Bibliometric analysis of publications related to the pharmaceutical supply chain before and after the Covid-19 pandemic in the period 2010-2021

Sovero Castro Lucia Isabel
Facultad de Ingeniería y Arquitectura
Carrera de Ingenieria Industrial
Universidad de Lima
Lima, Peru
20162558@aloe.ulima.edu.pe

Risco Guevara Fabiola Milagros
Facultad de Ingeniería y Arquitectura
Carrera de Ingenieria Industrial
Universidad de Lima
Lima, Peru
20171310@aloe.ulima.edu.pe

Garcia-Lopez Yvan Jesus
Facultad de Ingeniería y Arquitectura
Carrera de Ingenieria Industrial
Universidad de Lima
Lima, Peru
ygarcia@ulima.edu.pe

Abstract

The pharmaceutical industry has undergone changes in the management of its logistics processes, making it vulnerable to disruptions such as the Covid-19 pandemic. This study compares the scientific production on the pharmaceutical chain during the period 2010-2021, divided into two periods, through a bibliometric review of research indexed in Scopus and Web of Science. The main authors, institutions, countries, journals and thematic areas are identified, and the studies of greatest scientific relevance are analyzed. The VosViewer tool is used to visualize the relationships between authors and between keywords. A total of 785 publications related to the pharmaceutical chain were identified during 2010-2021. The institutions with the highest publication activity were concentrated in Iran, Morocco and Saudi Arabia. Co-authorship and keyword co-occurrence analyses show the main authors and research topics in both periods. Research on the pharmaceutical chain has been increasing in recent years, but few relate to COVID-19.

Keywords

Pharmaceutical supply chain, pharmaceutical industry, drug chain, Covid-19, bibliometric analysis

1. Introduction

On 11 March 2020, the World Health Organization (WHO) declared the Covid-19 outbreak a pandemic (Organización Panamericana de la Salud 2020), which originated in the Chinese city of Wuhan. As the virus spread rapidly around the globe, many supply chains were affected. Prior to the pandemic, relentless globalization had led to territorial decentralization in the design, production and distribution of many goods and services. The companies that made up these integrated network systems became vulnerable to disruptions such as natural disasters, political crises, terrorist attacks, epidemics, labor unrest and other events that were impossible to predict (Bustos et al. 2021). Therefore,

collaboration between each member of the chain is of utmost importance, as it can manage the negative impact of the "whiplash effect" and become more flexible in the face of market instability (Moosivand et al. 2019).

The "supply chain" comprises the following phases: the procurement phase, which consists of the process of supplying raw materials and materials; the processing phase, where the transformation of materials into finished products takes place; the distribution phase, where the final products are moved to the points where they will be stored; and the phase of acquisition by customers (Aponte et al. 2013).

Prior to the pandemic, large laboratories in the United States, China and Germany drove global pharmaceutical sales. In 2018, their profits were 147,319, 75,491 and 11,659 billion USD respectively (Euromonitor International 2021). In the case of laboratories, the top ranking by profits was held by Roche (Switzerland), Pfizer (USA) and Johnson & Johnson (USA) (Stürz et al. 2019). The medical products industry in countries such as China, India, Latin America and the Middle East witnessed unprecedented opportunities, due to rising populations and disposable incomes that should lead to increased demand for medical services and devices. Until a few years ago, the focus of the medical technology industry was on the US and Western Europe, now it is concentrating on China. Some weaknesses in the developed countries of the medical devices market included deficiencies in quality management, poor fixed financial management capacity and large scale of investment. In contrast, in developing economies, lack of human capital and lack of aggregate supply and demand are the main weaknesses (Maresova et al. 2015).

The Covid-19 pandemic has exposed major vulnerabilities in the pharmaceutical chain (Strong et al. 2020) that have affected the availability of medicines, such as supply and demand mismatches and risks of failure during drug production (Socal et al. 2021; Young and Esqueda 2005). This led to shortages of pharmaceuticals in different pharmacies, which was mainly due to increased demand for certain drugs for fear of running out. Due to containment restrictions to control the spread of the virus, many factories in China had to close temporarily (Choe et al. 2020), considering that China was the leading exporter of essential medical products globally in 2020, according to the World Trade Organization (Alifah 2021). Thus, the inability to obtain inputs and active substances from factories in the Asian country affected the operability of other drug manufacturers worldwide (Al-japairai, K., Almurisi, S., Mahmood, S., Al Khalidi, D., Chilakamarry, C., Naidu, C., Mohananaidu 2020). In addition, international logistics for sea, air and land routes experienced delays, postponements, cancellations and obstructions, due to large-scale travel restrictions and border closures (Xu et al. 2020).With the emergence of the pandemic, the risk of over-reliance on Chinese manufacturers was amplified, as around 60% of the world's active drug substances are manufactured in China (Ozili 2020). Thus, by being produced abroad, the transparency and visibility of the pharmaceutical network is affected (Strong et al. 2020).

To understand the level of impact of the pandemic on scientific research, the discipline used for this work was bibliometrics, which is based on the search for statistically regular behavior over time in the different elements related to the production and consumption of scientific information (Ardanuy and Rey Vázquez 2009). Measuring the literature related to COVID-19 is of great importance for understanding current research (Wang and Tian 2021). Some previous studies that have been conducted on this research topic are shown in Table 1.

