CHAPTER 3

THE APPLICATION OF ARTIFICIAL INTELLIGENCE TO THE HEALTHCARE SUPPLY CHAIN: A BIBLIOGRAPHIC STUDY

3.1 INTRODUCTION

Supply chain management is continuously evolving and emerging with new concepts and technology. The researchers continuously attempt to apply artificial intelligence in the healthcare supplychain through 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.

Artificial intelligence is highly likely to change 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, hospitals' margins can be increased up to 7%, and a reduction of 5% to 15% in total cost can be accomplished [Arzu Akyuz & Erman Erkan 2010]. Irrespective of all the artificial intelligence know-how, researchers say that hospitals have still not paid attention to the same complexityin 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 to cut down the cost of hospitals.

Currently, the service sector is India's largest sector, representing 54.40% of total India's Gross Value Added (GVA) contribution (92.26 lakh crore INR in 2018-19) compared to

the industry and agriculture sectors. It has created many employment opportunities. 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 withproven outcomes and problems doctors and patients face to adopt the new technology devices. However, AI techniques quickly analyze extensive data using machine learning, deep learning, natural processing languages, etc. Many 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, an 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 chainare Manufacturers, Distributors, Healthcare Providers, and Payers. Figure 3.1 depicts the typical healthcare supply chain.

There are two different types of manufacturers viz—Primary and Secondary Manufacturers. The formeris 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 patients can consume. The final products are passed onto the Distributors (wholesalers or a third party), which are further delivered to the healthcare providers for serving patients and others. Thesehealthcare providers serve as a customer of their manufacturers and suppliers flowing new information [Kritchanchai et al., 2010]. This flow of material and information causesa lack of transparency in the healthcare supply chain. Here, Artificial Intelligence techniques play an important role by making the system more transparent and helping in the decision-making process of the hospital supply chain.

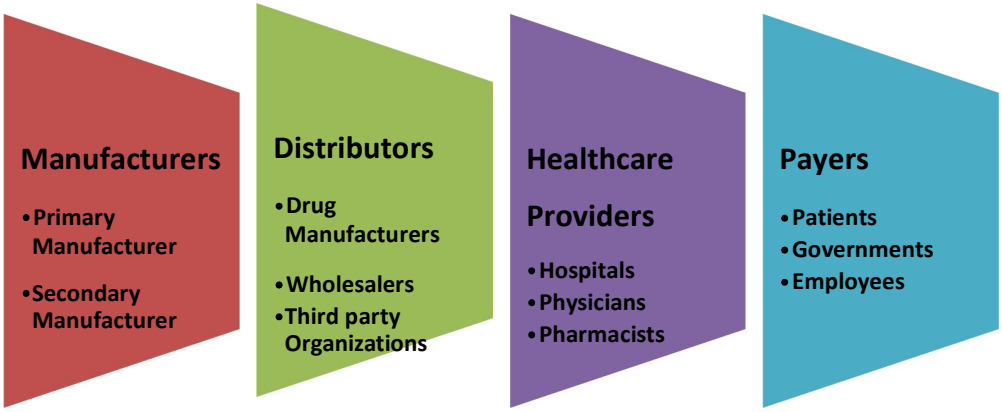

Figure 3.1 Healthcare Supply Chain (Kritchanchai et al., 2010)

Hokey Min has classified AI taxonomy into problem scope, methodology, and implementation. The other methodology is classified into different sub-fields viz. Artificial Neural Networks, Machine Learning, expert systems, Genetic Algorithms, fuzzy logic, and agent-based systems These methodologies help solve problems, optimize them, and make decisions in different hospital areas like inventory planning, transportation, forecasting, managing customers, etc. [Min, 2010]. Techniques like Artificial Neural Networks (ANN) can be used to forecast demands using various platforms such as the MATLAB ANN toolbox [Kochak & Sharma 2015]. Another technique, such as fuzzy logic, can help assess the performance of the suppliers, precisely their delivery time and product quality. It even helps to reduce inventory costs and improve the supply chain's efficiency [Lau et al., 2015].

