

Radiology, nuclear medicine, and medical imaging: A bibliometric study in Iran

Navid Zeraatkar

Medical Imaging Systems Lab, Research Center for Molecular and Cellular Imaging (RCMCI),
Tehran University of Medical Sciences, Tehran, Iran

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ABSTRACT

Introduction: Nowadays, science mapping is considered an excellent technique for decision-makers to find solutions for problems in research planning and development. In this work, we aimed to depict a science map of “radiology, nuclear medicine, and medical imaging” in Iran.

Methods: All publications indexed in Thomson Reuters Web of Science database in the fields mentioned above with at least one affiliation corresponding to “Iran” were included in the study. “Visualization of similarities” (VOS) viewer software was then utilized to analyze the data for generating density maps and density cluster maps of organizations, authors, and journals based on bibliographic coupling and co-citation similarity measures.

Results: Various maps were then formed and discussed. Tehran University of Medical Sciences in all fields of radiology, nuclear medicine, and medical imaging was proved to be the dominant organization in the country.

Conclusion: Applying VOSviewer software, data was analyzed for extracting bibliographic coupling and co-citation relations and their corresponding science maps in terms of affiliated organizations, authors, and publishing journals. More comprehensive studies can be performed to obtain more mature science maps. Performing such analyses for other countries and then comparing with the internal science maps can be useful for decision-makers.

Key words: Radiology; Nuclear medicine; Medical imaging; Bibliometric study; Iran

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Corresponding author: Navid Zeraatkar, Research Center for Molecular and Cellular Imaging (RCMCI), Dr. Kaboli Building, Imam Khomeini Hospital, Keshavarz Blvd, Tehran, Iran. E-mail: navid_zeraatkar@yahoo.com

INTRODUCTION

Science mapping has evolved to an approach for being used for practical purposes rather than a primarily academic research. Its significance is so much that the resultant visual maps in addition to numerical measures are considered a beneficial tool for decision-makers in solving the real-world problems of research planning and development [1]. For relating the objects of interest (authors, documents, organizations, etc.) to each other, some methods are used. Amongst them, bibliographic coupling and co-citation are more accurate [1]. Bibliographic coupling between two works, first introduced by Kessler [2], occurs when the two works cite a common third work as their references. When two works are bibliographically coupled, there is a probability that they have the same matter of interest [2]. Co-citation was later defined by Small [3] as a new measure of relationship. Co-citation relation between two works happens when the two works are cited simultaneously by a third work [3]. The more the number of bibliographic coupling occurrences for two works, the more strong their bibliographic coupling relation. Similarly, the co-citation frequency is defined as the frequency with which two works are cited by third works [4]. The main difference of bibliographic coupling and co-citation from similarity detection point of view is that bibliographic coupling is a retrospective similarity measure i.e. lies on past data leading to be static over time. In contrast, co-citation measure can change over time due to new work citations and so is a dynamic measure [3, 5]. However, both of them are more powerful than direct citation in finding the similarities and have been used in various mapping and clustering studies [1, 4, 6, 7]. "Visualization of similarities" (VOS) is a recently developed technique by which some visual maps based on the density of the relations and the cluster where some authors, organizations, etc. are more in relation can be generated [8-11].

In this study, we perform some bibliometric analyses to extract the science map of research fields "radiology, nuclear medicine, and medical imaging" in Iran based on the indexed publications in Web of Science (WoS). The authors, first authors, journals, and affiliated organizations contributed in mentioned fields of research in Iran were analyzed based on whether bibliographic coupling or co-citation or both depending on the case.

METHODS

Inclusion criteria

All papers indexed in Thomson Reuters WoS database in the research areas of "radiology, nuclear medicine, and medical imaging" having "Iran" in at

least one of the authors' addresses were included. Total number of 1,482 papers had the above criteria up to June 17, 2013. Since the notation of the affiliated organization was reported in different ways by authors in some cases, prior to data analysis, a unification process was applied on data to prevent misleading the results. Table 1 indicates some of common mismatches in affiliation reporting which were unified.

