Analysis of the Impact of Economic Sanctions on Health Research and Publication Activities of Scientists from Iran

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Abstract
The article discusses the publication activity of scientists in the field of studying the consequences of US economic sanctions against Iran, and their impact on the development of science and the economy in this country. The paper considers the dynamics of publication activity in the field of biomedicine of Iranian scientists over the past 20 years. Increased sanctions have led to a shortage of medicines and a lack of access to modern treatment methods. The population does not have access to modern medicines. Patients cannot afford to buy expensive medicines. The general deterioration of the working and living conditions of the Iranian population led to a significant decrease in the activity of scientists. The publication activity of Iranian scientists has significantly decreased after the imposition of sanctions against Iran due to US disagreement with the country's nuclear policy. The present study has used modern methods and scientific bases of documents. The data have been gathered from freely available electronic resources: PubMed and Dimensions. Graphs and diagrams were built using the analytical tools of electronic resources described above by the VOSviewer visualization tool. This paper has examined a new trans-corpus approach to studying the publication activity of Iranian scientists based on a comparison of the dynamics of changes in the number of publications and citations of the country's scientists in the field of medicine, depending on the imposed international sanctions and the influence of science on the development of medicine within the framework of the sanctions policy.
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1. Introduction

The purpose of this work is to conduct a study on the dissemination of articles related to economic sanctions against Iran, their impact on public health, medicine, and science.

The Dimensions.ai information system was used to conduct this analysis because it covers a large number of documents and makes it easy to download and analyze data sets.

The included tools can be divided into three categories: the general bibliometric analysis of publications, analysis of requests, and analysis of statistical data. VOSviewer software visualization tools were used, capable of loading and exporting information from many sources.

The authors point out [1] that international cooperation significantly influences the development of Iranian science. The economic sanctions imposed by the United States have a significant impact on the publication activity of Iranian scientists, who often cannot publish their articles in leading international magazines. They don't have access to the most advanced medical technologies and materials, and they are not allowed to participate in international conferences to exchange experiences.

The imposed sanctions have a significant impact on the development of science in Iran. Research teams do not have access to laboratory equipment and modern research materials. Despite the highly-scientific researchers, they have difficulty in accessing disease cures and disease studies based on global experience [2].

The economic sanctions imposed on Iran by a group of countries have several humanitarian consequences not only for the country's economy but also for the development of science in general. As a result of the implementation of the sanctions policy against Iran, the incomes of the country's citizens fell, unemployment increased, mortality among the population significantly augmented, and the quality of medical care was deteriorated [3].

Patients with various diseases in Iran are experiencing drug shortages due to economic sanctions. A significant deterioration in health has happened to many patients suffering from serious diseases. They need modern and highly-effective medicines. Even though there is no formal ban on the import of drugs, many patients experience serious difficulties in obtaining them. Because of the escalating inflation during the sanctions period, most Iranian citizens cannot buy the expensive medicines they need to stay healthy [4].

The imposed-on Iran sanctions are not directly aimed at health care, but they have significantly worsened the quality of medical care in the country. It has become difficult to conduct scientific research in Iran due to the deteriorating economic situation and falling living standards. The number of publications devoted to scientific research in medicine has decreased, but the number of publications related to drug shortages has increased [5].

Countries that imposed economic sanctions against Iran violated the Iranians' right to health (Kokabisaghi, [6]). The Constitution of the World Health Organization (WHO) defines the health of all people as a prerequisite for achieving global peace.

The sanctions have had a significant and negative impact on Iran's public health programs and institutions [7]. Economic sanctions make it difficult to obtain medicines, medical supplies, and medical devices from abroad, and they also limited the ability to finance procurement costs.

For example, Ghiasi et al. already in 2016 showed that the availability of asthma drugs in public pharmacies was dropped sharply after the strengthening of sanctions [8].

The consequences of the imposition of the sanctions are especially dangerous in the context of the coronavirus pandemic. Murphy et al. indicated that Iran's ability to respond to the coronavirus is significantly limited. US administration withdrew from the nuclear deal in May 2018. On March 18, 2020, the United States imposed additional sanctions on Iran [9].

A lack of medical, pharmaceutical, and laboratory equipment, including protective gowns and essential medicines, has led to limited access to essential medicines and equipment. This made the conditions for the fight against the pandemic worse [10].

2. Materials and Methods

The Dimensions Database is an advanced scientific database that includes books, chapters, and conference materials, as well as grants, patents, clinical trials, program documents, and altmetric information. The metadata for this database is obtained from

sources such as CrossRef, PubMed, Directory of Open Access Journals, Open Citation Data, clinical trial registries, patent offices, and more than 100 publishers [11]. The free version of the platform provides open access to more than 110 million publications, records, and related metrics [12].

VOSviewer is a software tool that is fully focused on the visualization of bibliometric networks. VOSviewer is a universal software tool for visualizing graphs, building models of network data. The program builds a graph based on an already created network or it can create a data network. With the VOSviewer we can build connected networks of scientific publications, citations, sets of related objects, authors, countries, terms, etc.

Graphs can be rendered in the following ways: density rendering, connected network, and overlay rendering. At the same time, maps can be scaled and scrolled.

Objects can only be linked by one link on the graph, but the link has a strength or weight that reflects the strength of the link (number of publications, terms, etc.). Also, objects have weights that indicate their importance. Similar objects can be grouped into clusters, which are indicated in the graph with different colors. In this case, the color can mean more important (blue) or less important objects (yellow).

