Co-authorship network in cardiology research studies: case study of Iranian output

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The basic objective of the study is to determine the co-authorship network of cardiology research in Iran. Scientometric approach was used to conduct the study. In the study, in addition to drawing the co-authorship network of cardiovascular articles of Iran indexed in WoS database, the researcher analysed the main cores of co-authorship network. Data was analysed by descriptive and analytical method. The centrality index which reflects the status of specific nodes in the network has also been determined. There were 2631 Iranian authors who published 1071 articles in cardiology. Density of 0.002 represents the continuity of the network and clustering coefficient of 0.51 indicates the willingness of the authors for research cooperation. Co-authorship network of cardiovascular area has a very large core. Tehran University of Medical Sciences had the highest degree and closeness centralities followed by most prolific and influential authors and the highest betweenness centrality was of Tabriz University of Medical Sciences. It is essential to note that people with more papers and citations, are not necessarily the central and influential members of the co-authorship network. Those with a small number of articles and citations can be a member of the key group of the co-authorship network and they control the flow and dissemination of information.

Keywords: Cardiology, co-authorship network, collaboration, scientometrics.

SCIENTIFIC production or research output in recent years has emerged as one of the potential indicators of strength, independence and development of a country[1,2]. To increase scientific productivity, interdisciplinary studies are being encouraged over disciplinary approaches. Interdisciplinary research integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines to produce new knowledge[3]. With an increase in interdisciplinary research, independent research has drastically reduced[4].

As a result, scientific cooperation has become considerably essential since no one can have expertise in multi fields[1,5,6]. With an increase in complexity of knowledge, the demand for particular specializations in interdisciplinary skills has evolved scientific collaboration. Such collaborations provide an opportunity for researchers to combine their capabilities in different research areas which were impossible to accomplish individually[6]. Research reveals that one way to improve the quality of science is through cooperation[7]. Therefore, the most evident form of scientific cooperation, in other words, 'co-authorship' is recognized as the key element in the advancement of knowledge, science and research collaboration[1,8–10]. It has been further facilitated with the availibility of information technology and network[7]. Many researchers consider co-authorship as one of the most important and common studies in scientometrics studies[11].

According to Chew, the growth in number of authors is much faster than the process of growth in number of articles. Different patterns of scientific collaboration such as international cooperation and inter-organizations between scientists and researchers are growing rapidly[12]. Indicators show that the process of joint research between experts from developing and developed countries and the number of scientific papers generated by the experts of these countries is still ongoing[13,14].

Scientific cooperation is as important as creation and dissemination of scientific research to promote and enhance the quality of scientific output[10,15]. Nevertheless, co-authorship is a reliable target of research collaboration that can be considered as an indicator of scientific evaluation as well[15]. Authorship in studies creates a social network where authors are the nodes of the network and the lines are their connections. Each of the nodes in the network signifies a specific location, and the author's contribution is characterized by the number of links that connects to the other nodes[16]. In the analysis of these networks there are various indicators which can be shown in scientific maps. For instance, the size of a network can be determined by the number of nodes, the density of the network, and the number of links[11]. The centrality index

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is also one of the most important indicators in the analysis of the network. This indicator reflects the status of specific nodes in the network. There are three common centrality measures: degree centrality, betweenness centrality and closeness centrality[15]. Degree centrality is the simplest type of centrality in which the value of each node is obtained by the number of neighbours, and the number of neighbours is obtained by the number of connections to that node. A larger centrality of an author would mean more connections and larger impact on the network. Betweenness centrality is the indicator of the importance of a node in terms of its location on the map and network data. The index of betweenness centrality is calculated based on the position of the individual in the network. An author with large betweenness centrality is an author in the middle of a large net of nodes where many links cross through it to other nodes. A node with large betweenness centrality has the ability to isolate or increase communications. The other is closeness centrality that extends the concept of degree centrality. It is focused on the closeness of nodes to each other; the shorter the links between the authors, the higher the closeness centrality index[11].

