Bibliometric Analysis and Visualization of Scientific Publications of Iran University of Medical Sciences during 1980-2020

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Abstract

In this research, all the scientific publications of the Iran University of Medical Sciences (IUMS) from 1980 to 2020 are studied using bibliometric analysis and scientific network visualization. This research applied quantitative research using bibliometrics and visualization of scientific publications. The research population included all the scientific publications of IUSM on the Web of Science Core Collection (WOSCC) from 1980 to 2020. Data from the WOSCC were extracted via the advanced search by searching the Iran University of Medical Sciences in the affiliation field. Microsoft Excel and VOSviewer were used for data analysis. First, the frequency distribution of the scientific publications was identified. Then, the level of international collaborations was analyzed. Finally, the citation clusters of researchers' scientific publications and keyword co-occurrence were examined. IUMS had 9950 documents indexed in the WOSCC. Malekzadeh jointly ranked first as the most prolific author. The Iranian Red Crescent Medical Journal, with 207 articles, has the highest number of articles. All highly-cited papers were published in high-level Q1 journals. The highest collaboration rate at a national level was with the Tehran University of Medical Sciences. Internationally, IUMS's researchers had the highest collaboration with authors from the United States, the United Kingdom, Canada, and Australia, respectively. Term clustering demonstrated five main clusters: pharmacological studies, epidemiological studies, general & and internal medicine, meta-analysis and systematic review, and Immunological studies. The methods and techniques of bibliometrics and visualization are optimal for depicting and analyzing the scientific status of researchers, publications, journals, universities, countries, and even the world. The current study can be a model for analyzing

bibliometric indices of other universities and research institutes in Iran and elsewhere.

Keywords: Bibliometric, Citation Analysis, Visualization, Iran University of Medical Sciences, WOSCC, Co-Word, Scientific Publications.

Introduction

An essential criterion for determining the scientific status of any country is the number of scientific productions by its universities and research institutions (Doulani, 2020). Universities and higher education institutions are among the main roads to scientific publication, and publishing scientific articles is an integral part of their scientific life, efficiency, and productivity (Chan, Seow & Tam, 2009). As such, examining the quantity and quality of the scientific publications of universities, especially at the international level, is a major criterion in evaluating their scientific performance (Mokhtari, Mirezati, Saberi, Fazli & Kharabati-Neshin, 2019), which is of great interest to scientific planners and policymakers (Jiang, Tan, Robinson, Liu & Chen, 2014). Annually, thousands of research articles are published worldwide, which can be evaluated in terms of topic, author, country, research institute, and university at different levels and in line with policymakers' goals (Mokhtari et al., 2019). There are different methods to perform these evaluations, one of the most important of which is bibliometrics and scientific visualization.

Bibliometrics identifies possible trends and gaps in knowledge and plays a major role in scientific and technological management and decision-making (Romanelli, Fujimoto, Ferreira & Milanez, 2018). Bibliometrics involves quantitatively analyzing documents and texts based on citation data from scientific publications (Ackermann, 2005). This method is a tool for assessing the status of scientific publications at the level of journal, institution, country, or subject (Mokhtari et al., 2019) and demonstrating scientific connections between authors, institutions, and countries (Özköse and Gencer, 2017). As a research field, bibliometrics analyzes scientific publications, citations, and references (Merigó, Gil-Lafuente & Yage, 2015).

In the past, researchers employed simple bibliometric analyses for journal articles, research fields, universities, and institutions. However, bibliometric analysis and visualization have been simultaneously performed as a hybrid method to conduct better bibliometric analyses. Currently, numerous software packages are available to facilitate bibliometric analysis, and this new approach to bibliometrics is defined as the visualization of literature or information (Milojevic, 2009; Mokhtari et al., 2019). Merely paying attention to the number of scientific publications (quantitative index) cannot express the success and progress of researchers and research institutions; instead, scientific publications should also be analyzed regarding their impact or use by other researchers at the national and international level. Consequently, citation-based indicators are regarded as qualitative evaluation criteria ; Garfield, 1983, 1993) and demonstrate the extent of scientific publications' use and effectiveness and visibility (Rogers, Hendee & Orton, 2006).

Scientific mapping aims to discover the relationships and phenomena latent in the structure of science through visual images that cannot be easily demonstrated otherwise. In other words, some connections and phenomena in the structure of science are abstractly understandable but cannot be physically viewed. This is why scientific mapping usually uses size and color symbols to indicate concepts and their significance (Şenel & Demir, 2018). Visualization

represents importance or impact using size (e.g., large symbols for major thematic classifications) or color symbols (e.g., light colors for less important symbols) (van Eck & Waltman, 2010, van Eck Waltman, Noyons & Bute, 2010). Visualization also uses thresholds to determine the categories that appear on the map. Overall, it is a powerful tool for studying the structure and dynamics of scientific publications, complementing bibliometrics, and aiding the evaluation and analysis of scientific outputs (Doulani, 2020; Mokhtari et al., 2019; Özköse & Gencer, 2017).