Table 1. Some of common differences in reporting affiliated organizations.

Amir Kabir University
Amir Kabir University of Technology
Amirkabir University
Amirkabir University of Technology
Imam Hospital
Imam Khomeini Hospital
Mashad University of Medical Sciences
Mashhad University of Medical Sciences
Shaheed Beheshti University
Shahid Beheshti University
Shaheed Beheshti University of Medical Sciences
Shahid Beheshti Medical University
Shahid Beheshti University of Medical Sciences
Tarbiat Modares University
Tarbiat Modarres University

VOSviewer software package

We used VOSviewer version 1.5.4 for our analyses. VOSviewer is a newly developed software package that creates maps based on network data using the "visualization of similarities" (VOS) mapping and clustering technique [8-13]. VOSviewer is intended to primarily be used for analysis of bibliometric networks and various bibliometric studies have been reported using this software (e.g. [14-16]; interested reader can visit VOSviewer website for finding a complete list of publications related to VOSviewer applications [17].) As an important advantage, VOSviewer has powerful visualization features for showing maps in different ways. Each visualization method emphasizes on a different aspect of a map in addition to providing zooming, scrolling, and searching abilities [12, 13, 18].

Analyses

It is noted that for all analyses, the data set corrected for organization notation discrepancies was used. The VOSviewer software is capable of performing 7 different analyses: bibliographic coupling of

documents, co-citation of cited references, bibliographic and co-citation of sources, bibliographic coupling of authors, co-citation of first author only, and bibliographic coupling of organizations. The analysis of documents relations was not of interest for the current work. Furthermore, for analyzing the sources of publications (the journals, etc.), co-citation was preferred rather than bibliographic coupling due to its inherent dynamicity in demonstrating the coupling relation. So, totally 5 analyses performed which are mentioned hereafter.

An analysis was performed for obtaining the bibliographic coupling of organizations. For this, organizations having at least 5 documents (64 organizations) were entered in the analysis.

In addition, authors having a minimum number of 5 documents (222 authors) were considered for bibliographic coupling analysis of authors. Also, co-citation of first authors who had at least 10 documents (85 authors) was analyzed.

Moreover, in order to identify the sources (where documents were published) co-citation, an analysis on sources having at least 20 citations (186 sources) in the database was carried out.

RESULTS

It should be noted that the text size of each item in density and density cluster maps denotes the contribution of the item in the map; the larger, the higher the contribution. Also, the distance between each two items corresponds to the number of bibliographic coupling or co-citation links between the two items; the closer, the stronger the link. Furthermore, the value of each point in density maps

relates directly to the number of the linkages (coupling events) at that point which is translated to a color in RGB (Red-Green-Blue) format. For example, a hot area in a map demonstrates that many linkages exist at that area of the map. The color map of the figure was included at the right end to show the relation between the color and linkage density. All values in density maps were normalized to the maximum value of the map to result in a 0-1 range in the maps [12, 18]. Moreover, for understanding the cluster density maps it should be reminded that clustering is to assign observations to groups (so-called clusters) in such a way that observations within each cluster are similar to one another with respect to attributes of interest, and the cluster themselves sit apart from one another [19]. Various techniques can be used for clustering. As mentioned earlier, VOSviewer applies "VOS" technique for this purpose. The fact that a cluster density map demonstrates depends on the primary map on which clustering is applied. It is also worth to mention that due to technical shortcomings, not all details seen in VOSviewer visualizer can be demonstrated in electronic or printed format of the current paper.

It is worth noting that the abbreviation used for organizations and journals in all figures are the same used in WoS as well. The density map of bibliographic coupling of organizations is illustrated in Figure 1. In addition, Figure 2 shows the top 20 organizations having the most contributions in the field of interest in Iran. Cluster density map of the organizations visualized in Figure 3 in which all organizations belonging to one cluster are colored the same. The members of each cluster are also summarized in Figure 3.

