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Bibliometric Survey on Supply Chain in Healthcare using Artificial Intelligence

Shruti Maheshwari
SIT, shruti.maheshwari@sitpune.edu.in

Gagandeep Kaur
SIT

Ketan Kotecha
Director, Symbiosis Institute of Technology (SIT) affiliated to Symbiosis International (Deemed University), Pune, India.

Pramod Kumar Jain Dr.
IIT BHU

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ABSTRACT

With the increasing demand for the supply chain in the service sector, new techniques have become essential. With the latest emerging technologies, it has become crucial to have a bibliometric analysis of supply chain management (SCM) in the healthcare sector. The paper represents the analysis of research supply chain in the service sector using artificial intelligence techniques. The main aim of the analysis is to accomplish the technology in healthcare supply chain management using SCOPUS, Google Scholar, Research Gate, etc. and the various softwares like Gephi, GSP Visualizer, etc. The bibliometric analysis shows that India has ranked 4th in publishing documents on healthcare supply chain and artificial intelligence after the US, China and the UK. The prominent keywords used are supply chain management and the healthcare sector. Artificial Intelligence is another vital keyword for this study, which applies to all domains.

Keywords: Bibliometric Analysis, Supply Chain Management, Healthcare sector, Artificial Intelligence

1. INTRODUCTION

Supply chain management is continuously evolving and emerging with new concepts and technology. The researchers are making a continuous attempt to apply artificial intelligence in the healthcare supply chain in areas like health and image processing. Machine learning, a type of artificial intelligence technology, is continuously evolving and its algorithms are refined continuously, which are used in healthcare supply chain management.

The artificial intelligence has a high probability of changing the face of the SCM in the healthcare sector. From detecting the disease to treatment options, from diagnosis to transparency in the system, artificial intelligence has enormous potential for the makeover of the supply chain in healthcare. A survey shows that the supply chain accounts for 40% - 45% of total operating costs in the healthcare sector. With proper planning and application, margins of hospitals can be increased up to 7% and a reduction of 5% to 15% in total cost can be accomplished [57]. Irrespective of all the know-how of artificial intelligence, researchers say that hospitals have still not paid attention to the same complexity in understanding and managing operations. The leaders in clinics need to understand the importance and application of the supply chain in healthcare for better efficiency and cutting down the cost of hospitals.

Currently, the service sector is serving as the largest sector of India that represents 54.40% of total India's Gross Value Added (GVA) contribution (92.26 lakh crore INR in 2018-19) as compared to industry and agriculture sector. It has created many opportunities for employment. A tremendous increase in the growth of the service sector and especially in the healthcare sector, can be observed in India.

Many challenges hold back the healthcare industry. The significant reasons are driving healthcare with proven outcomes and problems faced by doctors and patients to adopt the new technology devices. However, AI techniques analyze the large volume of data very quickly using techniques like machine learning, deep learning, natural processing languages, etc. Many different factors are responsible for the growth of artificial intelligence in the healthcare sector. Some of the elements are a tremendous increase in population, elderly population, and increment in disposable income of the people, modification in the lifestyle of the people, increase in literacy rate among the public, and increasing medical tourism.

According to Duangpun Kritchanchai (2012), the four major role players in the healthcare supply chain are Manufacturers, Distributors, Healthcare Providers and Payers. Figure 1 depicts the typical healthcare supply chain.
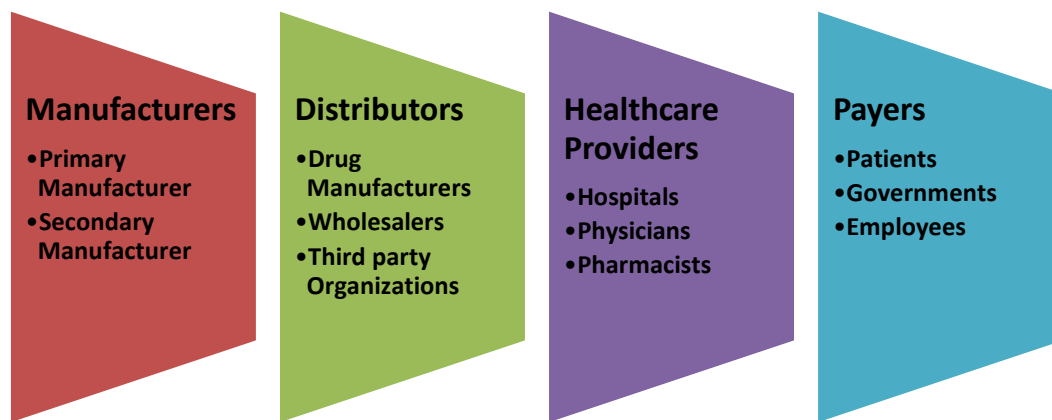

Figure 1 Healthcare Supply Chain (Kritchanchai D, 2012)

There are two different types of manufacturers viz. Primary and Secondary Manufacturer. The former is responsible for creating the main ingredient of the drugs. In contrast, the later is responsible for transforming the ingredient into a physical form such as tablets, capsules, liquids, etc. that can be consumed by patients. The final products are passed onto the Distributors (that can be wholesalers or a

third party), which is further delivered to the healthcare providers for serving patients and others. These healthcare providers not only serve as a customer of their manufacturers but also serve as suppliers to them by flowing new information *(Kritchanchai D, 2012)*. This flow of material and information causes a lack of transparency in the healthcare supply chain. Here, Artificial Intelligence techniques play an important role by making the system more transparent and help in the decision-making process of the hospital supply chain.

