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Article

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Scientific collaboration on open science in the field of Information Science

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ABSTRACT

Introduction: Open Science is a movement largely based on knowledge sharing and its discussion has been carried out by several areas, including Information Science. Scientific collaboration has potential to benefit science in several ways, however, little is known about country collaboration in this area. Objective: Therefore, the objective of this work is to analyze scientific cooperation between countries on the subject of Open Science in the field of Information Science. Methodology: The network analysis method (co-authorship between countries) and the frequency of keywords were used to identify the most discussed subjects. Results: The results showed that England has a central position in the scientific collaboration network. However, it is necessary to improve communication to avoid loss of quality in the information transmission. Conclusion: The Open Access theme is still the most evident, however, topics such as research data management have gained notoriety in discussions on Open Science in the field of Information Science.

KEYWORDS

Open access. Information science. Network communication. Co-authorship.

Colaboração científica sobre ciência aberta no campo da Ciência da Informação

RESUMO

Introdução: A Ciência Aberta é um movimento amplamente pautado no compartilhamento do conhecimento e sua discussão tem sido realizada por diversas áreas, inclusive na Ciência da Informação. A colaboração científica tem potencial para beneficiar a ciência por diversos aspectos, porém, pouco se sabe sobre a colaboração de países nesta temática. Objetivo: Logo, o objetivo deste trabalho é realizar uma análise da cooperação científica entre países sobre o tema de Ciência Aberta no campo da Ciência da Informação. Metodologia: Utilizou-se o método da análise de redes (coautoria entre países) e a frequência de palavras-chave para identificar os assuntos mais discutidos. Resultados: Os resultados mostraram que a Inglaterra possui posição central na rede de colaboração científica estudada. Entretanto, faz-se necessário melhorar a comunicação para evitar perda de qualidade na transmissão da informação. Conclusão: A temática Acesso Aberto ainda é a mais evidente, porém, temas como gerenciamento de dados de pesquisa tem ganhado notoriedade nas discussões sobre Ciência Aberta no campo da Ciência da Informação.

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Acesso aberto. Ciência da informação. Redes de comunicação. Coautoria.

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1 INTRODUCTION

The importance of science on the contemporary scene is notorious. Based on the formulation of empirical and logical assumptions that support it, science makes it possible to produce knowledge on the one hand and, on the other, to play a leading role as an institution responsible for social, economic, and political development.

Faced with this scenario of protagonism, discussions about science, especially and more recently, about the formats for its production and communication based on Open Science, have intensified in the academic community. As a disruptive phenomenon, Open Science brings socio-cultural and technological changes based on openness and connectivity. Based on these assumptions, the way research is designed, carried out, disseminated, captured, and evaluated is significantly impacted. Open data tools, open access platforms, open peer review methods, or public engagement activities are irreversible trends that are impacting all scientific actors and have the potential to accelerate the research cycle (Vicente-Saez; Martinez-Fuentes, 2018). For UNESCO (2021), Open Science aims for scientific knowledge to become available, accessible, and reusable in an open way for everyone. By opening up the processes of creating, evaluating, and communicating scientific knowledge, it is hoped to increase scientific collaborations and the sharing of information for the benefit of science itself and society. Other intergovernmental organizations (OECD, 2007; Crowley, 2014; United Nations, 2019) not only recognize but also establish and recommend open-access scientific policies for research funded by public agencies (OSTP, 2013; Wilkinson *et al*., 2016).

This shows the relevance of Open Science in the current scenario. Not surprisingly, several studies on the subject have led to empirical analyses that allow us to understand the scientific phenomena that establish the field. For Vicente-Saez and Martinez-Fuentes (2018), Open Science is conceptually understood as knowledge; transparent knowledge; accessible knowledge; shared knowledge; and collaborative knowledge for development. These studies are in line with what Bronner *et al*. (2022) presuppose as the four essential pillars of Open Science: quality and integrity, collective benefits, equity and justice, diversity and inclusion.

Much more than a movement of access and scientific processes made available to all, Open Science should be seen as an emerging field of research where collaboration is an essential feature. Collaboration and the sharing of information between researchers are fundamental in the context of the open movement and can also be intrinsically understood as presuppositions of Open Science.

