Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/jptcp.v30i10.6694

PHARMACEUTICAL SECTOR AND SUSTAINABILITY

Yahilina Silveira Pérez[1*],Claudia Rojas Martinez[2],William Niebles Nuñez[3]

[1*,2,3]Universidad de Sucre (Colombia)

***Corresponding Author:** Yahilina Silveira Pérez
*silveira@unisucre.edu.co

Abstract
This research performs a quantitative analysis of the scientific production on sustainability in the pharmaceutical industry, using the Scopus database and the Bibliometrix software where 99 documents published between 2002 and 2023 are examined. India stands out as the country with the highest contribution, followed by Italy and the United States. The research identifies leading authors and institutions, underlining the importance of sustainable practices in pharmaceutical supply chain management. The analysis reveals a significant growth in scientific production since 2019, reaching its peak in 2022. Key themes such as "Life cycle assessment" and "Competitiveness" are identified, and the COVID-19 pandemic as an influential factor. Co-citation networks show collaboration between researchers and highlight the main thematic lines of the field. The study concludes that sustainability is a central theme in pharmaceutical research, with an increasing focus on life cycle assessment and competitiveness, with the recommendation to foster interdisciplinary collaboration and develop more accurate methods to assess the environmental impact of pharmaceuticals. In addition, it suggests that government policies should support the integration of sustainable practices in the industry. This analysis provides a solid basis for future research and the development of sustainable strategies in the pharmaceutical sector.

Keywords: Bibliometric analysis, Bibliometrics, Pharmaceutical sector, Sustainability.

1. Introduction

The pharmaceutical industry has undergone a significant transformation in recent years, driven by corporate and government initiatives that support economic and environmental sustainability. The way pharmaceutical companies operate and are governed has undergone a substantial transition as a result of growing awareness of the environmental effect of industrial operations and the need to adopt sustainable practices Marques et al., (2020). The industry is being forced to reevaluate its procedures and use new tactics that reduce its ecological impact while preserving its economic viability due to a combination of stricter government regulations and investor and customer expectations for greater environmental responsibility (Bartolo, Azzopardi, & Serracino-Inglott, 2021). To promote greener and more efficient manufacturing, these adjustments also prioritize supply chain optimization and product innovation, in addition to proper waste management and emissions reductions.

The pharmaceutical industry plays a critical role in public health and human well-being, making it an important sector on a global scale. This industry is responsible for researching, developing, producing and distributing medicines that prevent and treat diseases, thus increasing global life expectancy and improving quality of life (Milanesi, Runfola & Guercini, 2020). The pharmaceutical industry is a vital economic pillar in many economies, creating millions of jobs and contributing substantially to the

GDP of many nations. The industry faces special difficulties in terms of sustainability due to the nature of its processes and products, which require strict regulation and a high degree of precision. In the pharmaceutical industry, sustainability refers not only to minimizing adverse effects on the environment, but also to implementing procedures that guarantee the efficacy and safety of medicines, energy efficiency, the conscious use of natural resources, and the proper disposal of waste (Sarkis et al., 2021)

Concern and interest in the sustainability of the pharmaceutical industry on a global scale has grown in recent years. Sustainability-related dynamics have become increasingly important in the industry's recent transition Ortiz-Avram, Ovcharova & Engelmann, 2024). In this sense, improvements in science and technology have made it possible to create more environmentally friendly processes for the manufacture and delivery of medicines. However, social pressure and regulatory pressure have accelerated the adoption of sustainable practices (Chen et al., 2020). These adjustments entail some difficulties for companies that must weigh the costs of adopting new sustainable technology with the requirement to be competitive in the global marketplace. Despite these obstacles, there are encouraging examples of companies that have successfully incorporated sustainability into their operations, demonstrating that it is feasible to balance financial success with environmental responsibility (Bade et al., 2024). These success stories demonstrate a favorable trend towards greater sustainability in the pharmaceutical sector and act as a model and source of encouragement for the rest of the industry.Despite the advances, there are still many obstacles to overcome in the link between sustainability and the pharmaceutical industry. These include the lack of a solid methodological basis, universal acceptability and consistency in the information collected so far. Disparate and even contradictory statistics have occurred as a result of differences in approaches used to assess sustainability and lack of agreement on best practices (Grangeia, 2020). This makes it more difficult to provide coherent and useful insights that can guide the strategic and operational decisions of the industry. In addition, regional and market acceptance of sustainable practices differs greatly, making it difficult to implement international standards (Becker, Manske, & Randl, 2022). In addition to impeding a thorough understanding of the industry's environmental impact, this lack of consistency and consensus also reduces the effectiveness of sustainable measures carried out by pharmaceutical corporations.Because of these obstacles, research must be conducted that advances the understanding of the interactions between sustainability and the pharmaceutical industry. The purpose of this study is to assess how sustainability has changed within pharmaceutical companies, identify the main themes and point out the networks of co-citations that exist between writers, publications and other sources of literature related to sustainability and the pharmaceutical sector. This research, seeks to trace the evolution and maturation of knowledge in this sector, highlight changes in research methodology and highlight the creation of interdisciplinary links within specific topics using bibliometric analysis. The aim of this study is to establish a solid foundation for future research and the creation of more efficient and lasting policies by identifying important trends and actors in this field (Ramírez-Durán et al., 2023).This research attempts to solve problems and harness the possibilities at the nexus between sustainability and the pharmaceutical sector by providing a comprehensive overview of present and future developments in the field. It aims to develop novel and lasting solutions that are advantageous to the pharmaceutical industry and society at large by promoting an interdisciplinary and international approach to research. In the end, incorporating sustainable practices would not only reduce the negative effects of the industry on the environment, but would also have positive effects on the economy and society, building a more responsible and resilient model that will be better equipped to handle problems in the future. To achieve this goal and ensure that the pharmaceutical industry continues to play its vital role in public health in a sustainable and responsible manner, collaboration between researchers, businesses and governments is important.

