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**Co-Authorship patterns and Topic Networks in the Scientific Publication
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Abstract

Introduction: Scientific co-operation is a process in which two or more authors share their resources and talents with the aim of creating a shared work. One of the forms of scientific co-operation is co-authorship that involves the production of a scientific output by several collaborative researchers and scholars. This research has been designed to map out co-authorship networks in the Hamadan University of Medical Sciences researches indexed in the Web of Science from 2012 to 2016, and analyzes scientific collaboration and co-authorship networks in this university.

Method: The present study is an applied study which has been carried out using the scientometric indicators and social network analysis. The statistical population of this research consisted of all the scientific articles that at least one of the authors of referred to the Hamadan University of Medical Sciences as the affiliation and indexed in the Web of Science from 2010 to 2016. In so doing, the network analysis technique and the software on Citespace and Gephi were run to analyze and visualize co-authorship networks. Furthermore, the software on HISTCITE was used for data analysis.

Findings: All articles related to Hamadan University of Medical Sciences during the years 2012 to 2016, based on a search on the Web of Science, have 838 records. The dominant co-authorship pattern in these years is the 4 and 5 authors with 171 articles and 20.41%. The mean number of authors or collaboration index in the period considered was 5.51, the degree of Collaboration was 0.99 and the Collaborative Coefficient was 0.759. Poorolajal, Alikhani and Shahidi were the most prolific authors. Tehran University of Medical Sciences, Shahid Beheshti University and Islamic Azad University were the most prolific organizations. The greatest collaboration of Iranian researchers has been with Switzerland. Saidijam, Mahjub, Mehdizadeh, and Moghimbeigi have allocated the highest betweenness centrality, whereas Saidijam, Mahjub, Hajilooi, and Khazaei have allocated the highest degree centrality.

Conclusion: The scientific production of Hamadan University of Medical Sciences during the period from 2012 to 2016 has grown dramatically, and collaborative research at this university is growing at an appropriate level. In this study, the degree of Collaboration and the co-operation rate are high which indicates that here is a great deal of interest in co-authorship and co-operation among researchers of Hamadan University of Medical Sciences, and it is relatively unlikely to see single-authorship, which reflects the willingness of individuals to co-authorship.

Keywords: Scientific Collaboration, Co-authorship Network, Hamadan University of Medical Sciences

Introduction:

The interdisciplinary nature of science, the complexity and cost of many studies are among the reasons why researchers join for scientific collaboration, which can increase academic productivity, quality of work and scientific development (1, 2), in other words, scientific collaboration brings together a set of talents for producing a scientific file (3). Co-authorship phenomenon has always been of interest to scholars as one of the most important forms of scientific collaboration, and new findings indicate increased collaboration in research (4), which is one of the criteria for assessing the quality of work of researchers and research groups, which is an effective way to acquiring advanced science and technology in developed and recently developed countries. Accordingly, the more collaboration between scientists, the higher quality of their work and, consequently, the higher the level of scientific development will be (5). Scientific collaboration creates a network of knowledge sharing and the collaboration of researchers in the production of science and scientific development and the emergence of a kind of social network among researchers, the network to be co-authored. In this way, researchers from different fields participating in research can overcome the breadth and complexity of science and take steps to develop their country's scientific development (6-8). Researches on the scientific network of scholars provide a good insight into the emergence of knowledge and the structure of the scientific community, the social structure of this society is in fact composed of relations among scientists (9, 10). Due to the complexity of scientific activities, most researchers call for scientific Collaboration, and that most scientific articles and research reports are the result of group work. Indeed, co-authorship phenomenon, as one of the most significant forms of scientific collaboration, has always been of concern to scholars, and new findings suggest increased collaboration in research (4). At the same time, due to the importance of scientific Collaboration, an investigation of the quality as well as the quantity of such collaborations has been the subject of scholarly research for decades (11, 12). On the other hand, the phenomenon of scientific Collaboration results in a network of knowledge sharing and the collaboration of researchers in the production of science and scientific development and the emergence of a kind of social network among researchers i.e. co-authorship network (13, 14).