Scientific collaboration has been recognized as a strategic way to gain breadth and recognition for research results. Other benefits of scientific collaboration include the sharing and transfer of knowledge, skills, and techniques that enhance the academic competence of collaborators (Katz; Martin, 1997), the development of technical-scientific human capital (Bozeman; Corley, 2004), the creation of more rigorous internal reviews by the team (Van Weswel; Wyatt; Ten Haaf, 2014), the recombination of knowledge and innovation due to different points of view (Katz; Martin, 1997; He; Geng; Campbell-Hunt, 2009; Talke; Salomo; Kock, 2011), and also the positive correlation between the number of citations and scientific collaboration (Shen *et al*., 2021). However, although Open Science is an emerging topic and its discussion is necessary to outline the future of scientific communication and practice, there is a lack of studies that explore and reveal the situation of this topic about scientific collaboration, especially in the context of international partnerships. Several studies have explored scientific collaboration related to open science in terms of workflow and data volume (Singh *et al*., 2007), an adaptation of strategies in a global community of operating systems (Joseph, 2021), demonstration of open science to promote and use open source software (Yu *et al*, 2016), collaborative design analysis of citizen science through co-creation (Senabre; Ferran-Ferrer;

Perelló, 2018), use of open data sources to identify changes in academic affiliation (Yan; Zhu; He, 2020), citation trend analysis to verify open ecosystems for knowledge transfer (Okamura, 2022). Despite this, there is little discussion of the extent of scientific collaboration and international partnerships on the topic of open science. In the field of information science, a field of knowledge concerned with the flow of information and scientific practice, the discovery of the degree of collaboration and international partnerships in Open Science is still subject to investigation and further scientific development. In the context of COVID-19, published studies assess and analyze the quality of open information flows and scientific collaboration (Homolak; Kodvanj; Virag, 2020) and open data transparency initiatives in the promotion of scientific collaboration (Rosa; Silva; Pavão, 2021). Other studies focus on both the Brazilian scenario for contextualizing and proposing models for organizing knowledge in open science (Silveira *et al.*, 2021) and the institutional scenario for verifying scientific production in open sources to improve discussions on the topic (Rodriguez *et al*., 2022).

In this sense, it is imperative to understand the cooperation between countries in the debate on Open Science, especially in the field of Information Science. Understanding this phenomenon would allow the establishment of research management policies, as well as the flow of information conditioned to the strengthening of scientific relations and cooperation between countries and institutions, collaborating with the Open Science movement in the field of Information Science. Therefore, the objective of this study was to investigate scientific cooperation between countries with scientific production on Open Science in the field of Information Science. It has identified the collaboration centers that discuss this topic and the main issues addressed, ultimately seeking to propose improvements that could facilitate the communication of information and research management strategies between countries discussing Open Science.

2 METHODOLOGY

This is a bibliographical study with an exploratory and descriptive design and a quantitative approach in the light of Information Metrics Studies (IMS). IMS analyzes scientific communication models and the processes of production, storage, dissemination, retrieval, and use of recorded scientific and technological information, using appropriate methods and procedures to obtain quantitative indicators for the objects analyzed (Glanzel; Schoepflin, 1994; Tague-Sutcliffe, 1992).

To analyze the international scientific cooperation in the field of information science on the topic of Open Science, we have chosen to use the method of network analysis, which makes it possible to identify the nuclei of cooperation in a given area of knowledge using the characteristics of the links between the nodes. Among the indicators of scientific collaboration, co-authorship has been used to assess collaboration between institutions, countries, or researchers through network analysis (Maia; Caregnato, 2008).

To identify the co-authorship network between countries, the Web of Science (WoS) database was used as a data source, internationally recognized for its breadth and quality in indexing scientific documents (Testa, 1998). The search term used was "open science" in the Author Keywords field, and the results were filtered by article-type documents in the Library and Information Science category. No date filters were used since the intention of the work was to verify the incidence of scientific co-authorship since the beginning of studies in this area.

As a result of the search performed on October 25, 2022, a total of 153 documents were retrieved, one of which was a duplicate, resulting in 152 valid documents. The complete records of the documents retrieved from WoS were exported in plain text format. To create the co-authorship matrix between countries, it was necessary to edit the "author address" field (tag

C1) in the .txt file to correct the information for authors from the United States (USA) since the state code appeared next to the country acronym. The Notepad replacement tool was then used to insert a comma before the word "USA". After this procedure, the file could be loaded into Vantage Point version 5.0 software and the correlation matrix between countries could be generated.

This matrix was exported to Microsoft Excel, where the blank cells were filled with zero, as was the diagonal. The finished matrix was imported into UCInet 6 software, version 6.732 32-bit, from which the coefficients were extracted: degree of centrality, degree of proximity, degree of intermediation, network density, and geodesic distance.