Background

In recent years, the phenomenon of co-authorship and scientific cooperation has penetrated all fields of science, including medical and biomedical science[1]. One of the most important areas of medical science is cardiology. Today, heart disease is common in the world, and is expected to be the main cause of death by 2020. Many studies in various areas of science, in particular medicine have shows the importance of collaboration and authorship networks analysis in assessing the status of the field. However, few studies highlight the co-authorship network of Iran's emergency medicine, oncology and cardiology fields[16–19]. Moreover, according to Subramaniyam[20], Iran has increased its publication output by nearly ten-fold from 1996 through 2004, and has been ranked first in terms of output growth rate, followed by China. Another study of SCImago states that Iran would rank fourth in the world in terms of research output by 2018, if the current trend persists[21]. With these motivations the authors have conducted the study to draw the co-authorship network of cardiovascular articles of Iran indexed in WOS database and analyse the main cores of co-authorship network.

Objective

(1) To determine the co-authorship pattern of cardiovascular studies carried out in Iran. (2) To identify top Iranian contributors in cardiovascular studies. (3) To analyse the main cores of co-authorship network.

Methods

This study, extracted a set of descriptive data from Web of Science (WoS) database using the formula, CU = Iran AND PY = 2002–2011, and analysed the data by descriptive and analytical method. CU = Iran, is to narrow down the results of the scientific productivity of Iran, and PY = 2002–2011, is to limit the results to 2002–2011. Using the above formula, the initial search recovered 127,548 papers. This is the total number of articles indexed in the WoS database related to Iran's publications during the mentioned period. Then using 'Result Refine' option, a feature of WoS database for refining the search results, the results were narrowed down to 'cardiovascular system cardiology'. As a result, 1222 articles were retrieved. Nevertheless, the 'Evidence of Correction', 'Letter', and 'Editorial' with respectively, 1, 88 and 62 papers were removed since these documents are naturally written by a single author. Other types of documents, such as 'article', 'software review', 'review', 'proceeding paper' and 'meeting abstract' were saved. Finally, 1071 articles formed the data for the study.

In order to draw the co-authorship network, the data was changed to a readable format and then used by Pajek software. In the next step, for co-authorship network analysis, the number of the nodes, number of lines, density and factor of impact cluster, were calculated by the Pajek software. The authors were then ranked based on the values of centrality including degree centrality, betweenness centrality and closeness centrality. Also, prolific authors were identified based on the number of papers, and influential authors based on the number of citations. The results were compared through drawing network and software calculations.

Results

Figure 1 shows the co-authorship network in the field of cardiovascular studies. The nodes represent authors, and the magnitude of each node refers to the number of papers contributed by each author. The larger the size of the node, the more articles the author has. Each line represents the co-authorship and the thickness of each line refers to the number of co-authorships. The number of nodes, the number of clusters, density of network and factor of impact cluster were also calculated.

There were 2631 authors who published 1071 articles in cardiology during the research years shown in Table 1. Density 0.002 represents the continuity of the network and clustering coefficient 0.51 indicates the willingness of the authors in this field for cooperation.

In addition, for a better picture of the co-authorship network of cardiovascular studies, a co-authorship map visualizing the structure of the collaboration network of authors was obtained. As shown in Figure 2,

co-authorship network of cardiovascular area has a large core, 12 medium cores and some smaller cores. Smaller core indicates that the author collaborated in smaller groups.

As seen in Table 2, the top 10 authors in terms of degree centrality were identified. It should be noted that for the sake of confidentiality the names of authors were omitted. In this network, an author affiliated to Isfahan University of Medical Science with three articles had the most cooperation with other researchers. Among these
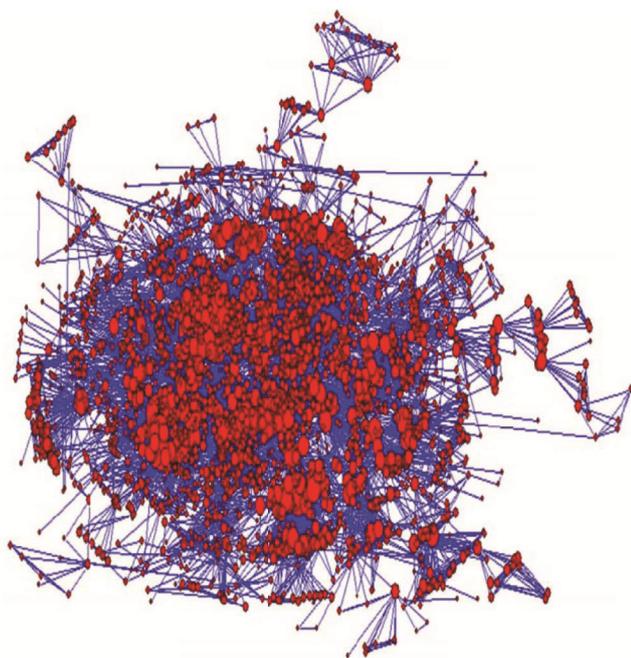

