International Journal of Information Science and Management
Vol. 15, No. 2, 2017, 1-13

Co-Authorship Patterns and Networks in Pharmacology and Pharmacy in Iran

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Abstract

This study aimed at investigating scientific collaboration and analyzing co-authorship networks in pharmacology and pharmacy research studies in Iran. Data used for this scientometric study included all pharmacology and pharmacy documents of Iran, indexed in Web of Science (WOS) from 2003 to 2014 and were analyzed using citation analysis section of WOS and Excell and SPSS. Citespace, and Gephi softwares were used for visualization and analysis of co-authorship network. The dominant co-authorship pattern was four-author pattern, with collaboration index, degree of collaboration and collaboration coefficient of 4.49, 0.96 and 0.691 respectively. The obtained density for co-authorship network and the clustering coefficient mean were 0.3 and 0.306 respectively. Despite the fact that the collaboration index in the field of pharmacology and pharmacy was much greater compared to other fields, the networks' total average density signified a great sparseness of co-authorship network. The clustering coefficient mean indicated that the network members' tendency towards forming different clusters was relatively low. There was no meaningful relationship between collaboration index and the number of productions as well as collaboration index and the citation impact. Authors indicated a greater tendency towards co-authorship. It is recommended that senior officials in scientific communities pay more attention to scientific collaboration activities, allocation of budget and appropriate facilities, and providing suitable circumstance to encourage more collaboration. It is recommended also, researchers pay more attention to constant team working with colleagues and students.

Keywords: Scientific Collaboration, Co-authorship Network, Pharmacology, Pharmacy, Web of Science, Iran.

Introduction

Scientific collaboration is a process during which two or more authors share their resources and talents to create a joint work. Nowadays scholars' capability of establishing scientific relationship at national and international levels has resulted in an increase in joint research activities which has in turn led to the development of science all around the world. Meanwhile, scientific collaboration is a yardstick for the evaluation of researchers and research groups' work quality which is considered as an effective method for achieving knowledge and advanced technology in developing and recently-developed countries. It has also mentioned that a growing collaboration amongst scientists leads to a better work quality, improved scientific development rate, solve complex scientific problems (Danesh, Mirzaee, Abdulmajid, Zeinolabedini, and Khosravi, 2009; Sonnenwald, 2007). Co-authorship is a major type of scientific collaboration which has been the focus of attention of researchers with a notable growth in recent years (Lu and Feng, 2009; Sonnenwald, 2007; Wang, Wu, Pan, Ma, and Rousseau, 2005). In his famous book "Little Science, Big Science", Price has also referred to co-authorship as one major measurable evolution(De Solla Price, 1973).

As Sonnenwald (2007) has said, there is a variety of terminologies, research approaches, and methods can be found in the literature about co-authorship. Mali, Kronegger, Doreian, and Ferligoj (2012) indicated that access to bibliographic databases and the availability of powerful quantitative social network approaches are the reason for increasing the number of studies of co-authorship networks in different scientific fields.

Three indices used in the investigation of co-authorship relationships are collaboration index (CI), degree of collaboration (DC) and collaboration coefficient (CC). CI signifies the average number of authors. DC indicates the ratio of co-authored articles over all articles under investigation. This index assigns a 0 weight to articles with one author while assigning a greater weight to articles with multiple authors. The amount of this index is a number between 0 and 1. If this number is inclined toward 1, it indicates that the number of articles with one author is lower, and if it is inclined toward 0, it shows that the number of articles with one author is greater. CC signifies the relative collaboration among the authors of articles. The amount of this coefficient is also a number between 0 and 1, illustrating a greater collaboration if it approaches toward 1 and less collaboration if it approaches toward 0. Articles with a single author are at priority(Ajiferuke, Burell, and Tague, 1988).

Another method utilized in co-authorship relationships is mapping co-authorship networks and analyzing them using Social Network Analysis (SNA). In particular, co-authorship networks among scientists are a particularly important part of the collaborative social structure of science (Mali, Kronegger, Doreian, and Ferligoj, 2012). There are social links among the individuals and members participating in research at co-authorship networks analysis. The main objective of social network analysis is the detection and analysis of social interactions among individuals (Cao, Pauleen, Wang, and Whitworth, 2011; De Nooy, Mrvar, Batagelj, and Granovetter, 2005). Each co-authorship network is comprised of a series of nodes or actors and edges or links. Nodes signify authors and edges signify co-authorship relations among authors (Hanneman and Riddle, 2005). Each network is investigated based on two perspectives: structure and network's members. The structural perspective contains the number of nodes and edges, network density, mean degree, cluster coefficient, and network

diameter.