Considering the importance of co-authorship in the scientific outputs of various fields, the present study intends to consider the co-authorship phenomenon in Hamadan University of Medical Sciences, plotting the structure of co-authorship networks in this area and analyzing these networks, examines the number of scientific outputs, the mean of the received citations

in this field, the scientific Collaboration index (CI), the degree of Collaboration and the coefficient of Collaboration.

The results of this study can clearly indicate the status and the process of Collaboration in the Hamadan University of Medical Sciences and can be effective in future planning and policy making of organizations and educational and research institutions and lead the researchers to carry out researches that ultimately improve the quantitative and qualitative scientific output of Hamadan University of Medical Sciences and the rise of our country's scientific rank in the region and the world. Also, by identifying the influential authors in co-authorship networks and introducing them to the scientific community, it will provide the ground for further participation and Collaboration at the university.

Research method:

The present study is an applied study that has been carried out using scientometric indicators and social network analysis. The statistical population of this research consisted of all the scientific articles that at least one of the authors of referred to the Hamadan University of Medical Sciences as the affiliation and indexed the science citation index of in Web of Science from 2010 to 2016. At the beginning of February 2018, the data were collected using the following formula.

$$AD=(\text{Hamadan Univ Med Sci}) \text{ OR } AD=(\text{Hamadan Univ Med Sci})$$

Timespan: 2012-2016. **Indexes:** SCI-EXPANDED, SSCI.

The data collected through science citation index was stored in three formats: txt, isi and ciw, and then uploaded using Gephi and Citespace software to draw up and analyze co-authorship networks. The use of the HISTCITE and EXCEL software was used to analyze the data and to answer some of the research questions.

Findings:

The number of scientific outputs of Hamadan University of Medical Sciences indexed in the web of science between 2012 and 2016 is 838 records. In the period under review, the largest amount of scientific outputs is related to articles with 4 and 5 authors with 171 documents (20.41%). The number of articles with 13 authors is two (0.24%) which has the least frequency among the articles under review.

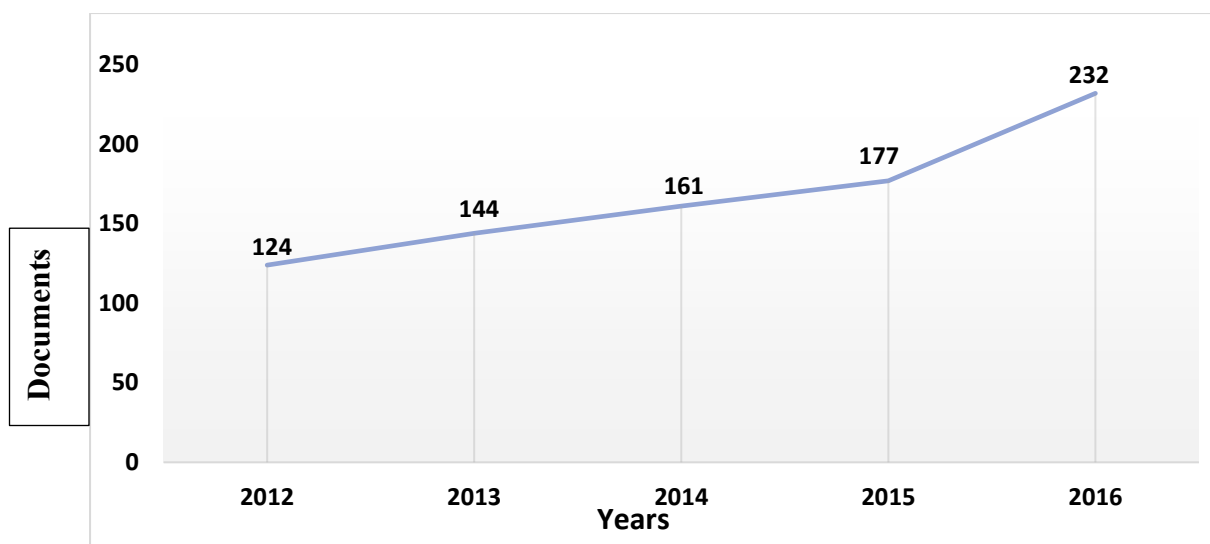


Figure1. Scientific production of Hamadan University Of Medical Sciences in 2012 to 2016