Any university or research institute should continuously evaluate its past and present status to plot a prospects map (Mokhtari et al., 2019). Iran University of Medical Sciences (IUMS), with ten faculties, 18 hospitals and medical training centers, 47 research centers, a central library, and more than 20 faculty and hospital libraries, is one of the three universities in Tehran affiliated with the Iranian Ministry of Health and Medical Education (MoHME) (Iran University of Medical Sciences, 2022). Thus, determining its status among competitors can contribute to its evidence-based planning. From the beginning of 1980 to the end of 2020, 9950 documents have been published by authors affiliated with this university on the Web of Science Core Collection (WOSCC). This merits a comprehensive study to analyze this university's publications in the WOSCC in this period. Such a study can determine the past, present, and future status of the scientific publications of IUMS and their strengths and weaknesses while aiding university policymakers. The findings can also serve as a model for analyzing the scientific performance of other universities and educational institutions worldwide.

Literature Review

The techniques utilized in bibliometrics generally fall into four categories: a) bibliometric analysis in different subject areas, b) bibliometric analysis of scientific publications of different countries/regions, c) bibliometric analysis of scientific journals, and d) bibliometric analysis of universities and research institutes. Given that the present study belongs to the fourth group, some of the most relevant and recent studies on this topic are briefly reviewed below.

In 2022, Janen (2022) examined the University of Jaffna, Sri Lanka's research output from 2000 to 2019. A continuous growth after 2014 was observed in this university's publications. Co-authorship was dominant in the University of Jaffna's articles; many of these publications belonged to multidisciplinary sciences. The University of Jaffna researchers collaborated with researchers from other countries, especially the UK (59 articles). Vennu, Alenazi, Abdulrahman, and Bindawas's (2021) study also demonstrated that articles increased from 73 in 2008 to 721 in 2017. The largest articles originated in universities in the country's capital (Riyadh; n = 2257) and King Saud University (n = 1538). Furthermore, about 80% of the articles were published in journals with an impact factor of less than 3 (Vennu et al., 2021).

Doulani (2020) examined the largest women's university in Iran and the Middle East (Alzahra University). This study performed a bibliometric and visualization of the scientific research of the said university in the Scopus database. Both the trend of publications and the trend of receiving citations were upward. Moreover, 70% of the highly cited articles of this university were published in Q1 journals. Most of the collaborations of Alzahra University researchers were with the University of Tehran nationally and internationally, with researchers from the US, Canada, and Germany, respectively. The scientific publications of this university belonged to five main subject clusters: a) chemistry, b) physics, c) biology, d) psychology-educational sciences, and e) accounting, management, and computer sciences (Doulani, 2020).

Mokhtari et al. (2019) also reviewed 3753 articles by researchers affiliated with Hamadan University of Medical Sciences (Iran) indexed in Scopus. The trend of publications and receiving citations was upward, and all highly cited articles of this university were published in Q1 journals. The greatest cooperation of this university's researchers was with Tehran University of Medical Sciences nationally and internationally, with the US, UK, and Switzerland, respectively. Besides, the clustering results showed four main research fields (epidemiological, laboratory, pharmaceutical, and microbiological studies) (Mokhtari et al., 2019).

A significant trend was observed in the publications of the investigated universities. The most prolific institution was the Bandung Institute of Technology (7828 articles). Moreover, most Indonesian researchers collaborated with Japanese researchers on 3907 articles (Darmadji, Prasojo, Kusumaningrum & Andriansyah, 2018). Dwivedi (2017) also examined 16,556 articles indexed in the WOSCC. The trend of publications witnessed significant growth after 2005. The most cooperation of university researchers was with the Council of Scientific & Industrial Research nationally on 443 articles and internationally, with the US and Germany, respectively. Most of the articles were on chemistry, followed by physics. Tsafe, Chiya, and Aminu (2016) reviewed the scientific publications of 165 librarians from 16 universities in Nigeria. The total number of articles was 373, most on information technology. More than half of the studied subjects (56.9%) had more than one article. Moreover, male librarians (81.2%) published more papers than female librarians (18.8%).

Siwach and Kumar (2015) reviewed 1,247 articles by Maharshi Dayanand University researchers indexed in Scopus. The dramatic growth of articles since 2009 has been remarkable. Most articles were on chemistry (36.49%), biochemistry and genetics (22.05%), and pharmacy and pharmacology (20.53%), respectively. In 2014, Sweileh, Zyoud, Al-Khalil, Al-Jabi, and Sawalha reviewed 791 articles by researchers from An-Najah National University, Palestine, indexed in Scopus. The most prolific journal was *Acta Crystallographica Section E Structure Reports Online*. Most articles (n = 146) were on medicine, and the most cooperation was with the US on 94 articles. Maharana and Sethi (2013) studied 170 articles published by this university's researchers in WOSCC. The Astrophysics and Space Science journal published the most chemistry articles and was the most prolific journal. The most cooperation was with the Indian Institute of Technology nationally and with US researchers internationally.

In summary, with the development of ICT and the increase in electronic resources, the volume of scientific publications in research articles and journals has accelerated (Arunachalam & Markanday, 1981; Haiqi & Yuhua, 1997). Since an institution's research activities are reflected through its publications, it is vital to assess the scientific performance of research institutions and universities. The current research results can inform the research centers and researchers affiliated with IUMS about this university's national and international status in terms of scientific publications in WOSCC and the effectiveness and impressionability of its scientific publications. This method will determine the trend of university publications and subject areas. Knowledge about the quantity and quality of academic studies can also help research and financial policies by university policymakers, the MoHME, and affiliated research centers. Identifying the core researchers and journals in this field can also serve as a guide and road map for research managers, policymakers, and young researchers to participate in national and international studies and delineate the future road map of the university in a purposeful and evidence-based manner. Finally, the present study can provide a model for analyzing the

scientific performance of other universities and research institutions in Iran and elsewhere regarding their scientific publications.

