Der Weijden I. Collaboration and competition in research [Internet]. Vol. 25, Higher Education Policy. 2012 [cited 2022 Apr 2]. p. 263–6. Available from: www.palgrave-journals.com/hep/
27. Malekpour M-RR, Abbasi-Kangevari M, Azadnajafabad S, Ghamari S-HH, Rezaei NN, Rezazadeh-Khadem S, et al. How the scientific community responded to the COVID-19 pandemic: A subject-level time-trend bibliometric analysis. Radfar A, editor. PLoS One [Internet]. 2021 Sep [cited 2021 Oct 18];16(9):e0258064. Available: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0258064