The total number of citations received in 838 articles of Hamadan University of Medical Sciences in 2012-2016 is 4264 citations. Therefore, the mean citation per paper is 6 citations i.e. each paper received an average of 6 citations within these years. Scientific outputs of 2012 with 9.1 and 2013 with 6.7 citations had the highest mean of received citations. Moreover, scientific outputs in 2016 with 2.5 citations obtained the lowest mean citation per paper (Table 1).

Table1- Mean citation per document in scientific production of Hamadan University of Medical Sciences in 2012 to 2016

Total	2016	2015	2014	2013	2012	Publication year
4264	596	783	782	973	1130	Number of received citations
738	232	177	161	144	124	Number of publications
5.5	2.5	4.4	4.8	6.7	9.1	Mean citation per document

As shown in Table 2, the Collaboration index in the reviewed years is 15.5, which means that the mean number of researchers per article is 5 (5.15). The degree of Collaboration is 0.99 and the coefficient of Collaboration is 0.759. This index is between zero and one. The closer the value to one, the higher the amount of co-authorship and the lower the amount of single-authorship will be. In total, during the years studied, the willingness of researchers of Hamadan University of Medical Sciences to scientific Collaboration has increased (Table 2).

Table 2- Co-authorship indices in Hamadan University of Medical Sciences in 2012 to 2016

Total	2016	2015	2014	2013	2012	Publication year
5.15	5.44	5.25	5.22	4.90	4.96	CI
0.98	0.99	0.99	1	0.96	0.97	DC
0.759	0.779	0.772	0.775	0.733	0.738	CC

Among the prolific researcher of Hamadan University of Medical Sciences, Poorolajal, Alikhani and Shahidi were ranked first to third, and the most cited researchers in Hamadan University of Medical Sciences were Poorolajal, Ghaleiha and Haghghi "(Table 3).

Table 3- Frequency distribution of the most productive authors in Hamadan University of Medical Sciences in 2012 to 2016

TGCS1	TLCS2	Scientific Production		Authors	Rank
		Percent	Document		
425	25	7.16	60	Poorolajal J	1
129	6	4.29	36	Alikhani MY	2
239	60	4.06	34	Shahidi S	3
155	5	3.58	30	Saidijam M	4
283	18	3.34	28	Haghghi M	5
271	18	2.98	25	Jahangard L	6
188	54	2.98	25	Komaki A	7
154	12	2.98	25	Tavilani H	8
235	16	2.86	24	Brand S	9
107	8	2.86	24	Moghimbeigi A	10

Table 4 indicates that Tehran University of Medical Sciences with 189 papers and 1206 citations was the most prolific organization that has had the most Collaboration in the outputs of Hamadan University of Medical Sciences in 2012-2016. Subsequently, Shahid Beheshti University of Medical Sciences with 87 papers and 440 citations and Islamic Azad University with 73 papers and 381 citations ranked next.

¹Total Global Citations

²Total Local Citations

Table 4- Frequency distribution of the most productive organizations in Hamadan University of Medical Sciences in 2012 to 2016

TLCS	TGCS	Scientific Production		Institutions	Rank
		Percent	Document		
1206	52	22.55	189	Univ Tehran Med Sci	1
440	14	10.38	87	Shahid Beheshti Univ Med Sci	2
381	17	8.71	73	Islamic Azad Univ	3
221	7	6.44	54	Iran Univ Med Sci	4
234	17	6.32	53	Kermanshah Univ Med Sci	5
216	19	5.01	42	Bu Ali Sina Univ	6
384	14	5.01	42	Kurdistan Univ Med Sci	7
182	4	3.22	27	Isfahan Univ Med Sci	8
112	4	3.10	26	Tabriz Univ Med Sci	9
235	16	2.86	24	Univ Basel	10

As shown in Chart 2, Switzerland has had the most Collaboration with Iranian researchers with 24 papers and 20% of internationally co-authored papers. After Switzerland, the United States is ranked second with 22 papers (18%) and Malaysia with 15 papers (12%) ranked third (Figure 2).