Hokey Min (2010) has classified AI taxonomy in three steps: problem scope, methodology, and implementation. The further methodology is classified into different sub-fields viz. Artificial Neural Network, Machine Learning, expert system, and Genetic Algorithm, fuzzy logic, and agent-based systems These methodologies help in solving the problems, optimizing them, and making decisions in different areas in the hospitals like inventory planning, transportation, forecasting, managing customers, etc. *(Min, 2010)*. Techniques like Artificial Neural Network (ANN) can be used for forecasting the demands using various platforms such as the MATLAB ANN toolbox *(Sharma A, 2015)*. Another technique, such as fuzzy logic, can help assess the performance of the suppliers precisely their delivery time and quality of the product. It even helps in reducing the cost of inventory and improving the efficiency of the supply chain *(Lau HCW, et al., 2015)*.

Apart from the above-discussed techniques, protocols of the hospitals can be determined by Interpretive System Modelling (ISM) approach. It helps in knowing the level of significance by knowing the elements and variables of the hospitals and then developing the relationship between these variables *(Gupta and Ramesh, 2015)*.

Big data analytics is yet another technique that can be used for forecasting and decision making. The technique can be used in the healthcare sector for assurance, safety, quality, real-time location, tracking, diagnosis of disease, etc. The big data analysis technique can effectively optimize the cost of the overall healthcare supply chain sector *(Alotaibi and Mehmood, 2017)*.

Another emerging and unexplored technology that can bring transparency in the supply chain is Blockchain. It can improve the efficiency of inventory in healthcare. Many techniques such as Vendor Vendor Managed Inventory (VMI), the use of Radio Frequency Identification (RFID) technologies, and the centralization of Hospital Inventory has been effective in inventory management, however, few issues such as perishable items inventory, transparency can be solved using Blockchain technology *(Leaven et al., 2017)*

The above is all about where artificial intelligence can be used in healthcare supply chain management. There was a need for a bibliometric analysis survey to get a view into a broader perspective. Section 2 shows the data collected for the last ten years on the application of artificial intelligence in the healthcare supply chain; section 3 represents a bibliometric analysis of the survey; section 4 concludes the analysis, and section 5 depicts the future scope and limitations of this research followed by the references.

2. DATA COLLECTION

There are several ways of data collection. For this research, data is collected from Google Scholar, Research Gate, Elsevier, Science Direct, and SCOPUS. Among this, the analysis can be done with the help of SCOPUS as it is having one of the largest databases from various sections of engineering, science, technology, arts, commerce, management, etc. The analysis of this research is done using SCOPUS data with primary keywords as "artificial intelligence, "healthcare" and "supply chain management." The abstract of the papers is available along with the citations on the website.

Table 1 Keywords for data analysis

Master Keyword	"Supply Chain Management" AND "Healthcare" AND "Artificial Intelligence"
Primary Keywords	"Decision Making" OR "Internet of Things" OR "Big data" OR "Radio Frequency Identification (RFID)" OR "Decision Support System" OR "Information System" OR "Blockchain"

2.1 INITIAL SEARCH RESULTS

When entering the above keyword in the SCOPUS websites, the search results show that a total of 2118 documents were published. Table 2 represents publications in other languages too. The remaining paper has been limited to English Language, only having 2080 publications in the last decade (2009 – 2019)

Table 2 Publications on master keywords in different languages

Publishing Language	Number of Documents
English	2080
Chinese	10
French	4
German	4

Source: http://www.scopus.com (accessed on 7th November 2019)

Few other languages in which two or less than two documents were published are Spanish, Arabic, Croatian, Portuguese, Turkish and few others. Out of 2189 total publication between the year 2009 – 2019, there are 302 papers published with open access, whereas 1887 papers are published without open access as shown in Table 3.

Table 3 Documents Publication Access Type

Access Type	Document Count
Open Access	302
Others	1887

The papers published so far in this area are published in many different types. Most publications are in the form of articles and journals that constitute 54.9% of the total (2078 documents), followed by conference papers, which is 24.2% of the total documents. Table 4 depicts the different types of documents published in the healthcare sector, supply chain using artificial intelligence.