Materials and Methods

This research applied quantitative, cross-sectional, and descriptive research using scientometrics and visualization of scientific publications. The research population included all the scientific publications of IUSM on WOSCC from 1980 to 2020 (9950 documents), where at least one of the authors had an organizational affiliation with IUMS or its research institutions. This is why not adding the results of studies before 1980 and after 2020. Data from the WOSCC were extracted via the *advanced search* by searching the *Iran University of Medical Sciences* in the field of *organizational affiliation* (OG=Affiliation) and limiting the publication period to 1980-2020 in the Science Citation Index-Expanded (SCIE). The retrieved records were extracted via the *Export* section of WOSCC with the *Tab-delimited file* option and saved as *txt* files. Microsoft Excel and VOSviewer were used for data analysis. The ESCI profile cannot be used in this context. SSCI and AHCI profiles are related to the fields of social sciences, arts, and humanities; Since the university reviewed in this article is a university of medical sciences and is active in the field of medical sciences, checking the mentioned profiles will not contribute much to the results of the study. The data were extracted on May 13-15, 2022.

First, the frequency distribution of the scientific publications of researchers affiliated with IUMS was identified. Then, the most prolific and highly cited researchers and journals and the highly cited articles were detected. Next, the level of international collaborations of the researchers, core journals, and average citations received at the author and journal level were analyzed. Finally, the citation clusters of researchers' scientific publications and keyword co-occurrence were examined. After completing this stage, data visualization and scientific mapping of the scientific publications of IUMS were performed in different fields while emphasizing the convergence relationships between specialties in scientific publications. Visualization and graphical representation of information by displaying data in clusters and specifying the convergence between fields was also performed in VOSviewer using weighted and directed graphs. The maps and relationships between specialties were analyzed based on social network analysis indicators. Finally, using VOSviewer, the history of the development of keywords was visualized.

Results
Frequency Distribution of Published Documents & Received Citations

In the studied period, IUMS has had 9950 documents indexed in the WOSCC. The oldest document is an article entitled *Pulmonary complications in lead miners* by Masjedi, Estineh, Bahadori, Alavi, and Sprince (1989), which has received five citations. From the beginning of 1980 to the end of 1988, no article by IUMS researchers was published in this database. Moreover, no article was published in 1990, 1992, or 1994. Most documents are original articles (n=7344; 73.80%). After original articles, the three most frequent types of articles include review articles (n=1095; 11%), meeting abstracts (n=892; 8.96%), and letters (n=379; 3.8%). The fewest articles were published in 1989 and 1991 (1 article each), whereas most were published in 2020 (n = 2041, 20.51%). More than half of the articles were published in the last four years reviewed (5864 articles, 58.93% from the beginning of 2017 to the end of 2020). The

publication trend was upward and growing (Figure 1).
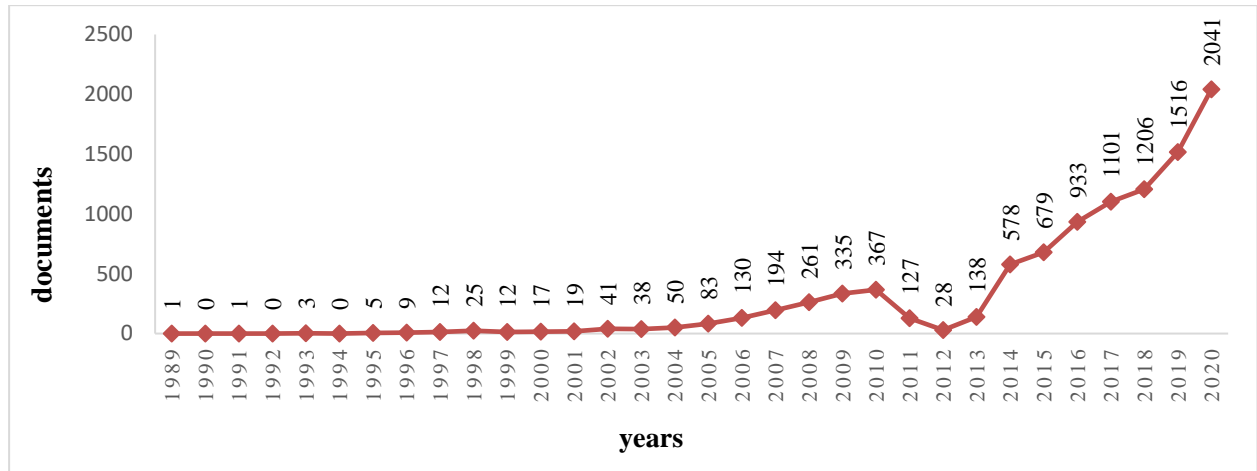
Figure 1: Frequency distribution of documents published by IUMS (1989-2020)