VOSviewer has a user-friendly customizable interface that can be used to adjust the image and to work with it, including such functions as creating a new graph, opening or saving an existing graph, taking a screenshot, screen copying, overlaying, clustering. By default, no more than 1000 links are displayed.

When building a graph of element densities at a specific point, the colors change from blue to yellow. If there are more elements in the vicinity of the point, then the color becomes yellow, if less, the color is closer to blue. A density graph can be built for both elements and clusters (if the elements are assigned to clusters).

VOSviewer has analytical tools, including the normalization of the strength of connections between objects, while normalization can be performed using various methods [13-17]. For the "layout" function, the "pull", and "repulsion" parameters can be adjusted. The program has a lot of settings. When constructing a graph, restrictions can be

introduced, the picture can be rotated, reflected horizontally and vertically.

VOSviewer supports four types of bibliographic database files: Web of Science files, Scopus files, Dimensions files, and PubMed files. The Web of Science can be accessed at www.webofscience.com (subscription required). Scopus can be accessed at www.scopus.com (subscription required). To load data from Scopus there is a need to select the export to CSV file. Dimensions can be accessed at https://app.dimensions.ai/discover/publication. You can use the free version of Dimensions, which does not require a subscription (user account required). PubMed can be accessed at www.ncbi.nlm.nih.gov/pubmed.

VOSviewer has its own thesaurus file. This is convenient when there are authors' names in the text, written in different ways. In this case, it can be indicated that the two authors are one and the same researcher. Also, the thesaurus allows you to combine synonyms of terms, abbreviations, and relate them to one complete term. In addition, the thesaurus file can be used to ignore terms (for example, general terms). Identical cited references in different sources, including Scopus, Web of Science, etc., can be identified using the VOSviewer thesaurus.

When building a graph of terms used in different articles, a term set is first created. It uses natural language processing algorithms. Parts of speech are highlighted. Nouns, word sequences, and determinants are identified. Stop words are excluded and words are combined into phrases.

VOSviewer has custom attributes: Incidents, Documents, Quotes, Normalized Reference Count, Document Year of Publication, Number of Citations Received by Document, and Average Number of References Received by Document.

The VOSviewer file format is described in sufficient detail, it is text. Files can be edited with a text editor. The network file includes information about the relationships of objects in the graph. There are several other special file types: thesaurus, cluster colors, overlay colors, and density colors.

VOSviewer can be launched from the command line, there are many parameters and commands to configure the launch of the program. There is a possibility to make the

graph available online via the link.

The distance between the two nodes indicates the relationship between the nodes in the visualizations provided by VOSviewer. Popular sites may have several orders of magnitude and more links than their less popular counterparts, representing highly cited publications. When analyzing bibliometric networks, the normalization of these differences between nodes by the strength of communication is usually performed [18].

The next step after the normalization of the network is to place the nodes in the network in a two-dimensional space so that the strongly-connected nodes to be closer to each other. A cluster is a collection of closely-related nodes. Each node in the network belongs exactly to one cluster. The number of clusters is determined by the resolution parameter. When visualizing a bibliometric network, VOSviewer uses colors to indicate the cluster nodes [19].

VOSviewer also supports overlay renderings. In overlay rendering, the color of a node indicates a specific property of the node. For example, nodes can represent magazines, and the color of a node can indicate the number of times a journal has been cited [20].

3. Results and Discussion

The scale of international cooperation in the field of scientific research has sharply increased in recent decades. The improvement of information technology and communication systems contributes to the rapid and wide exchange of information, experience, and ideas.

After World War I, sanctions are increasingly seen as a liberal alternative to war. Economic sanctions are actions aimed at reducing the aggregate economic welfare of a target state by reducing international trade.

Since the beginning of the 21st century, many economically developed countries have used economic sanctions to put pressure on other countries pursuing an independent policy in order to reduce the aggregate economic welfare of the target state by shrinking international trade and forcing them to abandon their own policies. The United States Foreign Assets Control Office (OFAC) interprets comprehensive sanctions as prohibiting all transactions between an authorized country and the United States. This means that there can be no import, export, financing of goods, the spread of technology and services, or resellers between American citizens and an authorized country. There are countries currently under comprehensive multilateral sanctions: Democratic People's Republic of Korea, Iran, Cuba, and Syria.

Iran has a young population (40% of the population under the age of 25 years). Iran takes a high rank in the world among graduates of scientific and technical special courses (3rd rank), higher education (3rd rank), and scientific publications (32nd rank) [1]. Iranian scientists are denied publication of articles in broadcasting magazines. They cannot gain access to medical and laboratory materials and information resources.

Currency exchange blockade excludes the payment of fees (publication, registration, membership), impedes international cooperation in the field of scientific research, and allows many magazines (and publishing companies) to refuse to submit the articles by Iranian organizations. IP address blocking can further limit access to software and an online resource. Clinical trials in Iran have been discontinued or suspended.

Sanctions directly impede the advancement of Iranian scholars, thereby limiting incomes and their ability to take care of their families. Indicators such as the Impact Factor have become an integral part of the promotion and work process at Iranian universities. Being forced to publish articles in journals with a low level of influence and not participating in international meetings and scientists or academic circles cannot have guidance for career growth.

Modern science is vulnerable to economic and official sanctions. International scientific cooperation can be heavily dependent on national circumstances, including political sanctions and an academic boycott, as it is in Iran now.