Table 4 Different types of documents in the healthcare supply chain

Publication Type	Number of Publications	Percentage of Documents
Article (Journals)	1141	54.9%
Conference papers	503	24..2%
Review paper	178	8.6%
Books	123	5.9%
Book Chapters	110	5.5%
Editorial	10	0.5%
Conference Review	8	0.4%

2.2 YEARLY DATA PUBLICATION STATISTICS

The different types of publications, i.e., Journals, Conference papers, etc. are of the time span 2009 to 2019. The statistics of data for healthcare supply chain using artificial intelligence that is published year wise is given in Table 5.

Table 5 Yearly Publication Data Trend

Year	Publication Count

2019	516
2018	358
2017	266
2016	198
2015	162
2014	164
2013	128
2012	101
2011	75
2010	57
2009	55

Source: http://www.scopus.com (accessed on 7th November 2019)
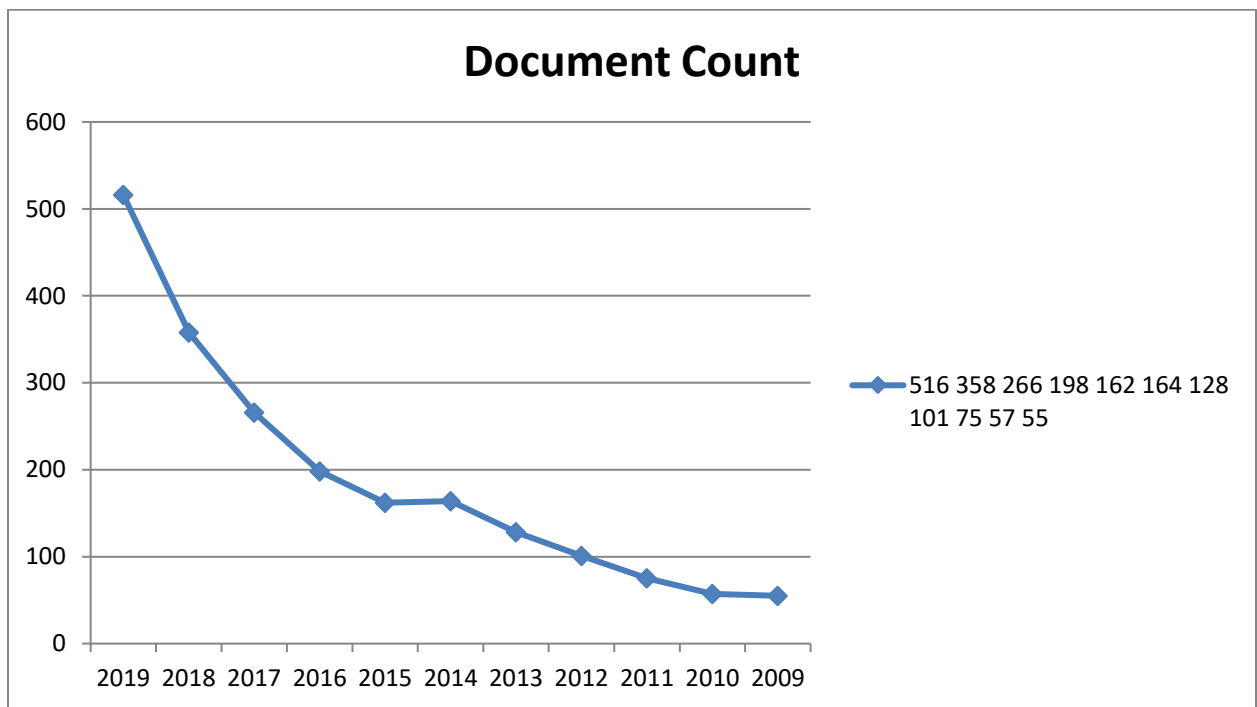
Document Count

Figure 1 Publication Count Year wise

The horizontal axis shows the year of publication and the vertical axis signifies the count of documents published in a particular year.

2.3 DATA INVESTIGATION

The data collected so far from the SCOPUS is then reviewed for further analysis. Section 3 represents a bibliometric analysis of the above data in terms of country-wise publications done, the different funding sponsors, types of affiliation of documents, etc. for a better overview of the research done so far.

3.   BIBLIOMETRIC ANALYSIS

For the bibliometric analysis of the supply chain in the healthcare sector using artificial intelligence, the criterions used are:

i.   Survey based on geographic region and citation etc.
ii.   Statistics about the affiliation, author, journal and keyword.

3.1 Geographical Region Analysis

The researchers from all across the world are doing research in supply chain management. Figure 3 represents the different regions across the globe publishing the research papers on the supply chain in healthcare using gpsvisualiser.com. The size of the circle depicts the attention paid towards the topic. It is evident from the figure that most of the research focus minds are from the US, China and UK, then India.