The degree of centrality in a network graph is the measure of the total sum of a node's direct links to other nodes. The degree of mediation, on the other hand, is the measure of how many mediations a node provides between two other nodes in the network. The degree of proximity measures the sum of the distances between a node and the other nodes in the network (Zhang; Luo, 2017). The geodesic distance between two nodes is a measure of the number of edges on the shortest path between them (Han; Kamber; Pei, 2012). Network density is a measure of the number of existing links relative to the total number of possible links between network nodes (O'malley; Marsden, 2008).

Zipf's law was used to identify the main topics of scientific collaboration. Zipf's law consists of measuring the frequency of occurrence of words, which provides an understanding of the terms or keywords and their region of concentration in a topic or discipline (Zipf, 1949). The word cloud with the most frequent terms in Open Science articles in the field of Information Science was created using the Bibliometrix software with the help of the RStudio application, and the co-authorship network graph was created using the VOSviewer software version 1.6.17.

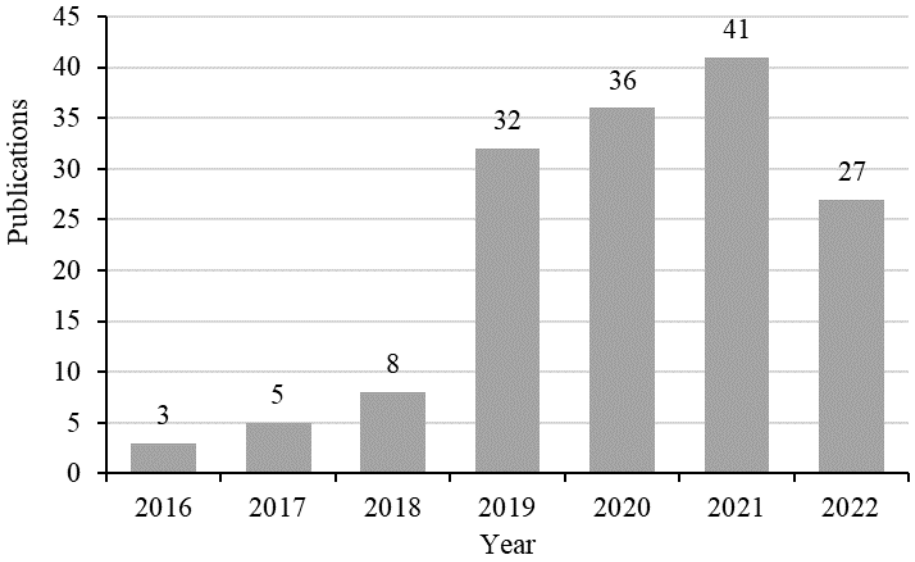
3 RESULTS AND DISCUSSION

The analysis related to Open Science in the field of Information Science (IS) consisted of 152 articles published on the Web of Science (WoS) database. Based on the total number of articles identified and processed for information metric analysis, scientific productivity indicators were produced to understand the quantitative and historical behavior of the theme in the field of Information Science. In addition, we looked specifically at co-authorship between countries with collaborative production, network density, degree of centrality, degree of intermediation, degree of proximity, geodesic distance, subject analysis, and correlation between subjects and countries.

3.1 Historical behavior of scientific production

The time frame of the scientific production analyzed is distributed over 7 years (2016-2022). As can be seen in Graph 1, the distribution is marked by a rise in the number of publications relating to Open Science in the field of IC.

Graph 1. Temporal evolution of production on "Open Science" in the field of IC, 2016-2022, WoS.