The search was carried out on the Dimensions platform based on the keywords "sanctions of Iranian scientists" and "economic sanctions of Iranian medicine and health science" in the names and annotations of the articles from 2000 to 2020.
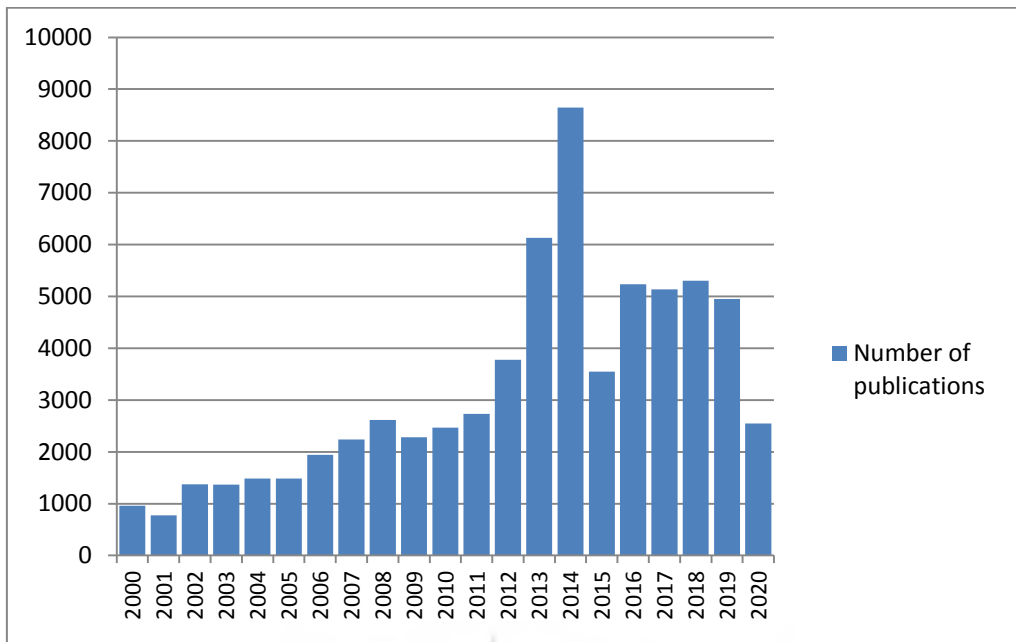
Figure 1. Number of Publications for "Sanctions of Iranian Scientists" (Dimensions database)
Source: Authors
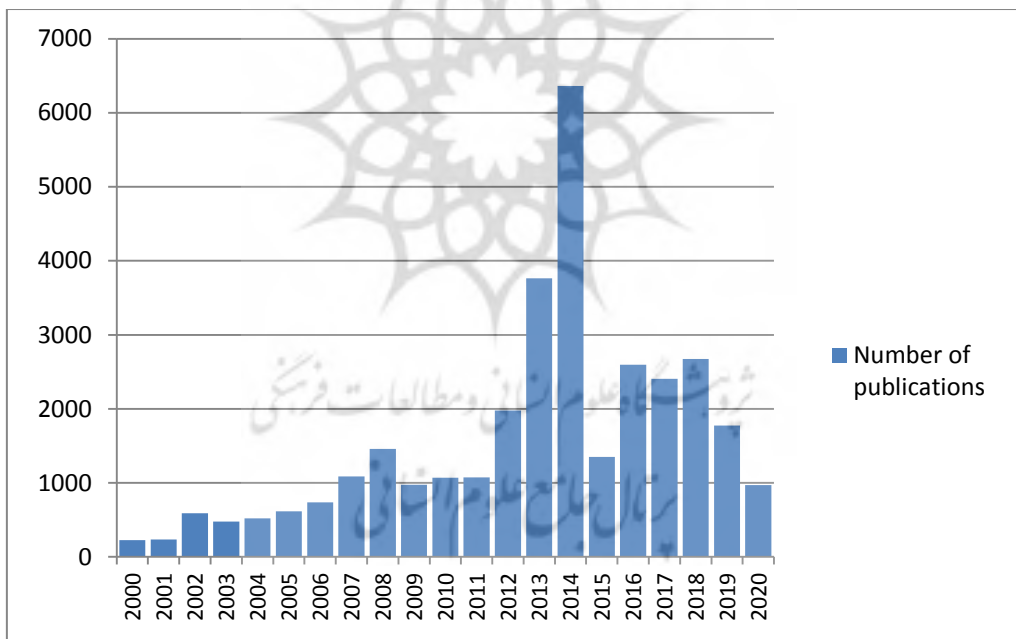
Figure 2. Number of Publications for "Economic Sanctions of Iranian Medicine and Health Science"
(Dimensions database)
Source: Authors

Figures 1 and 2 show that in 2014, there was a surge in research interest for the requests under consideration. The year 2014 was marked by the weakening of sanctions against Iran. In 2014, due to progress in the negotiations on the nuclear program, the United States suspended several sanctions. In particular, the ban on the purchase of petrochemical products from Iran was canceled. Apparently, this weakening of sanctions affected the publication activity of researchers, and Iranian scientists could publish their articles in Western journals. Since 2015, there has been a sharp decline in publication activity.

