# Co-authorship patterns and networks in the scientific publications of Shahid Beheshti University of Medical Sciences

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## ABSTRACT

The increasing amount of scientific collaboration has led to an increase  in the quality of scientific publications. The goal of this article is to analyze the co-authorship patterns and networks in SBUMS's scientific publications in WOS from 2009 to 2013. Hence, the co-authorship indicators and ratio of national to international collaborations are determined. This research is a descriptive survey including scientometric approaches. HistCite and NWB software is used to draw and analyze the networks. The findings show that the scientific publications of SBUMS are 6633 publications. The most productive authors are Fereidoun Azizi and Mohamad Reza Zali. The maximum number of scientific publications is allocated to the articles written by more than 5 authors. Collaborative Index (CI), Degree of Collaboration (DC), and Collaborative Coefficient (CC) are 4.27, 0.96, and 0.71 respectively. The ratio of national to international collaborations is 4.78. In co-authorship networks, there are 12825 nodes (authors) that are linked with 97618 edges. The highest degree and betweenness centrality belongs to Masjedi showing the communication paths of other nodes overtaking them. The most international collaboration belongs to the USA. The collaboration of authors in SBUMS is almost good but the international collaboration is not so. Encouraging policies for the further collaboration of authors surely leads to increasing the quality and quantity of the scientific publications. It is recommended to repeat the network analysis in different periods of time.

**Keywords:** Co-authorship Network; Scientific Collaboration; Network Analysis; Shahid Beheshti University of Medical Sciences

## INTRODUCTION

The interdisciplinary nature of sciences, complexity and the high cost of many studies are the reasons for the researchers to turn to scientific cooperation which can increase the academic productivity, the quality of the works, and scientific development [1, 2]. One of the obvious and documented forms of scientific collaboration is co-authorship [3] and examining the status of co-authorship is a method to measure the amount of scientific collaboration among various authors. The studies related to the co-authorship are of the most important and common studies in scientometric studies which have been paid attention to by many researchers [4]. In co-authorship studies, the co-authorship patterns are evident, representing the amount of the collaboration of authors or their numbers in scientific publications in different years. As a result, the indices of co-authorship are used; the most important are Collaboration Indices (CI), the Degree of Collaboration (DC) and Collaborative Coefficient (CC). CI is the mean of the number of authors of an article which was first used by Lawani and DC shows the ratio of the articles of multi-authors which was first used by Subramabyam. The index is a number between 0 and 1. If it is closer to 1, it represents that the number of multi-authored articles are more. In such an index, single authored articles are considered as 0. Collaborative Coefficient (CC)

also represents the ratio of collaboration among authors of the articles which was first introduced by Ajiferuke. This index is also a number between 1 and 0. If it is closer to 1, it shows that the amount of collaboration is more and if it is closer to 0, it represents that single-authored articles are the first priority [5]. Another index calculated in co-authorship studies is the ratio of nationalization collaboration to internationalization collaboration and its formula is as follows: [6]

$$P = \frac{NI}{INI}$$

NI (Nationalization Index) is an index for measuring the efficiency of national co-authored articles and INI (Internationalization Index) is an index for measuring the efficiency of international co-authored articles, and it is calculated as follows:

$$NI = \frac{\text{the number of national co-authored articles}}{\text{the number of all the articles}} \times 100$$

$$INI = \frac{\text{the number if international co-authored articles}}{\text{the number of all the articles}} \times 100$$

Examining the co-authored networks is also one of the most important approaches in co-authored studies in which social network analysis techniques are used [3, 7, 8]. The co-authored network is a structure created by the scientific collaboration of authors in the publication of common articles. The networks are composed of a number of nodes or vertices linked by one or more links or edges. The nodes represent the authors and links between the nodes representing the co-authorship among authors. In analyzing the networks, the number of nodes, links, the mean of the weight of links, network density, and determining the most important authors in this network regarding the indices of the degree centrality and the betweenness centrality are measured. The network density is one of the scales measuring the density or sparseness of network and calculated according to the following formula. If network density is greater, the network obtains more dense [9].

$$\text{Network Density} = \frac{\text{actual connections}}{\text{potential connections}}$$

Actual connections = the number of links in the network
Potentioal connections = $\frac{n(n-1)}{2}$ (n= the number of nodes)