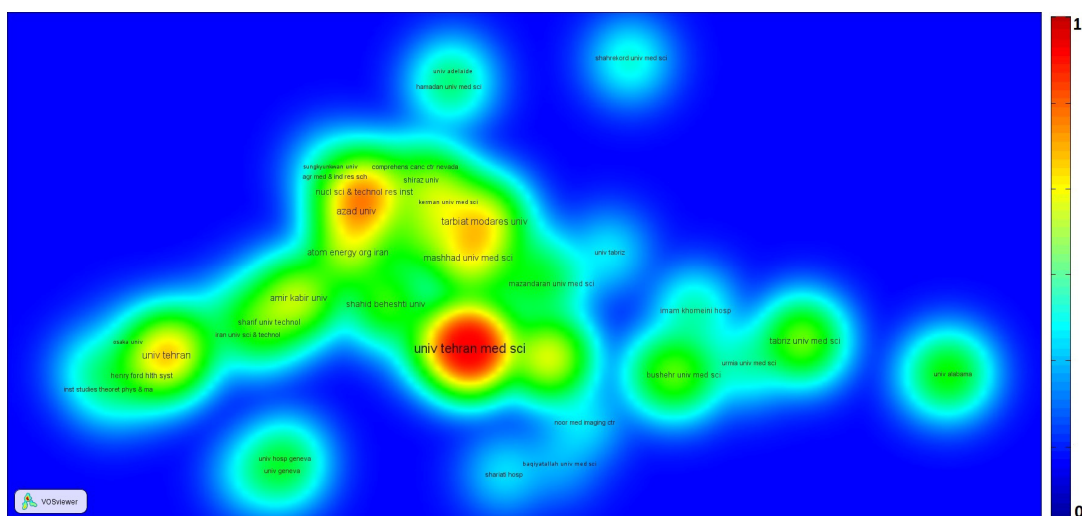


Fig 1. Density map of the affiliated organizations based on bibliographic coupling. All values were normalized to the maximum value of the map.

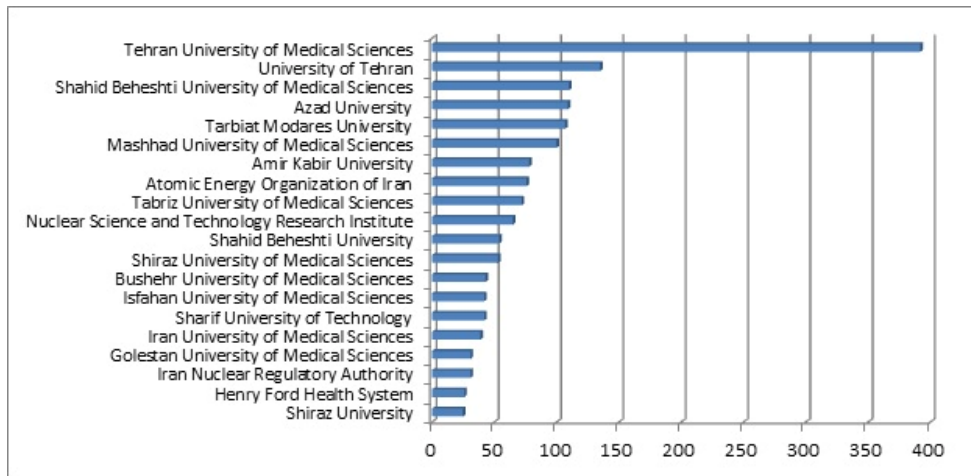


Fig 2. The quantitative contribution of top 20 organizations in Iranian publications in the field of radiology, nuclear medicine, and medical imaging.