2. Methodology.

A quantitative technique for evaluating literature in a discipline is the bibliometric analysis. Bibliometric techniques allow researchers to monitor the expansion and maturation of domains of study, identify changes in research methodologies, and signal the emergence of interdisciplinary partnerships within certain topics. Bibliometric methods have been widely used up to this point in many different fields, such as energy, the environment, economic management and social policy (He & Yu, 2020). There are seven main steps in the bibliometric literature evaluation process described in this article: (1) choosing the best database and software, then (2) identifying the most pertinent keywords and how to combine them, then (3) searching the database for documents, (4) filtering the collected data, (5) exporting the chosen data, (6) evaluate the chosen documents, and (7) produce a visual representation of the search results (Ramírez et al., 2023).

Social Media Analytics (SMA)

Graph and network theory is used in social network analysis (SMA), a method for studying social systems (Otte & Rousseau, 2002). There are several software solutions available for use in the SMA process. In this study, clustering analysis is used to create tables and other graphs using Excel, and the Biblioshiny application of the Bibliometrix package, which is a component of the R Studio statistical software, is used to map and evaluate relationships between sources, academic papers, countries, authors, and keywords.

Data collection

Elsevier created the Scopus database, which is among the world's most comprehensive metasearch engines for reviewing scientific literature. This database offers an enhanced service for academic and educational purposes by merging the best features of Web of Science and PubMed (Zyoud et al., 2015). Because of these factors, Scopus is the most reliable database for bibliometric analysis. As of June 2024, the bibliographic dataset for this article was collected using Scopus.

The terms "pharmaceutical sector" and "Sustainability" were checked in various combinations and were finally used as the most appropriate keywords, the search was narrowed by the years from 2002 to 2023 and also by the English and Spanish languages. The search formula used was as follows: (TITLE-ABS-KEY ("pharmaceutical sector") OR TITLE-ABS-KEY ("pharmacy sector") AND TITLE-ABS-KEY (sustainability)) AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish")), of which 99 documents were found whose titles, keywords and abstracts included the specific key terms.

3. Results.

Table 1 Main information

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2002:2023
Sources (Journals, Books, etc)	80
Documents	99
Annual Growth Rate %	4.94
Document Average Age	22.45
Average citations per doc	3.661
References	5673
DOCUMENT CONTENTS	
Keywords Plus (ID)	589
Author's Keywords (DE)	352
AUTHORS	
Authors	317
Author Appearances	327
Authors of single-authored documents	14
Authors of multi-authored documents	303
AUTHORS COLLABORATION	
Single-authored docs	15
Documents per Author	0.312
Authors per Document	3.2
Co-Authors per Documents	3.3

International co-authorships %	3.84
DOCUMENT TYPES	
article	63
book	1
book chapter	9
conference paper	6
conference review	5
review	15

Source: authors (2024)

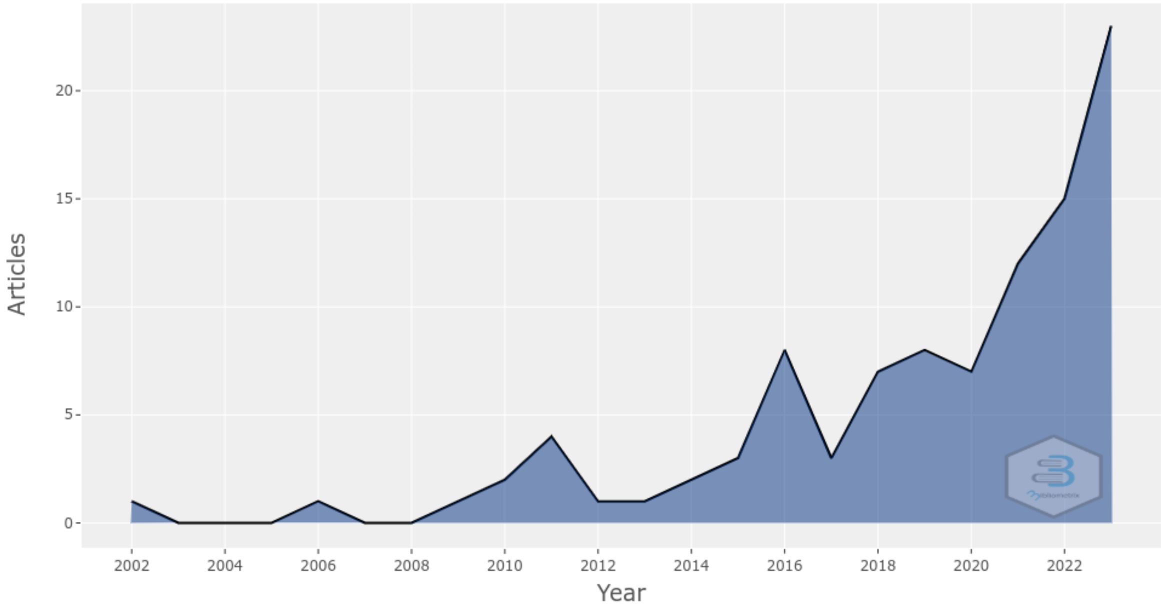

Figure 1. Annual scientific production.

Figure 1 shows the production of the papers located by year. This shows a production that fluctuates throughout the 20 years that formed the study, recognizing the increase in the researchers' production over certain years. This is how far 2020 has been reached, with 2022 being the most productive with more than 20 documents submitted.

Table 2 Scientific production by country

Country	Frequency
INDIA	74
ITALY	38
USA	19
UK	18
CHINA	16
BRAZIL	10
GREECE	10
PORTUGAL	10
BELGIUM	8
ROMANIA	7

Source: authors (2024)

The top 10 of the most productive countries in the field of study can be seen in Table 2, of which India is the one that contributes the most to the subject with 74 research papers, followed by Italy and the USA with 38 and 19 contributions each.
The most relevant research found from the most productive country (India) was the research by Kumar et al. (2018), which argues that, when it comes to giving society access to goods and services

that can save lives, the pharmaceutical business is crucial. Researchers have found that materials, products, and services related to the pharmaceutical industry have a wide range of environmental effects. These include the patient's mishandling of pills and tablets, expired or unused medications, improper dispensing of medications in pharmacies, and domestic wastewater containing mixed medication waste. In light of this, the cited document sought to include the idea of a Green Supply Chain (GSC) within the pharmaceutical sector within the framework of India's economic growth.
The aforementioned work prioritized risks in a confusing and uncertain environment using the fuzzy analytical hierarchy process (AHP) and performed a literature analysis and a fuzzy Delphi approach to determine dangers. The authors clarify that the categories of supply risk and cold chain technology have a high priority according to the results of the survey that was applied. The same authors (Kumar et al., 2018) believe that this work can help government authorities and practice managers design and implement GMP programs that successfully meet the sustainability goals of the pharmaceutical business.