Figure 1. Co-authorship network in the field of cardiovascular studies.
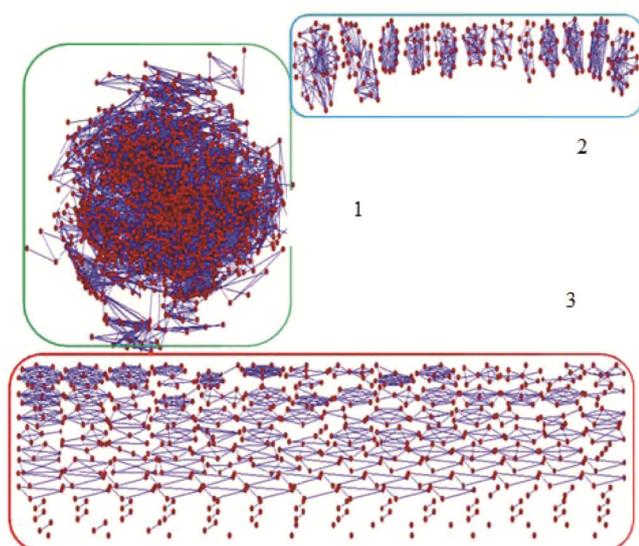

Figure 2. Co-authorship network articles in the field of cardiovascular.

ten authors, three of them affiliated to Medical University of Tehran, two of them to Medical University of Isfahan, one of them to Medical University of Kermanshah, and one affiliated to the Ministry of Health. Unfortunately, the affiliations of two researchers were not known. Furthermore, it was found that the researchers in the area of general medicine, social medicine and neurology also worked with members of the cardiovascular network.

Therefore, according to the research findings, one author with 6 articles from Tehran University of Medical Science had the highest closeness centrality. Based on affiliations, 4 authors worked in Medical University of Tehran, 3 authors in Medical University of Tabriz, and 1 worked in Medical University of Jundishapur. Again, affiliations of two authors were unknown. Based on closeness centrality, there was one author from University of Michigan in USA, among the top 10 authors. There were also general surgeons, general practitioners and medical students among the top ten authors who collaborated with the cardiovascular professions (Table 3).

Authors with the higher betweenness centrality are in the middle of many nodes and other communication lines cross from them. These authors have great influence on the network and control the information flow among other authors. Based on the outcome of this study, highest betweenness centrality in the co-authorship network of cardiovascular studies belonged to an author from Tabriz University of Medical Sciences with only seven papers (Table 4). Other authors were affiliated to the Medical University of Tehran, Medical University of Isfahan, Medical University of Iran and Medical University of Bushehr. Affiliation of one author was unclear. Again, the researcher from Michigan University of America, was among these top ten authors in the co-authorship network. In addition to cardiovascular specialists, there were researchers in nuclear medicine, general practitioners and medical students in this network.

As shown in Table 5, authors were ranked according to number of papers published in the WoS in the cardiovascular field. If the number of articles of two authors was equal, the excellence criterion was the number of citations.

The results indicated that the most prolific writers who released most number of cardiology articles were from the Tehran University of Medical Science with 51 and 41 articles, for the first and second ranked authors. Also four authors from Medical University of Tehran and Isfahan, two authors from Medical University of Iran and one author from Day hospital were also prolific writers in this field.