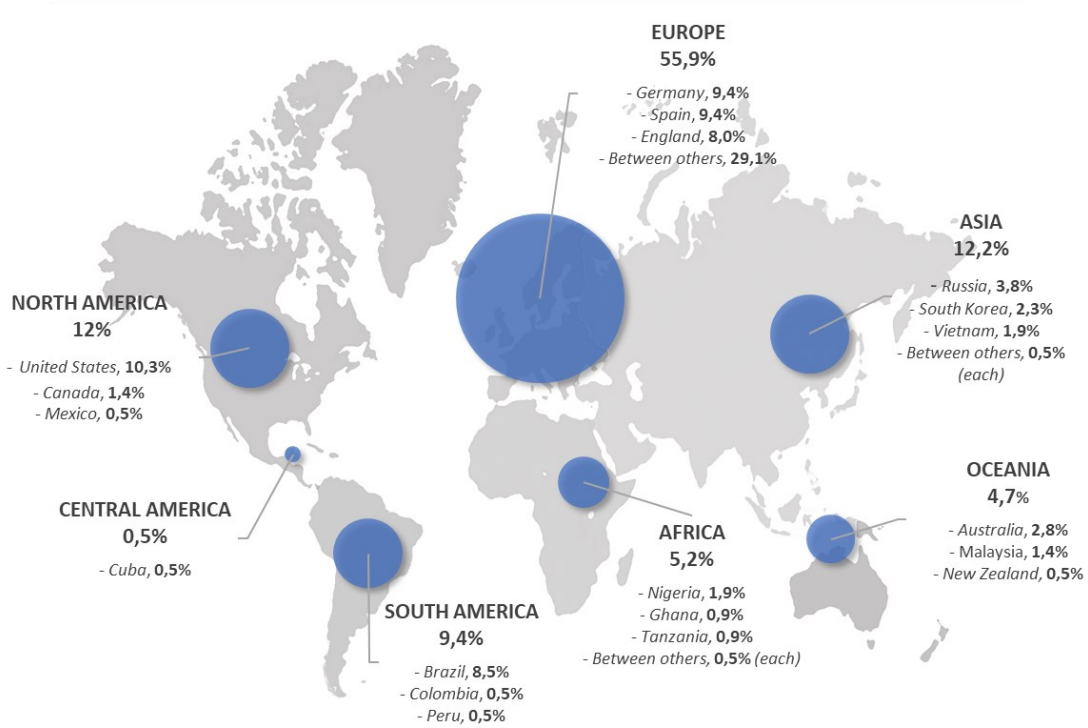
Source: The authors

Although recent, there has been constant and systematic scientific production on the subject of Open Science in the field of IC between 2016 and 2021. The emergence of open access policies over the last decade, especially international policies in the US (OSTP, 2013; Crowley, 2014), Europe (OECD, 2007), and Latin America (United Nations, 2019) may explain the significant production of articles in recent years. Currently, the development of guidelines for open scientific production and communication has intensified in many other countries, providing a diversity of authors and collaborations positioned in different geographical contexts.

3.2 Analysis of production and co-authorship between countries

Of the total of 152 scientific articles retrieved, from 2016 to 2022, geographical authorship linked to 46 countries was identified, with a predominance of scientific productivity on the subject of Open Science on the European, Asian, and American continents, mainly (Graph 2).

Graph 2. Geographical distribution of countries with production on "Open Science" in the field of IC, 2016-2022, WoS.



Source: The authors

In terms of geography, there was scientific productivity on Open Science in the field of IC by countries on all continents. Specifically, the United States of America (USA) was the country with the highest production with a total of 22 frequencies, 10% of the total. This was followed by Spain, Germany, Brazil, England, and France, which accounted for 50% of the total number of articles published. Therefore, half of the scientific production on Open Science in the field of Information Science is attributed to 6 countries, representing the European and American continents.

Italy, Portugal, Russia, Australia, Belgium, the Netherlands, Scotland, South Korea, Austria, Finland, Nigeria, and Vietnam account for another 30% of the countries with the highest scientific productivity. Thus, 18 out of a total of 46 countries account for 80% of all publications on the subject of Open Science in the field of Information Science.

Once productivity had been identified, scientific collaborations between countries were analyzed. Thus, it was observed that of the 46 countries that produced the 152 articles, 35 countries produced in co-authorship, and 11 countries had no collaboration in their productions: Russia, Japan, Croatia, Cuba, India, Lithuania, Mexico, Pakistan, China, Slovenia, and Turkey. Other countries, such as Colombia and Peru, as well as Saudi Arabia and Egypt, collaborated bilaterally and therefore did not form a network with other countries.

Of the countries with co-authored productivity on the subject, a total of 40 articles were identified, 26% of the total number of articles published. Despite higher productivity, it can be seen that several countries have a high level of productive collaboration on the subject of Open Science in the field of Information Science (Table 1).

Table 1. Total production and collaborative production of the 31 countries with production on "Open Science" in the field of CI, 2016-2022, WoS.

Country	Production			Country	Production		
	Freq.	Collaboration	%		Freq.	Collaboration	%
United States	22	8	36	United States	22	8	36
Spain	20	6	30	Spain	20	6	30
Germany	20	8	40	Germany	20	8	40
Brazil	18	5	28	Brazil	18	5	28
England	17	9	53	England	17	9	53
Italy	8	3	38	Italy	8	3	38
France	8	6	75	France	8	6	75
Portugal	8	4	50	Portugal	8	4	50
Australia	6	4	67	Australia	6	4	67
Scotland	5	4	80	Scotland	5	4	80
South Korea	5	3	60	South Korea	5	3	60
Netherlands	5	4	80	Netherlands	5	4	80
Belgium	5	3	60	Belgium	5	3	60
Austria	4	3	75	Austria	4	3	75
Vietnam	4	1	25	Vietnam	4	1	25
Finland	4	1	25	Finland	4	1	25