Table 1. Research related to the pharmaceutical supply chain and Covid-19

Year	Author	Research title	Objectives	Research method	Study findings	Conclusions
2020	(Senna et al. 2020)	Supply Chain Risk Management: A Bibliometric Analysis considering Healthcare Supply Chains	Conduct a bibliometric analysis to establish a picture of the SCRM research field and identify segments and techniques to establish trends.	The database used (Scopus and WOS), the research period (2014-2019) and the procedures were performed according to the Prisma Protocol.	The US leads with 16% of publications. The most commonly used techniques are simulation, survey analysis and stochastic programming.	The health sector is not widely explored. The items that make up the pharmaceutical sector do not show a broad contribution to the

						pharmaceutical supply chain.
2020	(Linlin and Zhi 2020)	Bibliometric Analysis of Drug Supply Chain in China	To study the development trend and hotspot of China's drug supply chain in terms of bibliometrics.	Data obtained from drug chain studies from 1999 to 2019 collected by CNKI, Wanfang and VIP and the graphical clustering toolkit.	China's drug supply research focuses on drug procurement and cost control, zero pharmacy inventory control, among others.	Improving supply chain efficiency will enhance the transformation and improvement of China's pharmaceutical circulation industry.
2021	(Guleid et al. 2021)	A bibliometric analysis of COVID-19 research in Africa	Describe COVID-19 research conducted in Africa in terms of geographical spread, methodologies and contributions of authors from Africa.	Articles published between 1/12/19 and 3/01/21 in PubMed, African Journals Online, medRxiv, Collabovid, WHO database and Google were used.	1296 articles were registered. The most common research topics include "country preparedness and response" and "health impacts of the pandemic".	This study highlights COVID-19 research in Africa and the continent's existing capacity to conduct research that addresses local issues.

This bibliometric analysis describes the literature on the pharmaceutical supply chain in the period 2010-2021. The aim is to explore the difference in scientific production on the medicines network before and after the onset of the pandemic. It also seeks to expose the main bibliometric indicators of the studies on this topic with the greatest impact published during these two periods.

2. Methods

The research design was non-experimental, longitudinal, descriptive and mixed. The data were obtained from publications indexed in the Scopus and Web of Science (WOS) databases. These are databases of international prestige that compile bibliographic information and provide the option of analyzing and generating bibliometric indicators (Rodríguez 2013).

As a search strategy, the keyword "PHARMACEUTICAL SUPPLY CHAIN" was used. Studies were considered in Spanish and English, from 2010 to 2021 divided into two periods: 2010-2019 and 2020-2021, with the aim of making a literature comparison of research published before and after the appearance of Covid-19. Relevant studies may have been overlooked, as they may not have been included in the keyword or may have been published in other databases.

To present the results, the characteristics of the documents found were classified into number of publications, authors, journals they belong to, countries, institutions and research categories. For data analysis and presentation of results, the bibliometric analysis graphs provided by the Scopus and WOS databases were interpreted and the Microsoft Excel tool was used for their registration, which was presented in tables. The search for the second period (2020-2021) was delimited by adding the keyword "Covid-19" to examine research relating the pharmaceutical chain to Covid-19. In addition, the studies with the highest impact were presented using bibliometric indicators to assess the quality and influence of the research. To do this, the articles with the highest number of citations in both periods were chosen, based on data from Scopus, WOS, CrossRef. To visualise the H-index of the journals of each publication, the Scimago Journal &Country Rank platform was used. Finally, the bibliometric network analysis tool VOSviewer was used to graphically describe the relationships between the most used keywords, the level of cooperation between the identified authors and the relationship between the titles found in both periods.

3. Results

3.1 Number of publications on Pharmaceutical Supply Chain

As of 16 October 2021, a total of 785 publications were found on the topic of supply chain in the pharmaceutical industry, of which 552 belong to Scopus and 233 to Web of Science. In the first period (2010-2019), 523 studies were published on this topic. In the second period (2020-2021), 262 research studies were recorded. The year 2020 was the year with the highest number of publications (n=89) in Scopus, while in WOS it was the year 2021 (n=52). Within the latter period, 43 Covid-related publications were found in both databases. Figure 1 below shows the publications found in the research period 2010-2021 according to database.

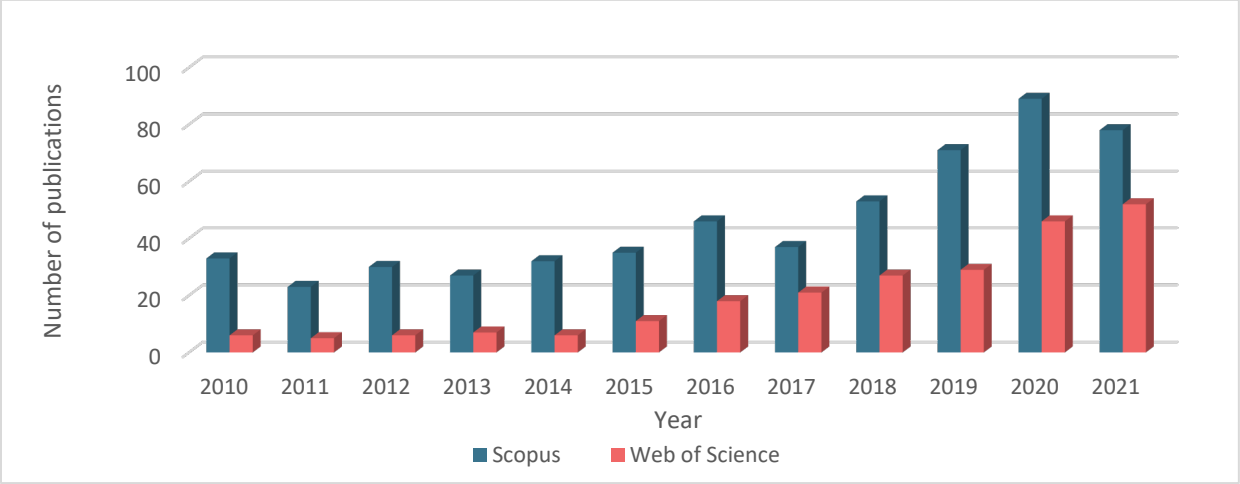

Figure 1. Number of documents published according to database in the period 2010-2021

3.2 Distribution of literature by country

More than 55 countries around the world have published on the pharmaceutical supply chain. The top countries with the most research in both databases in the first period were the USA (n=165), England (n=72) and Iran (n=67), while in the second period the USA (n=35), Iran (n=23) and India (n=23) also lead. Within the latter period, the countries with the highest number of studies focused on supply chain and Covid-19 were the USA and France in the case of Scopus. Meanwhile, the USA and Iran are the most prominent countries in Web of Science.