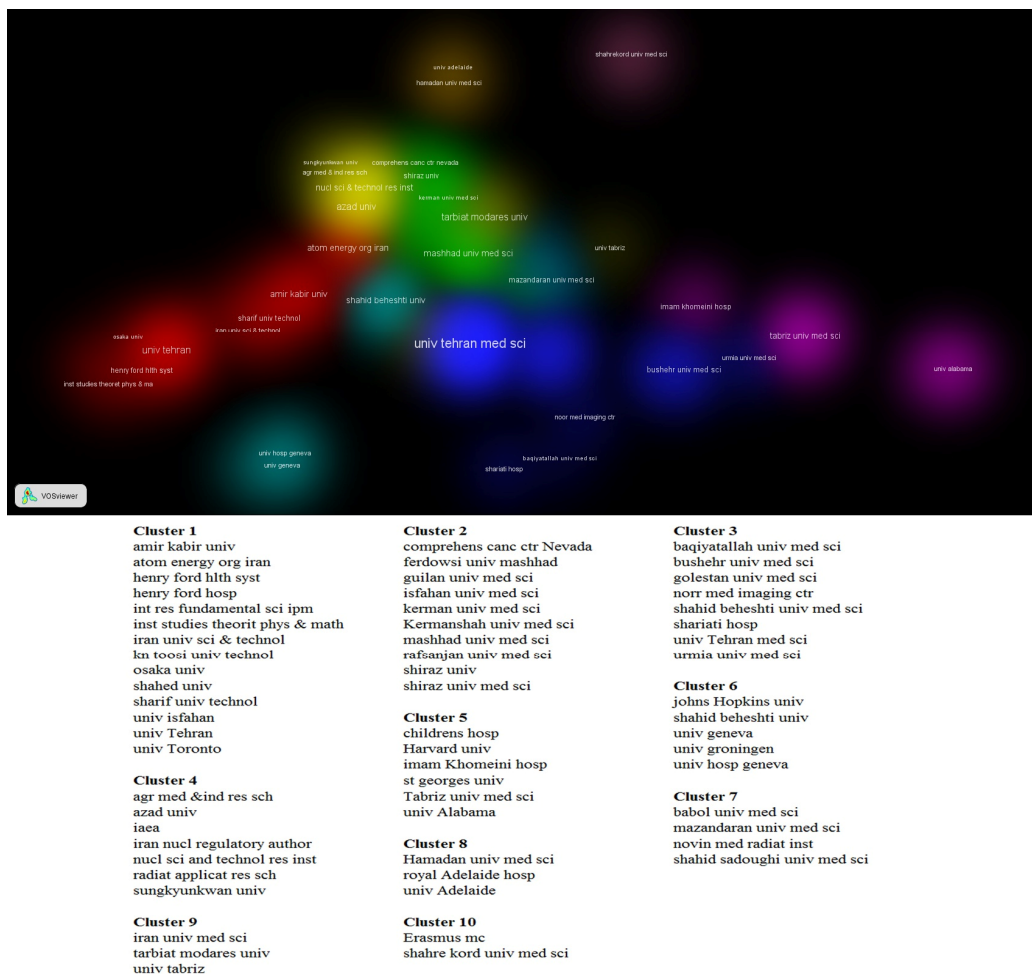


Fig 3. Cluster density map of the affiliated organizations based on bibliographic coupling together with the lists of the clusters. The organizations in each cluster were ordered alphabetically.

Figure 5a and 5b show density map and cluster density map of co-citation of first authors, respectively.

Density map and cluster density map of co-citation of publication sources were respectively illustrated in Figure 6a and 6b.