The degree centrality represents the number of nodes associated with a particular node. In this type of centrality, the value of each node is obtained by counting the number of its neighbors. If the degree centrality of a person is more, he can access more communications and networks which is more effective [10]. The betweenness centrality represents the importance of a node regarding its location on the map and information transfer in the network. A person has the maximum betweenness centrality if he is among a large number of nodes and the connections of other nodes pass it. The nodes having this feature have the ability to increase communication or isolate it since they play a mediating role among other nodes. If they are deleted, the flow of data in the network may be stopped [10, 11]. Shahid Beheshti University of Medical Sciences (SBUMS) is one of the most important among medical universities in Iran. It has the 12 schools, different departments and varied range of fields in different levels. It is among the most productive medical universities of Iran [12-13]. Despite the importance of this university and co-authorship studies, review of the literature indicates that although Iran has conducted research on co-authorship [2, 6, 14-26], no research has been carried out about co-authorship in SBUMS so far. Thus, the present study aims to determine co-authorship patterns, co-authorship indices (CI, DC, CC), the ratio of national collaboration to international collaboration, analyze and draw co-authorship networks in scientific publications of on the Web of Science database from 2009 to 2013. The results of this study can clarify the situation and the process of co-authorship in Shahid Beheshti University of Medical Sciences which can be effective in the future planning and policymaking of SBUMS to provide the necessary conditions for more collaboration among the researchers of this university.

## MATERIALS AND METHODS

This study is a descriptive survey including scientometric approach. The statistical population includes all the scientific publications of which at least one of the authors mentions SBUMS as the organizational affiliation and they are indexed in the citation indexes of Web of Science from 2009 to 2013. The reason for choosing the year 2013 is that at least 2 to 3 years are required to get the necessary citations after the publication of an article and the number of citations is used as the threshold for entering the bibliometric networks. At the beginning of February 2015, the data were collected using the following formula:

Address: (Iran)

Refined by: ORGANIZATIONS-ENHANCED :(SHAHID BEHESHTI UNIVERSITY MEDICAL SCIENCES) AND PUBLICATION YEARS:(2013 OR 2012 OR 2011 OR 2010 OR 2009)

Timespan: All Years

Indexes: SCI-EXPANDED, SSCI.

The collected data were saved through the Web of Science into two formats of isi and txt. Then, the data was uploaded using the software of Network workbench tool (NWB) and the co-authorship networks were mapped using the drawing features of the same software. In addition, the software of HistCite was used to answer some research questions. Research variables are: co-authorship patterns that shows the number of authors in articles, the number of publications, the number of received citations, the most productive and the most cited authors, Co-authorship indices (CI, CC, DC), the number of national and international collaborations; NI (Nationalization Index) and INI (Internationalization Index), and the ratio of NI to INI (P), and the structure of co-authorship networks (the number of articles, nodes, links, isolated nodes, co-authorship between two nodes, mean degree and density), the authors having the maximum degree centrality and betweenness centrality, and thirty stronger co-authored relationship in co-authorship networks. This research has approval of the Ethics Committee of SBUMS and the researchers have regarded the ethics of publication. The article conforms to the international regulations against scientific misconduct including fabrication, falsification, plagiarism, and etc.

## FINDINGS

The number of scientific publications of SBUMS on the Web of Science database was 6633 records. During the mentioned years, an increasing trend was shown; the number of publications was 705 in 2009 but it reached to 1715 in 2013. Table 1 shows the number of authors of the published articles during the mentioned years.

**Table 1.** The co-authorship patterns of the publications in Shahid Beheshti University of Medical Sciences since 2009 to 2013

| Co-authorship Patterns Year | 1 author | | 2 authors | | 3 authors | | 4 authors | | 5 authors | | 6 and more | | All the articles | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | the number | % | the number | % | the number | % | the number | % | the number | % | the number | % | the number | % |
| **2009** | 39 | 5.53 | 66 | 9.36 | 125 | 17.73 | 135 | 19.15 | 108 | 15.32 | 232 | 32.91 | 705 | 100 |
| **2010** | 21 | 2.2 | 104 | 10.84 | 198 | 20.65 | 202 | 21.06 | 160 | 16.68 | 274 | 28.57 | 959 | 100 |
| **2011** | 44 | 2.8 | 162 | 10.31 | 326 | 20.74 | 349 | 22.20 | 264 | 16.79 | 427 | 27.16 | 1572 | 100 |
| **2012** | 46 | 2.73 | 196 | 11.65 | 317 | 18.84 | 336 | 19.96 | 269 | 15.98 | 519 | 30.84 | 1683 | 100 |
| **2013** | 40 | 2.33 | 214 | 12.49 | 309 | 18.03 | 301 | 17.56 | 304 | 17.74 | 546 | 31.85 | 1714 | 100 |
| **All the years** | 190 | 2.86 | 742 | 11.19 | 1275 | 19.22 | 1323 | 19.95 | 1105 | 16.66 | 1998 | 30.12 | 6633 | 100 |

Table 1 shows that during the mentioned years, the highest number of scientific publications were devoted to the articles written by more than 5 authors (30.12%). After that, the articles written by 4 authors achieved the second rank (19.95%). The number of single-authored articles achieved the lowest rank among all the reviewed articles (2.86%).