Figure 3 Geographical representation of supply chain

Figure 4 shows the statistics of data published in the healthcare supply chain in the first ten countries worldwide. From the figure, it is clear that 8% of the total publications are from India, first being the US with 27% of the total.
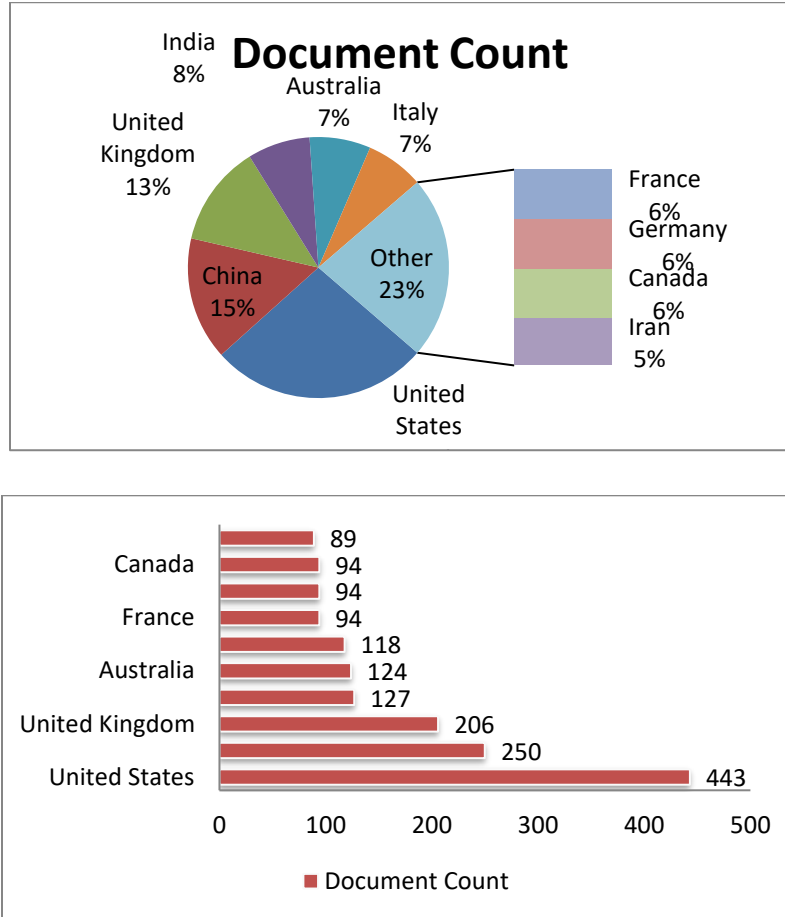

Figure 6 Top Ten Countries publishing papers on Supply Chain in Healthcare using Artificial Intelligence

3.2 Keywords Statistics

The keywords used by researchers for their research help them in better searching and exploring the content. Focused research depends on the keywords used for searching the data. Table 6 represents the number of publications done till now for significant keywords.

Table 6 Publication Data Count based on keywords

Keywords	Publication Count

Decision Making	235
Internet of Things	195
Radio Frequency Identification (RFID)	143
Big data	139
Blockchain	129
Decision Support Systems	128
Information Systems	126

Source of data: http://www.scopus.com (accessed on 7th November 2019)

3.3 NETWORK ANALYSIS

The network analysis is done to demonstrate the relationship between various parameters using a tool like the "gephi" tool. The tool helps in making hypotheses, discovering patterns of data. It provides real-time visualization for a better understanding of patterns and state-of-art algorithms for better efficiency and quality. The gephi tool is used for network analysis of various keyword statistics, authors, sources type, publication types, etc. Figure 7 shows the relationship of different keywords used by researchers and source title having __ nodes and __ edges.
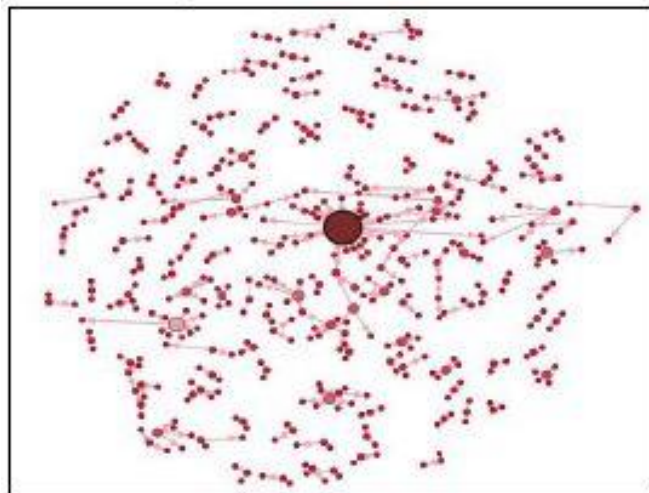