A contradictory picture is obtained in the field of publications on biomedicine for authors

affiliated with Iran (Iran [Affiliation]) based on PubMed, (shown in Figure 3). Nevertheless, it is seen that the trend of publication activity is declining. The trend line is linear, the coefficient of determination (R^2), which is also called the value of the reliability of the approximation, is 0.048.
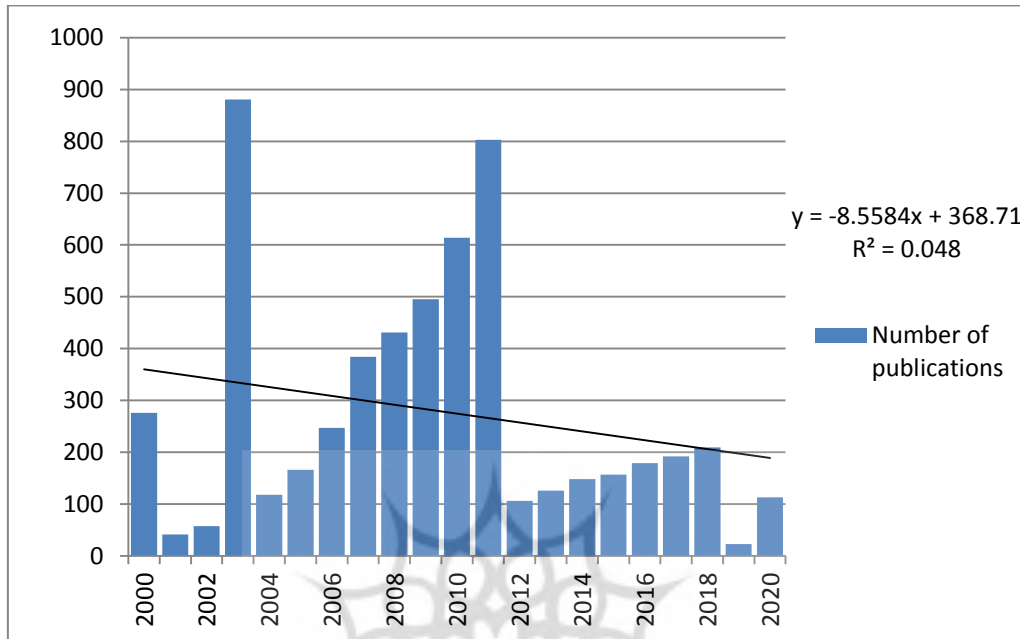

Figure 3. Number of Publications on the Query "Iran [Affiliation]" (PubMed database)
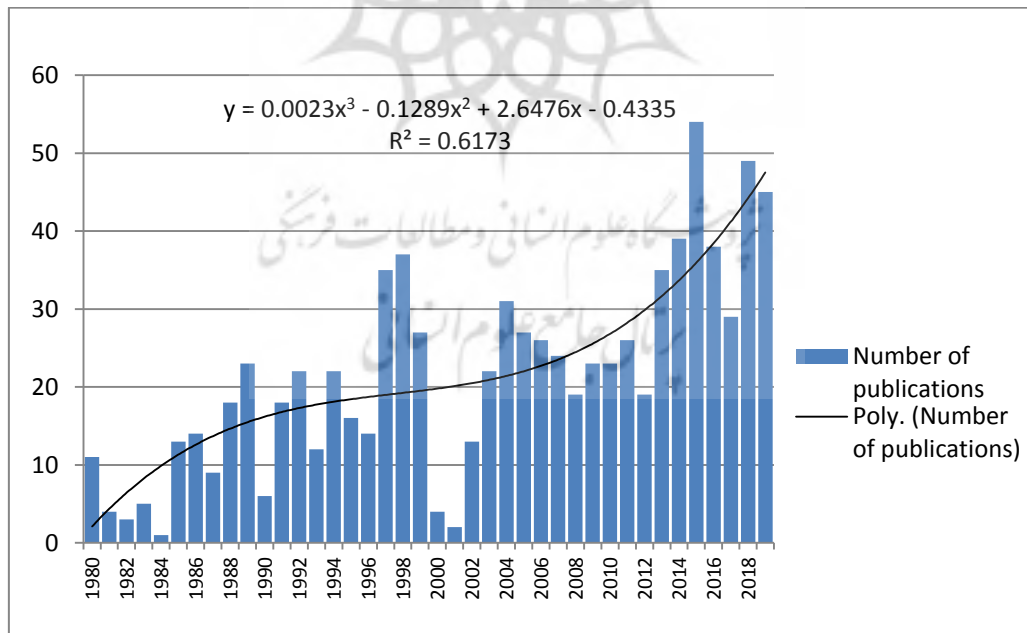**Source: Authors**