**Table 2.** The most producing and cited authors of Shahid Beheshti University of Medical Sciences since 2009 to 2013

| Rank | Author (the number of publications) | Author (the number of received citations) |
|------|-------------------------------------|-------------------------------------------|
| 1 | Azizi, Fereidoun (235) | Azizi, Fereidoun(1772) |
| 2 | Zali, Mohammad Reza (144) | Zali, Mohammad Reza (672) |
| 3 | Hedayati, Mahdi(98) | Hadaegh, Farzad(607) |
| 4 | Kazemi, Bahram (84) | Mirmiran, Parvin(579) |
| 5 | Mirmiran, Parvin(72) | Hedayati, Mahdi(577) |
| 6 | Hadaegh, Farzad(67) | Masjedi, Mohammad Reza (469) |
| 7 | Masjedi, Mohammad Reza (64) | Tabarsi, Payam(429) |
| 8 | Kobarfard, Farzad (60) | Khodagholi, Fariba (386) |
| 9 | Basiri, Abbas(58) | Hossein Panah, Farhad(370) |
| 10 | Khodagholi, Fariba (55) | Mansouri, Davoud(359) |

Table 2 shows that in the scientific publications of SBUMS, Azizi, Zali, and Hedayati achieved the first, second, and third rank respectively in terms of the number of publications. Moreover, Azizi, Zali, and Hadaegh achieved the first, second, and third in terms of the number of received citations. 60% of the authors are the same in the two lists of the most producing and cited authors.

**Table 3.** Co-authorship indices at Shahid Beheshti University of Medical Sciences since 2009 to 2013

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | All the years |
|------|------|------|------|------|------|---------------|
| CI | 4.28 | 4.25 | 4.21 | 4.27 | 4.32 | 4.27 |
| DC | 0.95 | 0.98 | 0.97 | 0.97 | 0.98 | 0.97 |
| CC | 0.71 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 |

Table 3 shows the co-authorship indices at SBUMS. The findings suggest that CI is 4.27 during the mentioned years. It represents the mean of the number of authors of each article. The DC is 0.97 and the CC is 0.72 representing that the number of single-authored articles is very low. The authors at SBUMS showed a great desire to collaborate with other authors. The tendency of the authors towards co-authorship has increased slightly during the mentioned years.

**Table 4.** The ratio of national to international collaboration at Shahid Beheshti University of Medical Sciences since 2009 to 2013

| Year | The number of national collaborations | The number of international collaborations | The number of all the articles | NI | INI | The ratio of national to international collaborations |
|------|------|------|------|------|------|------|
| 2009 | 545 | 121 | 705 | 77.30 | 17.16 | 4.5 |
| 2010 | 778 | 160 | 959 | 81.13 | 16.68 | 4.86 |
| 2011 | 1263 | 265 | 1572 | 80.34 | 16.86 | 4.77 |
| 2012 | 1380 | 257 | 1683 | 82 | 15.27 | 5.37 |
| 2013 | 1362 | 312 | 1714 | 79.46 | 18.2 | 4.37 |
| All the years | 5328 | 1115 | 6633 | 80.33 | 16.81 | 4.78 |

Table 4 shows that international collaboration is very low and the lowest extent belonged to 2009. However, as the number of articles in later years increases, the number of international collaboration increases as well. The maximum extent of international collaboration is related to 2013 with 312 cases and the ratio is 18.1 but the ratio of national collaboration to international collaboration in 2012 is 5.37 which is the highest. The maximum extent of international collaboration has been with the USA, England, and Canada, and then Germany and France. In

addition, among Islamic countries, Malaysia has

the highest extent of collaboration with Iran.

