Visualization of knowledge flow in interpersonal scientific collaboration network endocrinology and metabolism research institute

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Abstract

Purpose Research collaborations can help to increase scientific productivity. The purpose of the present study was to draw up the knowledge flow network of the Endocrinology and Metabolism Research Institute (EMRI) affiliated to Tehran University of Medical Sciences.

Methods The present study is a descriptive cross-sectional study on the publications of the EMRI. Web of Science Core collection databases were searched for the EMRI publications between 2002 to November 2019. Besides, publications were classified and visualized based on authorships (institutes and country of affiliation), and keywords (co-occurrence and trend). Scientometric methods including VOSviewer and HistCite were used for descriptive statistics and data analysis.

Results Total citations to the records were 47,528 and papers were published in 916 journals. The annual growth rate of publications and the citation was 14.2% and 18.9%, respectively. A total of 9466 authors from 136 countries collaborated in the publications. The co-authorship patterns showed that the average co-authorship and collaboration coefficient was 3.3 and 0.19.

Conclusion Knowledge flow between EMRI researchers with international collaborations, engagement with leading countries, and interdisciplinary collaborations have an increasing trend. To develop a full picture of co-authorship, using social network analysis indicators are suggested for future studies.

Keywords Bibliometrics · Data visualization · Knowledge discovery · EMRI

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Background

According to the statistical reports of the U.S National Library of Medicine, the average number of authors in papers on MEDLINE/PubMed has been estimated to be 4.01. Over the decades, the average number of authors per article was increased, from 1.68 in 1975 to 5.81 in 2019. It indicates the importance of expanding scientific collaborations in the field of medical research [1]. Research in the field of medicine requires considerable budgets, experts, and modern instruments and equipment [2, 3]. Scientific collaboration is a way to overcome the lack of resources [4, 5]. The term scientific collaboration refers to a process in the researchers' publishing behaviors, in which experts create the best way to research by seeking a collaborative network for the flow of knowledge [6–8]. Identifying the knowledge flow within collaboration networks and analyzing its indicators with valid global databases cannot only the determinant of the current status but also it is an approach in policymaking and planning [5, 9–11].

Recently, studies have visualized the scientific collaboration networks of research teams [12–15]. Their results showed that increasing the size of the research teams can quantitatively and qualitatively improve scientific productivity [16–18] that is identified by an increase in the number of citations [4, 12, 17, 19, 20].

The Endocrinology and Metabolism Research Institute (EMRI) affiliated to Tehran University of Medical Sciences (TUMS) was established at Shariati Hospital (Tehran, Iran) in 1993 [21]. Currently, the institute consists of 14 research centers. The results to emerge from the data comparison of endocrinology and metabolism research centers of TUMS [22, 23], high research performance was shown at the university and national levels [24, 25]. Nonetheless, the current situation of collaborations between EMRI researchers has not yet been illustrated. In the present paper, we aimed to visualize the research activities of the EMRI at both national and international levels.

Methods

In the present cross-sectional descriptive study, all records of the EMRI on the Web of Science databases by Clarivate Analytics were included. A search strategy, all formats of affiliations for EMRI were considered (Appendix 1). The search was limited to 2002 to November 2019. Data of 2843 records were entered into Excel. The authors' collaboration patterns were calculated by using three equations [26]. The Collaboration Index (CI) represents the average number of authors per article and the degree of collaboration (DC) represents the proportion of a multi-author of articles. Notably, DC dedicates zero weight to single-author articles. Coefficient Collaboration (CC) shows cooperation between researchers. DC and CC value is between zero and one [26, 27].

$$CC = 1 - \left\{ \sum_{j=1}^K \left(\frac{1}{j} \right)^f / N \right\}$$

$$DC = 1 - \frac{f_1}{N}$$

$$CI = \frac{\sum_{j=1}^K j \times f_j}{N}$$

K = the maximal number of authors in a single paper;

f_j = the number of papers having j authors in the collection;

N = the total number of papers;

Then, all documents converted into HistCite software for analyzing research performance indicators. This software calculates Total Local Citation Score (TLCS) (Native Citation Collection) and Total Global Citation Score (TGCS) (International Citation Collection) measures.

Bibliometric analysis and visualization software such as HistCite 12.03.17, and VOSviewer 1.6.5 were used for data analysis.

Results

Over 18 years, 2843 records (with 47,528 citations) affiliated to the EMRI have been indexed in the WOS databases. Until November 2019, 761 records were found with no citations. One article had the highest citations ($n = 4553$) [24]. The average of citations was 16.72 ± 107.08 per article. The pie chart shows that 88% types of scientific productions were original and review articles (Fig. 1).

As shown in Fig. 2(a), the researchers of EMRI published one article in 2012 that substantially increased to 426 papers in 2019. The rate of growth for scientific productions is 14.2%.