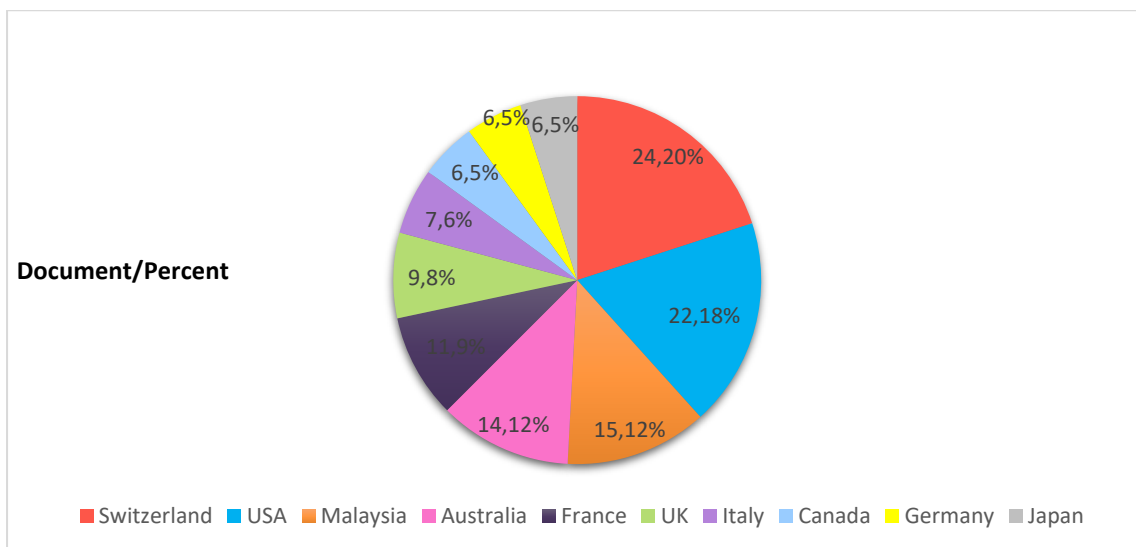


Figure2. Countries with majority of collaborations in Hamadan University of Medical Sciences in 2012 to 2016

Given the total number of researchers each year, we had to choose the threshold. Threshold restricts the number of nodes in the network based on the number of citations received, eliminates weak relationships, thus maintains more important nodes and relationships, and analyzes the network more accurately. After checking various thresholds, the threshold of 5.5.20 was selected. The threshold values from left to right represent the number of citations, the co-citation, and co-citation cosine coefficient. In the drawings, the number of nodes is the researchers who have crossed these thresholds. For example, between 2012 and 2016, 50 nodes (authors) have a cosine coefficient of 20 and a value of 3 and more than 3 citations and co-citations.

Co-authorship network of researchers from Hamadan University of Medical Sciences in 2012-2016 includes 50 nodes and 67 links. Saidijam, Mahjub, MehdiZadeh, Moghimbeigi, Alikhani, Shahidi, Hajilooi, Motamedzade, Bahrami and Tavidani have the most betweenness centrality. Furthermore, Saidijam, Mahjub, Hajilooi, Khazaei, Haghghi, Holsboer, Brand, Bajoghli, Ahmadpanah, and Jahangard have the highest degree centrality in Hamadan University of Medical Sciences in 2012-2016.