Figure 4. Number of Publications for "Economic Sanctions" (PubMed Database)
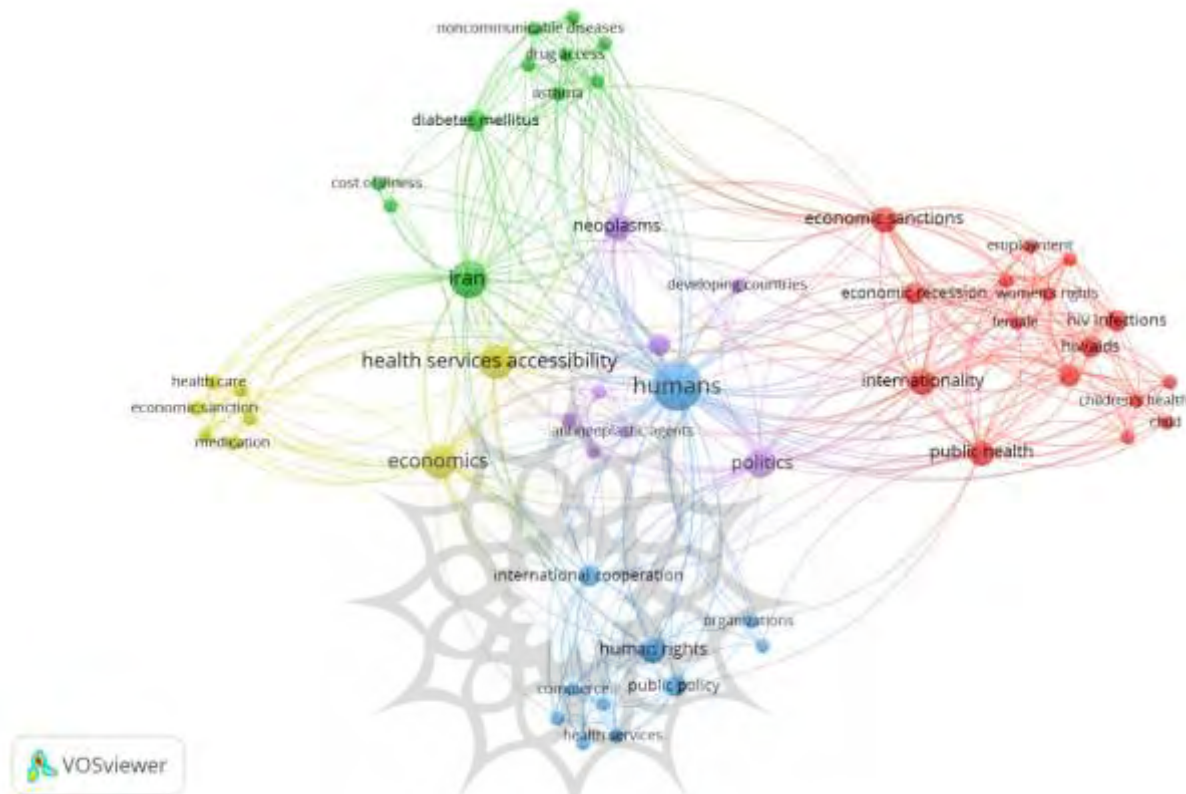**Source: Authors**

We searched through the PubMed database for economic sanctions. There were articles related to the impact of economic sanctions on public health (shown in Figure 4). The bursts of publication activity coincide with the imposition of sanctions against Iran (2013-2016). The trend line is polynomial, the coefficient of determination (R^2) is 0.6173.

VOSviewer extracts terms from annotations and keywords of articles and adds them to a single text corpus when constructing a map. Further, VOSviewer identifies clusters of terms based on their common occurrence in the texts used. When rendering, VOSviewer paints individual clusters in different colors. The size

of a node in the network depends on the number of occurrences of the term to which the node refers in a text box. There was built a mental map of terms related to the impact of economic sanctions on public health based on the totality of publications received at the request of "economic sanctions" (PubMed database).

Figure 5. A mental Map of Terms Related to the Impact of Economic Sanctions on Public Health (based on PubMed)

Source: Authors

The mental map (shown in Figure 5) contains 54 terms in 5 clusters.

The first cluster (red) includes 16 terms (child, children's health, the consequence of sanctions, economic recession, HIV infections, HIV/aids, gross domestic product, female labor participation, female, economic sanctions, employment, internationality, socioeconomic factors, public health, women's rights, and women's health). The conditional name of the cluster is "Women's and Children's Health under Economic Sanctions".

The second cluster (green) includes 11 terms (asthma, cost of illness, diabetes mellitus, drug access, drug shortage, economic crisis, health policy, Iran, multiple sclerosis, non-communicable diseases, and prescription drugs). The conditional name of the cluster is

"Access to medicines in Iran under economic sanctions."

The third cluster (blue) includes 11 terms (coercion, commerce, health services, health status, human rights, humans, international cooperation, Korea, organizations, public policy, and social control formal). The conditional name of the cluster is "Health Policy".

The fourth cluster (olive) includes 8 terms (economic sanction, economics, health care, health services accessibility, medication, policy, population health, and social determinants of health). The conditional name of the cluster is "Health in the context of economic sanctions".

The fifth cluster (purple) includes 8 terms (antineoplastic agents, delivery of health care, developing countries, international sanctions,

neoplasms, oncology, pharmaceutical preparations, and politics). The conditional name of the cluster is "Treatment of Oncology in Conditions of Sanctions".

Overlay visualization by the year of publication shows that the oldest cluster is the fifth and the newest is the first.

Terms, their weight <Links> (the number of terms where this term was mentioned) and <Avg. pub. year> the average value of the year of publication are shown in Table 1.