Figure 7 Relationship of keywords and source title

Figure 8 shows the cluster of publication year and title having __nodes and __ edges.
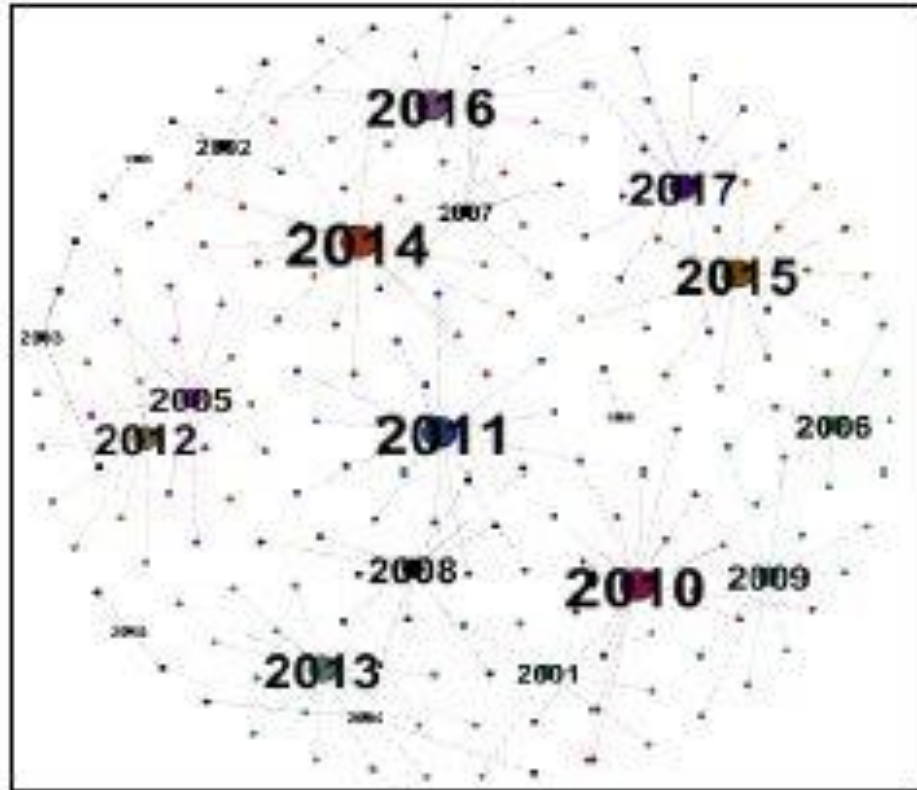
Figure 8 Cluster of Year wise Publications

Figure 9 shows the relationship between the author and keywords co-appearing in the same paper with __nodes and __ edges.
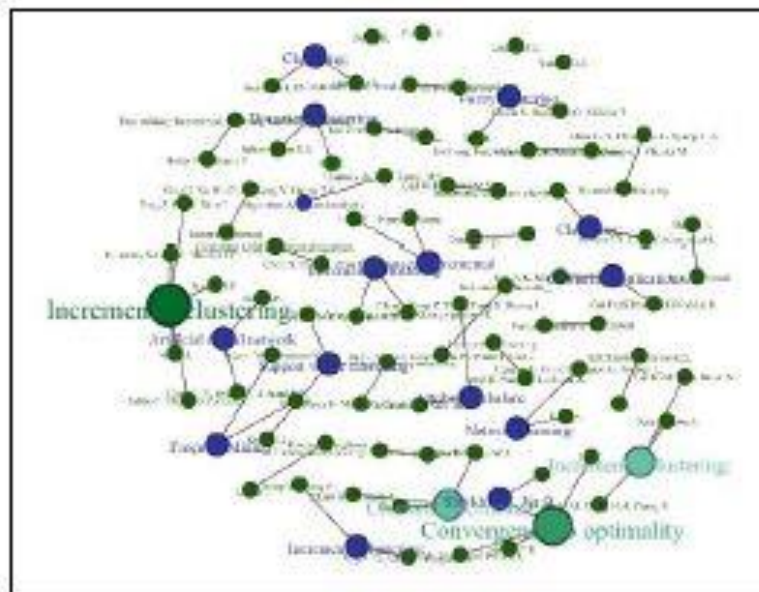

Figure 9 Relationship of keywords and authors appearing in the same topic

Figure 10 shows the data relationship between author keywords and source title with 184 nodes and 354 edges.
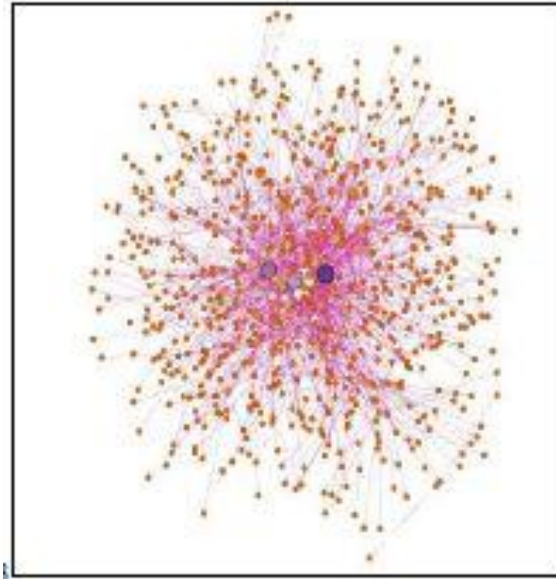