Fig. 1 Frequency of each type of scientific publication affiliated to the EMRI

Fig. 2 Annual growth trend of scientific productions (a) and citations (b) Endocrinology and Metabolism Research Institute of Tehran University of Medical Sciences in Web of Science Databases

As presented in Fig. 2(b), the rate of growth for citations was 18.9%. Fluctuations in the number of citations are due to less opportunity to get a citation.

Scientific journals are one of the most important official channels for information exchange in scientific disciplines. The research articles of the EMRI were published in 916 journals of the WOS Citation Index databases. Table 1 shows

the information about journals that was published by 19% of the EMRI papers.

In this study, the frequency of the Total Local Citation Score (TLCS) indicates to what extent the research papers published by the EMRI rely on the scientific output cited by their researchers (intra-organizational self-citation). The abundance of Total Global Citation Score (TGCS) also reflects the

Table 1 Selected journals of the EMRI researchers for publications

	Journal	Indexing	Recs	TLCS	TGCS
1	Osteoporosis International	ISI, Scopus, PubMed, Embase	147	10	74
2	Archives Of Iranian Medicine	ISI, Scopus, PubMed, Embase	106	311	937
3	International Journal Of Electrochemical Science	ISI, Scopus	102	471	1634
4	Iranian Journal Of Public Health	ISI, Scopus, PubMed, Embase	100	138	508
5	Journal Of Diabetes And Metabolic Disorders	ISI (ESCI), Scopus, PubMed, Embase	83	1	439

worldwide citation of research work. Therefore, a comparison of these two indicators can show the similarity of citation behavior of the EMRI researchers with international researchers. Table 1 shows that articles published in Osteoporosis International, and the Journal of Diabetes and Metabolic Disorders have lower citation levels.

For investigating the pattern of co-authorships, the Collaboration Index (CI) was used for the average number of authors per article that was calculated at 3.33. The higher CI indicator shows greater co-authorships. The frequency of single-author paper in this study was 16 titles. The degree of collaboration (DC) was calculated 0.988 that shows the highest proportion of EMRI authors' contributions in research. In this study, Coefficient Collaboration (CC) for the ratio of cooperation was estimated at 0.19.

In the publication of 2838 articles, total of 9466 authors collaborated. Larijani B, Ganjali MR, Qorbani M, Heshmat R and, and Norouzi P are the most prolific researchers, by the affiliation of EMRI, who have published 803, 520, 315, 298, and 275 articles, respectively. The frequency of collaborations for 378 authors was more than 20 repetitions, illustrated in three different clusters. As displayed in Fig. 3(a) with a blue cluster, five authors had the most research activities due to their collaborations.

There were 3162 national and international organizations involved in the publications. Based on Fig. 3(b), 283 organizations with a collaboration frequency of more than 20 times are illustrated in four-color clusters. Neighboring organizations' names were more involved in publishing articles. Among the internal organizations, TUMS and Medical Universities such as Isfahan, Alborz, Iran as well as Shahid Beheshti had the highest number of collaborations with the Institute, with 686, 353, 330, 308 and 292 joint publications, respectively. In the blue cluster area, most of the institutions are domestic. Organizations in the red and green clusters are more from Europe and the U.S.

As results are shown, papers have also been published in collaboration with 136 countries. The most collaborations are with five countries, including the United States, Canada, Britain, Australia, and Germany, 243, 156, 134, 104, and 100, respectively. Figure 4(a) shows 80 countries with more than 20 collaborations in two clusters. It seems that smaller countries mostly are on the right, while larger countries are in the red cluster on the left hand of the figure.

Both HistCite and VOSviewer softwares were used for co-occurrence patterns of keywords analysis. With HistCite software, terms were extracted according to their frequencies in titles and keywords. Apart from general terms such as "Iran", "Analysis", and "Review" that are not conceptually valuable, Diabetes ($n = 208$), Bone ($n = 156$), Nanoparticles ($n = 129$), and Gene ($n = 127$) were the most frequent words. Besides, with the VOSviewer software from the article keywords section, 11278 terms of visualization were extracted. The frequency of

keywords can help us to identify the nature of the subject that appeared in the papers. Researchers attempted to evaluate the impact of scientific collaborations. Keywords ($n = 194$) with a frequency more than 20 times are shown in three different clusters in Fig. 4(b). Each circle in the map has different sizes, that shows the frequency of keywords in the articles.

Discussion

As mentioned in the literature review, we aimed to provide an overview of the status of knowledge flows in the Scientific Research Collaboration Network of the EMRI in the Web of Science. Researchers of Tehran University of Medical Sciences have published about 8% total of Iranian articles on the Web of Science databases, which 1 % affiliated by EMRI. Results revealed that researchers have published 2843 articles over 18 years and received an average of 17 citations per article. Prior studies that have noted one of the most critical indicators for citing articles are Multi-authorship and co-authorship [12]. Another important finding was that there is a link between authorship and the citation of research papers. This relationship is also visible at different levels, meaning that international authorship articles are on average more citations than other documents [24, 25]. National co-authorship (internal organization) has received more citations than the works of the researchers by the domestic co-authorship (EMRI). The most prominent finding to emerge from the analysis is that, due to the scientific status and capabilities of the EMRI, expanding research collaborations with top global institutions can be effective in enhancing the quality of scientific outputs and improving the research rank [22, 28].