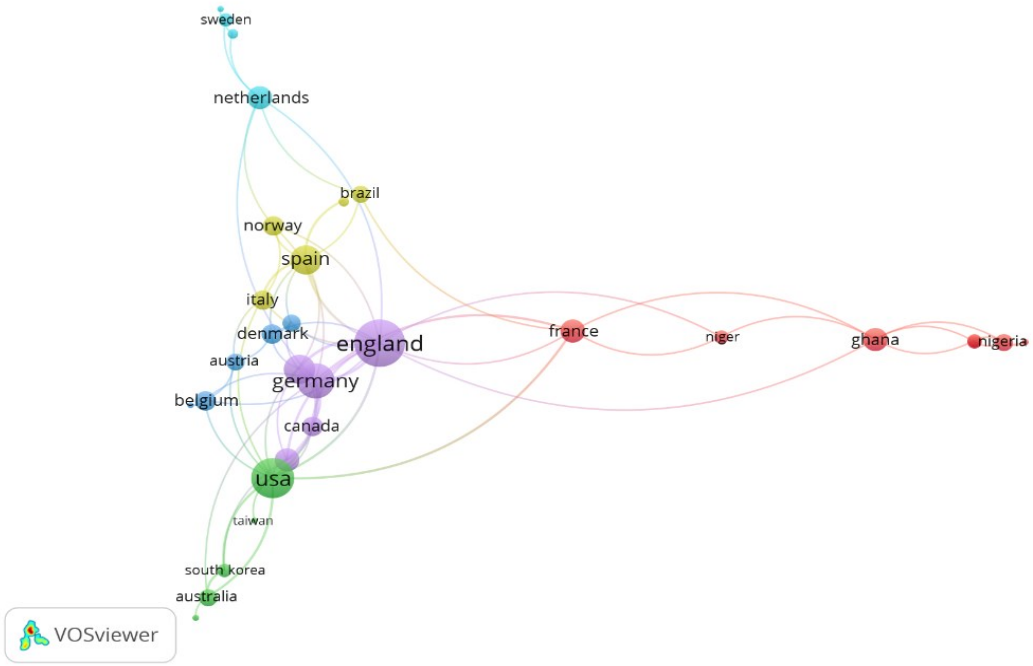
Source: The Authors.

Switzerland, with 100%, Scotland and the Netherlands, with 80% each, as well as France, Austria, and Nigeria, with 75% each, are among the countries with the most authorial collaboration of articles according to the frequencies identified. Other countries such as Norway, Sweden, Canada, Malaysia, and Australia, with 66% authorial collaboration, as well as South Korea and Belgium with 60%, England with 53%, and Portugal with another 50%, are highly representative in terms of the collaboration of their respective scientific productions, since, despite the modest productivity of articles on the subject in the field of IC, compared to the most productive countries, they have high authorial collaboration. In essence, they publish less and collaborate more.

At the end of this analysis, it is worth highlighting that the countries with the highest scientific productivity on the subject of Open Science in the field of IC have stood out on the local and world stage for pioneering discussions on open access policies. This fact may contribute to a quantitative understanding of the production of these countries and their moderate authorial collaboration. In contrast, the analysis allowed us to identify that the countries of Asia and Oceania (Australia, South Korea, Vietnam, and Malaysia) collaborate authorially with other countries, on average 55% of the total of their respective scientific productions on the subject.

Based on this scenario, a co-authorship network was built, considering 31 countries that have published in collaboration. The co-authorship network between countries found on the subject of Open Science in the field of Information Science is made up of 31 nodes (countries) and 73 links (Graph 3).

Graph 3. Co-authorship network of the 31 countries on the topic of "Open Science" in the field of CI, 2016-2022, WoS.



Source: The authors

The network is made up of 6 main groups, differentiated by the colors red, yellow, light blue, dark blue, green, and purple. Despite being the fifth most productive country on the subject of Open Science in the field of Information Science, England is a country that occupies the central position in the network, interacting with 15 other countries. It leads group 1, which also includes Germany, Canada, Scotland and Switzerland. Group 2 is led by the United States, which also plays an important role in the network, interacting with 12 other countries. This group is made up of Australia, Taiwan, New Zealand, and South Korea. Next is group 3, led by Spain, which interacts with 8 other countries. Also in this group are Brazil, Italy, Norway and Portugal. Group 4, led by France, which interacts with 8 other countries, is also made up of Niger, Nigeria, Ghana, Tanzania, Uganda and Malaysia. Group 5, led by the Netherlands, which interacts with 6 other countries, is made up of Sweden, Finland, and Bulgaria. Finally, group 6 is made up of Denmark, Belgium, Austria, Qatar and Vietnam.