**Table 5.** Comparing the structure of co- authorship networks at Shahid Beheshti University of Medical Sciences since 2009 to 2013

| Year | The number of articles | The number of nodes | The number of isolated nodes | The number of links | The number of co-authorship between two nodes | Mean degree | Density |
|---|---|---|---|---|---|---|---|
| **2009** | 705 | 2221 | 11 | 8951 | 1-13 | 8.06 | 0.004 |
| **2010** | 959 | 2962 | 6 | 17359 | 1-23 | 11.72 | 0.004 |
| **2011** | 1572 | 4311 | 17 | 15745 | 1-24 | 7.3 | 0.002 |
| **2012** | 1683 | 5077 | 12 | 44568 | 1-20 | 17.56 | 0.003 |
| **2013** | 1714 | 5001 | 7 | 21259 | 1-15 | 8.5 | 0.002 |
| **All the years** | 6633 | 12825 | 19 | 97618 | 1-70 | 15.22 | 0.001 |

The report of co-authorship networks in the years mentioned in Table 5 shows that generally 12825 authors collaborated in these productions and only 19 authors have produced the publications individually. The number of links is 97,618 and the mean degree is 15.22 which means that each of the authors have been in contact with 15 others on average during the mentioned years.

Table 5 indicates that the number of authors who are present in the co-authorship network increases as the number of the articles increases and 2221 nodes in 2009 increases to 5077 nodes in 2012 and the number of nodes decreases slightly again in 2013. The number of links among the authors is between 1 to 24 times in different years. This number is 70 times at most which means that an author is at least in contact with 1 author in terms of co-authorship and at most with 70 authors. The mean degree is 17.56 in 2012 which is significantly different in comparison to the rest of the mentioned years. This number is 15.22 in other years of the study on average. The network density (0.001) indicates that during the years of study, co-authorship networks face a lot of sparseness. Figures 1 to 3 represent the co-authorship networks of the researchers at SBUMS during the years of the study which are drawn according to the maximum degree centrality, maximum betweenness centrality, and the strongest co-authorship relations.
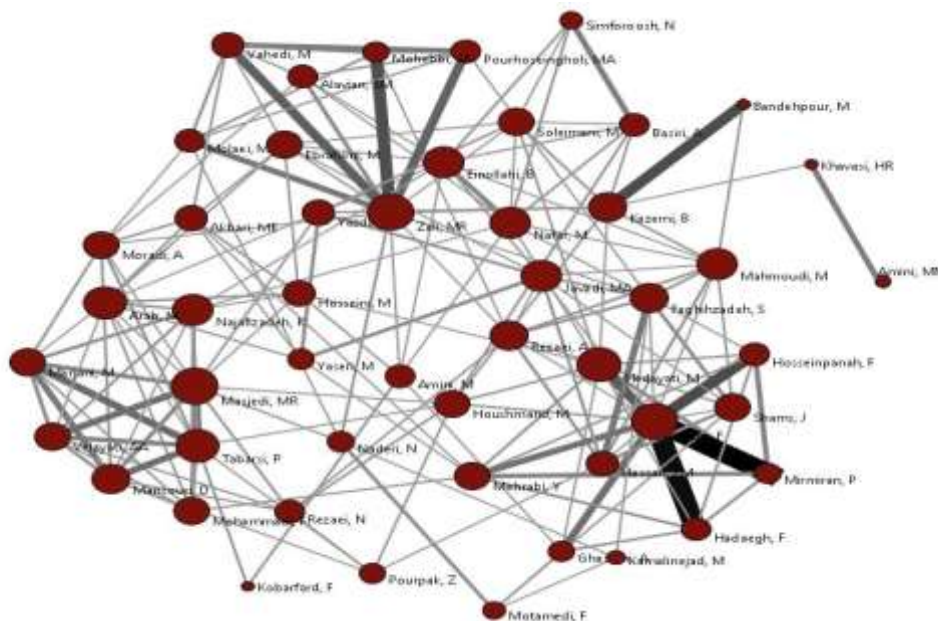


**Figure 1.** The authors having the maximum degree centrality in co-authorship networks at Shahid Beheshti University of Medical Sciences