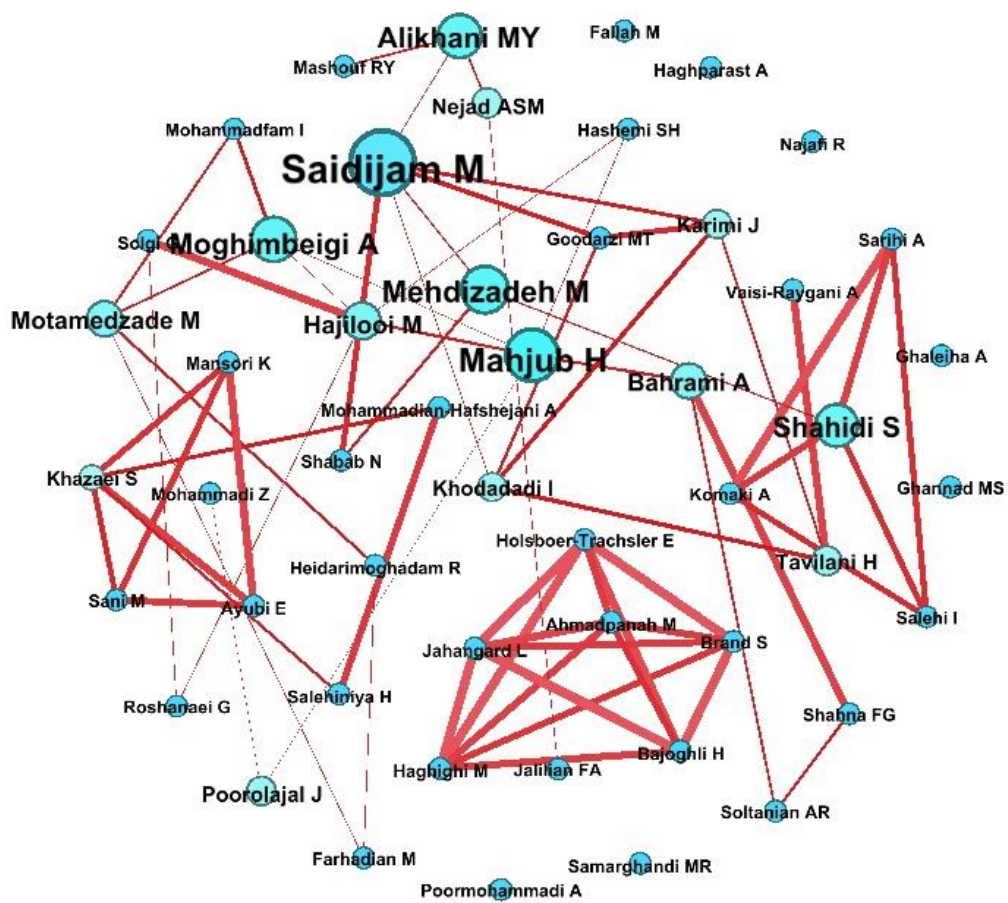


Figure 3. The authors having the maximum betweenness centrality in co-authorship networks at Hamadan University of Medical Sciences Since 2012 to 2016