Table 1. Statistics for the Co-Occurrence of Terms

| Term	Cluster	Weight<Links>	<Avg. pub. year>
Antineoplastic Agents	5	12	2015
Asthma	2	12	2018
Child	1	10	2019
Children's Health	1	10	2019
Coercion	3	10	2009
Commerce	3	10	2009
Consequence of Sanctions	1	17	2019
Cost of Illness	2	5	2016
Delivery of Health Care	5	14	2016
Developing Countries	5	6	2018
Diabetes Mellitus	2	15	2017
Drug Access	2	12	2018
Drug Shortage	2	12	2018
Economic Crisis	2	12	2018
Economic Recession	1	17	2018
Economic Sanction	4	9	2019
Economic Sanctions	1	28	2018
Economics	4	28	2015
Employment	1	13	2019
Female	1	13	2019
Female Labor Participation	1	13	2019
Gross Domestic Product	1	10	2019
Health Care	4	9	2019
Health Policy	2	5	2016
Health Services	3	10	2009
Health Services Accessibility	4	32	2017
Health Status	3	10	2009
HIV Infections	1	17	2019
HIV/Aids	1	17	2019
Human Rights	3	15	2015
Humans	3	53	2017
International Cooperation	3	19	2012
International Sanctions	5	12	2015
Internationality	1	27	2017
Iran	2	32	2017
Korea	3	10	2009
Medication	4	9	2019
Multiple Sclerosis	2	12	2018
Neoplasms	5	23	2017
Non-communicable Diseases	2	12	2018
Oncology	5	12	2015
Organizations	3	6	2019
Pharmaceutical Preparations	5	12	2015
Policy	4	9	2019
Politics	5	31	2015
Population Health	4	9	2019
Prescription Drugs	2	12	2018
Public Health	1	22	2019
Public Policy	3	14	2014
Social Control, Formal	3	6	2019
Social Determinants of Health	4	9	2019
Socioeconomic Factors	1	10	2019
Women's Rights	1	13	2019
Women's Health	1	13	2019

Source: Authors

The data on publications received from the Dimensions platform for the keywords "Economic Sanctions of Iranian Medicine and Health Science" in the heading and annotations for the period from 2000 to 2020 were analyzed using visualization networks.

We constructed the networks of authors based on co-authorship and the bibliographic coupling from 2,500 publications selected by relevance.
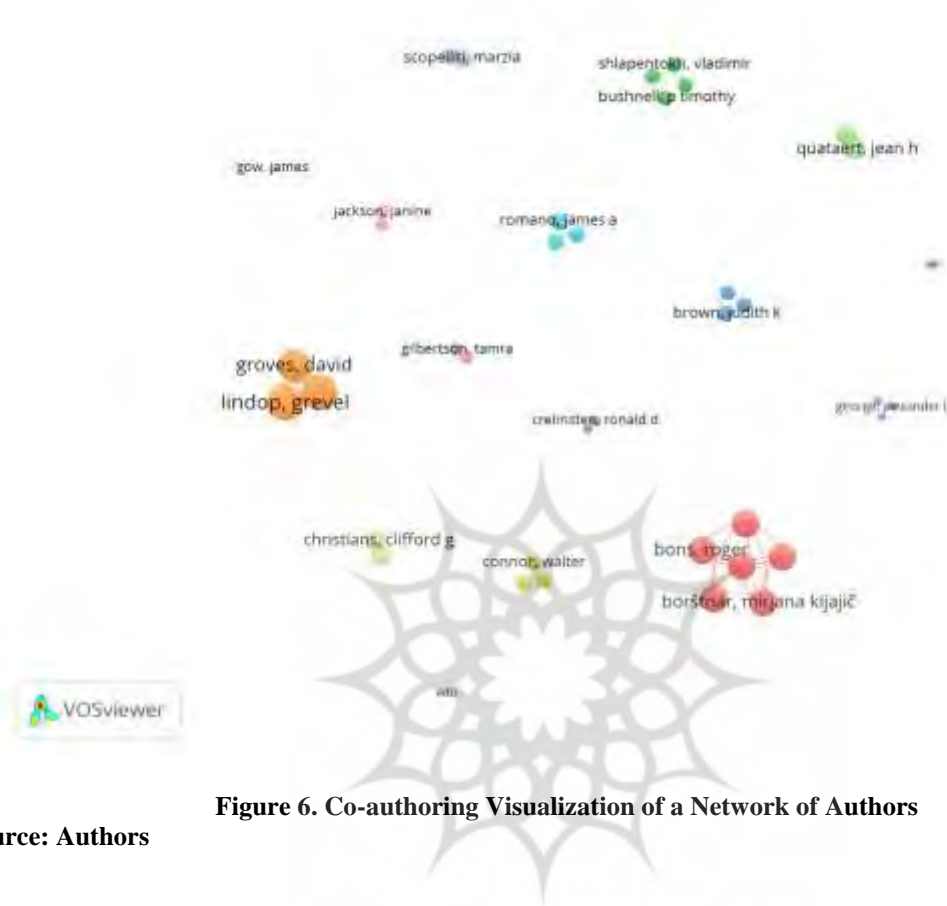
Figure 6. Co-authoring Visualization of a Network of Authors

Source: Authors

The minimum number of articles by the author was taken to be seven when building a co-authorship network for 3143 authors from 92 countries. There were 40 such authors in 16 clusters (shown in Figure 6). The largest cluster included 6 authors, and the contribution of the authors is equal (the size of the circles is close to each other). The smallest clusters included only one author. The network shows a high degree of separation of authors from different countries [21,22].