Keramatfar & RafieeKhoshnood (2016), evaluated 892 scientific publications of the Royan Institute indexed in the Web of Science from 1997 to 2014. The average annual growth rate was about 43%. Average citation for each article for international collaborations, national collaborations, and non-collaboration papers was 14, 6, and 4, respectively. Articles of co-authorship in the Royan Institute had a higher quality of citation, respectively [12]. Erfanmanesh (2017), also examined the impact of international research collaboration on the quality of 17,763 scholarly outputs of Tehran University of Medical Sciences (TUMS) in the Scopus database from 2011 to 2015. According to the findings, only 16.9% of the total scientific outputs international collaborations were observed. This study indicated that papers with international collaborations had higher field-weighted citation impact compared with other publications [20].

The number of papers and their citations have had significant growth in the past 5 years. These results are in agreement with Osareh & Wilson (2000) findings. They reported that the trend of annual growth rate for articles has been increasing [29]. The results of studies by Adams et al. (2005) Nasli-

(a) three different clusters of the 378 authors

(b) four different clusters of the 283 organizations

Fig. 3 Visualization of Scientific Collaboration in EMRI: **(a)** researchers and **(b)** organizations

(a) two different clusters of the 80 Countries

(b) Conceptual map of 194 Keywords

Fig. 4 Visualization of Scientific Collaboration in EMRI: (a) countries and (b) keywords

Esfahani et al. (2017), Aazami et al. (2020), and Gazni et al. (2012) confirmed the association between scientific

collaborations in research teams and positive effects on scientific productivity [11, 17, 30, 31]. In the present study to

increase citations, the comparison of two indicators, TLCS and TGCS, was done for journals [21]. Findings suggested that to increase the visibility of scientific work, specific measures such as changes in citation behavior, an increase in co-authorship [17] as well as promoting the sharing of research articles in scientific or social networks should be considered [5, 32, 33]. These results confirm the association between the number of researchers and scientific productivity and efficiency in this study.

According to the study, most researchers have written papers as a group. The Collaboration Index of 3.3 shows the average number of the contribution of authors per article, that is lower than the average number of authors in the PubMed database [1]. Less than 1 % of papers have been written by a single author who represents the interdisciplinary nature of the research areas of the EMRI [31]. These results are also supported by the Collaboration coefficient (CC).

These findings suggest that cluster Networking Research authorship of EMRI, researchers who are involved in promoting global science shows [34, 35]. In these clusters, there are authors of various specialties that demonstrate the dynamics of research in the EMRI and, on the other hand, can have a significant impact on the further development of the scientific field [7, 8, 13, 29].

The most important finding is international scientific collaborations between Iran and 136 countries, and this means that the scope of international cooperation of researchers has been extended. In this study, the average citation for any scientific evidence derived from international co-authoring is lower than national authorships [24, 25]. According to the findings of the relationship between international cooperation and increase scientific citation was confirmed [12, 30].

Most importantly, relevant to finding EMRI's international scientific collaborations have conducted by 136 countries, and This means that the scope of international cooperation of researchers has been extended. In this study, the average citation for any scientific evidence derived from international co-authoring is lower than national authorships. According to the findings of the relationship between international cooperation and increase scientific citation was confirmed [12, 30]. This outcome is contrary to that of Ebrahimi et al. (2017), who found that there was no significant relationship between multinational scientific collaboration and citation [10]. It can therefore be assumed that the increasing capabilities of network communication technologies can enhance international communications across a broader geographic area and eliminate location limitations [32, 33]. Studying the characteristics of international research collaboration will highlight new aspects of scientific communication behavior that can be of great importance in formulating policies, strategic research management, and facilitating cooperation among researchers [5, 36].

Conclusion

Findings showed that developed collaborations for scientific productivity can increase the citation of research output of the EMRI. Moreover, it seems that the researchers of EMRI, as far as possible, conduct their research in collaboration with researchers from the outside institute, especially researchers from other countries. Greater efforts are needed to ensure in enhancing international scientific cooperation. As follows (i) Holding workshops and training sessions to communicate with researchers abroad, (ii) facilitating and expanding academic links between Iran and other countries, (iii) forecasting and allocating specific budgets and privileges for joint research projects, and (iv) exploring the subject trends of international authorship articles and policies in creating appropriate international cooperation frameworks.

Overall, this study strengthens the idea that the knowledge flow network visualizes with scientific productivity and collaboration. One source of weakness in this study that could have affected the illustration of scientific collaboration was the diversity of indexing of researchers' names. Network analysis centrality indicators for co-authorship EMRI an issue that was not addressed in this study. Further research should focus on determining indicators of social network analysis for the outputs of the researchers at EMRI.

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Compliance with ethical standards

Conflict of interest The Authors declare that there is no conflict of interest.

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