Network density is one of the calculation scales indicates a network's density or sparseness. "The density of a graph is defined as the number of lines in a graph, expressed as a proportion of the maximum possible number of lines."(Scott, 2012). Density is an amount between 0 and 1. If this amount is inclined toward 1, the network is a dense one and if it is inclined toward 0, it is a spares one (Nikzad, Jamali, and Hariri, 2011; Scott, 2012).

Diameter is the maximum separation of pairs of nodes. It assesses the greatest distance among paired nodes. It corresponds to the maximum number of edges or steps between two nodes. Similarly, a high network diameter indicates the network tendency toward having fewer edges (Clarke, 1964; Newman, 2001).

Clustering coefficient is an index which indicates the network nodes' tendency toward forming clusters together. This illustrates how one node is connected to other surrounding nodes in a good way. If its neighbors are well connected together the clustering coefficient equals to1, and if the connections among neighboring nodes are difficult to form, the clustering coefficient equals to 0 (Cao, Pauleen, Wang, and Whitworth, 2011; Clarke, 1964).

Average degree is the average number of edges between each node and other nodes (Newman, 2001)

Centrality index is used for network players(Taba, Hossain, Atkinson, and Lewis, 2015). It refers to the position of certain nodes in a network including degree centrality, betweenness centrality, closeness centrality and eigenvector centrality (Cao, Pauleen, Wang, and Whitworth, 2011).

Degree centrality is the simplest type of centrality in which the value of each node is obtained by counting the number of its neighbors. The number of its neighbors is obtained based on the links attached to that node which equals the number of co-authors of a node. When an individual's degree centrality is higher it has more connections and it is more effective (Acedo, Barroso, Casanueva, and Galán, 2006; Izquierdo and Hanneman, 2006).

Betweenness centrality indicates the importance of a node with regard to its position and also information transmission in a network. For example, if one node is the only connection between two irrelevant clusters, this node has a high betweenness centrality and plays the role of connecting different groups. If one node is the only connecting path among other nodes and plays a vital role in information transmission, it has high betweenness centrality. Information transfer may stop if this node is omitted (Acedo, Barroso, Casanueva, and Galán , 2006; Izquierdo and Hanneman, 2006; Shekofteh and Hariri, 2013; Yan and Ding, 2009).

Closeness centrality evaluates an individual's position and real distance to all other individuals in a network and determines the time required for information to transfer from a certain node to other nodes in a network. Individuals with high closeness centrality, probably receive the information much faster than others. This is due to the fact that there are fewer intermediaries among them. Eigenvector centrality assesses the significance of a node with regard to its relation to more important nodes (Izquierdo and Hanneman, 2006; Nikzad, Jamali, and Hariri, 2011; Noyons, Moed, Glänzel, and Schmochl, 2004).

"Pharmacology and pharmacy" is an important basic domain in education and research domains in Iran and are known as the most productive field of medicine and allied health domains. Research studies indicate that Iran occupies the second rank after Egypt considering

the number of pharmaceutical documents indexed in three databases of WOS, Scopus and IPA (International Pharmaceutical Abstract) among the Middle East and North African countries (Mesgarpour, Etemadi, Fotouhi, Kebriaeezadeh, and Younesian, 2009). In such a productive and dynamic basic science domain, it is difficult to assess the impact and influence of researchers using traditional methods and in spite of the significance of co-authorship and the role of pharmacology and pharmacy in knowledge production in Iran, the state of the collaboration, research community and co-authorship networks in this domain is not obvious. Therefore it seems essential to conduct a research study to deeply investigate scientific collaboration and co-authorship networks in this domain using social network analysis.