A network of scientists based on the bibliographic coupling was built. In this case, a link between the researchers can be formed if the researchers cite the same sources. A network of scientists was built based on a bibliographic combination. A link between the researchers can be built if they quote the same sources. The size of the network node depends on how the researcher quoted other scientists. There was a minimum number of citations equal to 5 for 46 authors in 36 clusters (shown in Figure 7).
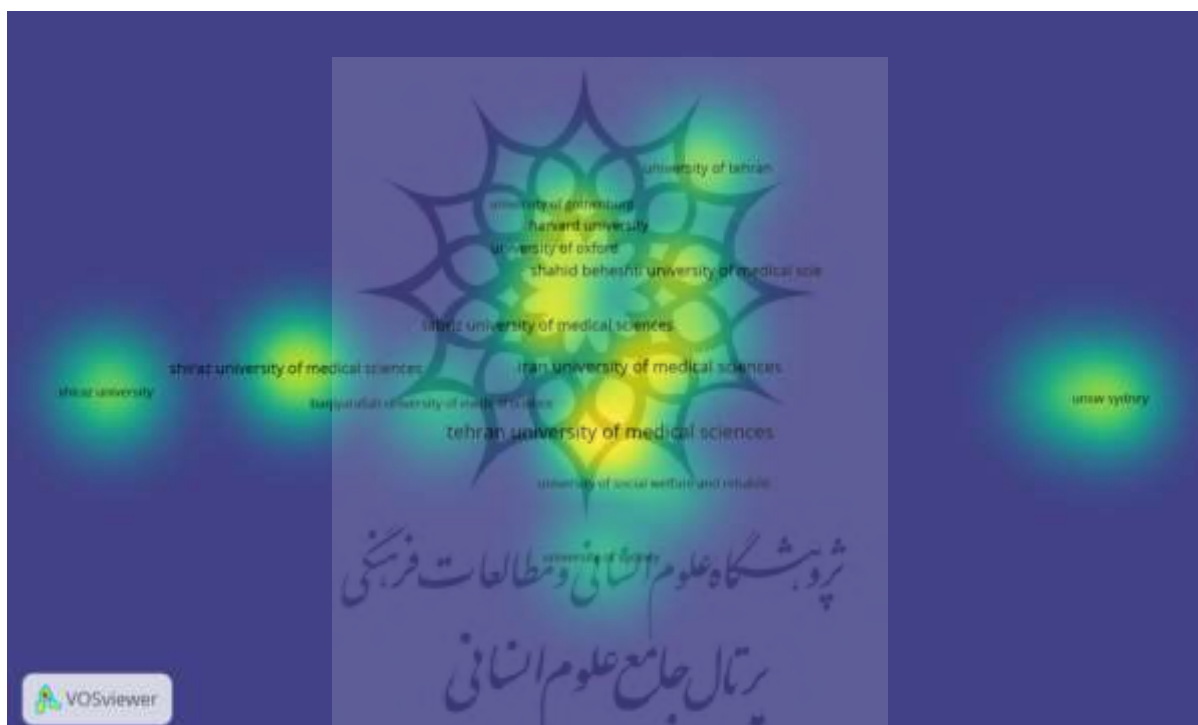
Figure 7. Visualization of a Network of Authors Based on the Bibliographic Coupling
Source: Authors

Figure 8. Visualization of a Country Co-authorship Network for Publications on Economic Sanctions against Iran and Their Impact on Science, Medicine, and Public Health
Source: Authors

Visualization of a network of authors based   on co-authorship and bibliographic coupling

proves that researchers act extremely fragmented, and they are not familiar with the works of authors of other research groups and do not even quote the same sources.

We examined a co-authorship network by country. The minimum number of articles by the author was assumed to be 5. Out of 3143 authors from 92 countries, 31 countries were connected in five clusters (shown in Figure 8). The two largest clusters included 10 and 8 countries, respectively. The first cluster included countries: Brazil, Canada, China, Denmark, Iraq, Norway, South Africa, Sweden, Switzerland, and the USA. The highest density of overlay visualization is in the USA (cluster center). The second cluster included countries:

Austria, Belgium, France, Germany, Italy, the Netherlands, Poland, and Spain. There is no real cluster center here. Cluster 3 contains Japan, New Zealand, Singapore, Turkey, and Great Britain. Center Cluster is the UK. Cluster 4 consists of Australia, Greece, India, and Iran. The cluster center is Iran. The cluster contains Indonesia, Malaysia, Pakistan, and Qatar. There is no real cluster center.

A visualization of co-authorship networks by organizations was built to identify the most influential organizations for the studied topics. The minimum number of articles of the organization was taken equal to 5. Out of 711 organizations, 22 ones that met these requirements were selected (shown in Figure 9).

Figure 9. Visualization of a Co-authorship Network by the Organization (Density Visualization)
Source: Authors

The visualization of a collaborative network of organizations confirms the fragmentation of research (21 organizations form 6 clusters). The largest cluster includes 4 organizations. Figure 9 shows that the Tehran University of Medical Sciences is the most influential organization in the publication field on the topic under study.

The authors of the present study aimed to build a citation network by selecting the most cited articles. The smallest number of citations was chosen to be 2. It turned out that the

citation network by the author includes only one author (Mojtaba Mehtarpour, as shown in Figure 10). Moreover, this does not depend on the number of smallest citations. We checked the citation network starting from 1 document citation.