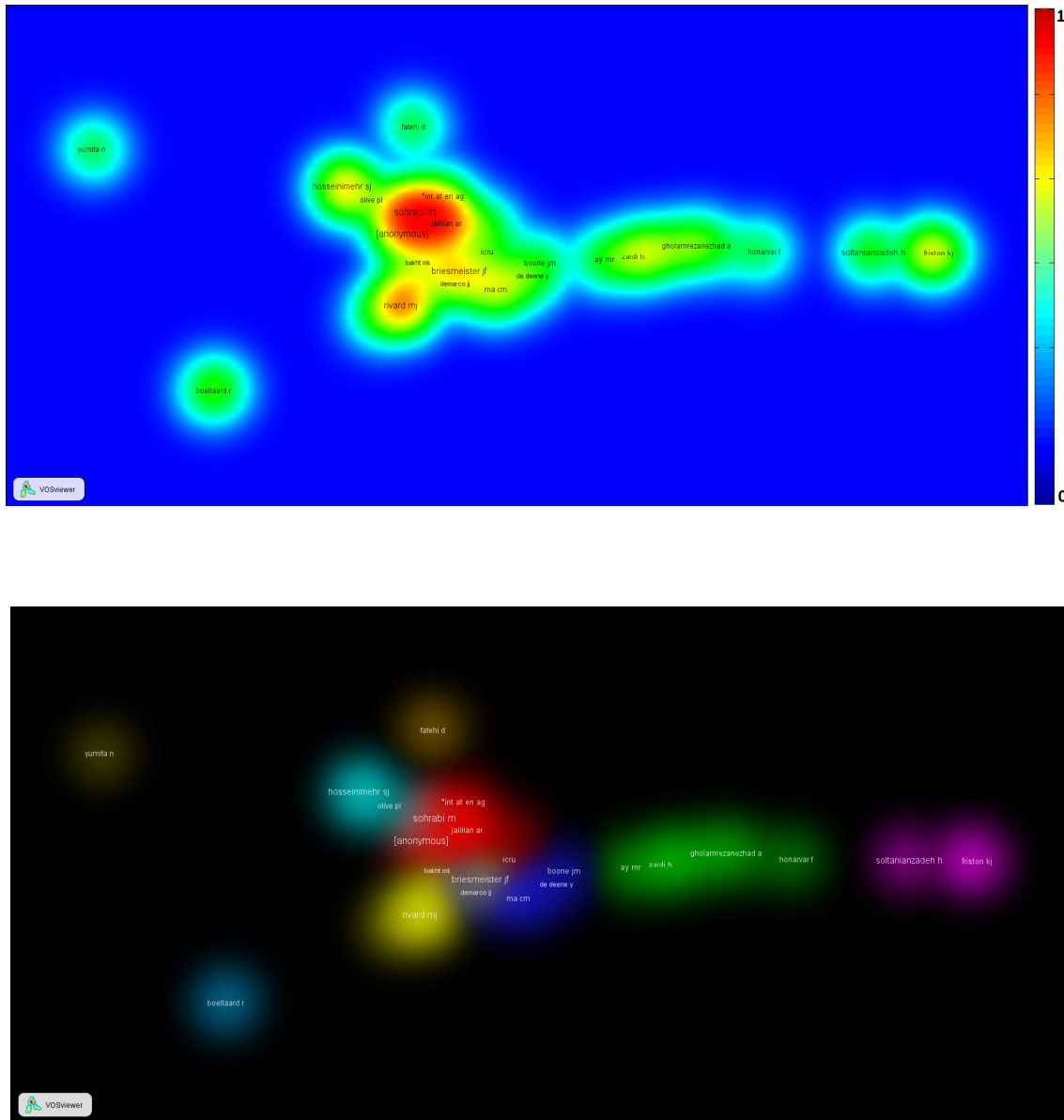


Fig 5. Density map (5a: above) and cluster density map (5b: below) of the first-authors based on co-citation. All values in the density map were normalized to the maximum value of the map.