3.3 Main authors, institutions and journals in the literature

In Scopus, 1504 authors were found who carried out research on the subject, 973 of them published between 2010 and 2019, with Berrado, A. and Patrono, L. being the most active. Meanwhile, 531 authors published between 2020 and 2021, with Benabbou, L. and Berrado, A. having the highest number of publications. Within the latter period, the number of authors publishing research related to Covid 19 and the pharmaceutical supply chain was 135, with Breen, L. publishing more than one study. In the case of WOS, a total of 727 authors have been identified as having published in this database, of which 439 published in the first period, with Ghatari, R. having the highest number of publications. In the following period, 309 authors published, of which Breen, L. and Hosseini-motlagh, S. have the highest publication activity. In the case of authors who published on the pharmaceutical chain and covid 19, there were 36 authors, of which none published more than once.

For the analysis of the relationships between authors, the criterion was that the authors had at least two published papers. In the first period, of the 1412 authors, only 166 met this criterion, in whose map 64 clusters were identified. In the case of the authors who published in the second period, of the 840 authors, only 58 met this criterion, in whose map 27 clusters were identified. Finally, in the case of authors who published research related to Covid-19 and the pharmaceutical chain, the 171 authors who published on this literature were considered, generating a map with 42 clusters. Figure 2 shows the relationships between authors in each case. Likewise, the details of the author co-citation clusters for the first and second period and for research related to Covid 19 are shown in the Table 2.

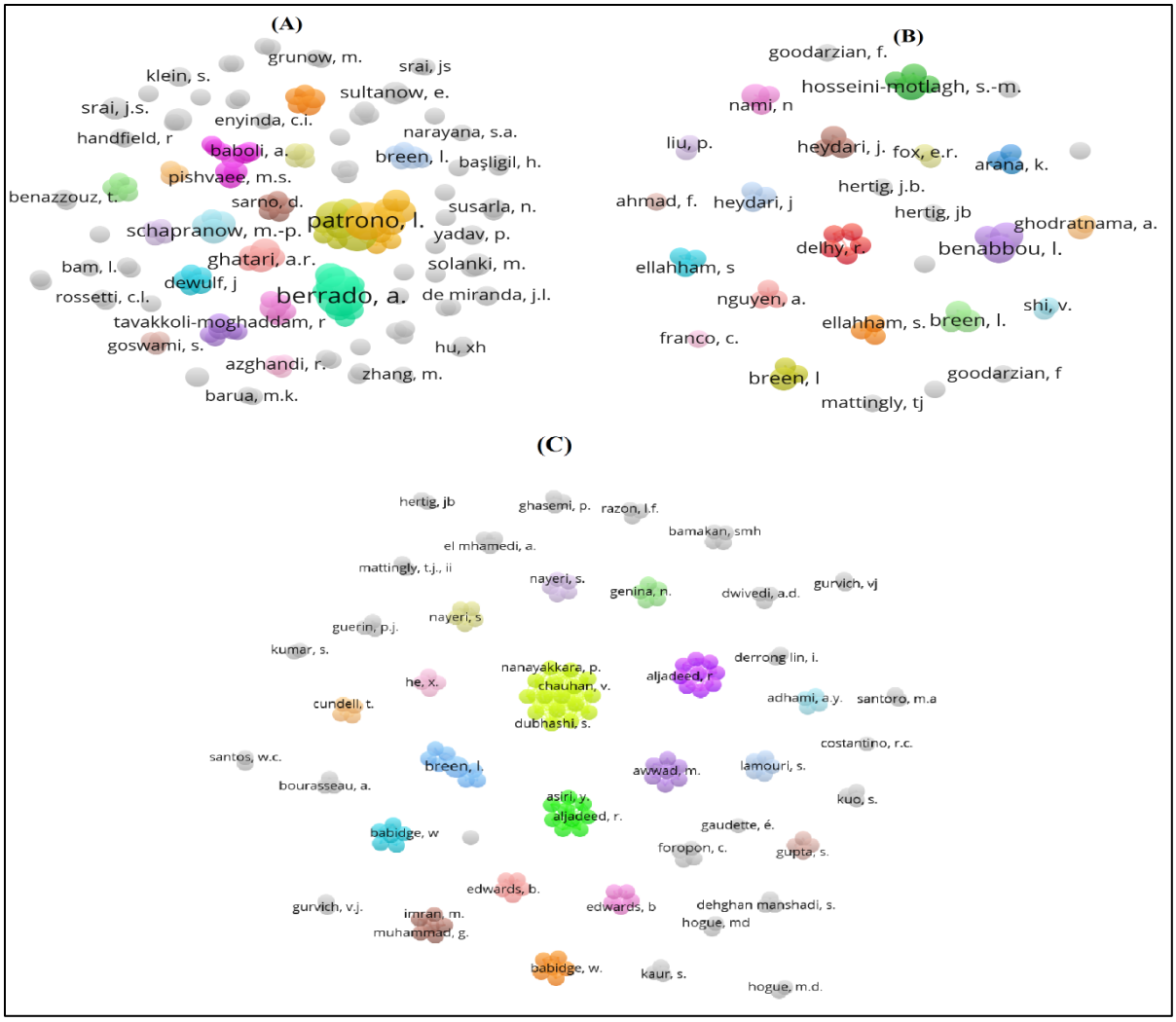

Figure 2. Level of cooperation between identified authors publishing on the pharmaceutical chain during the period 2010-2019 **(A)**, period 2020-2021**(B)** and research involving Covid-19 **(C)**.