On the other hand, Opinions in the literature on the possible relationship between co-authorship and number of citations vary (Avkiran, 1997; Iribarren-Maestro, Lascurain-Sánchez, and Sanz-Casado, 2008) and the relationship between co-authorship and the number of publications and received citations in pharmacology and pharmacy domain in Iran is not obvious. For these reasons, the present study aims at determining co-authorship patterns and indices, co-authorship network structure, analyzing these networks and evaluating the relationship between the number of scientific publications and the average citations with scientific collaboration in domain of pharmacology and pharmacy in Iran. Findings of this study can affect future policy makings and programming of education and research institutes and universities. Additionally, it can be effective in the tendency of researchers toward co-authorship or one-authorship. The results lead researchers to conduct studies which can ultimately bring about both qualitative and quantitative improvements of scientific productions.

As mentioned above, many researchers has been studied various aspects of co-authorship in different fields and countries. For example, Maria Bordons and Barrigón (1992) pointed out high collaboration rate in publications of scientific pharmacologists based on SCI documents. In another article, Maria Bordons, García-Jover, and Barrigón (1993) investigated the relation between collaboration and visibility of scientific publication in the field of pharmacology and pharmacy in Spain. Findings shows impact factor of the internationally co-authored documents was higher than that of the remaining collaborative documents or non-collaborative ones. Kundra (1996) studied the evolution of collaboration and co-authorship in the field of medical sciences during 1900–1945 in India. Avkiran (1997) indicated that there is no differences between the quality of collaborative and individual researches in Finance documents. Iribarren-Maestro, Lascurain-Sánchez, and Sanz-Casado (2008) showed that co-authorship and number of citations are unrelated. Yousefi-Nooraie, Akbari-Kamrani, Hanneman, and Etemadi (2008) visualized co-authorship maps of three research centers of Iran and calculated social network measures. Their findings showed Centers with denser, more decentralizedandmore open to outside connections networks showed better scientific productivity and impact. María Bordons, Aparicio, and Costas (2013) explored existing trends in the collaborative structure of the Pharmacology and Pharmacy field in Spain and its relationship with research impact. They observed growing heterogeneity of collaboration and impact of research over the years. Average journal impact and citations tend to grow with the number of authors and the number of institutions and collaboration type.

Materials and methods

The method of this study descriptive survey and scientometrics. The research population involves all scientific productions of pharmacology and pharmacy in Iran, which have been indexed in WOS since 2002. The search formula was [*SU=(pharmacology AND pharmacy) AND CU=Iran]*. Data were retrieved in 12th of November 2013 in *Timespan=2003-2012* using the advanced search section of WOS and updated in 3rd April 2016 *for Timespan=2013-2014.*

The retrieved records (7323 documents) were saved in isi and txt file formats in full record. Data were analyzed using citation analysis section of WOS. All types of documents (articles, reviews, meeting abstracts, proceeding papers, letters, and so on) were analyzed in this study.

Citespace, Gephi softwares were used for visualization and analysis of co-authorship network. Co-authorship patterns were investigated using direct observation of the articles, counting the number of authors in each article and inserting them in a checklist. Co-authorship indices were calculated by Excel. Spearman's correlation coefficient and SPSS were used to investigate the relationship between the number of productions and citations and CI.

Results

The document types of pharmacology and pharmacy documents are articles (5731), reviews (364), meeting abstracts (950) and proceeding papers (52), letter (104), editorial materials (127) and corrections (18).

Table 1 shows the researchers' scientific production in pharmacology and pharmacy filed in Iran is 7323 documents and the number of received citations is 63867. Each published product during these years has received 7.67 citations on average. The highest citation effect of 2.5 is in the productions of 2013 and 2014 and the lowest is 2004.

Table1

The number of publications, citations, and mean citation in pharmacology and pharmacy scientific productions of Iran in 2003 to 2014

Publication year	Number of publications	Number of received citations	Mean citation per document	Citation effect (Mean Citation per year in each document)
2003	151	4063	22.03	1.84
2004	284	3001	14.31	1.3
2005	243	5136	21.14	2.11
2006	347	5294	15.26	1.7
2007	414	5886	14.22	1.78
2008	531	7884	14.85	2.12
2009	650	5612	8.63	1.44
2010	749	6916	9.23	1.85
2011	1053	6447	6.12	1.53
2012	924	5170	5.60	1.87
2013	1009	5089	5.04	2.52
2014	968	2428	2.51	2.51
All years	7323	63867	7.67	-

As illustrated in fig 1, pharmacology and pharmacy authors in Iran show greater tendency to publish articles with 3 and 4 authors. The dominant co-authorship pattern during these years has been three-author pattern encompassing %19.72. This is followed by tour-author pattern, five-author pattern and two-author pattern. Among all scientific productions, less than 5% of articles have just one author.