Table 1. Co-authorship network article in the field of cardiovascular

Impact factor clusters	Network density	Number of lines	Number of nodes
0.51	0.002	10242	2631

Table 2. Authors with highest degree centrality in co-authorship network of cardiovascular studies

Expertise researcher	Affiliation	Number of citations	Number of articles	Degree centrality	Author name
Cardiologist	Isfahan University of Medical Sciences	5	3	0.035741	Ali Akbar Tavassoly
Cardiologist	Unknown	6	4	0.030038	Ali Ismail Nadimi
General practitioner	Isfahan University of Medical Sciences	8	3	0.029658	Mohammad Talaei
Professor of cardiology	Tehran University of Medical Sciences	47	20	0.024715	Majid Maleki
Unknown	Unknown	0	1	0.024715	Sajjadi
Professor of cardiology	Shiraz University of Medical Sciences	3	7	0.023954	Amir Ghofran
Cardiologist	Tehran University of Medical Sciences	138	28	0.023574	Zahra Emkanjou
Neurologist	Kermanshah Tehran University of Medical Sciences	4	1	0.022433	Daryoush Afshari
General practitioner	Tehran University of Medical Sciences	22	6	0.022053	Mohammad Asadin Rad
Specialist in community medicine	Ministry of Health	84	17	0.021293	Manely Sadeghi

Table 3. Authors with highest closeness centrality in co-authorship network of cardiovascular

Centre near	Number of articles	Number of citations	Affiliation	Expertise researcher
0.183051	6	22	Tehran University of Medical Sciences	General practitioner
0.178616	1	0	Tabriz University of Medical Sciences	Unknown
0.176331	1	3	Tabriz University of Medical Sciences	Medical student
0.174415	2	4	Tehran University of Medical Sciences	General practitioner
0.173437	28	138	Tehran University of Medical Sciences	Cardiologist
0.173105	2	8	Unknown	Unknown
0.171979	9	31	Tehran University of Medical Sciences	Professor of General Surgery
0.170866	1	1	University of Michigan America	Cardiologist
0.170682	2	1	Jondi Shapour University of Medical Sciences	Fellowship cardiologist
0.169111	6	9	Tabriz University of Medical Sciences	Cardiologist

Since having more number of citations is important to any author, researchers who received the highest number of citations for their papers were identified in the next step (Table 6).

The results indicated that the authors who had ranked first and second in the number of publications, also ranked first and second in the number of citations with 266 and 252 citations respectively. In terms of affiliation, three of them worked in the Medical University of Tehran; two in the Medical University of Iran, one in the Medical University of Shahid Beheshti and the last one worked in the Medical University of Isfahan. It should be noted that authors from the Netherlands and America collaborated with the Iranian specialists. It is noteworthy that besides cardiologists, pediatricians, professors of endocrinology and metabolism, clinical epidemiologists and pathologists also cooperated in this area.

Discussion

The findings of this study showed that, the co-authorship network of cardiology studies in Iran consisted of 2631 authors who cooperated with each other to produce 1071 papers published in the WoS database. The studies of Basir Ghafouri et al.[16] and Hariri and Nikzad[22] in emergency medicine showed lower density in co-authorship network than the density of cardiovascular network. This could represent the more discrete nature of this network[16,22]. In the analysis of the structure of cores of the co-authorship network, it was revealed that among the most cited authors in this field, there are three international authors, of which two are from America. This shows the tendency of Iranian authors to cooperate with their counterparts in United States and the influence of American researchers in the cardiology area. This finding was in accordance with a study by Hassanzadeh et al.[23] in the immunology field, who determined that Iranian scientists had the most cooperation with American researchers in the articles from the WoS database. In another study, it was also reported that the co-authorship of most Korean researchers was with their counterparts in America[24]. Must[25] in relation to Estonia, also indicated that most scientific cooperation in recent years, was with America. The research of Zare-Farashbandi, Gerayi and Siyamaki, also suggested the same results[26]. Therefore, it could be concluded that in many countries, especially in developing countries, scientific cooperation with American scientists, is at the top in terms of international cooperation.