The three graphs show that there are a large number of authors who have published studies on this literature, but there is almost no interrelation between the clusters, which is evidence that there is a low strength of co-authorship between them. However, in some groups, there is a high correlation between authors in the same cluster. In case (A), the size of the authors' labels shows that there are only two groups with the highest publication activity, which is the case of Patrono, I and Berrado, A. In the second map (B), Benabbou, L. and Hosseini-motlagh, S. stand out with the highest number of publications. In the third case (C), the yellow cluster stands out for its high interrelation between authors in the same group; however, the size of the labels is the same for all of them.

Table 2. Detail of co-authorship of the most relevant groups by period or section

Period / section	Clúster	Number of ítems	Total link strenght	Co-authorship
2010-2019	1	9	24	Baboli, Mirzazadeh, Mohammadi, Mousazadeh, Pishvaee, Tavakkoli M., Torabi, Zahiri, Zavvar S.
2010-2019	2	8	142	Barchetti, Bucciero, Catarinucci, Colella, De Blasi, Guido, Patrono, Tarricone.

2010-2019	3	8	96	Benabbou, Berrado, Dafaoui, El Mhamedi, El Mokrini, El Amrani, Laghrabli, Mouaky.
2010-2019	4	7	150	Acierno, Carata, De Pascali, Fanizzi, Maffia, Mainetti, Urso.
2020-2021	1	5	40	Delhy, Kazemi, Rosenberg,Ruiz-Barnes, Tillman.
2020-2021	2	4	18	Hosseini, Johari, Nami, Nematollahi.
2020-2021	3	3	12	Arana, Flores, Ramos.
2020-2021	4	3	12	Bamford, Breen, Papalexi.
Covid-19	1	16	240	Chauhan, Dubhashi,Dutta, Firstenberg, Galwankar, Garg, Jayatilleke, Miller, Nanayakkara, Papadimos, Saddikuti, Sharma, Singh, Soghoian, Stawicki,Taylor.
Covid-19	2	9	72	Alotaibi,Alrumaih,Alruthia,Alwhaibi, Asiri, Balkhi, Sales.
Covid-19	3	8	32	Bamford, Breen, Hou,Nikitas, Papalexi, Sowter,Tipi,Yaroson.
Covid-19	4	7	42	Awwad, Bates, Delzell, Fitzpatrick, Haley-hyer,Strong, Trygstad

The main journals that published the most papers on the topic in both periods are International Journal Of Pharmaceutical And Healthcare Marketing, International Journal Of Logistics Systems and Management, Annals of Operations Reasearch and Lecture notes in Logistics.

The institutions with the highest participation in both databases during the first period were Ecole Mohammadia d'Ingenieurs, Mohammed V University in Rabat, Shahid Beheshti University Medical Sciences and University of Tehran. In contrast, for the second period they were University of Tehran, Mohammed V University in Rabat, Iran University Science Technology and University of Bradford. The institution that did the most research on Covid-19 and the pharmaceutical network was King Saud University. A large number of US institutions have also published on the drug chain and the pandemic.

3.4 Category of literature research

The main subject areas of the papers published in both databases in the first and second periods were Business, Management and Accounting, Computer Science, Engineering, Pharmacology and Operations Research Management Science. Whereas, of the studies that focused on the pharmaceutical chain and Covid-19, the main subject areas were Business, Management and Accounting, Engineering and Pharmacology, Toxicology and Pharmaceutics, Health Science Services and Health Policy Services.

3.5 Co-occurrence of keywords

For research conducted on the pharmaceutical supply chain, 203 keywords were extracted for the first period and 98 for the second period. In the case of published studies related to Covid-19, 20 keywords were found. A minimum number of occurrences of 5 was used as a criterion for all three cases. Table 3 shows the details of the keyword co-citation clusters for the first and second periods and the research related to Covid 19.

In the first map, SUPPLY CHAINS was the keyword with the most occurrences (n=137), followed by PHARMACEUTICAL SUPPLY CHAINS (n=132). Five clusters with related keywords were identified, which show a strong interrelation between them, especially the turquoise and fuchsia clusters. In the second map, PHARMACEUTICAL SUPPLY CHAIN was the most used keyword (n=86), followed by SUPPLY CHAIN (n=52). Four groups were distinguished, of which the blue and green clusters reflect a higher frequency of occurrence of the terms in the published studies. There is also a high interrelation between the keywords in all groups. In the third map, COVID-19 was the most frequently found keyword (n=16), followed by HUMAN (n=11). In this case, 2 clusters were identified. It is observed that there is a low strength of co-authorship among the keywords and that there are few distinguishable themes among the publications. In all three cases, it is evident that there is a strong interrelationship between the clusters and that there is a large number of keywords. However, the size of the clusters is not the same in

the first two figures (A and B) as in the last one (C), as this is proportional to the amount of research carried out and the pandemic topic is recent. These relationships are shown in the Figure 2.