Apart from the above-discussed techniques, the hospitals' protocols can be determined by InterpretiveSystem Modelling (ISM) approach. It helps in knowing the significance level by knowing the elements and variables of the hospitals and then developing the relationship between these variables [Gupta & 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 techniques can effectively optimize the cost of the overallhealthcare supply chain sector [Leaven & Ahmmad, 2017]. Another emerging new technology that can bring transparency to the supply chain is Blockchain. It can improve the efficiency of inventory in healthcare. Many techniques, such as Vendor Managed Inventory (VMI), the use of Radio Frequency Identification (RFID) technologies, and the centralization of Hospital Inventory, have been effective in inventory management; however, few issues, such as perishable items inventory, transparency can be solved using Blockchain technology [Leaven & Ahmmad, 2017].

The diversity of data and use of artificial intelligence in healthcare supply chain management arises the need for bibliometric analysis survey to analyze and evaluate the literature spread everywhere in the domain topic. Section 2 of this chaptershows 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 concludesthe analysis, and section 5 depicts the future scope and limitations of this research followed by the references.

3.2 DATA COLLECTION

There are several ways of data collection. This research collects data from Google Scholar, Research Gate, Elsevier, Science Direct, and SCOPUS. The analysis can be done with thehelp of SCOPUS, as it has 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 such as "artificial intelligence, "healthcare," and "supply chain management." The abstract of the papers is available along with the citations on the website.

Table 3.1 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"

3.3 INITIAL SEARCH RESULTS

When entering the above keyword in the SCOPUS websites, the search results show that 2118documents were published. Table 3.2 represents publications in other languages too. The remaining paperhas been limited to English Language, only having 2080 publications in the last decade (2009 – 2019).

Table 3.2 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 a few others. Out of 2189 total publications between 2009 and 2019, there are 302 papers published with open access, whereas 1887 papers were published without open access, as shown in Table 3.3.

Table 3.3 Documents Publication Access Type

Access Type	Document Count
Open Access	302
Others	1887

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

The papers in this area are published in many different types. Most of the publications are 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 3.4 depicts the different types of documents published in the healthcare sector, and supply chain using artificial intelligence.

Table 3.4 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%

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

3.4 YEARLY DATA PUBLICATION STATISTICS

The different types of publications, i.e., Journals, Conference papers, etc., are from 2009 to2019. The statistics of data for the healthcare supply chain using artificial intelligence published year-wise is given in Table 3.5.

Table 3.5 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)

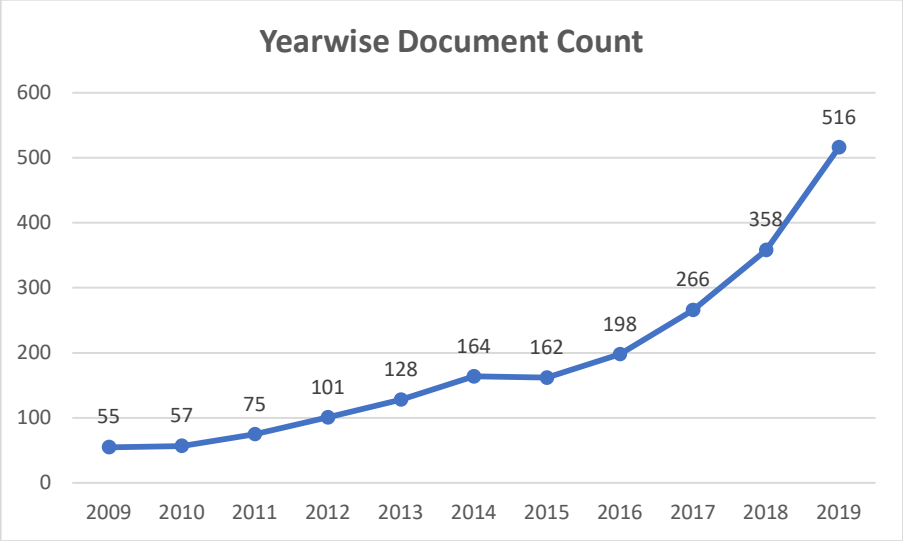

Figure 3.2 Publication Count Year wise

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

3.5 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, the different funding sponsors, types of affiliation of documents, etc., for a better overview of the research done so far.

3.6 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.

3.7 GEOGRAPHICAL REGION ANALYSIS

Researchers from various countries are looking into different aspects of supply chain management. Figure 3.3 represents the worldwide regions that have published research papers on the supply chain in the healthcare industry using gpsvisualiser.com. The amount of focus placed on the subject is represented by the size of the circle. The statistic makes it clear that most of the research focus minds come from the United States of America, China, the United Kingdom, and India.