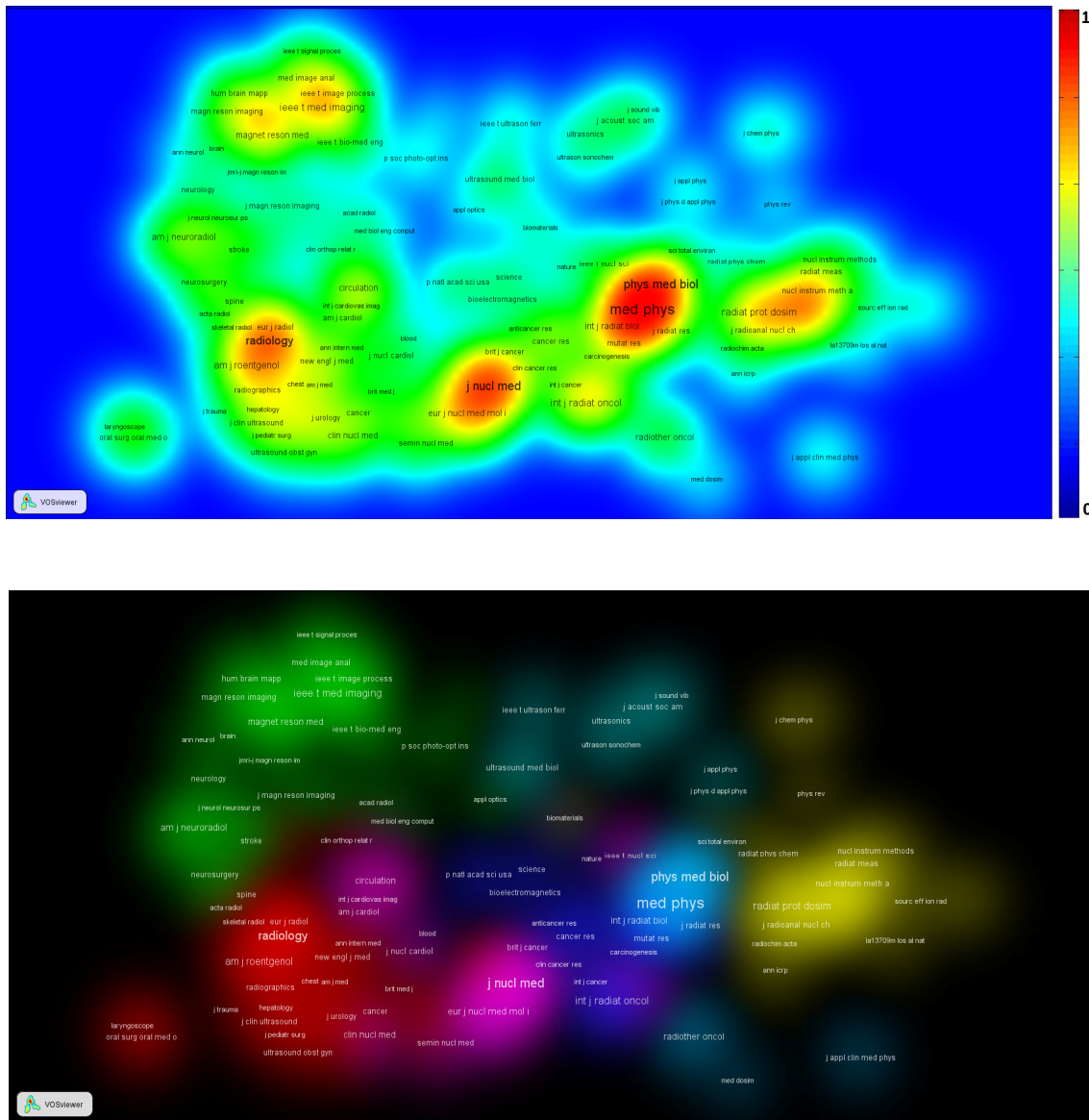


Fig 6. Density map of publishing journals (sources) based on co-citation (6a: above), and its corresponding cluster density map (6b: below). All values in the density map were normalized to the maximum value of the map.