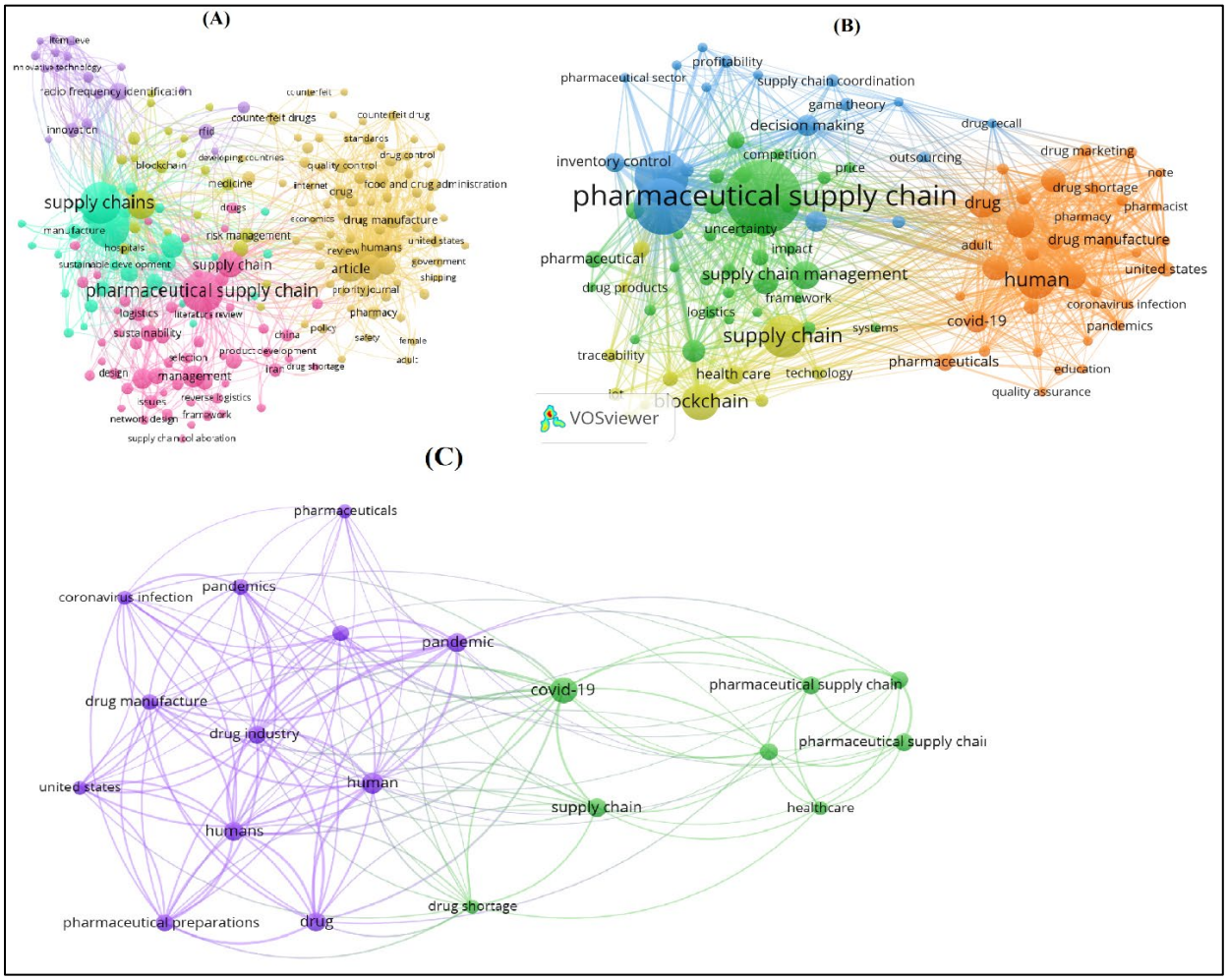

Figure 2. Keyword clusters of pharmaceutical chain studies in the period 2010-2019 **(A)**, period 2020-2021 **(B)** and research involving Covid-19 **(C)**.

Table 3. Detail of keyword co-citation groups by period or section

Period / section	Clúster	Number of items	Keyword co-citation
2010-2019	1	76	Article, Drug Manufacture, Quality control, Pharmacy, etc.
2010-2019	2	56	Pharmaceutical supply chain, Logistics, Sustainability, Management,etc.
2010-2019	3	31	Supply chains, Drug products, Pharmaceutical industry, Health care,etc.
2010-2019	4	21	Risk management, Medicine, Supply chain risk,Blockchain,etc.
2010-2019	5	19	Innovation, Tracking system, Innovative technology, Pharmaceutical sector, etc.

2020-2021	1	35	Drug industry, Pharmacy, Pharmaceutical preparations, Human,etc.
2020-2021	2	33	Data analytics, Performance, Drug shortages,Coordination, etc
2020-2021	3	18	Supply chain, Inventory control, Decision making, Profitability,etc.
2020-2021	4	12	Supply chain, Blockchain, Technology,Internet of things, etc.
Covid-19	1	12	Drug industry, Coronavirus disease 2019, Coronavirus infection, Pharmaceutical preparations, etc.
Covid-19	2	8	Covid-19, Drug shortage, Blockchain, Pharmaceutical supply chain, Healthcare,etc.

Twenty impact research projects were identified (13 related to the supply chain during the first period and 7 during the second period), which are listed in the following table together with their respective bibliometric indicators.