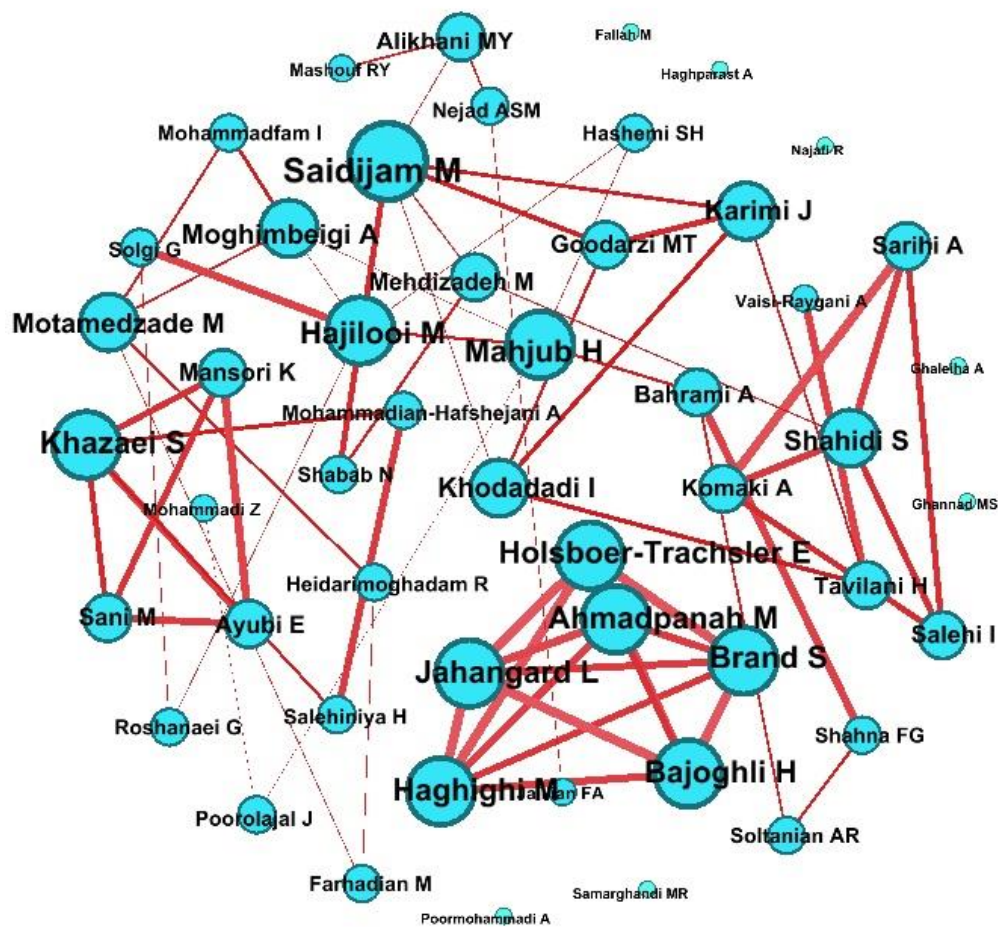


Figure 4. The authors having the maximum degree centrality in co-authorship networks at Hamadan University of Medical Sciences Since 2012 to 2016

The topic network of Hamadan University of Medical Sciences articles comprises 38 nodes and 47 links between 2012 and 2016. Larger circles with more prominent letters represent the topics that have more betweenness centrality. NEUROSCIENCES, NEUROLOGY, ENGINEERING, ENDOCRINOLOGY, METABOLISM, PHARMACOLOGY, PHARMACY, IMMUNOLOGY, NEUROSCIENCES, CHEMISTRY, PUBLIC ENVIRONMENTAL OCCUPATIONAL HEALTH, MEDICAL RESEARCH EXPERIMENTAL, AND RESEARCH EXPERIMENTAL MEDICINE have the most betweenness centrality (Figure 5).