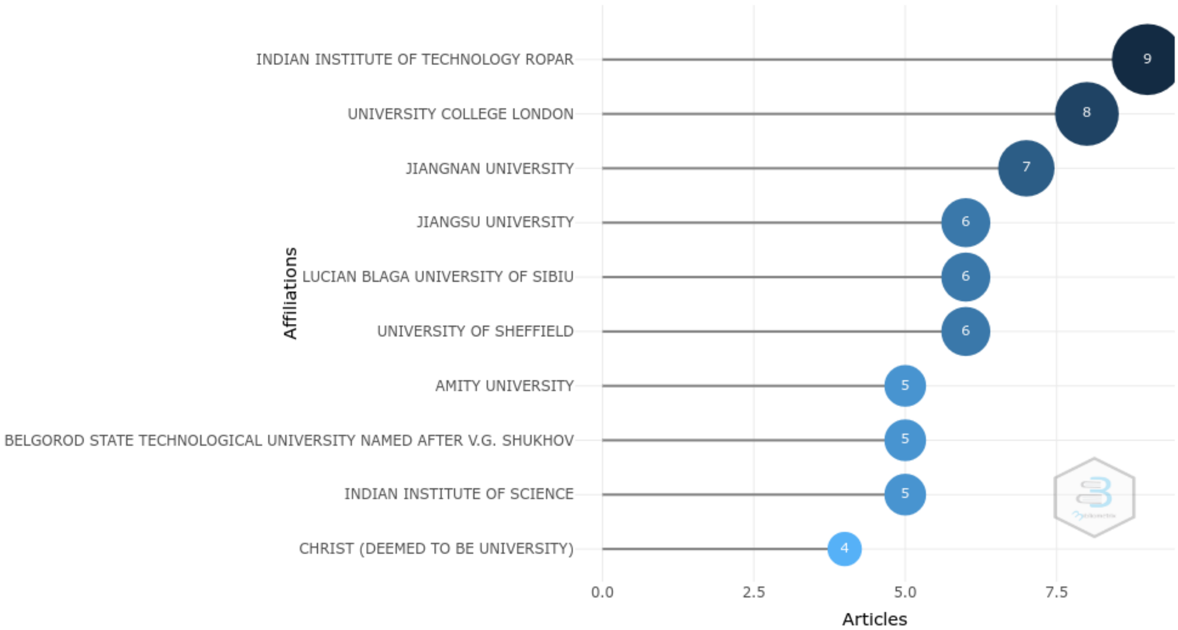

Figure 2. Scientific production by institution.

Figure 2 shows the 10 institutions with the most publications in the pharmaceutical field, highlighting institutions such as Indian Institute of Technology Ropar, University College London and Jiangsu University with 9, 8 and 7 publications respectively.

From the Indian Institute of Technology, an article stands out that talks about the concept of sustainability, stating that it has generated a lot of interest in organizations and as a research topic (Liew et al., 2014).

The main objective of this article is to propose a system to evaluate the environmental sustainability of products (pharmacological forms) developed in the pharmaceutical industry. The researchers also present the indicators that the industry uses to assess environmental sustainability.

This article focuses on the environmental aspects of the sustainable development of the pharmaceutical industry. Liew et al., (2014) conducted a review of life cycle assessment (LCA) studies in the pharmaceutical industry and provided a list of these studies.

Based on a literature review, the authors developed methods that can be used to quantify the environmental impact of pharmaceuticals that have been formulated.

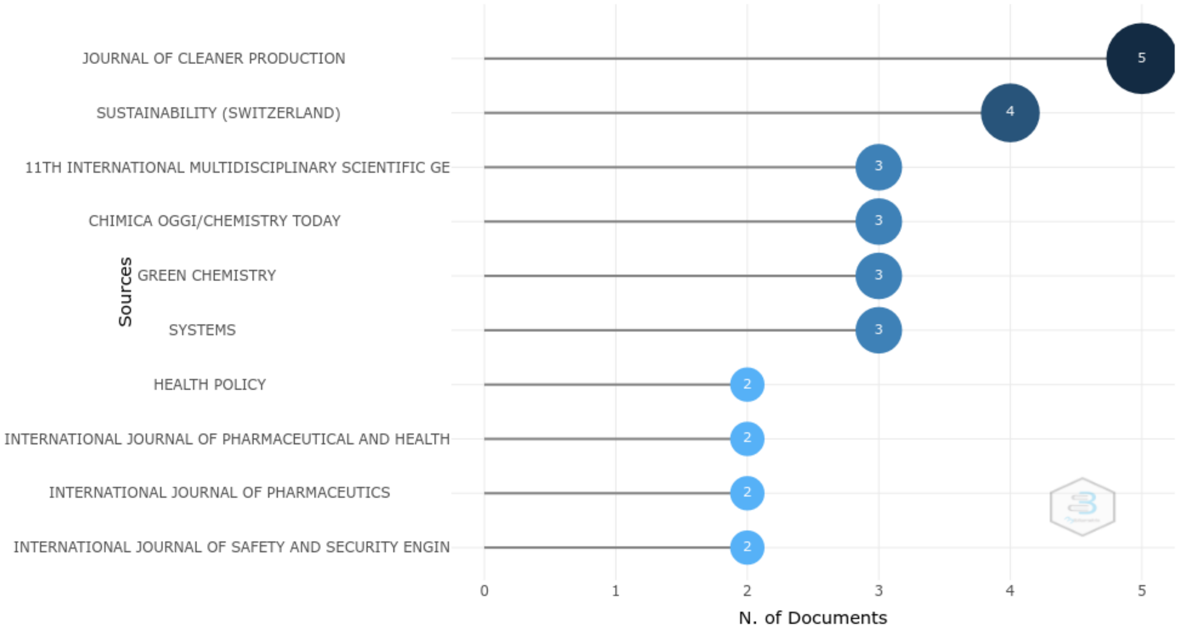

Figure 3. Scientific production by source.