Table 4. Research on Pharmaceutical Supply Chain during the first and second period with the highest impact

Title	Year	Authors	Total cites	H-Index	Prominence percentile
A review of existing and emerging digital technologies to combat the global trade in fake medicines	2017	Mackey, T.K., Nayyar, G.	325	73	94.147
A literature review of RFID-enabled healthcare applications and issues	2013	Wamba, SF; Anand, A; Carter, L	321	114	97.37
Pharmaceutical supply chain in China: Current issues and implications for health system reform	2010	Yu, XA; Li, C; Shi, YH; Yu, M	302	92	98.021
Managerial research on the pharmaceutical supply chain - A critical review and some insights for future directions	2014	Narayana, SA; Pati, RK; Vrat, P	298	85	84.836
Clinical trials on drug repositioning for COVID-19 treatment	2020	Viveiros Rosa, S.G., Santos, W.C.	281	57	99.987
Blockchains everywhere - A use-case of blockchains in the pharma supply-chain	2017	Bocek, T., Rodrigues, B.B., Strasser, T., Stiller, B.	277	13	99.98
A robust possibilistic programming approach for pharmaceutical supply chain network design	2015	Mousazadeh, M; Torabi, SA;Zahiri, B	271	139	95.465
Toward an integrated sustainable-resilient supply chain: A pharmaceutical case study	2017	Zahiri, B; Zhuang, J; Mohammadi, M	251	110	95.465
Pharmaceutical supply chain and inventory management strategies: Optimization for a pharmaceutical company and a hospital	2013	Uthayakumar, R., Priyan, S	198	23	84.836
Integrated supply chain planning for multinational pharmaceutical enterprises	2012	Susarla, N., Karimi, I.A.	187	139	95.465

Retention in Care and Medication Adherence: Current Challenges to Antiretroviral Therapy Success	2015	Holtzman, CW; Brady, KA and Yehia, B	182	164	96.048
Pharmaceutical supply chain specifics and inventory solutions for a hospital case	2012	Kelle, P., Woosley, J., Schneider, H.	153	23	84.836
Forces, trends, and decisions in pharmaceutical supply chain management	2011	Rossetti, CL; Handfield, R; Dooley, KJ	150	111	57.954
Greening community pharmaceutical supply chain in UK: a cross boundary approach	2012	Xie, Y; Breen, L	147	115	27.89
A multi-objective pharmaceutical supply chain network based on a robust fuzzy model: A comparison of meta-heuristics	2020	Goodarzian, F., Hosseini-Nasab, H., Muñuzuri, J., Fakhrzad, M.-B.	71	143	95.465
Short and long term impacts of COVID-19 on the pharmaceutical sector	2020	Ayati, N., Saiyarsarai, P., Nikfar, S.	51	42	80.181
Blockchain based secured information sharing protocol in supply chain management system with key distribution mechanism	2020	Dwivedi, S.K., Amin, R., Vollala, S.	47	40	99.980
Can global pharmaceutical supply chains scale up sustainably for the COVID-19 crisis?	2020	Yu, D.E.C., Razon, L.F., Tan, R.R.	39	130	99.927
The benefits and threats of blockchain technology in healthcare: A scoping review	2020	Abu-elezz, I., Hassan, A., Nazeemudeen, A., Househ, M., Abd-alrazaq, A.	37	106	99.980
The consequence of COVID-19 on the global supply of medical products: Why Indian generics matter for the world?	2020	Guerin, P.J., Singh-Phulgenda, S., Strub-Wourgaft, N.	35	60	87.804

From the results in table 4, it can be seen that 90% of the most relevant studies have a prominence percentile between 80.101 and 99.987. With respect to the H-index of the journals of the selected studies, it can be seen that 10 of them have more than 100 publications with at least 100 citations each.

On the other hand, the study with the highest number of citations was Mackey and Nayyar (2017), which was published in the first period. It identifies "digital" solutions to combat counterfeit medicines such as mobile devices, radio frequency identification, online verification, advanced computational methods and blockchain technology. Meanwhile, Xie and Breen (2012) study seeks to promote a green supply chain through an integrated green supply chain model that involves all critical parties to eliminate unavoidable pharmaceutical waste. Other works such as those by Mousazadeh et al. (2015), Zahiri et al. (2017) and Susarla and Karimi (2012) develop mathematical models to solve problems in the design of pharmaceutical networks to combat uncertainty conditions such as shelf life of materials, inventory costs, international tax differentials, among other factors. According to the research that relates the pharmaceutical chain to Covid 19, the one with the highest number of citations was the one conducted by Rosa and Santos (2020). It reviewed clinical trials that apply the repositioning of more than 20 drugs for the treatment of COVID-19, including interferons, chloroquine, hydroxychloroquine, arbidol, remdesivir, favipiravir, oseltamivir, thalidomide, among others. The second study with the greatest impact was by Goodarzian et al. (2020). It proposes a new multi-target, multi-period, multi-product and multi-step pharmaceutical supply network in order to address uncertainty parameters. While, Ayati et al. (2020) in their research identified the short and long term effects of

pandemic such as changes in demand, slowdown in industry growth, trend changes in consumption of pharmaceuticals and ethical dilemma.

4. Discussion

From the results obtained, It is evident that the period with the highest number of publications on the pharmaceutical chain was the first period, which may be due to the fact that more years are considered; however, the second period presents more publications per year, due to advances in pharmaceutical practices (Gilmartin et al. 2016), which has generated pharmaceutical industries in various countries to invest in research and development (R&D), as happened with the U.S. in 2016, whose industry spent around USD 65 billion, being the country that invested the most in R&D (OECD 2019). Of the articles published in the second period, less than half are related to Covid 19, as this is a recent topic and there may not be enough information on the impact of the pandemic on the pharmaceutical chain in the various countries. However, it is not excluded that the number of research projects involving the pharmaceutical industry with Covid will increase in the coming years.