Figure 10 Relationship of keywords and authors in the same topic

Figure 11 shows the cluster of affiliation, language, and type with 28 nodes and 45edges.
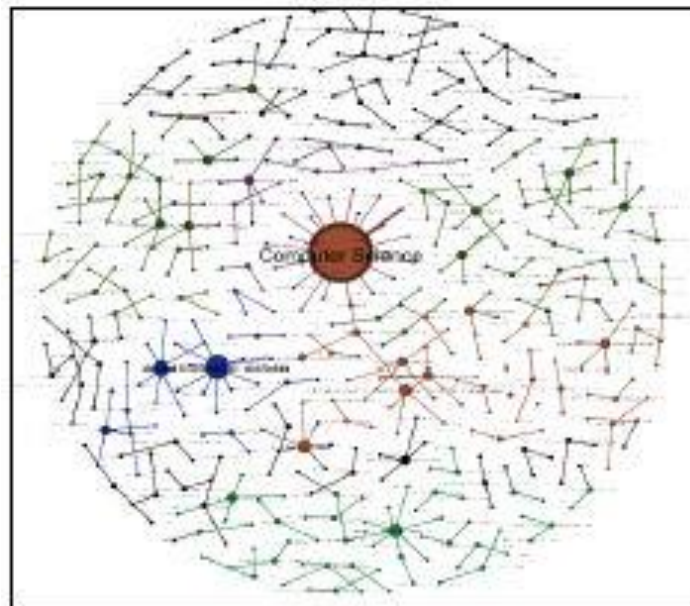

Figure 11 A constellation of affiliation, language, and type

3.4 PUBLICATION IN DIFFERENT DISCIPLINES

Figure 7 shows the publication of data in different subject areas i.e. computer engineering, science, technology, arts, etc. From the figure, it is concluded that computer science has been the major area of research with 28.2% of the total publication (2080) followed by engineering which is 17.8%. It can also be seen in the figure that other areas like Mathematics, Social Science, Economics, and even Physics and Astrology have been the areas that attracted researchers to publish in this field using the master keywords.
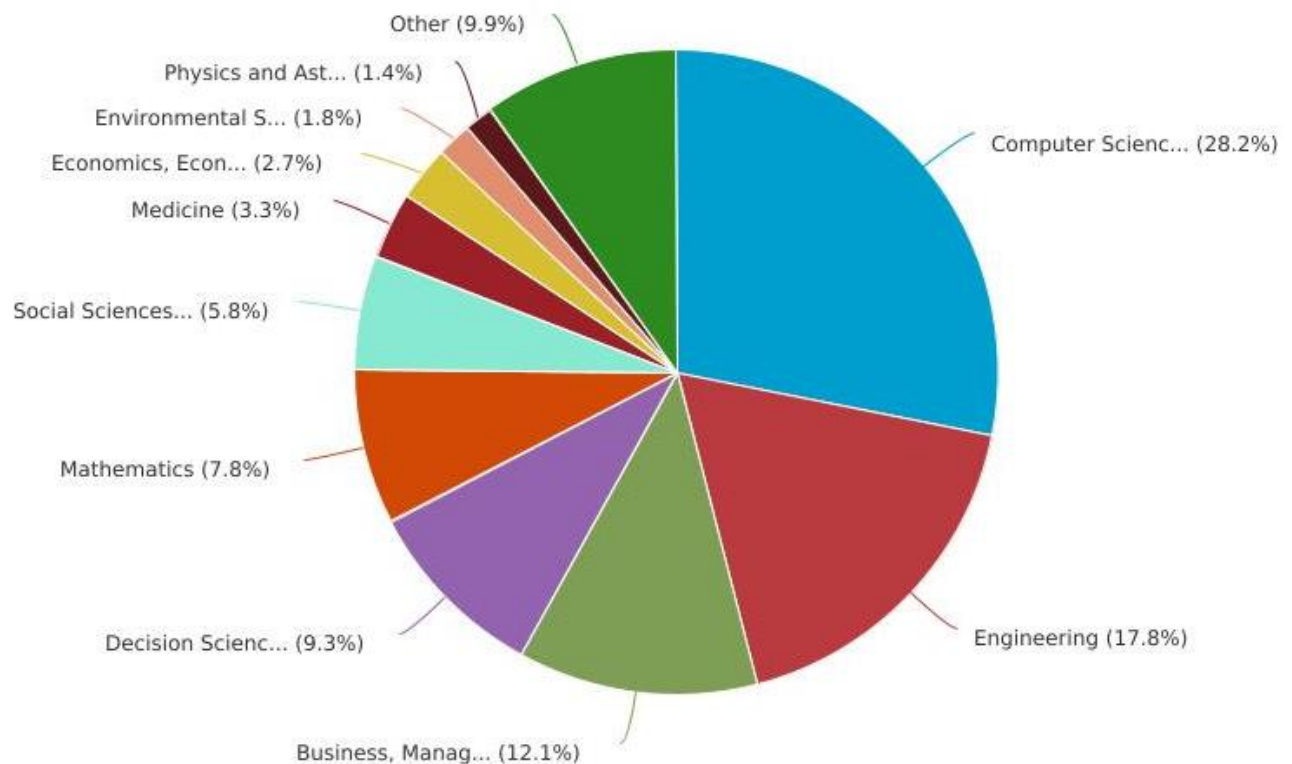