These articles received 174,362 citations in total and 165,926 citations without self-citations. The H-index of the articles was 118, and the average citation per article was 17.52. Of the 9950 articles, only 1682 (16.90%) received no citations, while the rest had at least one citation. Furthermore, 156 articles received more than 100 citations. The highest number of citations belonged to 2017 (n=29755; 17.06%), 2018 (n=29187; 16.73%), and 2016 (n=23550; 13.50%), respectively (Figure 2).
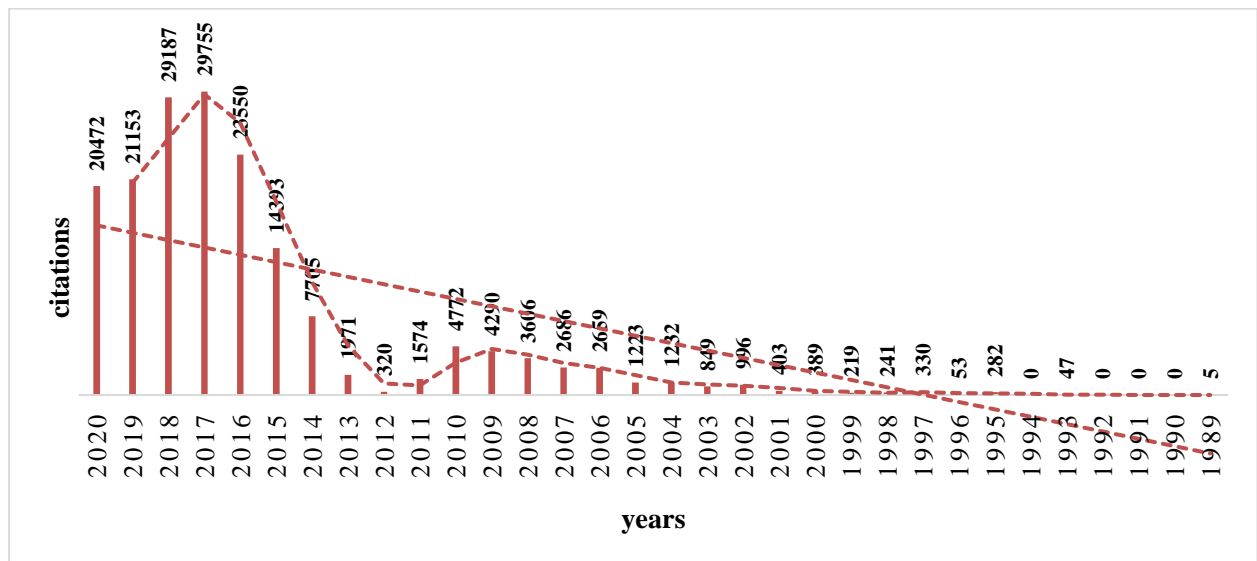
Figure 2: Frequency distribution of citations received by published papers of IUMS (1989-2020)

Highly Prolific and Highly Cited Authors & Journals

Table 1 presents information on ten prolific authors. Malekzadeh and Moradi-Lakeh jointly ranked first (135 articles each), and Fereshtehnejad and Qorbani, respectively, ranked second and third with 129 and 128 articles each. Malekzadeh (49140), Moradi-Lakeh (47088), and Qorbani (42485) had the highest number of received citations, respectively. The highest number of self-citations (n = 423) belonged to Moradi-Lakeh and the lowest (34 citations) to Shidfar (Table 1).

Table 1
Top 10 most productive and influential authors

Row	Author's name	No. of articles	Total Citations (rank)	Self-citations	Citation/document (rank)	h-index (rank)
1	Malekzadeh, Reza	135	49140 (1)	382	364 (1)	60 (1)
2	Moradi-lakeh, Maziar	135	47088 (2)	423	348.8 (2)	52 (2)
3	Fereshtehnejad, Seyed Mohammad	129	35252 (4)	303	273.27 (4)	38 (4)
4	Qorbani, Mostafa	128	42485 (3)	325	331.91 (3)	51 (3)
5	Esrafili, Ali	125	2864 (7)	106	22.91 (7)	32 (5)
6	Rezaei, Nima	121	5255 (5)	52	43.43 (5)	26 (6)
7	Keyvani, Hossein	120	1208 (9)	114	10.07 (9)	18 (8)
8	Joghataei, Mohammad Taghi	119	2254 (8)	49	18.94 (8)	26 (6)
9	Shidfar, Farzad	114	1137 (10)	34	9.97 (10)	19 (7)
10	Mozafari, Masoud	111	3049 (6)	197	27.47 (6)	32 (5)

Table 2 presents ten core and prolific journal articles published by IUSM researchers. The *Iranian Red Crescent Medical Journal,* with 207 papers (2.08%), and *Obesity Surgery,* with 63 articles (0.63%), published the highest and lowest articles on this list, respectively. The highest number of citations received belonged to the *Journal of Cellular Physiology* (2003), *Archive of Iranian Medicine* (1532), and *Iranian Red Crescent Medical Journal* (1341), respectively. Moreover, 5 out of 10 core journals (5%) were Q4, and three journals on this list were Q3.