In terms of affiliation, University of Tehran had the most central people in the co-authorship network, and had

Table 4. Authors with highest betweenness centrality in co-authorship network of cardiovascular studies

Betweenness centrality	Number of articles	Number of citations	Affiliation	Expertise researcher
0.071019	7	17	Tabriz University of Medical Sciences	Cardiovascular surgery
0.065883	1	3	Tabriz University of Medical Sciences	Medical student
0.051087	1	11	University of Michigan America	Cardiologist
0.045837	6	22	Tehran University of Medical Sciences	General practitioner
0.042692	1	2	Unknown	Unknown
0.042191	3	8	Isfahan University of Medical Sciences	General practitioner
0.038849	3	5	Isfahan University of Medical Sciences	Cardiologist
0.037303	1	2	Iran University of Medical Sciences	Cardiologist
0.034781	2	8	Unknown	Unknown
0.03001	4	5	Bushehr University of Medical Sciences	Nuclear medicine specialist

Table 5. Authors with highest publications in co-authorship network of cardiovascular studies

Total articles	Total citations	Affiliation	Expertise researcher
51	266	Tehran University of Medical Sciences	Cardiologist
47	252	Tehran University of Medical Sciences	Professor of Cardiology
41	146	Iran University of Medical Sciences	Cardiologist
31	111	Isfahan University of Medical Sciences	Professor of Cardiology
30	181	Tehran University of Medical Sciences	Cardiologist
28	203	Isfahan University of Medical Sciences	Pediatricians
28	138	Tehran University of Medical Sciences	Cardiologist
28	60	Isfahan University of Medical Sciences	Doctor of Pharmacy
27	140	Iran University of Medical Sciences	Cardiologist
25	95	Day hospital	Professor of Cardiology

Table 6. Most highly cited authors in co-authorship network of cardiovascular

Total citations	Total articles	Affiliation	Expertise researcher
266	51	Tehran University of Medical Sciences	Cardiologist
252	47	Tehran University of Medical Sciences	Professor of Cardiology
203	28	Isfahan University of Medical Sciences	Paediatricians
187	20	Shahid Beheshti University of Medical Sciences	Professor of Endocrinology
181	30	Tehran University of Medical Sciences	Cardiologist
167	4	Unknown	Unknown
149	1	University of Leiden	Specialist Clinical Epidemiology
149	1	American Hopkins University	Pathologist
146	41	Iran University of Medical Sciences	Cardiologist
140	27	Iran University of Medical Sciences	Cardiologist

the most prolific and most cited authors in the cardiovascular area as well. According to Yousefi et al.[27], most prolific authors in immunology were also from the Medical University of Tehran. Nevertheless, Basir et al.[16] determined that the prolific authors in emergency medicine worked in the Medical University of Tehran. Therefore, it can be concluded that the Medical University of Tehran plays a fundamental role in scientific production in various areas of medical sciences[27]. In Basir et al.[16] study it was also determined that the emergency medicine research can comprise emergency medicine specialists and medical and non-medical professionals. Therefore, the nature of the interdisciplinary sciences provides avenues of cooperation for scientists in various fields.

In studying the prolific and most authoritative writers in cardiovascular articles of Iran in the main cores of the co-authorship network, it was revealed that writers of various specialties engaged in scientific collaboration, indicating the dynamics and interdisciplinary of the cardiovascular area. This finding in not limited to the cardiovascular area. Basir et al.[16] also found that the field of emergency medicine could involve emergency medicine specialists and other specialists in medical and non-medical areas. Erman[28] suggested that the centrality indicators were influenced by authors who had the most cooperation with other authors and were connected to prolific authors in the network. Therefore, the interdisciplinary nature of the various sciences provides the basis

for the cooperation of scientists from different disciplines.

Conclusion

According to this study, it is essential to note that people with more number of papers and citations, are not necessarily the central and influential members of the co-authorship network. Thus participation and co-authorship of scientific works can be unaffected by the number of papers and citations. In other words, those with a small number of articles and citations can be members of the key group of the co-authorship network, and they control the flow and dissemination of information. Hence, we can conclude that in scientometrics, the number of papers and citations and analysis of structure of the co-authorship network is effective. In order to achieve detailed scientometric output, all the factors of information flow, sharing and dissemination of the selected field should be considered and analysed.

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