The institutions with the highest number of publications on the pharmaceutical chain in both the first and second periods are concentrated in Iran and Morocco. In the Asian country, published studies have shown that research and development is the main weakness of the Iranian pharmaceutical sector. Therefore, the Iranian government has also taken some measures to motivate pharmaceutical companies to advance their R&D activities (Ebadi Fardazar et al. 2019). According to a UNESCO report, the number of publications from Iranian institutions has grown enormously since 2011 in the fields of engineering and chemistry (Brito 2010). In the case of African countries such as Morocco, there have been changes in the allocation of public funds for scientific research and European influence on scientific collaboration has grown (O'Brien and Arvanitis 2020). In 2000, Morocco asked the EU to conduct an external evaluation of Moroccan capabilities in the field of scientific research, covering nine areas, including medical and pharmaceutical research (Waast and Kleiche-Dray 2009). Of the institutions that published studies related to covid-19, one in Iran and one in Saudi Arabia (King Saud University) stand out with more than one publication. The latter may be due to the fact that the Saudi Arabian National Board of Health has proposed strategies to support research and development programs to combat the pandemic (Saudi Ministry of Health portal 2020). King Saud University serves the needs of the community and the world for scientific research on COVID-19 (Masmali 2021). Regarding the analysis of co-authorship, it is observed that in the first period Patrono, I. and Mainetti, I. have had greater publication activity, which coincides with the size of their clusters. On the other hand, in the second period, no author predominates because they have a similar number of publications. In the case of the keywords, in the first period it is reflected that these focused on the use of innovative and technological tools for pharmaceutical supply chain management; whereas, in the second period, they focus on the impact of uncertainty conditions on the management of the drug chain.

5. Conclusion

Science and research on the pharmaceutical sector are important for the development of a country, which is reflected in the technological advancement of this industry in nations such as the USA. This study was able to identify and show the differences in scientific research on the pharmaceutical supply chain before and after the pandemic in internationally recognized databases. It showed that the number of publications on this industry has been increasing and is expected to continue to do so in the coming years; however, there is no evidence of a large number of publications linking the pharmaceutical supply chain to Covid-19. It is shown that the research published in each period shows a different approach that is in line with the current trends or situations that are being experienced. Likewise, the participation of institutions from Iran, Morocco and Saudi Arabia in this field of research in the last 11 years stands out.

References

Al-japairai, K., Almurisi, S., Mahmood, S., Al Khalidi, D., Chilakamarry, C., Naidu, C. and Mohananaidu, K., Impact of COVID 19 Pandemic Crisis on the Health System and Pharmaceutical Industry, *Letters in Applied NanoBioScience*, vol. 10, no. 2, pp. 2298–2308, 2020.

Alifah, U., *El Comercio de Productos Médicos En El Contexto de La Lucha Contra La COVID-19: Evolución En 2020*, 2021.

Aponte, B., González, A. and González, A., Ingeniería Industrial. Actualidad y Nuevas Tendencias, *Ingeniería Industrial. Actualidad y Nuevas Tendencias*, vol. 3, no. 10, p17, 2013.

Ardanuy, J., and Vázquez, L., Breve Introducción a La Bibliometría, *Universitat de Barcelona*, vol. 25, 2009.

Ayati, N., Saiyarsarai, P. and Nikar, S., Short and Long Term Impacts of COVID-19 on the Pharmaceutical Sector, *DARU, Journal of Pharmaceutical Sciences*, vol. 28, no. 2, pp. 799–805, 2020.

Brito, L., *Unesco Science Report 2010*, 2010.

Bustos, A., Balbuena, J., Zamora, A. and Ascencio, J., *Resiliencia En El Desempeño Logístico Ante Eventos Disruptivos de La Cadena de Suministro. Instrumentación de Un Marco Conceptual*, 2021.

Choe, J., Crane, M., Greene, J., Long, J., Mwanga, J., Sharfstein, J., Socal, M. and Strodel, R., *The Pandemic and The Supply Chain*, 2020.

Ebadi, F., Asiabar, A., Safari, H,. Asgari, M., Saber, A. and Ebadi, A., Policy Analysis Of Iranian Pharmaceutical Sector; A Qualitative Study, *Risk Management and Healthcare Policy*, vol. 12, pp. 199–208, 2019.

Euromonitor International, *Profitability | Historical Geography Category*, 2021.

Gilmartin, J., Nguyen, T., Reeve, E. and Tan, E., Incorporating Research into Current Pharmacy Practice: The Future of Australian Pharmacy?, *Journal of Pharmacy Practice and Research*, vol. 46, no. 4, pp. 397–98, 2016.

Goodarzian, F., Hosseini, H., Muñuzuri, J. and Fakhrzad, M., 2020. A Multi-Objective Pharmaceutical Supply Chain Network Based on a Robust Fuzzy Model: A Comparison of Meta-Heuristics, *Applied Soft Computing*, vol. 92, 2020.

Guleid, F., Oyando, R., Kabia, E., Mumbi, A., Akech, S. and Barasa, E., A Bibliometric Analysis of COVID-19 Research in Africa, *BMJ Global Health*, vol. 6, no. 5, pp. 1–7, 2021.

Linlin, Cao, and Zhi, W., Bibliometric Analysis of Drug Supply Chain in China, *Asian Journal of Social Pharmacy*, vol. 15, no. 3, pp. 159–70, 2020.

Mackey, T. and Nayyar, G., A Review of Existing and Emerging Digital Technologies to Combat the Global Trade in Fake Medicines, *Expert Opinion on Drug Safety*, vol. 16, no. 5, 2017.

Maresova, P., Penhaker, M., Selamat, A. and Kuca, K., The Potential of Medical Device Industry in Technological and Economical Context, *Therapeutics and Clinical Risk Management*, vol. 11, pp. 1505–14, 2015.

Masmali, A, *King Saud University Ascending to the Country Needs and Community Services*, 2021.

Moosivand, A., Ghatari, A. and Rasekh, H., Supply Chain Challenges in Pharmaceutical Manufacturing Companies: Using Qualitative System Dynamics Methodology, *Iranian Journal of Pharmaceutical Research*, vol. 18, no. 2, pp. 1103–16, 2019.

Mousazadeh, M., Torabi, S. and Zahiri, B., A Robust Possibilistic Programming Approach for Pharmaceutical Supply Chain Network Design, *Computers & Chemical Engineering*, vol. 82, pp. 115–28, 2015.