In Figure 1, 50 nodes have been shown having the maximum degree centrality in co-authorship networks (the considered threshold is having at least 3 degrees and 3 citations). Zali, Azizi, and Masjedii achieved the maximum degree centrality.
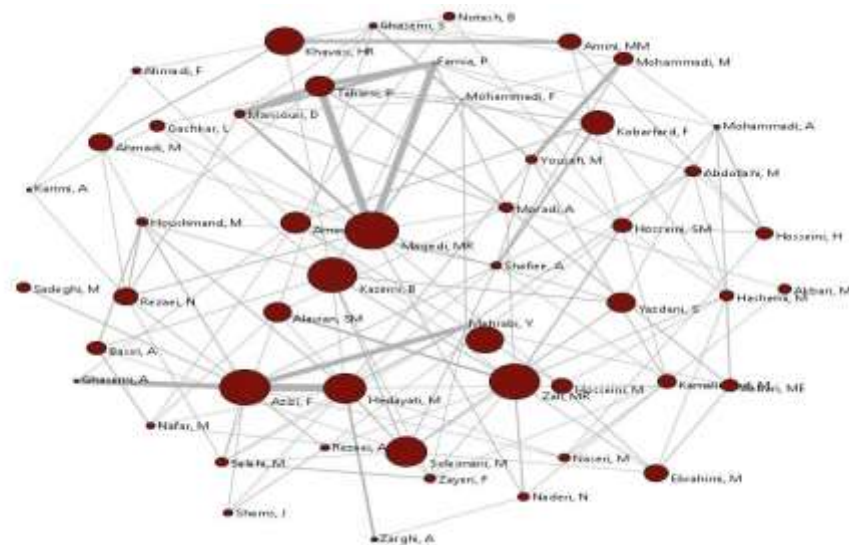


**Figure 2.** The authors having the maximum betweenness centrality in co-authorship networks at Shahid Beheshti University of Medical Sciences

In Figure 2, 50 nodes have been shown having the maximum betweenness centrality in co-authorship. Zali, Azizi, and Masjedi and Kazemi achieved the maximum betweenness centrality and have shown as greater nodes.
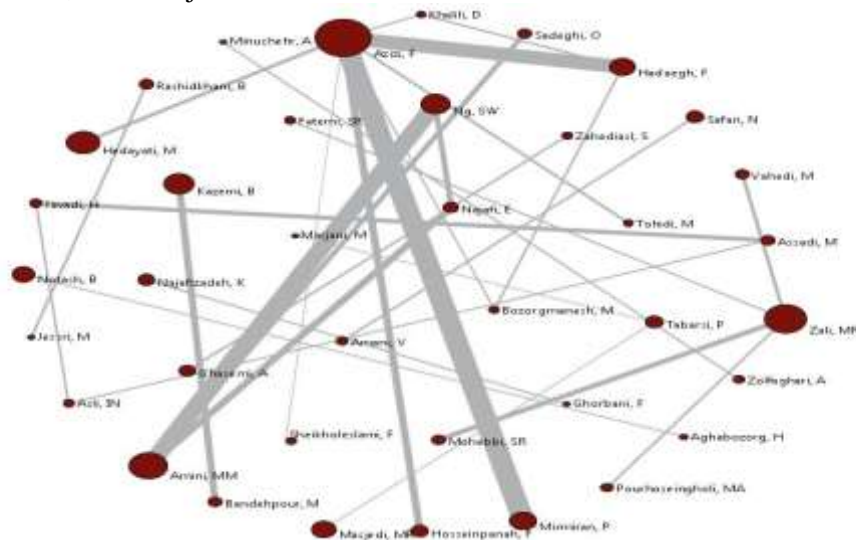


**Figure 3.** Thirty stronger co-authored relationship at Shahid Beheshti University of Medical Sciences on the map since 2009 to 2013

Figure 3 shows that the highest extent of co-authorship between Azizi and Mirmiran having 70 co-authorship and after that it is between Azizi and Hadaegh having 64 co-authorship. The minimum extent of co-authorship in the figure is 21 and the maximum extent is 70. In the above figure, there are 38 nodes and 30 links. The most important authors in terms of the degree centrality and betweenness centrality during the years of the study are shown in Table 6

**Table 6.** The most important authors in terms of degree centrality and betweenness centrality at Shahid Beheshti University of Medical Sciences

| Rank | Author (degree centrality) | Author (betweenness centrality) |
|---|---|---|
| 1 | Masjedi, Mohammad Reza (457) | Masjedi, Mohammad Reza(0.943859E+07) |
| 2 | Zali, Mohammad Reza (366) | Zali, Mohammad Reza (0.853704E+07) |
| 3 | Azizi, Fereidoun (334) | Azizi, Fereidoun (0.853067E+07) |
| 4 | Kazemi, Bahram(254) | Kazemi, Bahram (0.818140E+07) |
| 5 | Mansouri, Davoud (253) | Hedayati, Mahdi (0.647951E+07) |
| 6 | Tabarsi, Payam(250) | Soleimani, Masoud (0.638264E+07) |
| 7 | Hedayati, Mahdi(231) | Kobarfard, Farzad (0.464531E+07) |
| 8 | Khavasi, Hamid Reza(216) | Tabarsi, Payam (0.385870E+07) |
| 9 | Rezaee, Nima(183) (Tehran University of Medical Sciences) | Shahin, Yazdani (0.375189E+07) |
| 10 | Parvaneh, Nima(177) (Tehran University of Medical Sciences) | Amini, Mohsen (0.397096E+07) (Tehran University of Medical sciences) |