Based on the co-authorship network constructed, analyses of network density, degree of centrality, geodesic distance, degree of intermediation, and degree of proximity were generated (Table 2).

Table 2. Scientific collaboration indicators of the co-authorship network between countries on the topic of "Open Science" in the field of CI, 2016-2022, WoS

Network Group	Country	Degree of Centrality	Degree of Intermediation	Degree of proximity
Group 1	England	23	177,8	138
	Germany	16	55,7	147
	Canada	6	-	158
	Scotland	9	7,4	157
	Switzerland	10	13,2	153
Group 2	United States	17	82,0	148
	Australia	6	30,3	168
	Taiwan	1	-	177
	New Zealand	1	-	197
	South Korea	5	0,7	174
Group 3	Spain	11	27,2	157
	Brazil	5	12,9	163
	Italy	6	7,8	156
	Norway	5	5,3	155
	Portugal	4	-	180
Group 4	France	8	35,9	151
	Niger	3	-	160
	Nigeria	5	29,0	181
	Ghana	6	104,0	156
	Tanzania	3	-	182
	Uganda	3	-	182
	Uganda	2	-	210
Group 5	Netherlands	6	84,7	154
	Sweden	3	29,0	180
	Finland	2	-	181
	Bulgaria	1	-	209
Group 6	Denmark	5	4,9	160
	Belgium	5	32,1	157
	Austria	4	3,3	168
	Qatar	4	-	161
	Vietnam	1	-	186

Source: The Authors.

3.2.1 Network density

The density analysis of a network aims to show its connectivity, i.e. its potential in terms of information flow (Restrepo-Arango; Alvarado, 2018). Thus, for the network under analysis, a density of 9.2% was found, with a standard deviation of 0.358. This therefore indicates a network with low communication density, i.e. it makes effective use of less than 10% of its possible links. Fundamentally, a more intense relationship is observed in terms of the flow of information between countries belonging to the same collaboration groups.

3.2.2 Degree of centrality

The degree of centrality considers all the paths in a network and the direct connections between a node and the others (Carvalho; Fleury; Lopes, 2013), thus showing the relevance of authors and/or countries in the context of the network, highlighting the most significant positions, links and relationships (Oliveira; Grácio, 2012). The degree of centrality reveals the number of connections a country has with other neighboring countries, indicating that those with a greater number of connections are more active in terms of collaboration.

Through the collaboration network identified, it can be seen that England is the country with the central role in the network, which has collaborated the most and has the greatest number of connections. Its degree of centrality is 35% higher than that of the United States, which ranks second in this indicator. Therefore, England and the United States are the central countries in collaboration throughout the network.

Looking at the degree of centrality of the countries in their respective collaboration groups, it can be seen that, in addition to England and the United States, in groups 1 and 2 respectively, Spain in group 3, France in group 4, the Netherlands in group 5, Denmark and Belgium in group 6, centralize the collaborations. As such, they stand out in their collaboration groups on the studies published on Open Science in the field of Information Science.

3.2.3 Geodetic distance

The geodesic distance indicates the effort, or average distance, that an element makes to reach all the other participants in the network. Shorter distances mean faster, safer, and more accurate transmission of information to share (Restrepo-Arango; Alvarado, 2018).

For the co-authorship network between countries on the subject of Open Science in the field of Information Science, it was found that the average distance between the countries in the network is 2.591 with a standard deviation of 1.088. The data observed from the average geodesic distance of this network, approximately 2.6 (±1.1), allows us to understand that the countries have, on average, a distance of 2 to 3 countries between them. The overall clustering coefficient was 0.785, indicating that if two countries, A and B, have collaborated separately with C, there is a 78.5% probability that A and B will collaborate in the future.

Therefore, the flow of communications in the co-authorship network can be considered long, as it can take up to 3 countries to transmit information or, in this case, collaborative production on Open Science in the field of Information Science. Regardless of the number of countries collaborating on the subject, it can be summarized that there is a high probability of future collaborative authorship between the countries and groups identified.

3.2.4 Degree of intermediation

The degree of intermediation seeks to understand the nodes that stand in the way between two other nodes in the network (Carvalho; Fleury; Lopes., 2013) and shows how much a node has favored intermediation between others (Lopes; Carvalho, 2012). In this way, the degree of intermediation means the shortest path to connect two nodes in a network (Chen, 2006). Thus, intermediation is based on the shortest routes to connect to other actors in the network. Countries with high intermediation perform the task of linking various groups, acting as a bridge in the network. The one that is located on the shortest route between other countries will be more intermediary, as it is necessary to pass through it to connect to other countries in the network (Restrepo-Arango; Alvarado, 2018).