Figure 12 Publication percentage in different Disciplines

Source: http://www.scopus.com (accessed on 7th November 2019)

3.5 AFFILIATION STATISTICS

Figure 8 describes the affiliations of publications in the healthcare supply chain using artificial intelligence. As already discussed, the US has the major focus on supply chain and healthcare. The researchers in a university in the US are exploring more in this field than in China. The old dominion university in Virginia, US has a maximum affiliation with a statistic number of 26 than in Hong Kong Polytechnic University, China with 24 in number. It is interesting to

note that researchers from different regions of the country i.e. US, China, Middle East, Asia etc. are working in the supply chain field.
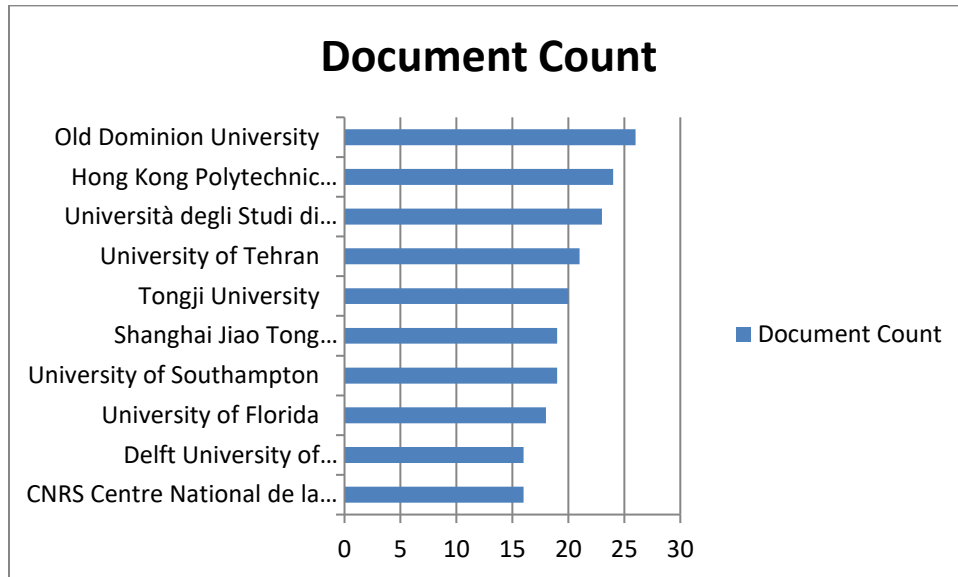

Figure 13 Number of Publications based on the affiliation of universities

Source: http://www.scopus.com (accessed on 7th November 2019)

3.6 AUTHOR STATISTICS

Figure 9 represents the data of the number of authors that have worked on the area of the supply chain or healthcare or artificial intelligence technique.
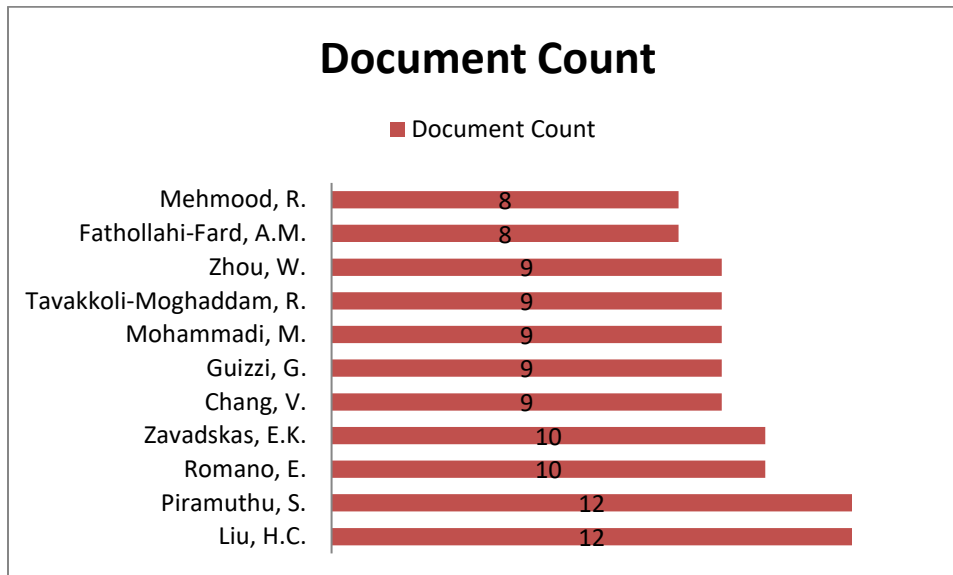