Table 6 shows that during the years of the study, Masjedi, Zali, and Azizi achieved the maximum degree centrality and betweenness centrality in the co-authorship networks of the University. Sixty percent of the authors are the same on the 2 list of top authors in terms of degree centrality and betweenness centrality. Some of the authors of Tehran University of Medical Sciences are present in the two lists.

## DISCUSSION

The findings indicate that the authors at SBUMS have a great tendency towards writing the articles having more than five authors and such articles form one third of the articles during the years of the study. A small percentage of the articles are single-authored articles during the years of the study. The findings of Hayati and Didgah also show that Iranian researchers have a great desire to write articles having more than 4 authors in comparison to other articles [27]. The results of the present study confirm the findings of Mohammad Hassanzadeh et al. showing that the authors at SBUMS have a low tendency towards single authorship [28]. However, the findings of other researches [6, 29] are not in line with the findings of the present study that shows the maximum number of scientific publications is allocated to the articles written by more than 5 authors. The authors in social sciences tend to write articles in collaboration with 2 or 3 authors [6]. In the field of Management, another study

conducted by Acedo et al. showed that the tendency towards co-authorship is less in the field of management compared with medicine [29]. Since the authors at SBUMS, as part of the medical community, have a great tendency towards publishing the articles having more than five authors, it can be concluded that the tendency towards co-authorship in the field of medicine is much more than social sciences. In this regard, in a study by Basir Ghafouri et al. in the field of Emergency Medicine of Iran as one of the medical fields, it was shown that the authors in this field have a great tendency to write the articles in collaboration with 5 or more authors [30]. Reviewing the article of the "Journal of Research in Medical Sciences" showed that the authors of the articles in this journal have a great tendency towards publishing the articles by 4 authors [31]. The authors in the field of pharmacy and pharmacology also tend to publish the articles having 5 or more authors [20]. But, Shahrabi Farahani et al. indicated that Iranian researchers in the field of cardiovascular diseases tend to publish the articles written by 3 authors, but if they have had used "5 and more" or "6 and more" in data analysis, the results would be different [19]. The collaboration index (CI) showed that the mean of the number of the authors in the resources under review is 4.37. This number is almost the same as in Iranian cardiovascular articles (4.7) [19] but it is less in social sciences [6, 26]. The degree of collaboration (DC) is 0.97,

and the collaborative coefficient (CC) is (0.72) which confirms that there is a great tendency towards co-authorship at SBUMS but the tendency towards single-authorship is low. DC was the highest in 2013 showing an increasing tendency towards scientific collaboration among the authors of the university. The finding was in line with the findings of Heydari and Safavi calculating the collaborative coefficient of the articles of the "Journal of Research in Medical Sciences" [31] and the findings of Asadi et al. calculating the collaborative coefficient at Sharif University of Technology. In the field of pharmacy and pharmacology in Iran also the collaborative coefficient of 0.7 is obtained which is similar to the coefficient obtained in the present study [20]. The ratio of national to international collaboration of the university is 4.78 showing that the international collaboration at the university is not favorable but this ratio shows that during the 5 years of the study, the number of international collaboration has increased slightly. The international collaboration at Sharif University of Technology is the same as the present study and it is not favorable [22]. However, in Korea and China the international collaboration is more than the national collaboration [32, 33]. The Findings of this research shows the maximum extent of international collaboration is with the USA that is the same as the results of international co-authorship of Iranian researchers' scientific outputs in SSCI [23] and in international co-authorship of Sharif university scientific outputs [22]. But, it is not in line with international co-authorship of pharmacology and pharmacy, or, parasitology in Iran. These studies revealed that most co-authorship of the researchers of Iran is with researchers of England [20, 24]. Findings show that in co-authorship networks, there are 12825 nodes (authors) that are linked with 97618 edges. These numbers are different in the networks of other fields. For example, in co-authorship network of Iranian researchers in Technology Policy and management, there are 238 nodes and 436 links between them [25]. And in co-authorship network of parasitology in Iran there are 500 nodes [24]. Since the structure of co-authorship networks is unique, we couldn't compare it with other networks.    The most prolific and most cited authors and the authors with the highest centralities are shown in this article. As other researchers indicate, considering high-degree nodes as influential has long been a standard approach for social and other networks and authors located in central situations, have important role in the growth and evolution of networks and absorption of new authors to the networks [34, 25]. In this research, the highest degree and betweenness centrality belongs to Masjedi which shows that he is related to many authors; it also shows the communication paths of other nodes overtaking him. This author is also between the first ten productive and cited authors. It is recommended that the authors or individuals achieving high scores in terms of centrality indices in the drawn networks be introduced and encouraged by the university.