The degree of intermediation identified in the co-authorship network shows only the non-zero values obtained as a result, which was the case for 19 countries. England is once again

in a prominent position in the network, acting as an intermediary for connections between other countries. Ghana comes second in this indicator, although it has a 41% lower degree of intermediation than England, which further consolidates England's position among the countries identified in terms of the degree of intermediation. Other countries such as the Netherlands, the United States, Spain, and Denmark are consolidated as intermediary countries in the network.

These figures show that the network is not widely spread, but that a small group of countries, representing 19% of the total, concentrate and mediate relations between the other players in the network.

3.2.5 Degree of proximity

The degree of proximity can be defined as the ability of an element to be closer to others within the network and is inversely proportional to the degree of centrality, i.e. the greater the proximity, the less central the actor (Alves *et al*., 2014).

When analyzing the network, the centrality of England was identified, with a degree of closeness of 138. Of the total, 12 countries (39%) had a degree of closeness in the 150 to 160 range, considered an intermediate degree. Countries such as Bulgaria and Malaysia, on the other hand, had a degree of closeness above 200, indicating that they were on the periphery of the network.

On the other hand, many countries are distant from the central countries within each group but have close collaborative relationships with each other. In group 1, Canada and Scotland have a high degree of proximity and distance from England. In Group 2, Taiwan and South Korea are close to each other in terms of collaborative production, but far from the United States. In group 4, Tanzania and Uganda, as well as Nigeria, are close to and far from France. Finally, the same configuration is observed in group 5, with close collaborative production between Sweden and Finland and distance from the Netherlands.

This composition shows that the degree of proximity is appropriate, as many countries are closer to others within the network, inversely proportional to the degree of centrality within each collaboration group. Therefore, these are countries that are dispersed in terms of collaboration concerning the central countries within each group, but with a high degree of collaborative proximity between them. In short, the dispersed countries within each group collaborate more with each other.

An exception in this composition is Qatar in group 6 and its proximity to Denmark, the central country in this group. Although there is little intermediation between these two countries, there is a strong degree of proximity in terms of collaborative production between them. In particular, group 3 also has a high degree of proximity between Italy Norway, and Spain, the central country in the group. Brazil stands out from the other countries in terms of collaboration in this group, as it has the second best intermediation, but is distant from the other countries, as is Portugal.

3.3 Subject analysis - keyword frequency

Using Zipf's Law, it was possible to identify, among the documents retrieved, the most studied subjects and the thematic collaboration between countries on the subject of Open Science in the field of Information Science. Thus, in addition to understanding which countries have the most prominent position in the scientific communication network on this topic, it is possible to identify what has been discussed and related between them.

Using Zipf's Law, 293 keywords were identified, of which 14 were "core" subjects, 80 were "interesting" and 199 were "noise". Subsequently, it was found that the terms "open

access", "scientific communication", "open data", "research data management" and "data sharing" are the most frequent that make up the core, which represents 5% of the total subjects identified in research on Open Science in the field of IC (Graph 4).

The subject of open access, for example, was the precursor to the Open Science movement, which began with the Journal Crisis and gave strength to the movement. The Journal Crisis, according to Mueller (2006), began in the 1980s and fostered the process of acceptance of electronic journals and the open access movement by the scientific community, as well as confronting barriers and prejudices in terms of legitimacy.

Graph 4. Most frequent topics on "Open Science" in the field of CI, 2016-2022, WoS