Figure 3 analyzes the top ten journals with the highest number of research contributions to the field of study throughout the decade investigated, of which the most outstanding are: Journal of Cleaner Production (5), Sustainability (4) and 11th International Multidisciplinary Scientific GE (3). According to a pertinent article in the most influential journal, written by Belkhir, and Elmeligi, (2018), the sustainability community has paid little attention to the global carbon footprint of the pharmaceutical and healthcare industries, despite the growing need to reduce carbon emissions globally. The authors of that research present an industry-specific benchmarking of the world's leading pharmaceutical companies along with an analysis of the pharmaceutical industry's total contribution and historical trends in emissions.

Table 3 Most cited documents

Paper	DOI	Citations
ZAID AA, 2018, J CLEAN PROD	10.1016/j.jclepro.2018.09.062	430
MASRI HA, 2017, J CLEAN PROD	10.1016/j.jclepro.2016.12.087	343
BELKHIR L, 2019, J CLEAN PROD	10.1016/j.jclepro.2018.11.204	121
KUMAR A, 2019, INT J PROD RES	10.1080/00207543.2018.1543969	114
LIEW WT, 2014, COMPUT IND	10.1016/j.compind.2014.01.004	94
CESPI D, 2015, GREEN CHEM	10.1039/c5gc00424a	86
SINGH RK, 2016, INT J PHARM HEALTHC MARK	10.1108/IJPHM-10-2015-0050	82
PARK J, 2021, WORLD DEV	10.1016/j.worlddev.2020.105198	75
MEHARIYA S, 2021, J ENVIRON CHEM ENG	10.1016/j.jece.2021.105989	68
DEWULF J, 2006, RENEWABLES-BASED TECHNOLOGY: SUSTAINABILITY ASSESS	10.1002/0470022442	68
FERRAZZANO L, 2022, GREEN CHEM	10.1039/d1gc04387k	62
DELBEKE EIP, 2015, GREEN CHEM	10.1039/c5gc02187a	54
SCHNEIDER JL, 2010, BENCHMARKING	10.1108/14635771011049371	53
KOLLER M, 2019, EUROBIOTECH J	10.2478/ebtj-2019-0004	44
HOSSEINI-MOTLAGH S-M, 2020, J CLEAN PROD	10.1016/j.jclepro.2020.124173	36
PANDA S, 2018, NEW J CHEM	10.1039/c8nj00336j	34
KUMAR V, 2021, J CLEAN PROD	10.1016/j.jclepro.2021.128332	33
GARDAS BB, 2019, INT J PRODUCT PERFORM MANAGE	10.1108/IJPPM-04-2018-0154	30
LI J, 2019, REACT CHEM ENG	10.1039/c9re00019d	29
JORGE VF, 2016, INT J SAFETY SECUR ENG	10.2495/SAFE-V6-N2-282-292	18

Source: authors (2024)

Table 3 shows the top 20 of the most cited research regarding the field of study. Of all these, the work of Zaid et al. (2018) stands out with 430 citations. The aim of this study is to look at how three sustainability outcomes are affected by a combination of green supply chain management (internal and external activities) and green methods of human resource management through business metrics (i.e. financial, social and environmental). The researchers used a quantitative method to collect data from 121 companies in Palestine's most polluting production sectors: the food, chemical and pharmaceutical industries. A partial least squares structural equation model was used to analyze the data.
Following on from the research of Zaid et al. (2018), the results of their data analysis indicate that the combination of green supply chain management and green human resource management strategies, has a favorable effect on sustainable outcomes. The authors state that the findings demonstrate a clear relationship between sustainable performance and ecological supply chain management, which in turn influences ecological methods of human resource management. The researchers specifically state that only the environmental dimension of GHRM and sustainable performance are positively correlated with external green supply chain management practices, while internal green supply chain management practices have a positive correlation with green people management practices and sustainable performance.

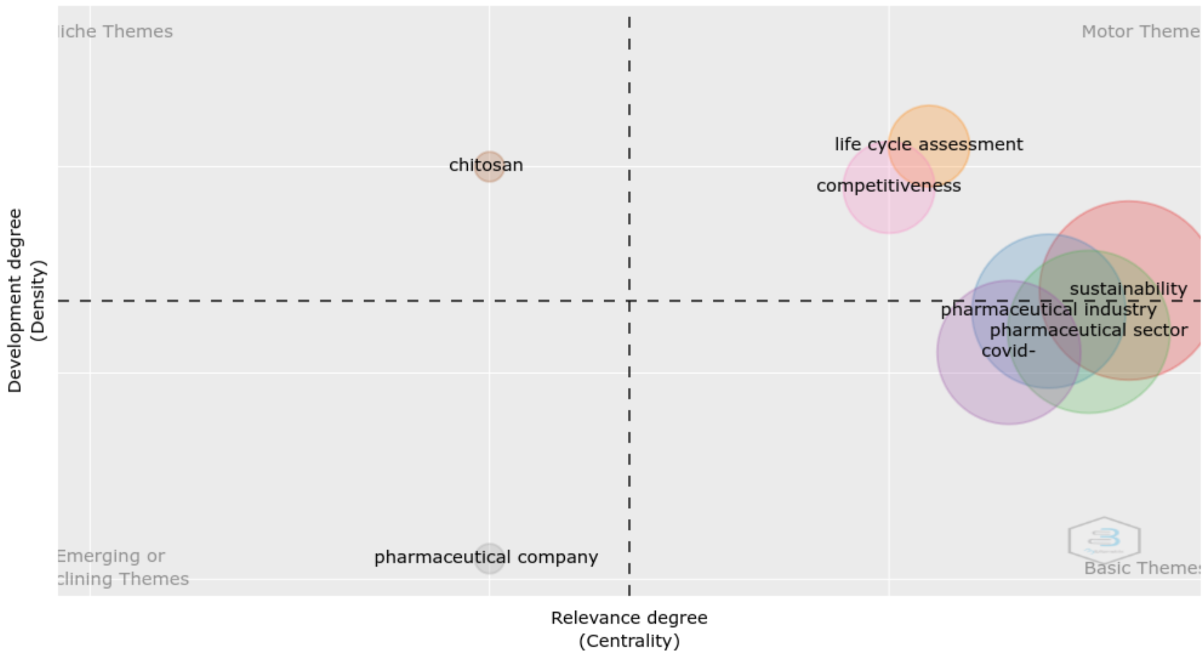

Figure 4. Thematic map.