The structure of co-authorship networks at Shahid Beheshti University of Medical Sciences in different years shows that the number of articles and nodes and links in 2013 is more than two times than 2009. It shows the revolution of co-authorship network in these years is considerable. Findings of mean degree [15.22] demonstrate that, on average, each person is connected to about 15 other persons. This amount shows that the overall relationship among authors is good. But, density of network is 0.001 that indicates the sparseness of network. It means only the %0.01 of the whole number of potential links has formed in this network, solidarity of network is not high, information transmission among nodes and in the whole network is performed at a low rate.

## CONCLUSION

According to the findings of the study, the planning and policy-making of the university can provide the faculty members with some facilities such as taking a sabbatical and participating in international conferences which can increase the international collaboration and reduce the ratio of national to international collaborations; therefore, the faculty members can communicate with foreign researchers and provide shared studies. Ultimately, it can increase the ranking of the university and affect the national and international rankings because the international collaboration and national collaborations with other universities are important indices in many systems of ranking

[35]. While providing encouraging policies for collaboration among the authors can increase collaboration among the researchers and can ultimately increase co-authorship among authors, it is suggested that SBUMS pays more attention to scientific collaborations. Authors should increase their interactions with other authors from different universities and countries in regard to research ethics. The structure of co-authorship networks should be studied in different times to explore effective authors and encourage them.

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## REFERENCES

1. Bozeman B, Lee S. The Impact of Research Collaboration on Scientific Productivity. Annual Meeting of the American Association for the advancement of Science Denver, Colorado.2003.

2. Rahimi M, fattahi R. [Scientific collaboration and information production: a glance atconcepts and current models of co-authorship]. national studies on librarianship and information organization 2007;18(3):235-48.

3. Glänzel W, Schubert A. Analysing scientific networks through co-authorship. Handbook of quantitative science and technology research. Netherlands: Springer; 2005. p. 257-76.

4. Khosrowjerdi M, Zeraatkar N, Hajipour M. Proximity and Matthew Effect in co-authorship pattern of Iranian top universities. Malaysian Journal of Library & Information Science. 2012;17(2):71-82.

5. Ajiferuke I, Burell Q, Tague J. Collaborative coefficient: A single measure of the degree of collaboration in research. Scientometrics. 1988;14(5):421-33.

6. Nikzad M, Jamali HR, Hariri N. Patterns of Iranian co-authorship networks in social sciences: A comparative study. Library & Information Science Research. 2011; 33(4):313-9.

7. Zare-Farashbandi F, Geraei E, Siamaki S. [Study of co-authorship network of papers in the Journal of Research in Medical Sciences using social network analysis]. Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences. 2014;19(1):41.

8. Cheong F, Corbitt BJ. A social network analysis of the co-authorship network of the Pacific Asia Conference on Information Systems from 1993 to 2008. PACIS 2009 Proceedings. 2009:23.

9. Rosenbalt G. What is network density- and how do you calculate it?. 2013. Available from: http://www.the-vital-edge.com/what-is-network-density/.

10. Shekofteh M, Hariri N. [Scientific mapping of medicine in Iran using subject category co-citation and socialn network analysis]. Journal of Health Administration (JHA). 2013;16(51):43-59.

11. Chen C, Ibekwe-SanJuan F, Hou J. The structure and dynamics of cocitation clusters: A multiple-perspective cocitation analysis. Journal of the American Society for Information Science and Technology. 2010;61(7):1386-409.

12. Fakhree MA, Jouyban A. Scientometric analysis of the major Iranian medical universities. Scientometrics. 2011; 87(1):205-20.

13. Shekofteh M, Mohseny M, Shahbodaghi A, Zayeri F, Rahimi F. The correlation among Y-index and other scientometric indicators. Current Science.2016; 110 (9):1823-1828.