This amazing picture prompted us to look at the citation network by the author. It turned out that, regardless of the smallest number of citations, it includes only 4 authors (shown in Figure 11).
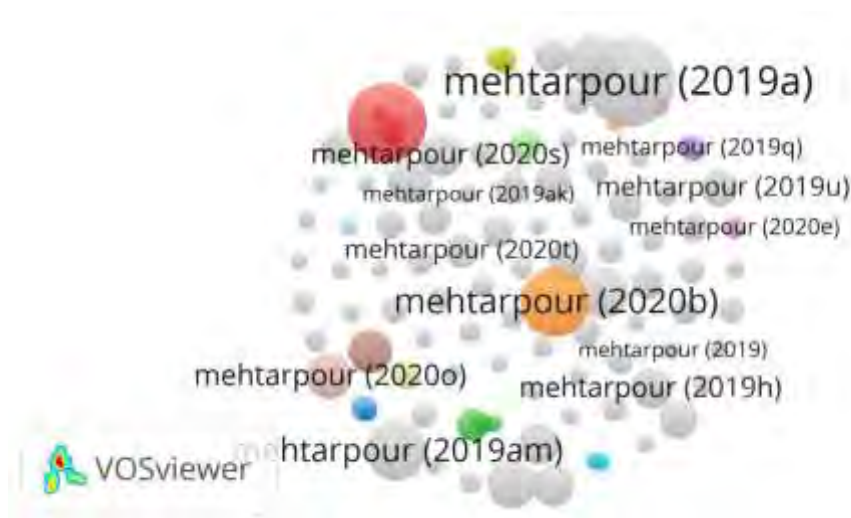
Figure 10. Article Citation Network
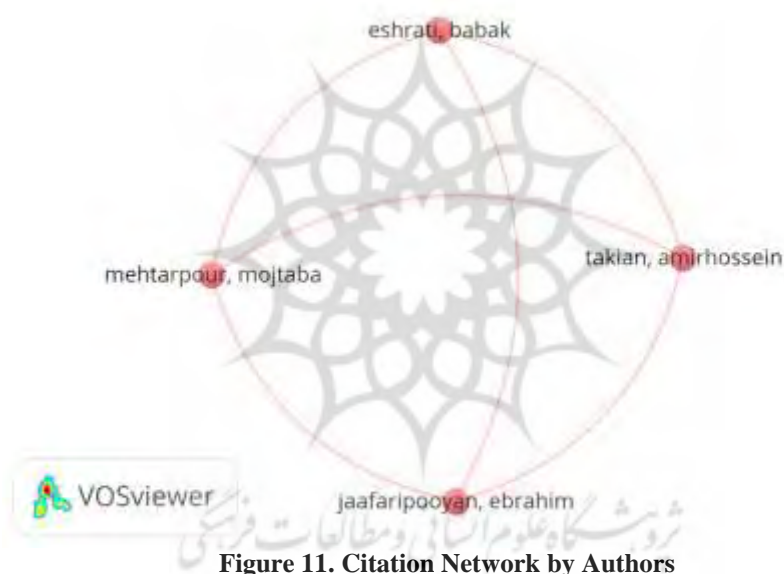
Source: Authors

Figure 11. Citation Network by Authors

Source: Authors

All authors (Babak Eshrati, Ebrahim Jaafaripooyan, Mojtaba Mehtarpour, and Amirhossein Takian) are Iranian researchers.

4. Conclusion

The authors of the present study carried out a bibliometric and scientometric study of articles on economic sanctions against Iran, their impact on public health, medicine, and science. VOSviewer was used for scientific mapping.

The economic sanctions (imposed by the United States) have particularly affected Iran's health care negatively during the coronavirus pandemic. The economic sanctions imposed on Iran by a group of countries had a negative impact on the development of science.

The analysis of the dynamics of publication activity showed the presence of ups and downs during the 21st century. It was conducted on the Dimensions and PubMed platform for keywords related to sanctions against Iran. The analysis showed that the temporary relaxation of sanctions in 2014 immediately led to an increase in the activity of Iranian scientists. Then, with the strengthening of sanctions, the number of publications by Iranian scientists in the PubMed database falls.

VOSviewer gives an opportunity to map terms by the strength of their relationship to other terms. Based on the corpus obtained from the PubMed database, a map of terms related to the impact of economic sanctions on the health

of the population in Iran was built. Clusters combine terms that are most used together. The content of the clusters can be used to determine the ideological and semantic content of research areas. Analysis of the term map showed that the following areas of research in the field of studying the impact of sanctions on health care in Iran can be distinguished:

- "Health of women and children under the conditions of economic sanctions",

- "Access to medicines in Iran under the conditions of economic sanctions",

- "Health policy",

- "Health under the conditions of economic sanctions",

- "Treatment of oncology under sanctions".

We studied the networks of co-authorship and citation using a corpus obtained from the Dimensions database with the keywords "economic sanctions, Iran, healthcare, medicine, science".

Visualization of author networks showed an extreme degree of separation of scientists from different countries involved in analyzing the impact of sanctions on medicine and healthcare. Scientists do not refer to each other's work. The authors are not linked by bibliographic references. Moreover, the authors do not even cite the same sources.

The visualization of co-authorship by country made it possible to identify 5 clusters of cooperating countries, with the centers of the clusters being the USA, Great Britain, and Iran. The visualization of the collaborative network of organizations confirms the fragmentation of the research. The most influential organization in the field of publications on the topic under study is the Tehran University of Medical Sciences.

The analysis of the citation of authors from documents and authors showed that Iranian authors either cite themselves or their colleagues very limitedly.

There is a recommendation to Iranian scientists to quote other scientists more often, even to use self-citation in order to increase the number of links between publications in the bibliometric analysis.

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