Source: The authors

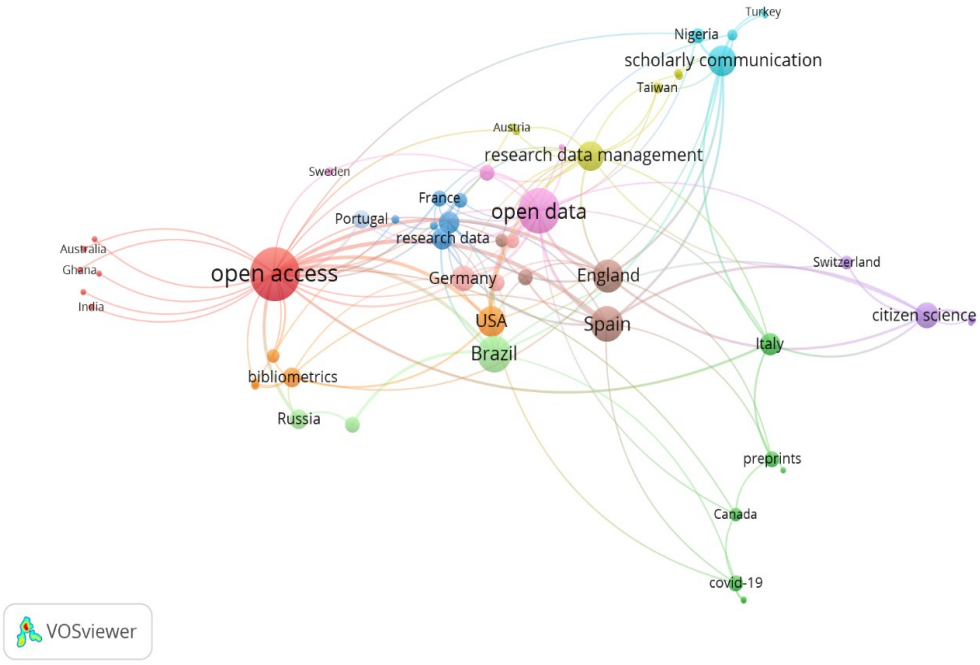
Although it began in previous decades, the open access movement found shelter in institutional guidelines and policies from the 2000s onwards, such as the Budapest (BOAI, 2002), Bethesda (NIH, 2003) and Berlin (Max Planck Society, 2003) Declarations, as well as scientific open access policies established by public agencies in various countries (OECD, 2007; Crowley, 2014; United Nations, 2019; Ostp, 2013; Wilkinson *et al*., 2016).

These discussions have also identified reflections on open data, infrastructure, technological tools for storing, managing, and analyzing data, preservation, availability, sharing, access to information, and institutional repositories. Discussions in recent years have provided spaces for improving methodologies and practices for management, preservation, structured use of repositories, as well as public policies, as observed in studies published by Weitzel and Mesquita (2015), Sayão and Sales (2016) and Santos, Almeida and Henning (2017). In the light of scientific collaboration between countries with productivity on Open Science, there is a concentration of these themes between the central countries and certain peripheral countries (Graph 5).

Studies on "open access" were developed by 60% of the 46 countries identified with scientific production on the subject of Open Science in the field of IC. This group includes the countries identified as central in each group of the collaboration network: England, the United States, Spain, France, the Netherlands and Belgium. Relationships were also observed between the themes of "open access", "scientific communication", "open data"; "institutional repositories", "data sharing" and "data management", highlighting the centrality of production and collaboration on these themes between these countries. Denmark was the only country

identified by the centrality indicator that has developed studies in different contexts, such as those related to the role of Open Science as a citizenship practice.

Graph 5. Thematic collaboration between countries with scientific production on "Open Science" in the field of CI, 2016-2022, WoS



Source: The authors

In particular, the United States, Spain, and Brazil share related thematic interests beyond the identified thematic core, especially "research data" and "data sharing". Together with Canada, they are the only countries to have developed studies related to Open Science and COVID-19.

In short, the core countries have a major impact and influence on scientific production and collaboration on the subject of Open Science in the field of Information Science.

4 CONCLUSION

The purpose of this article was to analyze scientific collaboration between countries that produce on the subject of Open Science in the field of Information Science (IS). To this end, the bibliometric method and network analysis with a focus on co-authorship were used. Of the 152 documents retrieved, effective collaboration was identified between 31 countries, which make up the collaboration network distributed into 6 groups.

Based on the indicators and coefficients, the collaboration movements between the countries were observed. The data showed that the network has low density, i.e. the possible links between the countries on the subject of Open Science are not well used to circulate the information produced, although they are more intense between countries belonging to the same collaboration groups. This fact is corroborated by the geodesic distance, which showed a certain distance between the countries, prolonging communication, which can lead to a loss of quality in the flow of information and, consequently, less productive collaboration on the subject between them.

The degrees of centrality and intermediation showed England, followed by the United States and Germany, as the centralizing countries in the network. These are the countries with the greatest connections and intermediation in communications between other countries. This shows the importance that these countries play in disseminating information on the subject of Open Science in the field of Information Science, especially in the production and collaboration on subjects such as "open access", "scientific communication", "research data management" and "institutional repositories", which are often the most studied by the countries identified in the network.

It can therefore be concluded that the co-authorship network between countries with scientific production on Open Science in the field of Information Science needs to be strengthened. Of all the countries identified with productivity on the subject, there is weak collaboration between many and strong collaboration between a few. Some countries need to advance in their research on the subject of Open Science to broaden the movement and strengthen the repercussions of the knowledge produced in the field of IC, shortening distances for the dissemination of information and improving the possibilities of articulation that the current network already allows.

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