14. Didgah F, Erfanmanesh MA. [Review of co-authorship between Iran and Asean countries]. Information Sciences and Technologies]. 2009; 24(4):85-102.

15. Velayati K, Noruzi A. [Scientific Research Collaboration between Iran and Its Neighbour Countries]. Journal of Science and Technology Policy. 2009;1(4):73-5.

16. Osare F, Soheili F, Farajpahlo A, Moarefzadeh A. [A survay on centrality measure in co-authorship networks in information science journals]. Library and Information Research Journal. 2013;2(2).

17. Afshar M, Abdulmajid A, Danesh F, editors. Survey on authors collaboration rate and citation behaviors in JRMS articles curing 2004–2006. Fourth International Conference on Webometrics, Informetrics and Scientometrics & Nineth COLLNET Meeting; 2008.

18. Afshar M, Abdulmajid A, Hakimi Z, Majidfard A. Survey of authors' collaboration rate in scientometrics journal articles during 2004 to 2008. International Journal of Information Science and Management (IJISM). 2012;9(1):47-56.

19. Shahrabi Farahani H, Eskrootchi R, Mohaghegh N, Hosseini A. [A Study of scientific collaboration in Iranian cardiovascular articles in Web of Science; 2002 – 2011]. Journal of Health Administration. 2014;17(56):46-55.

20. Osareh F, Serati Shirazi M, Khademi R. [A Survey on co-authorship network of Iranian researchers in the field of Pharmacy and Pharmacology in Web of Science during 2000-2012]. Journal of Health Administration. 2014;17(56):33-45.

21. Osareh F, Wilson CS. Collaboration in Iranian scientific publications. Libri. 2002;52(2):88-98.

22. Asadi M, Joolaei S, saghafi s, Bazrafshan A. [Scientific collaborations and co-Authorship networks in scientific publications of Sharif University of Technology during 2005-2010]. National studies on librarianship and information organization. 2013;24(1):166-86.

23. Osareh F, Khademi R, Rostami MK, Shirazi MS. Co-authorship network structure analysis of Iranian researchers' scientific outputs from 1991 to 2013 based on the Social Science Citation Index (SSCI). Collnet Journal of Scientometrics and Information Management. 2014 Jul 3;8(2):263-71.

24. Sadoughi F, Valinegadi A, Shirazi MS, Khademi R. Social network analysis of Iranian researchers on medical parasitology: A 41 year co-authorship survey. Iranian Journal of Parasitology. 2016;11(2):204-12.

25. Roshani, S, Ghazinoori S, Tabatabaeian Sh. [A co-authorship network analysis of Iranian researchers in Technology Policy and Management]. Journal of Science and technology policy. 2014;6(2): 1-16.

26. Choobbasti HJ, Alizadeh M. [An analysis of co-authorship network in the Iranian sociology]. Journal of Applied Sociology. 2015;59(3):76-98.

27. Hayati Z, Didegah F. [A Comparative study of propensity of Iranian researchers for collaboration and team work for the period 1998-2007]. Information Sciences & Technology. 2010;25(3).

28. Mohammad Hassanzadeh H, A Gorji H, Shokranehnanehkaran F, Valinejadi A. [Scientific products of Iran University of Medical Sciences' Authors with co-authorship networks in Web Of Science (WOS) Database, up to 2007]. Journal of Health Administration. 2009;11(34):59-67.

29. Acedo FJ, Barroso C, Casanueva C, Galán JL. Co-Authorship in Management and Organizational Studies: An empirical and network analysis. Journal of Management Studies. 2006;43(5):957-83.

30. Basir Ghafouri H, Vakilian M, Mohammadhassanzadeh H, Farahmand S. [Mapping of co-authorship network of Iranian Emergency Medicine using cluster analysis]. Journal of Health Administration. 2012;15(48):69-80.

31. Heydari M, Safavi Z. [The survey of collaborative coefficient of article authors in "Journal of Research in Medical Sciences" since 2007 to 2011]. Research in medicine. 2012;36(2):109-13.

32. Kim M-J. Korean international co-authorship in science 1994-1996. Journal of Information Science. 1999;25(5):403-12.

33. Royle J, Coles L, Williams D, Evans P. Publishing in international journals. Scientometrics. 2007;71(1):59-86.

34. Kempe D, Kleinberg J, Tardos É. Maximizing the spread of influence through a social network. Theory of Computing.2015;11(4):105-47.

35. Alimohammadi D. [The Comparison and analysis of university ranking systems] 2002 [cited 2014 10 jan.]. Available from: http://www.lisna.ir/Away/11257