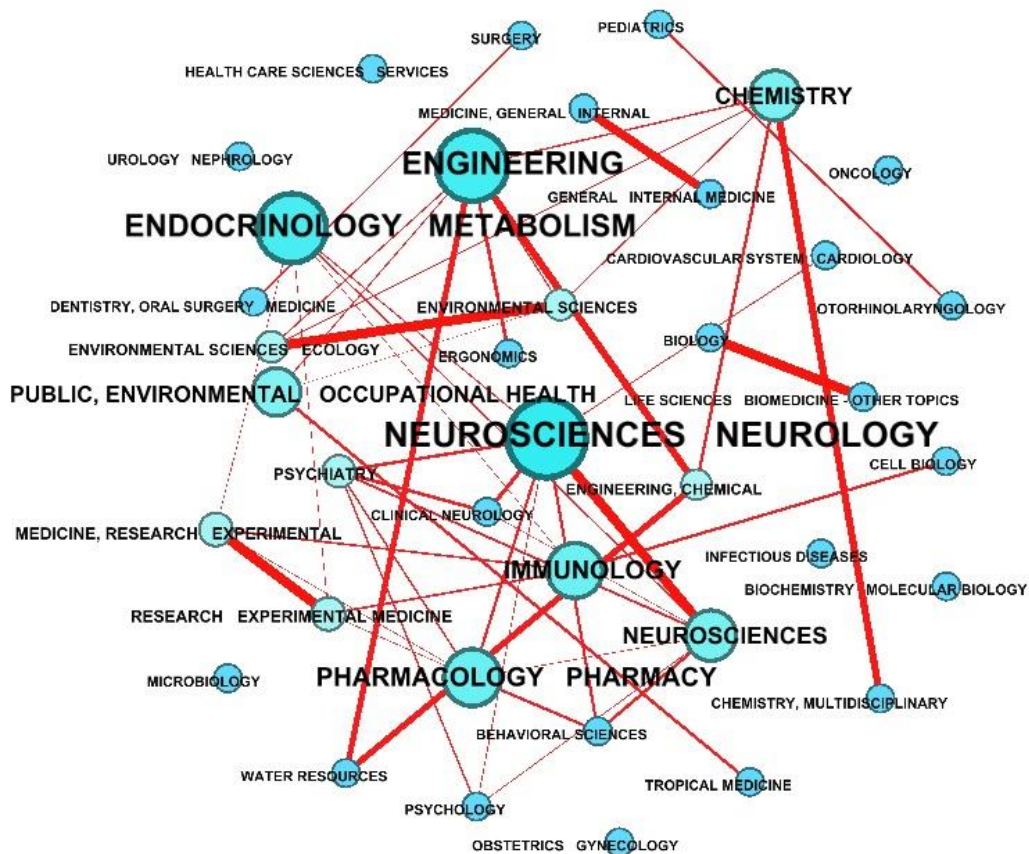


Figure 5. The Topic Network of Hamadan University of Medical Sciences Articles based on betweenness centrality Since 2012 to 2016

Larger circles with more pronounced letters represent the topics that have more degree centrality. NEUROSCIENCES NEUROLOGY, ENGINEERING, NEUROSCIENCES, PHARMACOLOGY PHARMACY, ENDOCRINOLOGY, METABOLISM, CHEMISTRY, PSYCHIATRY, IMMUNOLOGY, PUBLIC ENVIRONMENTAL, OCCUPATIONAL HEALTH AND MEDICINE RESEARCH EXPERIMENTAL have the highest degree centrality (Figure 6).