Figure 14 Number of Publication Count by different authors

3.7 STATISTICS OF DIFFERENT TYPES OF PUBLICATIONS

Figure 10 describes the different types of Publication Count as in Journals, Articles, Conference Paper, Proceedings, etc. The statistics demonstrates that 80% of the publications are either articles or papers in the conference. And, significantly less percentage represents publications in review (9%), book (6%) and chapters (5%). The data concludes the need for more research in the field of the supply chain.
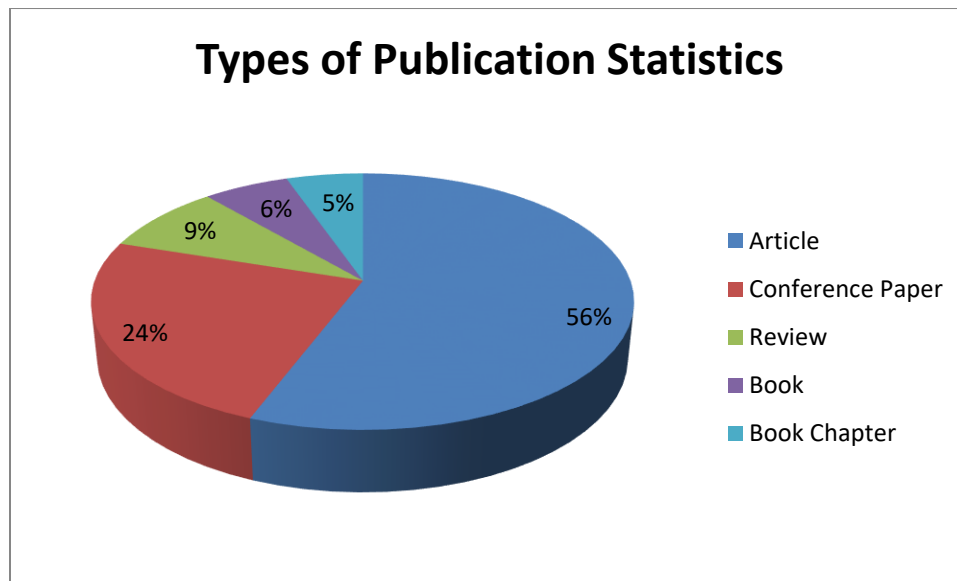

Figure 15 Statistics of different types of Publications.

3.8 ANALYSIS OF CITATIONS

Table 7 shows the citations of the first 2000 documents published in the year 2010 to 2019. The total citations for these 200 publications are 27829. The data is for keyword supply chain, healthcare and artificial intelligence individually.

Table 7: Statistics report for citations of publication from year 2010 to 2019 for first 2000 documents

Year	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	**Total**
No. of citations	872	2362	3265	2969	3825	6460	2266	2943	2270	597	**27829**

3.9 STATISTICS ON SOURCE TITLE

Table 8 represents the different source titles and their publication count. It is seen from the table that maximum numbers of publications are in the field of Computer Science.

Table 8: Statistics report for a number of publications from different sources

Source Title	Document Count
Lecture transcripts In Computer Science (Including Subseries);Artificial Intelligence; and Bioinformatics	60
Expert Systems With Applications	33
IEEE Access	27
International Journal Of Production Research	27
Lecture transcripts In Business Information Processing	26
Sustainability Switzerland	26
Computers And Industrial Engineering	22
Decision Support Systems	21
European Journal Of Operational Research	20
International Journal Of Information Management	19

Source of report: http://www.scopus.com (accessed on 7th November 2019)

4. RESEARCH CONSEQUENCE OF THE BIBLIOMETRIC ANALYSIS

Supply chain management is a significant area of research across the globe. The bibliometric analysis done for the keywords used in Table 1 demonstrates the fair idea of the research done so far and it focuses on the scope of research that can interest the researchers.

From the primary keywords used in table 1 for analysis, few new words have emerged like Blockchain technology which finds more areas for exploration. US and China are making the research in this field at a growing rate. For India, many opportunities exist in the same field as it is one of the developing countries. The demand for the supply chain can never diminish as it is one of the core areas of practice in every industry, whether a product or service sector of the supply chain.

5. CONCLUSION AND FUTURE SCOPE

The bibliometric analysis is done in the paper using SCOPUS, Google Scholar, etc. on the significant keywords as "artificial intelligence", "healthcare," and "supply chain". The various analyses represent data count of journals that are having open access and others. The paper also represents the different types of publications in the field of the supply chain. It gives a fair idea of publication statistics by the different funding agencies, affiliation and country-wise publications worldwide. The statistics of different papers by different authors are also calculated giving an overview of the number of papers published by authors in different subject areas. The count of citations is also demonstrated in the paper from 2010 to 2019 for the first 2000 papers extracted from the SCOPUS.

The analysis is restricted to the English language only. However, the number of publications in other languages are less, still it gives the researchers a new scope area. Also, the study from various other sources like Web of Science and others can be considered for better analysis of the keyword areas.

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