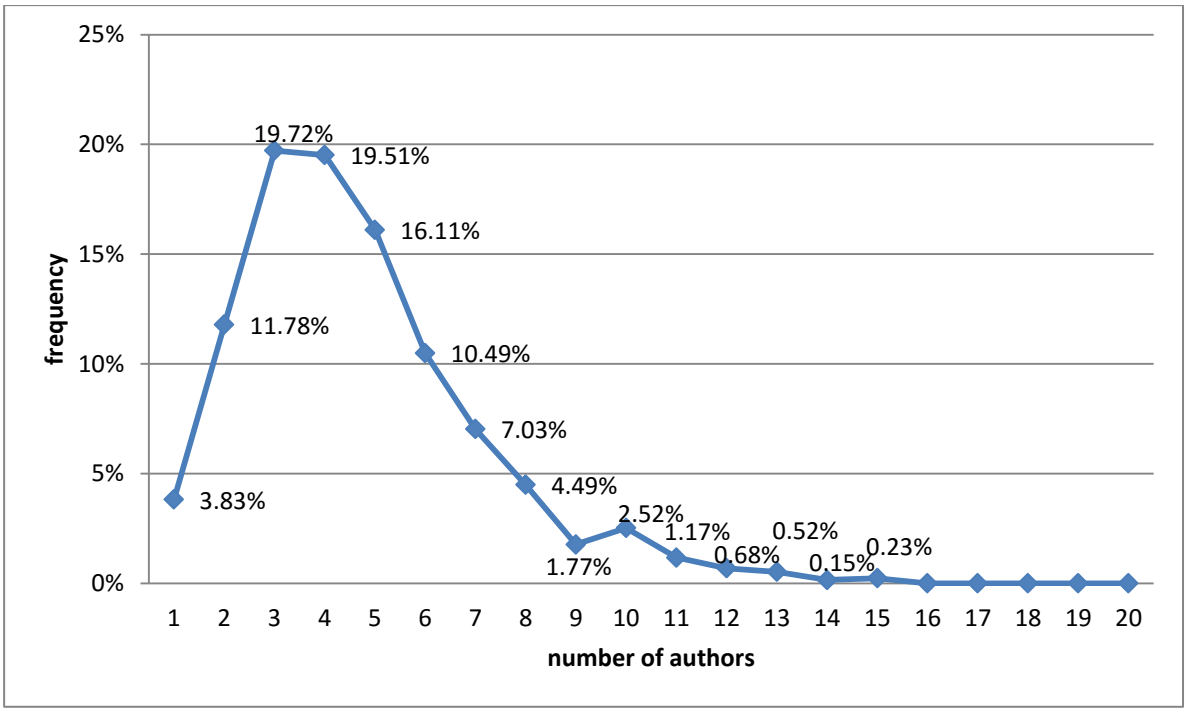

Figure 1. Frequency distribution of the number of authors in pharmacology and pharmacy scientific productions of Iran

Table 2 indicates that CI, DC and CC is 4.69, 0.96 and 0.691 respectively, in all years under investigation.

Table 2

Co-authorship indices in pharmacology and pharmacy domain in Iran in 2003 to 2012

Publication year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
CI	4.14	3.85	4.43	5.86	4.01	4.27	4.61	4.49	4.35	4.61	4.94	4.84	4.69
DC	0.98	0.94	0.97	0.95	0.93	0.96	0.96	0.96	0.96	0.96	0.97	0.97	0.96
CC	0.695	0.677	0.724	0.547	0.684	0.701	0.712	0.710	0.721	0.720	0.722	0.722	0.691

Spearman's correlation coefficient between CI and the number of scientific productions is estimated 0.383 (p=0.275) and between CI and citation effect is estimated -0.18(p= 0.6) by SPSS. This indicates that there is no meaningful relationship between CI and the number of scientific publications and citation effect.

The co-authorship network in this domain was mapped in a 10-year period (2003-2012). Its analysis specified that a total number of 12930 authors were present in this network. Due

to the large number of network nodes, a suitable analysis of the networks was not possible. Cases like this lead the researcher to select threshold. Threshold restricts the network nodes based on the number of received citations and omits weak relationships. This way, less important nodes in a network will also be deleted while more important nodes and relationships will be maintained. This will enhance more accurate analysis of a network.