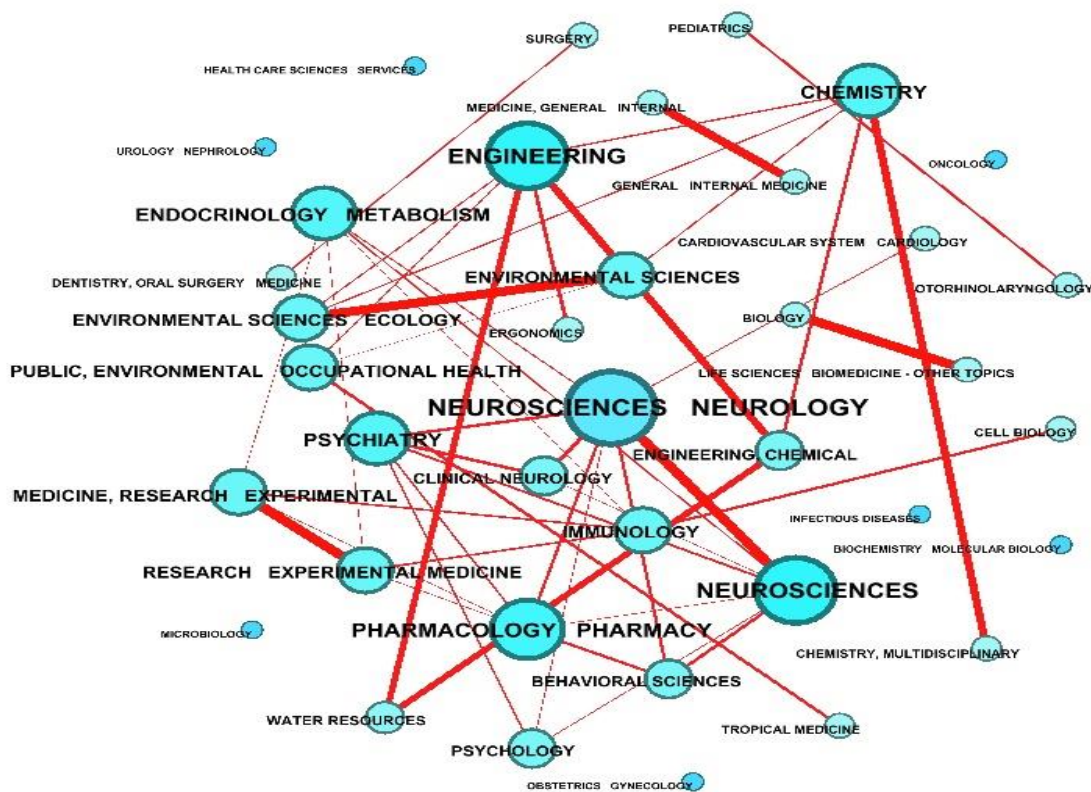


Figure 6. The Topic Network of Hamadan University of Medical Sciences Articles based on degree centrality since 2012 to 2016

Discussion and conclusion:

The results of this study showed that the scientific outputs of Hamadan University of Medical Sciences during the period from 2012 to 2016 have grown significantly, indicating more attention of researchers in this field to the publication of the article in the publications covered by web of science. The findings showed that the authors of Hamadan University of Medical Sciences tend to write articles with 4 and 5 authors, and such articles account for about 30% of all articles during the study years. The results of this study showed that the tendency to group work among researchers of Hamadan University of Medical Sciences is high and these findings are in line with the results of studies by Shekofteh and Rahimi (15), Shekofteh et al. (16) and Osreh et al. (17) who investigated scientific collaboration among researchers and different fields of medicine and paramedics that concluded that the level of teamwork among researchers in these areas is high. Also, the results of this study showed that individuals such as Saeedi-Jam, Mahjub, Mahdizadeh, and Moghim Beygi have the most betweenness centrality that act as communication bridges in the network, and if they are removed from the map, communication in the network will be destroyed.

The findings showed that the collaboration index or the mean number of authors in general was 5.15, and this figure was the highest in the year 2016 with the value of 5.44, and the lowest number was in 2013. In the study conducted by Osareh and Marefat in the field of co-authorship of Iranian scholars in the field of basic sciences and interdisciplinary medicine (18), this value was 3.4, which is less than that of the present research; however, in the study carried out by Shekofteh and Rahimi (15) in the area of co-authorship networks in the scientific outputs of the authors of Shahid Beheshti University of Medical Sciences, the amount of Collaboration index obtained was 4.27, which is somewhat in line with the present study. In this study, the degree of Collaboration was equal to 0.99 and the coefficient of Collaboration was 0.759, which indicates that there is a great tendency towards co-authorship and collaboration among researchers of Hamadan University of Medical Sciences and tendency to single-authorship is relatively low. These indices are between zero and one, the more the value toward one, the greater the degree of co-authorship and collaboration, and the lower the degree of single-authorship and collaboration will be. It can be concluded that the researchers' desire for co-authorship is greater.

The total mean of citations per paper received is 6, meaning that each paper published by the university has received six citations. In 2016, the average value equal to 2.5 has the lowest value in this regard.

The findings of this study showed that Poorolajal, Alikhani and Shahidi were the most prolific and most cited authors of Hamadan University of Medical Sciences and that Tehran University of Medical Sciences, Shahid Beheshti University, and Islamic Azad University were the most prolific organizations. Also, international collaboration of the authors of Hamadan University of Medical Sciences with Switzerland, The United States and Malaysia are more than the rest of the world.

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