Table 2
Top 10 Core Journals publishing IUMS Articles

Row	Journal's name	Articles (N= 9950) N	%	Total Citations (rank)	Citation/document (rank)	Impact Factor 2020 (rank)	Category Quartile	ISSN	Publisher (Country)
1	Iranian Red Crescent Medical Journal	207	2.08	1341 (3)	6.48 (6)	0.611 (9)	Q4	2074-1812	Kowsar Publishing Company (Netherlands)
2	Archives Of Iranian Medicine	202	2.03	1532 (2)	7.58 (4)	1.354 (7)	Q3	1735-3947	Academy of Medical Sciences of I.R. Iran (Iran)
3	Iranian Journal of Public Health	187	1.87	1147 (4)	6.13 (7)	1.429 (6)	Q4	2251-6093	Iranian journal of public health (Iran)
4	Journal of Research in Medical Sciences	106	1.06	860 (5)	8.11 (3)	1.852 (4)	Q3	1735-7136	Wolters Kluwer Medknow Publications (Iran)
5	Iranian Journal of Pharmaceutical Research	77	0.77	545 (7)	7.08 (5)	1.696 (5)	Q4	1726-6890	Iranian journal of pharmaceutical research (Iran)
6	Journal of Cellular Physiology	71	0.71	2003 (1)	28.21 (1)	6.384 (1)	Q2	1097-4652	Wiley-Liss Inc. (United States)

Row	Journal's name	Articles (N= 9950)		Total Citations (rank)	Citation/ document (rank)	Impact Factor 2020 (rank)	Category Quartile	ISSN	Publisher (Country)
		N	%						
7	Iranian Journal of Basic Medical Sciences	66	0.66	686 (6)	10.39 (2)	2.699 (3)	Q3	2008-3874	Mashhad University of Medical Sciences (Iran)
8	Iranian Journal of Kidney Diseases	65	0.65	359 (8)	5.52 (8)	0.892 (8)	Q4	1735-8604	Iranian Society of Nephrology (Iran)
9	Iranian Journal of Pediatrics	65	0.65	298 (9)	4.58 (9)	0.364 (10)	Q4	2008-2150	Kowsar Medical Publishing Company (Iran)
10	Obesity Surgery	63	0.63	213 (10)	3.38 (10)	4.129 (2)	Q1	1708-0428	Springer New York (United States)

Highly Cited Papers

Table 3 lists the information related to 20 of the most cited articles in which at least one of the authors had an organizational affiliation with IUMS. All of these 20 highly cited papers were authored by a Group of Authors, which includes well-known and famous authors with great scientific credibility in their fields. Besides, 14 of these articles (70%) were published in the credible journal of *Lancet* (IF 2020 = 79.323). These articles received 37062 citations (21.25%). The highest altmetric score (3617) belonged to the third article, and the lowest score (76) belonged to the 17th article.

Table 3
Top 10 highly cited papers authored/co-authored by IUMS (1980-2020)

Rank	Title	First author (year)	Source title (IF 2020)	Total citations	Quartile	Altmetrics score
1	Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015	Vos, Theo (2016)	Lancet (202.731)	3708	Q1	1087
2	Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017	James, Spencer Lewis (2018)	Lancet (202.731)	3413	Q1	1127
3	Health Effects of Overweight and Obesity in 195 Countries over 25 Years	Afshin, Ashkan (2017)	New England Journal of Medicine (176.082)	2728	Q1	3617
4	Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries,	Vos, Theo (2017)	Lancet (202.731)	2709	Q1	956

Rank	Title	First author (year)	Source title (IF 2020)	Total citations	Quartile	Altmetrics score
	1990-2016: a systematic analysis for the Global Burden of Disease Study 2016					
5	Global, regional, and national age-sex specific mortality for 264 causes of death, 1980-2016: a systematic analysis for the Global Burden of Disease Study 2016	Naghavi, Mohsen (2017)	Lancet (202.731)	2429	Q1	984
6	Global, Regional, and National Cancer Incidence, Mortality, Years of Life Lost, Years Lived with Disability, and Disability-Adjusted Life-years for 32 Cancer Groups, 1990 to 2015 A Systematic Analysis for the Global Burden of Disease Study	Fitzmaurice, Christina (2017)	JAMA Oncology (33.012)	2392	Q1	1453
7	Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980-2017: a systematic analysis for the Global Burden of Disease Study 2017	Roth, Gregory A. (2018)	Lancet (202.731)	2315	Q1	860
8	Global, regional, and national comparative risk assessment of 79 behavioral, environmental and occupational, and metabolic risks or clusters of risks, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015	Forouzanfar, Mohammad Hossein (2016)	Lancet (202.731)	2066	Q1	334
9	The Global Burden of Cancer 2013 Global Burden of Disease Cancer Collaboration	Fitzmaurice, Christina (2015)	JAMA Oncology (33.012)	1879	Q1	697
10	Global, regional, and national comparative risk assessment of 79 behavioral, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013	Forouzanfar, Mohammad Hossein (2015)	Lancet (202.731)	1679	Q1	1294

Co-authorship networks for contributing institutions and countries

Figure 3 displays the collaboration map of researchers from other universities and research institutions with IUMS researchers. Of the 3300 institutions that cooperated with IUMS, 220, 155, 113, 95, and 87 collaborated with IUMS researchers on at least 10, 15, 20, 25, and 30 articles, respectively. In the co-authorship map of institutions, 87 institutions were entered with a threshold of 30. This map consists of four clusters with at least nine institutions per cluster. The most cooperation was with Tehran University of Medical Sciences (3291 articles, 85 links, and a total edge of 8060), Shahid Beheshti University of Medical Sciences (1500 articles, 85 links, and a total edge of 4205), Islamic Azad University (841 articles, 82 links, and total edge of 2338), and Tarbiat Modares University (419 articles, 76 links, and total edge of 1057) (Figure 3).