The thematic map in Figure 4 is analyzed, which clearly indicates that the main theme or driving force (upper right part) is the key terms: "Life cycle assessment" and "Competitiveness"; As basic themes (lower right) there are 4 key terms, with greater strength or more frequently present, which are "Pharmaceutical industry", "Sustainability", "Pharmaceutical sector" and "Covid-19". These topics are considered to be transversal with the other terms that appear on the map; and finally, it can be stated that the terms that appear on the left side, both in the upper and lower part, are emerging or declining themes.

Co-citations analysis

The analysis of co-citations is based on the idea that, at least from the point of view of the citing author, there is a thematic similarity between two or more documents that are co-citated (cited together) in a third and subsequent work; the more often a document is quoted, the more affinities exist between them. The number of works mentioned that include the same pair of documents in their references indicates the strength of this link. Co-citation patterns could be used to determine and illustrate the connections between major ideas in a field of study if widely cited research is believed to reflect essential theories, procedures, or experiments (Small, 1973).

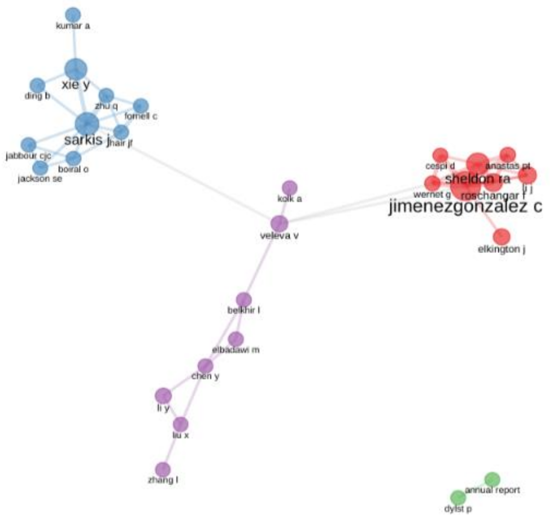

Figure 5. Co-citation map by authors.

The map of co-citation of researchers shown in Figure 5 indicates that the field of research is made up of four lines with thematic similarity. The red one is made up of 10 authors, which include Jimenez-Gonzales C, Sheldon RA, Roschangar Y; the Blue Cluster is made up of 10 researchers, including Kumar A & Xie Y; the purple cluster is made up of 6 authors, including Li Y, Chen Y, & Zhang l. Each of these groups represents a similarity in the subject matter that these authors investigate, which will serve as a guide to identify the researchers who have the most influence on the area of study.

Conclusion

The understanding of scientific production, new trends and research patterns in the pharmaceutical industry and sustainability over the last 20 years has been greatly improved thanks to works such as this bibliometric analysis. A set of findings has been obtained through an exhaustive methodology and data collection from the Scopus database. These results identify the main contributors and themes, as well as the dynamics of collaboration and suggestions for future studies.

The amount of research produced in the area of sustainability and pharmaceuticals has increased over time, with a considerable increase in the number of publications, especially between 2019 and 2024. This expansion is a reflection of the pharmaceutical industry's growing awareness and commitment to sustainability. With almost 20 articles presented, Figure 1 illustrates the annual trend of scientific production and shows that 2022 was the year of highest productivity. The need to address sustainability concerns across industry sectors (including the pharmaceutical industry) may be the reason for this increase in production. This is especially true towards the COVID-19 pandemic, which drew attention to the need for stronger and more sustainable systems.

According to a country-by-country analysis of scientific production, India leads the world in number of publications in this discipline, followed by the United States and Italy. India's remarkable involvement, including 74 research papers, is indicative of its growing curiosity and efforts to address sustainability in the pharmaceutical industry. This discovery is noteworthy because it emphasizes how important it is for developing countries to engage in research and development of sustainable practices within the pharmaceutical sector. The academic institutions that have published the most on this topic include the Jiangsu University, University College London, and Indian Institute of

Technology Ropar. In particular, the Indian Institute of Technology Ropar has made substantial contributions to the understanding and creation of more sustainable practices through its extensive research on the assessment of environmental sustainability in the pharmaceutical business.

Among the most notable findings is the identification of the study of sustainability as a key concern in the scientific production of the pharmaceutical industry. The most frequently referenced studies emphasize how crucial it is to include sustainable practices in pharmaceutical production and supply chain management. Based on these findings, companies can achieve sustainable results by implementing green supply chain management and human resource management practices.

On the other hand, the thematic map shows that while phrases such as "Pharmaceutical industry", "Sustainability", "Pharmaceutical sector" and "Covid-19" are considered as basic and cross-cutting topics, terms such as "Life cycle assessment" and "Competitiveness" are topics that drive contemporary research. This emphasises the value of competitiveness and life cycle assessment in the context of sustainability in the pharmaceutical sector, as well as the current importance of the industry in relation to the COVID-19 pandemic and current research.

The analysis of co-citations shows how authors and research subjects relate to each other. Authors such as Jimenez-Gonzales C, Sheldon RA and Roschangar Y in the red group and Kumar A and Xie Y in the blue group stood out in four main lines with thematic similarities. These groups demonstrate the establishment of thematic and collaborative networks, which are fundamental for the progress of research in the field of pharmaceutical sustainability. On this analysis depends to find patterns of cooperation and thematic impacts in the study. The high frequency of co-citations between authors and specific papers suggests a significant thematic affinity, which could direct future studies towards areas with greater impact and multidisciplinary collaboration.

The findings of the research have a number of important ramifications for the sustainability of the pharmaceutical industry in the future. First, the fact that India and other developing countries are producing a large amount of scientific research implies that they are at the forefront of incorporating sustainable practices in the pharmaceutical sector. This can result in greater international cooperation and the exchange of sustainable technology and information between developed and developing countries. In addition, the discovery that sustainability is a primary issue in research implies that academic institutions and pharmaceutical companies are becoming more aware of the importance of sustainable operations. Government policies and regulations should support these efforts by offering financial incentives and legal protections that foster sustainability throughout the pharmaceutical supply chain.