O'Brien, D. and Arvanitis, R., The Transformation of Research in the South : An Introduction, *The Transformation of Research in the South*, IRD Éditions, 2020.

OECD, *Health at a Glance 2019: OECD Indicators*, OECD, 2019.

Organización Panamericana de la Salud, La OMS Caracteriza a COVID-19 Como Una Pandemia, *Organización Panamericana de La Salud*. Available: https://www.paho.org/es/noticias/11-3-2020-oms-caracteriza-covid-19-como-pandemia, 2020.

Ozili, P., Spillover of COVID-19 : Impact on the Global Economy, *SSRN Electronic Journal*, 2020.

Rodríguez, A., Scopus y Su Importancia Actual En La Publicación Científica Colombiana, *Scientia Et Technica*, vol. 18, no. 4, pp. 12–14, 2013.

Saudi Ministry of Health portal, Al-Rabiah Chairs First Meeting of Saudi National Institute of Health, May 8, 2020.

Senna, P., Reis, A., Sant'anna, D. and Gomes, A., Supply Chain Risk Management: A Bibliometric Analysis Considering Healthcare Supply Chains, *Revista Fatec Zona Sul*, vol. 6, no. 4, pp. 1–15, 2020.

Socal, M., Sharfstein, J. and Greene, J., The Pandemic and the Supply Chain : Gaps in Pharmaceutical Production and Distribution, *American Journal of Public Health*, vol. 111, no. 4, pp. 635–39, 2021.

Strong, S., Delzell, P., Trygstad, W., Fitzpatrick, G. and Haley-hyer, P., The Impact of COVID-19 on the Pharmaceutical Supply Chain, *Proceedings of the 5th NA International Conference on Industrial Engineering and Operations Management* , Pp. 800–807, *Detroit, Michigan, USA, August 10 - 14, 2020.*

Stürz, G., Bialojan, S. and Nuyken, A., *The Largest Pharmaceutical Companies Worldwide Analysis of Key Financial Indicators*, 2019.

Susarla, N. and Karimi, I. Integrated Supply Chain Planning for Multinational Pharmaceutical Enterprises, *Computers & Chemical Engineering*, vol. 42, pp. 168–77, 2012.

Viveiros, R. and Santos, W. Clinical Trials on Drug Repositioning for COVID-19 Treatment, *Revista Panamericana de Salud Pública*, vol. 44, 2020.

Waast, M. and Kleiche-Dray, M., *Evaluation of a National Research System : Morocco*, 2009.

Wang, P. and Tian, D., Bibliometric Analysis of Global Scientific Research on COVID-19, *Journal of Biosafety and Biosecurity*, vol. 3, no. 1, pp, 4–9, 2021.

Xie, Y. and Breen, L., 2012. Greening Community Pharmaceutical Supply Chain in UK: A Cross Boundary Approach,

Supply Chain Management: An International Journal, vol. 17, no. 1, 2012.

Xu, Z., Elomri, A., Kerbache, L. and El Omri, A., Impacts of COVID-19 on Global Supply Chains: Facts and Perspectives, *IEEE Engineering Management Review*, vol. 48, no. 3, pp. 153–66, 2020.

Young, R. and Esqueda, P., Supply Chain Vulnerability: Considerations for the Case, *Academia. Revista Latinoamericana de Administración*, no. 34, pp. 63–78, 2005.

Zahiri, B., Zhuang, J. and Mohammadi, M., Toward an Integrated Sustainable-Resilient Supply Chain: A Pharmaceutical Case Study, *Transportation Research Part E: Logistics and Transportation Review*, vol. 103, pp. 109–42, 2017.

Acknowledgements

Thanks to the industrial engineering career for all the teachings received during our academic studies and to the professors of the faculty.

Biographies

Sovero Castro Lucia Isabel is a candidate to receive the title of industrial engineer from the Faculty of Engineering and Architecture of the University of Lima, Lima, Peru.

Risco Guevara Fabiola Milagros is a candidate to receive the title of industrial engineer from the Faculty of Engineering and Architecture of the University of Lima, Lima, Peru.

Garcia-Lopez Yvan Jesus is PhD (c) in Engineering and Environmental Science, UNALM, "Master of Business Administration" from Maastricht School of Management, Holland, and master's in strategic business administration from Pontificia Universidad Católica del Perú. "Master of Science" in Computer Science, Aerospace Technical Center - Technological Institute of Aeronautic, Brazil. Stage in Optimization of Processes and Technologies, University of Missouri-Rolla, USA, and Chemical Engineer from the National University of Callao. Specialization Study in Digital Transformation, by Massachusetts Institute of Technology, Business Analytics, Wharton School of Management, Data Science by University of California, Berkeley, Big Data and Data Scientist by MITPro, USA Postgraduate Professor: Specialized Master from IT, MBA Centrum Católica, MBA from Calgary, Canada, and Centrum Católica. Principal Consultant DSB Mobile, Executive Director of Optimiza BG, advisor to the Office of Electronic Government and Information Technology (ONGEI) - PCM, Managing Director of Tekconsulting LATAM, Executive Director of Optimiza Business Group, Ex- Vice Dean of Information Engineering of the Universidad del Pacifico, Former Information Technology Manager of "MINERA CHINALCO PERU" Subsidiary of the Transnational Aluminum Corporation of China, Beijing, China. Former Manager of Systems and Communications of Maple Energy PLC, Director of Information Technology of Doe Run Peru SRL, Project Manager in implementation of ERP SAP, E-Business Suite - Oracle Financial and PeopleSoft. Process Analyst in transnational companies Fluor Daniel Corporation-USA, PETROBRAS-Brasil, Petróleos del Perú. He has more than 25 years of extensive experience in the management of investment projects, execution, and commissioning in Peru, Colombia, USA, Brazil, China.