Figure 3: Co-authorship map of institutions contributing with IUMS (1980-2020)

Furthermore, 114 countries cooperated with IUMS researchers. 91, 73, 65, 57, 42, and 33 countries collaborated with IUMS on at least 2, 5, 7, 10, 20, and 30 articles, respectively. The co-authorship map of Figure 4 consists of four clusters (each cluster with at least four items) in which 42 countries with a threshold of 20 articles were entered to plot the map. The most cooperation of IUMS researchers in publishing articles indexed in the WOSCC was respectively with researchers from the US (912 articles, 41 links, and total edge of 1979), UK (349 articles, 41 links, and total edge of 1076), Canada (348 articles, 41 links, and total edge of 939), and Australia (189 articles, 41 links, and total edge of 714) (Figure 4).

Figure 4: Co-authorship map of countries contributing with IUMS (1980-2020)

Clustering papers, Research areas & Keyword co-occurrence

146,680 terms and keywords were used in the titles and abstracts of articles published by IUMS researchers. Among these, 6661, 3137, 2040, 1192, 558, and 261 keywords were used at least 10, 20, 30, 50, 100, and 200 times, respectively. In the co-occurrence map of Figure 5, keywords with a threshold of 200 were entered; some keywords are invisible on the map due to a high overlap. Based on the map, five clusters are displayed. The first cluster (red) has keywords such *as effect, treatment, drug, dose,* and *removal* and can be called *pharmacological studies*. The second cluster (green), named *epidemiological studies*, includes keywords such as *Iran, year, person, prevalence, age, gender,* and *mortality*. The third cluster (blue) contains keywords such as *patient, group, symptom, outcome, placebo, injection, significant,* and *decrease,* and can be named *general & internal medicine*. The fourth cluster (yellow), called *meta-analysis and systematic review,* contains keywords such as *study, information, knowledge, systematic review,* and *meta-analysis*. The fifth cluster (purple), the *immunological studies* cluster, includes keywords such as *gene, infection, detection, resistance,* and *mutation* (Figure 5).

Figure 5: Term clustering of papers authored/co-authored by IUMS (1980-2020)

Figure 6 represents 20 of the most prolific research fields in the articles published by Iranian researchers affiliated with IUMS in the WOSCC. According to the diagram, among these 20 research fields, the most prolific area was *general internal medicine,* with 855 articles, while the lowest number of articles belonged to *ecology* (n = 260).
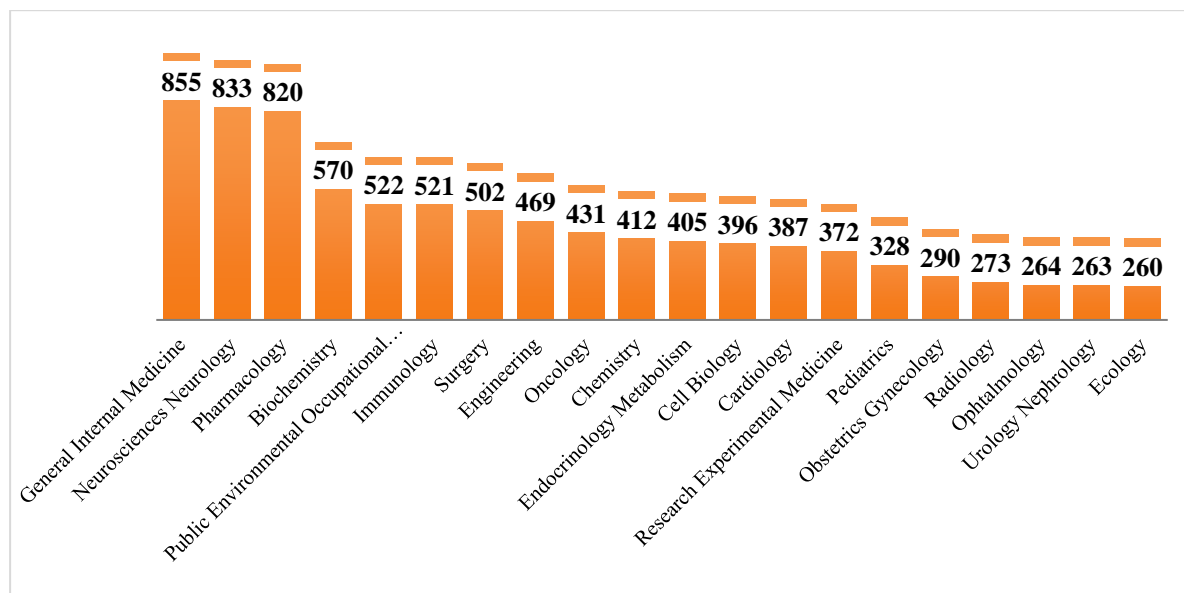
Figure 6: Top 20 Research areas of papers authored/co-authored by IUMS (1980-2020)

Table 4 presents the 30 most frequently used keywords by the authors of published articles (author keywords) affiliated with IUMS. Each of these keywords was used by authors at least 49 times. The 1st to fif[th] most frequent keywords were *Iran, apoptosis, oxidative stress, meta-analysis,* and *inflammation,* with 565, 186, 181, 179, and 154 repetitions and co-occurrences, respectively. By comparing the statistics presented in Figures 5 and 6 and Table 4, we find that the five main subject keyword clusters are compatible with the most prolific research fields for IUMS researchers provided by the WOSCC. By focusing on the 30 most frequent author keywords, we realize that each of these keywords belongs to a part of the research fields and subject clusters mentioned in Figures 5 and 6