This study selected threshold of 20, 3, 3. These numbers show citation numbers[1], co-citation numbers[3], and co-citation cosine coefficient[2], respectively (Hassanzadeh, Khodadust, Hassanzadeh, Yates, and Akhgar, 2012; Olmeda-Gómez, Perianes-Rodríguez, Antonia Ovalle-Perandones, Guerrero-Bote, and de Moya Anegón, 2009; Osca-Lluch, Velasco, López, and Haba, 2009). The number of nodes in maps represents those authors who have passed these thresholds. In addition, co-authorship networks have been mapped based on centrality indices which include degree centrality, betweenness centrality, closeness centrality and Eigenvector centrality.

Mean degree is 1.792 which means that each individual is connected to about two other individuals. Network density (0.3) is close to 0 which signifies a sparse co-authorship network. The amount of clustering coefficient shows that the relationships among neighboring nodes are difficult to make and network members show relatively low tendency toward forming clusters. Network diameter also notifies that the maximum distance between paired-nodes in the network is about 5.

Figure 2. Co-authorship network in pharmacology and pharmacy in Iran based on degree centrality

Figure 2 indicates that Zarrindast is the most important individual in the network based on degree centrality which has established more co-authorship relationships with others. Generally, the co-authorship relationships among this network's members are limited.

As observed in Table 3, Zarrindast has the highest degree centrality, and eigenvector centralit. Dehpour ranks first regarding betweenness centrality and Ostad ranks first regarding closeness centrality. Five individuals have shared betweenness centrality and degree centrality indices. There is no convergence among leading individuals regarding closeness centrality index and eigenvector centrality.

Table 3
Centrality Indices in pharmacology and pharmacy authors of Iran

Indices / Rank	Degree centrality		Betweenness centrality		Closeness centrality		Eigenvector centrality	
	Author	amount	Author	amount	Author	amount	Author	amount
1	Zarrindast	10	Dehpour	367	Ostad	5.2	Zarrindast	1
2	Dehpour	9	Shafeei	340.66	Eidi	4.57	Dehpour	0.82
3	Shafeei	8	Zarrindast	325	Eidi	4.57	shafaroudi	0.79
4	Shafeei	6	Khavandgar	136.5	nowrouzzadeh	4.48	Khavandgar	0.77
5	shafaroudi	6	Homayoun	136.5	Khoshbaten	4.48	Homayoun	0.77
6	Khavandgar	5	Shafeei	83	Shafa'ati	4.42	Haajrasouliha	0.72
7	Homayoun	5	Oryan	66	Khoddam	4.42	Ebrahimi	0.72
8	Asgari	5	Zarghi	66	Nikkavar	4.42	Tavakkoli	0.72
9	Ghoshouni	5	Iranshahi	65.33	Larijani	4.31	Dehpour	0.72
10	Sahraei	5	shafaroudi	55	Nowrouzi	4.31	Sadeghipour	0.72

Discussion

The findings indicate that the prevalent co-authorship pattern refers to the articles with four authors and Iranian authors in the field of pharmacology and pharmacy do not show a great tendency towards writing articles individually. Maria Bordons and Barrigón (1992), also pointed out high collaboration rate in pharmacology and pharmacy publications in Spain from 1980 to 1989 based on SCI documents. The comparison of the findings of this study with previous studies demonstrates that the rate of scientific collaboration in Iran in domain of pharmacology and pharmacy is higher than other fields such as cardiovascular studies (Farahani, Eskrootchi, Mohaghegh, and Hosseini, 2014) and social sciences . As well as in Osareh and Marefat (2005) study, two-author pattern is introduced as the dominant co-authorship pattern among Iranian researchers. CI (4.46) also shows that the average number of authors in this study is higher as compared to the CI in the field of pharmacology and pharmacy in Spain during 1980-1989 (4.07) and other fields (Ajiferuke, Burell, and Tague, 1988; Bordons, García-Jover, and Barrigón, 1993; Hassanzadeh, Khodadust, Hassanzadeh, Yates, and Akhgar, 2012; Nikzad, Jamali, and Hariri, 2011; Osareh, Norouzi Chakoli, and Keshvari, 2010), but it is lower than CI in the field of pharmacology and pharmacy in Spain during 2006-2008 (5.6). Since DC (0.96) and CC (0.689) approach toward 1, it is concluded that the researchers in this domain have a great tendency towards working collaboratively. Findings of mean degree (1.792) demonstrate that, on average, each person is connected to about two other persons. This amount shows that the overall relationship among authors is weak. Density signifies a noticeable sparseness of co-authorship network. In a dense network there is always a path or a link among all present nodes, while in a sparse network such a relationship does not exist. Considering this point, it can be said that no considerable density exists in co-authorship network of pharmacology and pharmacy in Iran. Therefore, information transmission among nodes and in the whole network is performed at a low rate. The obtained clustering coefficient mean (0.306) also illustrates that interactions among the neighboring nodes are difficult to make and the network members have a low tendency toward forming various clusters.