It is recommended that future studies take a more comprehensive approach to assessing sustainability throughout the life cycle of pharmaceuticals. This covers not only the manufacture and distribution of pharmaceutical products but also their waste management and post-consumer environmental effects. Research should focus on producing more accurate measures and techniques to assess these effects, as well as practical mitigation plans. It is also crucial to promote greater multidisciplinary collaboration. The pharmaceutical sector cannot achieve sustainability unless it integrates knowledge from various disciplines, including supply chain management, environmental engineering, green chemistry, and economics. When these disciplines work together, they can provide important breakthroughs and lasting solutions to complicated problems facing the industry.

References

1. Alenina, K. A., Bengoa, D. S., & Vlasova, Y. (2016). Russian high-tech pharmaceutical enterprises: reasons and factors for sustainable innovation. J. for Global Business Advancement, 9(2), 146. https://doi.org/10.1504/jgba.2016.075706
2. Aslam, M., Jabbar, S., Abbas, Q., Albathan, M., Hussain, A., & Raza, U. (2023). Leveraging ethereum platform for development of efficient tractability system in pharmaceutical supply chain. Systems, 11(4), 202. https://doi.org/10.3390/systems11040202
3. Bade, C., Olsacher, A., Boehme, P., Truebel, H., Bürger, L., & Fehring, L. (2024). Sustainability in the pharmaceutical industry—An assessment of sustainability maturity and effects of

sustainability measure implementation on supply chain security. Corporate Social Responsibility and Environmental Management, 31(1), 224-242. https://doi.org/10.1002/csr.2564

4. Bartolo, N. S., Azzopardi, L. M., & Serracino-Inglott, A. (2021). Pharmaceuticals and the environment. Early Human Development, 155(1), 105218. https://doi.org/10.1016/j.earlhumdev.2020.105218
5. Becker, J., Manske, C., & Randl, S. (2022). Green chemistry and sustainability metrics in the pharmaceutical manufacturing sector. Current Opinion in Green and Sustainable Chemistry, 33(1), 100562. https://doi.org/10.1016/j.cogsc.2021.100562
6. Belkhir, L. y Elmeligi, A. (2018). Huella de carbono de la industria farmacéutica mundial e impacto relativo de sus principales actores. Revista de Producción Más Limpia. https://doi.org/10.1016/j.jclepro.2018.11.204
7. Breyer, F. (2002). Reimbursement and Cost Containment. PharmacoEconomics, 20(Supplement 3), 87–94. https://doi.org/10.2165/00019053-200220003-00009
8. Cespi, D., Beach, E. S., Swarr, T. E., Passarini, F., Vassura, I., Dunn, P. J., & Anastas, P. T. (2015). Life cycle inventory improvement in the pharmaceutical sector: assessment of the sustainability combining PMI and LCA tools. Green Chemistry, 17(6), 3390–3400. https://doi.org/10.1039/c5gc00424a
9. Chen, T. L., Kim, H., Pan, S. Y., Tseng, P. C., Lin, Y. P., & Chiang, P. C. (2020). Implementation of green chemistry principles in circular economy system towards sustainable development goals: Challenges and perspectives. Science of the Total Environment, 716(1), 136998. https://doi.org/10.1016/j.scitotenv.2020.136998
10. Chomać-Pierzecka, E. (2023). Pharmaceutical Companies in the Light of the Idea of Sustainable Development—An Analysis of Selected Aspects of Sustainable Management. Sustainability, 15(11), 8889. https://doi.org/10.3390/su15118889
11. Chowdhury, R., Das, S., & Ghosh, S. (2017). CO2 Capture and Utilization (CCU) in Coal-Fired Power Plants: Prospect of In Situ Algal Cultivation. Green Energy and Technology, 231–254. https://doi.org/10.1007/978-981-10-7188-1_10
12. Daemmrich, A., & Mohanty, A. (2014). Healthcare reform in the United States and China: pharmaceutical market implications. Journal of Pharmaceutical Policy and Practice, 7(1), 1-9. https://doi.org/10.1186/2052-3211-7-9
13. Delbeke, E. I. P., Movsisyan, M., Van Geem, K. M., & Stevens, C. V. (2016). Chemical and enzymatic modification of sophorolipids. Green Chemistry, 18(1), 76–104. https://doi.org/10.1039/c5gc02187a
14. De Soete, W. (2016). Towards a Multidisciplinary Approach on Creating Value: Sustainability through the Supply Chain and ERP Systems. Systems, 4(1), 16. https://doi.org/10.3390/systems4010016
15. Dewulf, J., & Van Langenhove, H. (Eds.). (2006). Renewables-based technology: sustainability assessment. John Wiley & Sons. https://doi.org/10.1002/0470022442
16. Doroshenko, Y. A., Starikova, M. S., Somina, I. V., Malykhina, I. O., & Riapukhina, V. N. (2019). Strategic analysis of competitiveness of high-tech companies as a tool for managing the region's innovative development. Journal of Applied Engineering Science, 17(4). https://doi.org/10.5937/jaes17-22338
17. Dubey, R., & Dubey, J. (2009). Pharmaceutical product differentiation: A strategy for strengthening product pipeline and life cycle management. Journal of Medical Marketing, 9(2), 104–118. https://doi.org/10.1057/jmm.2009.10
18. Elbadawi, M., Basit, A. W., & Gaisford, S. (2023). Energy consumption and carbon footprint of 3D printing in pharmaceutical manufacture. International Journal of Pharmaceutics, 639(1), 122926. https://doi.org/10.1016/j.ijpharm.2023.122926
19. Emmanuel, B. D., Abu-Thabit, N. Y., & Ngwuluka, N. C. (2018). Responsive polyelectrolyte complexes based on natural polysaccharides for drug delivery applications. Stimuli Responsive Polymeric Nanocarriers for Drug Delivery Applications, Volume 1, 267–287. https://doi.org/10.1016/b978-0-08-101997-9.00014-x