Table 4
Top 30 highly frequent author keywords of papers authored/co-authored by IUMS

Rank	Keyword	Frequency	Rank	Keyword	Frequency	Rank	Keyword	Frequency
1	Iran	565	11	Quality of life	86	21	Mortality	62
2	apoptosis	186	12	children	85	22	Reliability	61
3	Oxidative stress	181	13	Multiple sclerosis	84	23	Diabetes mellitus	61
4	Meta-analysis	179	14	prevalence	82	24	Parkinson's disease	59
5	Inflammation	154	15	Rat	78	25	validity	58
6	Systematic review	116	16	Tissue engineering	74	26	Diabetes	54
7	Covid-19	107	17	Epidemiology	69	27	Prostate cancer	53
8	Cancer	101	18	depression	67	28	Spinal cord injury	51
9	Breast cancer	100	19	Pregnancy	64	29	Vitamin D	50
10	Obesity	94	20	polymorphism	63	30	Gene expression	49

A time-based map of the most frequent keywords is presented in Figure 7. As a guide, the colored bar at the bottom of the map indicates which keywords have been dominant at what time. Since the most frequent keywords belong to 2016 to 2018, this period is displayed in the color bar. According to the map, the yellow and light green keywords were trending from mid-2017 to early 2018. Light blue and dark green keywords became popular from mid-2016 to mid-2017. Darker keywords (in dark blue) were trending from the beginning 2016. The results of the map indicate that in the last decade, the articles of IUMS researchers with keywords such as *prevalence, expression, oxidative stress, diagnosis, risk factors,* and *therapy* have been dominant; these keywords were popular mainly from mid-2016 to mid-2017, marked in light blue and green on the map (Figure 7).

Figure 7: Time-based co-occurrence map of highly frequent keywords

Co-citation map of cited sources

A total of 37050 sources were cited by 9950 articles reviewed in this study. Among them, 1475, 782, 482, 327, 173, and 77 sources received at least 50, 100, 150, 200, 300, and 500 citations, respectively. Figure 8 depicts the co-citation network of 77 sources with a threshold of 500 citations. This network consists of three clusters. The first cluster (red) contains 32 items dominated by *Plos One*; the second cluster (green) has 26 items dominated by *Proceedings of the National Academy of Sciences of the United States of America*; and the third cluster (blue) consists of 19 items dominated by *Biomaterials*. The most cited journals were *Plos One* with 3953 citations, *Lancet* with 3262 citations, and *Proceedings of the National Academy of Sciences of the United States of America* with 2257 citations, respectively (Figure 8).
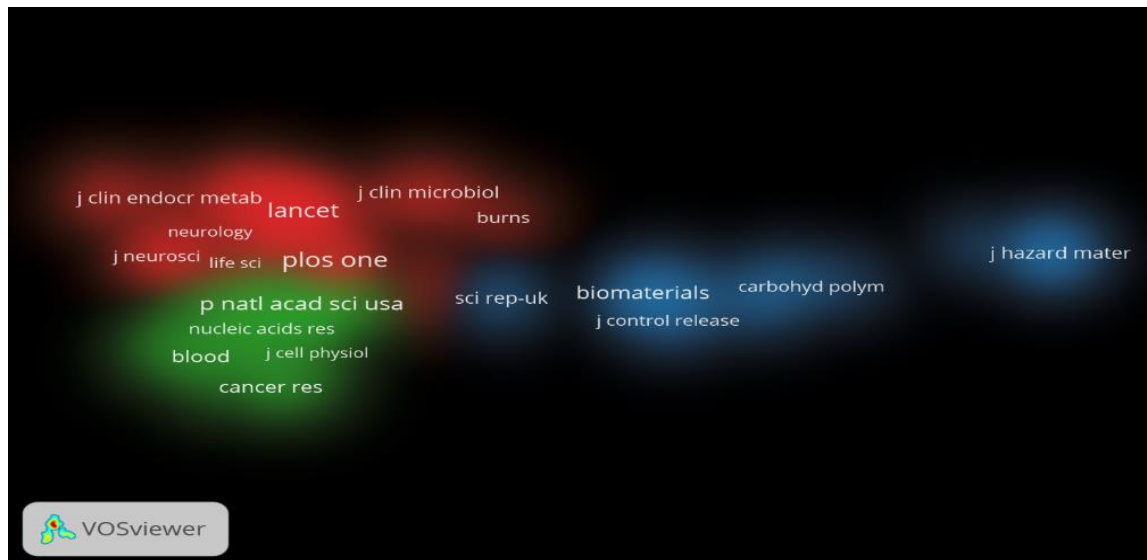
Figure 8: Co-citation map of sources cited by papers authored/co-authored by IUMS (1980-2020)

Discussion

As influential institutions, universities play a fundamental role in scientific, technological, economic, social, and cultural development by producing knowledge in various fields. Therefore, every university or research institute should continuously assess its past and present status to delineate a map of prospects. As mentioned before, IUMS, with 10 faculties, 18 hospitals and medical training centers, 47 research centers, a central library, and more than 20 faculty and hospital libraries, is one of the three universities in Tehran affiliated with the MoHME and is one of the best universities in Iran. Thus, determining its status compared to competitors can contribute to its evidence-based planning. The present study aimed to comprehensively evaluate this university's scientific publications (9950 documents) in the SCIE, WOSCC, from the beginning of 1980 to 2020.