DISCUSSION

Hot points in Figure 1 demonstrate the organizations with most collaboration and involvement in the fields of radiology, nuclear medicine, and medical imaging. Obviously, four hot areas can be distinguished: i) Tehran University of Medical Sciences, ii) Nuclear Science and Technology Research Institute and also Azad University, iii) Tarbiat Modares University, and iv) Tehran University. Moreover, Figure 2 shows the top 20 organizations having the most publications. Tehran University of Medical Sciences positioned at

the first rank having a large gap with the other organizations. Figure 1 and 2 are not in complete accordance enlightening some facts. Tehran University of Medical Sciences is almost at the center of the density map of the bibliographic coupling dictating its dominant role in both the quantity (Figure 2) and bibliographic coupling with the other organizations. Stances of Azad University is rather complicated because almost all the publication of the extensive branches of this university all over Iran are affiliated with "Azad University" which causes high ranking for this university as demonstrated in Figure

2. However, deciding about Azad University branches bibliographic coupling needs further study and clarification. Interestingly, Nuclear Science and Technology Research Institute participated in forming a hot area in Figure 1, while it is ranked 10 as shown in Figure 2, which is an indication of common and sharing projects with other organizations. Tehran University and Tarbiat Modares University have important positions both in density map (Figure 1) and ranking (Figure 2). Another point which can be seen in Figure 1 is that Tehran University of Medical Sciences and Tehran University, having a relatively wide distance in Figure 1, are not bibliographically coupled. The same pattern in smaller scale can be seen for Tabriz University of Medical Sciences and Tabriz University. This finding despite their geographic proximity is interesting. A similar pattern can be observed for Imam Khomeini Hospital and Shariati Hospital; despite being affiliated by Tehran University of Medical Sciences, they don't have a strong bibliographic coupling with Tehran University of Medical Sciences or even with each other. Some other organizations e.g. Shahrekord University of Medical Sciences or Hamadan University of Medical Sciences are far from the other organizations with loose coupling, forming some scientific islands in Figure 1. The collaboration of some foreign organizations with domestic organizations is also of interest showing the movement of the internal organizations fields of research toward internationally hot topics and also their coupling with international organizations. The presence of Henry Ford Health System at 19th rank (Figure 2) highlights such collaboration.

Based on the bibliographic coupling of the organizations, 10 clusters were formed which are illustrated in Figure 3. According to what was mentioned earlier about the clustering, here the organizations were clustered according their inter-organizational bibliographic coupling similarities i.e. each cluster had the same topics of research interest. Each cluster is identified by a unique color. The corresponding names of every cluster are listed below the figure. It should be stressed again that each cluster has almost the same research topics of interest. Some interesting patterns can be deduced from the Figure 3. All members of cluster 1 except Henry Ford Health System and Henry Ford Hospital are non-medical organizations mostly with the scope of basic sciences or engineering. Cluster 2 is formed by medical institutes except for Ferdowsi University of Mashhad and Shiraz University. However, the presence of these two universities together with their medical university sister in a cluster shows appropriate collaboration between them. Tehran University of Medical Sciences, which clearly can be considered as the excellent center of radiology,

nuclear medicine, and medical imaging of Iran, is a member of Cluster 3. This cluster is purely formed by medical organizations. Cluster 4 is meaningfully made up of some organizations affiliated to Atomic Energy Organization of Iran (AEOI) together with International Atomic Energy Agency (IAEA). The presence of Azad University in this cluster seems interesting. Cluster 5 composed of some domestic medical organizations and some foreign institutes. Shahid Beheshti University together with some outstanding foreign organizations formed Cluster 6 showing the similarity of Shahid Beheshti University research mainline to those foreign institutes rather than internal organizations. Clusters 7, 8, and 10 composed of some so-called scientific islands with outstanding conclusion except their relative isolation from other Iranian organizations topics of research. Cluster 9 seems strange to some extent due to having only 3 members with almost distinct geographical positions and fields of activity.