There are many authors coauthored in the pharmacology and pharmacy of Iran, but the relation between them is not strong in co-authorship network. It seems if researchers co-authored many times, then the networks will be stronger. This means most of authors in the field of pharmacology and pharmacy in Iran have coauthored in few times; probably in university dissertations or theses and after student graduation the collaboration between authors has stopped.

As Kempe, Kleinberg, and Tardos (2015) indicate considering high-degree nodes as influential has long been a standard approach for social and other networks. We can say, authors with the highest rank of degree centrality, are the most influential and effective ones in the network. Authors with the highest rank in betweenness centrality, have a better position and special significance in the network, since they can reach other authors in shortest path length and in case of omission, the information processing may stop. Authors with the highest rank of closeness centrality, receive the information so faster than others because the co-authorship network among these authors has higher density and has a shorter distance to other members in the network. Authors with highest rank of eigenvector centrality are closer to other important groups in the network and have more influence on other members of the network. In addition, these authors have strongest relationships with more significant nodes or authors. Therefore, these authors should be supported and encouraged and provided with better facilities.

There are various opinions about the relation between co-authorship and the number of publications and citations. For example, Iribarren-Maestro, Lascurain-Sánchez, and Sanz-Casado (2008) study based on the scientific production of ten Carlos III University of Madrid departmental areas between 1997 and 2004 indicates co-authorship and number of citations are unrelated. But Danesh, Mirzaee, Abdulmajid, Zeinolabedini, and Khosravi (2009) study in the domain of library and information sciences, did yield significant relationship between science production and collaboration rate. Yousefi-Nooraie, Akbari-Kamrani, Hanneman, and Etemadi (2008) findings showed centers with denser, more decentralized, and more open to outside connections networks showed better scientific productivity and impact. Publication in the field of pharmacology and pharmacy in Spain shows impact factor of the internationally co-authored documents was higher than that of the remaining collaborative documents or non-collaborative ones and average journal impact and citations tend to grow with the number of authors and the number of institutions (Bordons, Aparicio, and Costas, 2013; Bordons, García-Jover, and Barrigón, 1993).

Findings of the present study indicated that the relationship between CI and the number of scientific productions and citation effect is not significant. This issue signifies that there are many factors influencing the number of scientific productions, among which scientific collaboration has a low impact. It shows also collaboration has no effect in the received citation in the field of pharmacology and pharmacy in Iran. As told in previous lines, this maybe because there is no continual collaboration between researchers and most of authors in the field of pharmacology and pharmacy in Iran have coauthored in few times; probably in university dissertations or theses and after student graduation the collaboration between authors has stopped. Considering different opinion has mentioned in literature review, it seems we can’t definitely say there is a positive relationship between these factors in all

fields, times and countries.

It is suggested that the Iran's universities and research institutes pay more attention to continual scientific collaborations in the field of pharmacology and pharmacy via providing budget and facilities to increase collaborations and establishing information flow among researchers. Promotion of collaboration culture between researchers in organizations can be affect in continual collaboration and increasing received citations.

End notes

1. Abbreviated as "c" for "citation in the software
2. Abbreviated as "cc" for "co-citation" in the software
3. Abbreviated as "ccv" for "cosine coefficient" in the software. However, in the study conducted by Hassanzadeh et. Al, "c" is used for "authorship threshold", "cc" for "o-authorship threshold", and "ccv" for "co-authorship cosine coefficient threshold".

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