20. Ferrazzano, L., Catani, M., Cavazzini, A., Martelli, G., Corbisiero, D., Cantelmi, P., ... & Tolomelli, A. (2022). Sustainability in peptide chemistry: current synthesis and purification technologies and future challenges. Green Chemistry, 24(3), 975-1020. https://doi.org/10.1039/D1GC04387K
21. Festa, G., Kolte, A., Carli, M. R., & Rossi, M. (2021). Envisioning the challenges of the pharmaceutical sector in the Indian health-care industry: a scenario analysis. Journal of Business & Industrial Marketing, 37(8), 1662-1674. https://hdl.handle.net/11575/137051
22. Gardas, B. B., D. Raut, R., & Narkhede, B. E. (2019). Analysing the 3PL service provider's evaluation criteria through a sustainable approach. International Journal of Productivity and Performance Management, 68(5), 958–980. https://doi.org/10.1108/ijppm-04-2018-0154
23. Garmidolova, A., Desseva, I., Mihaylova, D., & Lante, A. (2022). Bioactive peptides from lupinus spp. seed proteins-state-of-the-art and perspectives. Applied Sciences, 12(8), 3766. https://doi.org/10.3390/app12083766
24. Grangeia, H. B., Silva, C., Simões, S. P., & Reis, M. S. (2020). Quality by design in pharmaceutical manufacturing: A systematic review of current status, challenges and future perspectives. European journal of pharmaceutics and Biopharmaceutics, 147(1), 19-37. https://doi.org/10.1016/j.ejpb.2019.12.007
25. Grigoriadou, K., Krigas, N., Sarropoulou, V., Maloupa, E., & Tsoktouridis, G. (2021). Vegetative propagation and ex-situ conservation of Acantholimon androsaceum and Limonium chersonesum, two promising local endemics of Crete (Greece) available for floricultural and pharmaceutical sustainable exploitation. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 49(1), 12261-12261. https://doi.org/10.15835/nbha49112261
26. Grundy, Q., Parker, L., Wong, A., Fusire, T., Dimancesco, D., Tisocki, K., ... & Kohler, J. (2022). Disclosure, transparency, and accountability: a qualitative survey of public sector pharmaceutical committee conflict of interest policies in the World Health Organization South-East Asia Region. Globalization and Health, 18(1), 33. https://doi.org/10.1186/s12992-022-00822-8
27. He, X., & Yu, D. (2020). Research trends in life cycle assessment research: A 20-year bibliometric analysis (1999–2018). Environmental Impact Assessment Review, 85(1), 106461. https://doi.org/10.1016/j.eiar.2020.106461
28. Hosseini-Motlagh, S.-M., Nami, N., & Farshadfar, Z. (2020). Collection disruption management and channel coordination in a socially concerned closed-loop supply chain: A game theory approach. Journal of Cleaner Production, 276(1), 124173. https://doi.org/10.1016/j.jclepro.2020.124173
29. Koller, M. (2019). Switching from petro-plastics to microbial polyhydroxyalkanoates (PHA): the biotechnological escape route of choice out of the plastic predicament?. The EuroBiotech Journal, 3(1), 32-44. https://doi.org/10.2478/ebtj-2019-0004
30. Kolsi, M. C., Ananzeh, M., & Awawdeh, A. (2021). Compliance with the global reporting initiative standards in Jordan: Case study of hikma pharmaceuticals. International Journal of Sustainable Engineering, 14(6), 1572-1586. https://doi.org/10.1080/19397038.2021.1970273
31. Kumar, A., Zavadskas, E. K., Mangla, S. K., Agrawal, V., Sharma, K., & Gupta, D. (2018). When risks need attention: adoption of green supply chain initiatives in the pharmaceutical industry. International Journal of Production Research, 1–23. https://doi.org/10.1080/00207543.2018.1543969
32. Kumar, V., Bahuguna, A., Ramalingam, S., & Kim, M. (2021). Developing a sustainable bioprocess for the cleaner production of xylooligosaccharides: An approach towards lignocellulosic waste management. Journal of Cleaner Production, 316(1), 128332. https://doi.org/10.1016/j.jclepro.2021.128332
33. Li, H., Alkahtani, M. E., Basit, A. W., Elbadawi, M., & Gaisford, S. (2023). Optimizing environmental sustainability in pharmaceutical 3D printing through machine learning. International Journal of Pharmaceutics, 648(1), 123561. https://doi.org/10.1016/j.ijpharm.2023.123561

34. Li, J., & Eastgate, M. D. (2019). Making Better Decisions During Synthetic Route Design: Leveraging Prediction to Achieve Greenness-by-Design. Reaction Chemistry & Engineering. https://doi.org/10.1039/c9re00019d
35. Liew, W. T., Adhitya, A., & Srinivasan, R. (2014). Sustainability trends in the process industries: A text mining-based analysis. Computers in Industry, 65(3), 393–400. https://doi.org/10.1016/j.compind.2014.01.004
36. Lima, P. A. B., Delgado, F. C. M., dos Santos, T. L., & Florentino, A. P. (2022). Medications reverse logistics: A systematic literature review and a method for improving the Brazilian case. Cleaner Logistics and Supply Chain, 3(1), 100024. https://doi.org/10.1016/j.clscn.2021.100024
37. Malay, O. E., & Aubinet, S. (2021). Improving government and business coordination through the use of consistent SDGs indicators. A comparative analysis of national (Belgian) and business (pharma and retail) sustainability indicators. Ecological Economics, 184(1), 106991. https://doi.org/10.1016/j.ecolecon.2021.106991
38. Marinkovic, V., Bekcic, S., Pejovic, G., Sibalija, T., Majstorovic, V., & Tasic, L. (2016). An approach to TQM evaluation in pharma business. The TQM Journal, 28(5), 745–759. https://doi.org/10.1108/tqm-10-2015-0134
39. Marques, C. M., Moniz, S., de Sousa, J. P., Barbosa-Povoa, A. P., & Reklaitis, G. (2020). Decision-support challenges in the chemical-pharmaceutical industry: Findings and future research directions. Computers & Chemical Engineering, 134(1), 106672. https://doi.org/10.1016/j.compchemeng.2019.106672
40. Masri, HA y Jaaron, AAM (2017). Evaluación de prácticas ecológicas de gestión de recursos humanos en el contexto manufacturero palestino: un estudio empírico. Revista de Producción Más Limpia, 143(1), 474–489. https://doi.org/10.1016/j.jclepro.2016.12.087
41. Mehariya, S., Fratini, F., Lavecchia, R., & Zuorro, A. (2021). Green extraction of value-added compounds form microalgae: A short review on natural deep eutectic solvents (NaDES) and related pre-treatments. Journal of Environmental Chemical Engineering, 9(5), 105989. https://doi.org/10.1016/j.jece.2021.105989
42. Mihaiu, D. M., Șerban, R.-A., Opreana, A., Țichindelean, M., Brătian, V., & Barbu, L. (2021). The Impact of Mergers and Acquisitions and Sustainability on Company Performance in the Pharmaceutical Sector. Sustainability, 13(12), 6525. https://doi.org/10.3390/su13126525
43. Milanesi, M., Runfola, A., & Guercini, S. (2020). Pharmaceutical industry riding the wave of sustainability: Review and opportunities for future research. Journal of cleaner production, 261(1), 121204. https://doi.org/10.1016/j.jclepro.2020.121204
44. Miller, V., Nwokike, J., & Stergachis, A. (2012). Pharmacovigilance and global HIV/AIDS. Current Opinion in HIV and AIDS, 7(4), 299–304. https://doi.org/10.1097/coh.0b013e328354d8e7
45. Mills, M., & Kanavos, P. (2020). Do pharmaceutical budgets deliver financial sustainability in healthcare? Evidence from Europe. Health Policy, 124(3), 239–251. https://doi.org/10.1016/j.healthpol.2019.12.002
46. Niño-Amézquita, J., Legotin, F., & Barbakov, O. (2017). Economic success and sustainability in pharmaceutical sector: a case of Indian SMEs. Entrepreneurship and Sustainability Issues, 5(1), 157-168. https://dx.doi.org/10.9770/jesi.2017.5.1(13)
47. Ortiz-Avram, D., Ovcharova, N., & Engelmann, A. (2024). Dynamic capabilities for sustainability: Toward a typology based on dimensions of sustainability-oriented innovation and stakeholder integration. Business Strategy and the Environment, 33(4), 2969-3004. https://doi.org/10.1002/bse.3630
48. Otte, E., & Rousseau, R. (2002). Social network analysis: a powerful strategy, also for the information sciences. Journal of information Science, 28(6), 441-453. https://doi.org/10.1177/016555150202800601
49. Panda, S., Kundu, K., Basaiahgari, A., Singh, A. P., Senapati, S., & Gardas, R. L. (2018). Aggregation behaviour of biocompatible choline carboxylate ionic liquids and their