Figure 4a shows three hot points in terms of bibliographic coupling density mainly induced due to Eftekhari, M., Ay, MR., Akhlaghpour, S., and Soltanian-Zadeh, H.. These results are in accordance with the findings reported by Zarifmahmoudi et al. [20]. Neglecting Loucas, M. who formed a distinct area in the map, the second hot area (Ay and Akhlaghpour) can be distinguished as the central area having the most bibliographic coupling relations with the other authors. It is also notable that Eftekhari, M., Ay, MR., and Akhlaghpour S. are faculty members of Tehran University of Medical Sciences and Soltanian-Zadeh, H. is the faculty member of Tehran University. This is in accordance with the results in Figures 1 and 2. Moreover, Figure 4b shows the clusters in addition to some detailed information about the bibliographic coupling strength of each author (as described earlier), demonstrates that the dominant clusters consists of members who works in the same organization. Figures 4a and 5a are different in terms of the method of analysis (Figure 4a based on bibliographic coupling and Figure 5a based on co-citation). In addition, while all authors were considered for Figure 4a analysis, co-citation analysis in Figure 5a only represented the first authors. However, with respect to the major specialties and authors relation to each other, the outcome of first-author co-citation analysis and all-author co-citation analysis are largely equivalent [21]. As stated before, co-citation is a dynamic measure of relation from one viewpoint and also shows the level of citation from another viewpoint. In contrast, bibliographic coupling is retrospective and also does not show the citation by the other works (or authors). Figure 5a shows one dominant hot area mainly due to Sohrabi, M., Jalilian, AR., and publications of IAEA. Unwillingly, since all reports, standards, datasheets, etc. which don't contain author

name considered in the database as "anonymous". It can be seen that almost all authors who were present at hot areas in Figure 4a, are also noticeable in Figure 5a but not with the same dominance as the Figure 4a. In general, the more bold the notation of the author and the hotter its position, the larger co-citation frequency was present. Also, the closer the authors' relation was associated with stronger co-citation. Figure 5b shows the clusters generated based on co-citation analysis of first author (Figure 5a). The authors present in each cluster have the most co-citation relation with each other.

Figure 6a, obtained using co-citation analysis, helps to recognize the relation between journals wherein Iranian works are published in the field of radiology, nuclear medicine, and medical imaging and also the journals with the most citations. Five dominant hot regions can be seen in Figure 6a mainly due to i) "Medical Physics" and "Physics in Medicine and Biology," ii) "Journal of Nuclear Medicine," iii) "Radiology," iv) "Radiation Protection Dosimetry," and "IEEE Transactions on Medical Imaging." The point should be taken into account is the clear absence of Iranian Journals in the map demonstrating firstly the lack of enough quality of the Iranian Journals in the other word the low quality of the papers published by them and secondly the inclusion criteria of the current study in selecting only WoS publications and hence not considering some valuable journals which are not indexed in WoS. An example is Iranian Journal of Nuclear Medicine which has a potential of high impact factor if indexed in ISI [22], as a result not represented in Figure 6a. Figure 6b meaningfully divided the journals of the fields of interest of the current study to various clusters having the most intra-cluster co-citation relations.

CONCLUSION

In this study, all publications in the research field of "radiology, nuclear medicine, and medical imaging" with at least one affiliation relating to Iran were acquired using WoS database. Applying VOSviewer software, data was analyzed for extracting bibliographic coupling and co-citation relations and corresponding science maps in terms of affiliated organizations, authors, and publishing journals. The results showed that Tehran University of Medical Sciences and its faculty members have a decisive role in these areas of research in Iran. Although the results of the current work can draw a general science map of radiology, nuclear medicine, and medical imaging in Iran which is worthy for both the researchers as well as the decision-makers, however, more comprehensive studies with much wider and

unbiased search of the databases and resources are necessary for better and more reliable conclusions.

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