The findings revealed that, in general, the trend of publications was upward and growing. More than half of the articles were published in the last four years examined (n = 5864). This clearly shows that IUMS has found its way into scientific publications and pays attention to the importance of internationalizing research findings. These results are consistent with the findings of Doulani (2020), Mokhtari et al. (2019), Darmadji et al. (2018), Dwivedi (2017) and Siwach and Kumar (2015).

IUMS articles received 174362 citations in total, with the average citation per article of 17.52. The process of receiving citations was also relatively upward; the highest number of received citations belonged to 2017 (29,755 citations; 17.0%). Furthermore, 83% of the articles received at least one citation, while 156 received more than 100. This indicates the impact of this university on scientific development. The rate of self-citation by IUMS researchers was very low, at about 5% (4.83). The trend of received citations was upward in the studies by Mokhtari et al. (2019) and Doulani (2020). In line with the survey by Mokhtari et al. (2019), all highly cited university articles (top 20 articles) were published in Q1 journals, and 85% of highly cited papers were published in the *Lancet*. Therefore, researchers who wish to receive more citations are advised to publish their articles in well-known and high-impact journals.

In the list of 10 core journals that publish articles by researchers affiliated with IUMS, there was only one Q1 journal, and 50% of these journals were Q4. Consistent with the findings of

Mokhtari et al. (2019) on the publications of Hamadan University of Medical Sciences, eight of the 10 core journals were published in Iran in the current study. This shows that the most desirable journals for authors and researchers at this university were the *Iranian Red Crescent Medical Journal* (Q4) and the *Archives of Iranian Medicine* (Q3). Thus, providing more research opportunities and motivation should be on the agenda of the country's scientific policymakers to promote the quality of publications and their scientific level.

Given the cooperation of researchers from 114 countries with IUMS, this university has had reasonable international co-authorships. Most international collaborations of this university were with US researchers (912 articles; 9.16%). These findings are consistent with the results of Doulani (2020), Mokhtari et al. (2019), Dwivedi (2017), Sweileh et al. (2014) and Maharana and Sethi, 2013). The US has successfully garnered international cooperation, especially with credible universities in other countries. This has led to continuously improving the ranking of universities, institutions, and journals in most ranking systems (Doulani, 2020). After the US, the most cooperation of IUMS researchers was with the UK (349 articles; 3.5%). In a study at the University of Jaffna, Sri Lanka, Janen (2022) mentioned that the most cooperation of this institution was with UK researchers (59 articles). In the current study, at the national level, most collaborations were with researchers affiliated with universities in the country's capital, especially the Tehran University of Medical Sciences (3291 articles; 33.07%). The same conclusion was drawn by Doulani (2020) and Mokhtari et al. (2019). Vennu et al. (2021) also pointed out that the largest number of articles were published by universities in the capital of Saudi Arabia (Riyadh), especially King Saud University (1538 articles).

Thematic clustering of keywords also indicated that IUMS researchers have targeted the essential fields and sub-fields of medical sciences. Most IUMS studies in the WOSCC were conducted in five clusters and areas: pharmaceutical studies, epidemiological studies, general and internal medicine studies, immunological studies, and meta-analysis and systematic review studies. In Mokhtari et al.'s (2019) study, pharmaceutical and epidemiological studies were two of the most prolific subject areas in the works of researchers affiliated with Hamadan University of Medical Sciences. Similarly, Sweileh et al. (2014). noted that most articles of An-Najah National University of Palestine were conducted on medicine. Likewise, according to Siwach and Kumar (2015), pharmaceutical studies was one of the three most prolific subject areas at Maharshi Dayanand University. Based on the data extracted from the Scopus database about IUMS and the comparison of Figure 5, Figure 6, and Table 4, the scientific growth of IUMS researchers is not balanced and is reflected more in some specific subject areas. Consequently, some fields and subfields, e.g., pediatrics, urology, nephrology, ophthalmology, radiology, and cardiology, need more emphasis on scientific publication. Mokhtari et al. (2019) have also pointed out that some sub-fields, such as lifestyle medicine, traditional medicine, medical informatics, and local cancer research, need to be emphasized at Hamadan University of Medical Sciences.

The time-based map information of author keywords (Figure 7) also depicted that in the last decade, the articles of IUMS researchers with keywords such as *prevalence, expression, oxidative stress, diagnosis, risk factors,* and *therapy* were dominant. These keywords became popular mainly from mid-2016 to mid-2017. The co-citation map of the references also demonstrated that IUMS researchers were more inclined to cite articles published in high-ranking and well-known journals. The dominance of two prominent journals on the map (Figure 8) confirms this issue; *Plos One* received 3953 citations and *Lancet* 3262 citations from the

articles of IUMS researchers and ranked first and second among the cited sources, respectively.

Conclusion

The methods and techniques of bibliometrics and visualization are optimal for depicting and analyzing the scientific status of researchers, publications, journals, universities, countries, and even the world. The current study can be a sample for analyzing bibliometric indices of other universities and research institutes in Iran and elsewhere. In addition, IUMS policymakers can use these findings for better policy-making in the future for scientific development. To complement the results of this research, other methods of scientific publication measurement, such as altmetric, can also be employed. This can overcome some limitations in the results of such studies, including the method of reporting and displaying data. Also, in the future, other researchers can examine the indexed articles of Iran University of Medical Sciences in the Scopus database to conduct a similar study.

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