interactions with biomolecules through experimental and theoretical investigations. New Journal of Chemistry, 42(9), 7105–7118. https://doi.org/10.1039/c8nj00336j

50. Park, J., & Chung, E. (2021). Learning from past pandemic governance: Early response and Public-Private Partnerships in testing of COVID-19 in South Korea. World Development, 137(1), 105198. https://doi.org/10.1016/j.worlddev.2020.105198
51. Ramirez, J., Gallego, G., Ez, W. N. N. N., & Tirado, J. G. (2023). Blockchain Technology for Sustainable Supply Chains: A Bibliometric Study. Journal of Distribution Science, 21(6), 119-129. https://doi.org/10.15722/jds.21.06.202306.119
52. Ramírez-Duran, J. A., Niebles-Núñez, W., & García-Tirado, J. (2023). Aplicaciones bibliométricas del estudio del capital intelectual dentro de las instituciones de educación superior desde un enfoque sostenible. Saber, Ciencia y Libertad, 18(1). https://n9.cl/2ofg4
53. Sabat, K. C., Bhattacharyya, S. S., & Krishnamoorthy, B. (2022). Circular economy in pharmaceutical industry through the lens of stimulus organism response theory. European Business Review, 34(6), 936-964. https://doi.org/10.1108/EBR-02-2022-0037
54. Sarkis, M., Bernardi, A., Shah, N., & Papathanasiou, M. M. (2021). Emerging challenges and opportunities in pharmaceutical manufacturing and distribution. Processes, 9(3), 457. https://doi.org/10.3390/pr9030457
55. Sax, P., & Shmueli, A. (2010). Impact of pharmaceutical regulation and policies on health system performance goals in Israel. Advances in Health Economics and Health Services Research, 77–101. https://doi.org/10.1108/s0731-2199(2010)0000022007
56. Schneider, J. L., Wilson, A., & Rosenbeck, J. M. (2010). Pharmaceutical companies and sustainability: an analysis of corporate reporting. Benchmarking: An International Journal, 17(3), 421–434. https://doi.org/10.1108/14635771011049371
57. Singh, R. K., Kumar, R., & Kumar, P. (2016). Strategic issues in pharmaceutical supply chains: a review. International Journal of Pharmaceutical and Healthcare Marketing, 10(3), 234–257. https://doi.org/10.1108/ijphm-10-2015-0050
58. Small, H. (1973). Co-citation in the scientific literature: A new measure of the relationship between two documents. Journal of the American Society for information Science, 24(4), 265-269. https://doi.org/10.1002/asi.4630240406
59. Vargas, J., & González, D. (2016). Model to assess supply chain resilience. International Journal of Safety and Security Engineering, 6(2), 282-292. https://www.witpress.com/elibrary/SSE-volumes/6/2/1171
60. Vola, F., Vinci, B., Golinelli, D., Fantini, M. P., & Vainieri, M. (2020). Harnessing pharmaceutical innovation for anti-cancer drugs: Some findings from the Italian regions. Health Policy. https://doi.org/10.1016/j.healthpol.2020.07.016
61. Woutersa, O. J., & Kanavosa, P. G. (2015). Transitioning to a national health system in Cyprus: a stakeholder analysis of pharmaceutical policy reform. Bulletin of the World Health Organization, 93(1), 606-613. https://doi.org/10.2471/BLT.14.148742
62. Zaid, AA, Jaaron, AAM y Talib Bon, A. (2018). El impacto de la gestión verde de los recursos humanos y las prácticas verdes de gestión de la cadena de suministro en el desempeño sostenible: un estudio empírico. Revista de Producción Más Limpia. https://doi.org/10.1016/j.jclepro.2018.09.062
63. Zhu, Z., Wang, Q., Sun, Q., Lexchin, J., & Yang, L. (2023). Improving access to medicines and beyond: the national volume-based procurement policy in China. BMJ Global Health, 8(7), e011535. https://doi.org/10.1136/bmjgh-2022-011535
64. Zyoud, S. E. H., Al-Jabi, S. W., Sweileh, W. M., Al-Khalil, S., Alqub, M., & Awang, R. (2015). Global methaemoglobinaemia research output (1940–2013): a bibliometric analysis. Springerplus, 4(1), 1-7. https://doi.org/10.1186/s40064-015-1431-7