Figure 3.3 Geographical representation of supply chain

Figure 3.4 shows the statistics of data published in the healthcare supply chain in the first ten countries worldwide. The figure shows that 8% of the total publications are from India, the first being the US with 27% of the total.

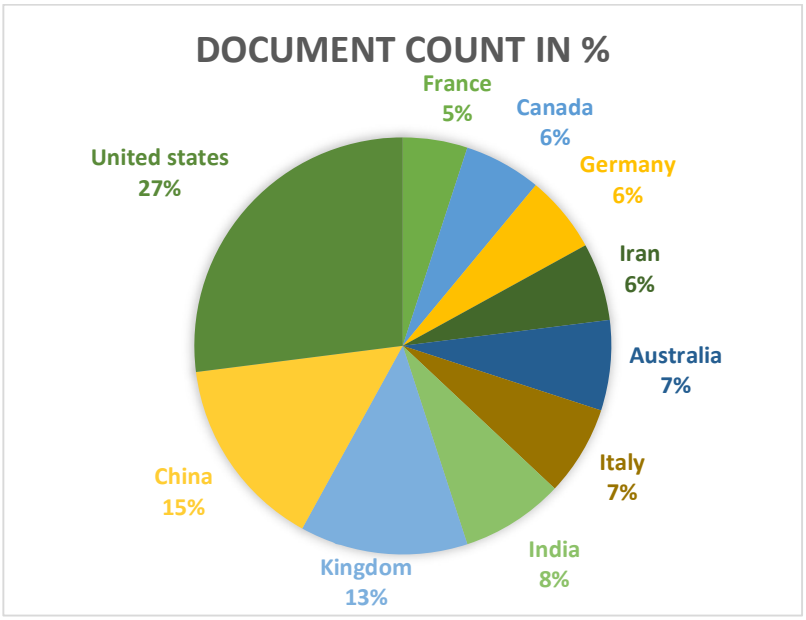

Figure 3.4 Top Ten Countries publishing papers on Supply Chain in Healthcare using Artificial Intelligence

In figure 3.5, actual count of the papers published in different countries is presented.

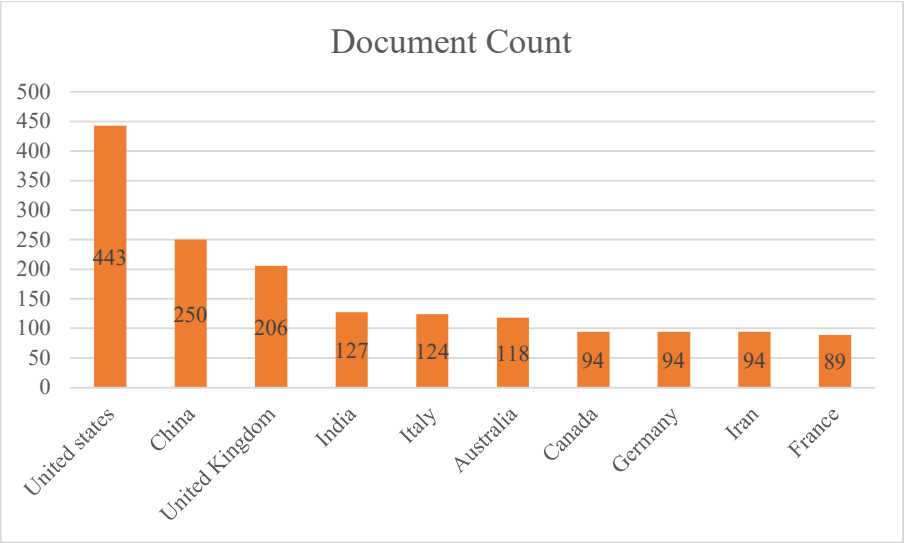

Figure 3.5 Count of papers on Supply Chain in Healthcare usingArtificial Intelligence published by top ten countries

3.8 KEYWORDS STATISTICS

The keywords used by researchers for their research help them better search and explore the content. Focused research depends on the keywords used for searching the data.Table 3.6 represents the number of publications done till now for significant keywords.

Table 3.6 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)

3.9 NETWORK ANALYSIS

The network analysis demonstrates the relationship between various parameters using a tool like the "gephi" tool. The tool helps in making hypotheses and 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 3.6 shows the relationship between different keywords used by researchers and source titles having nodes and edges.

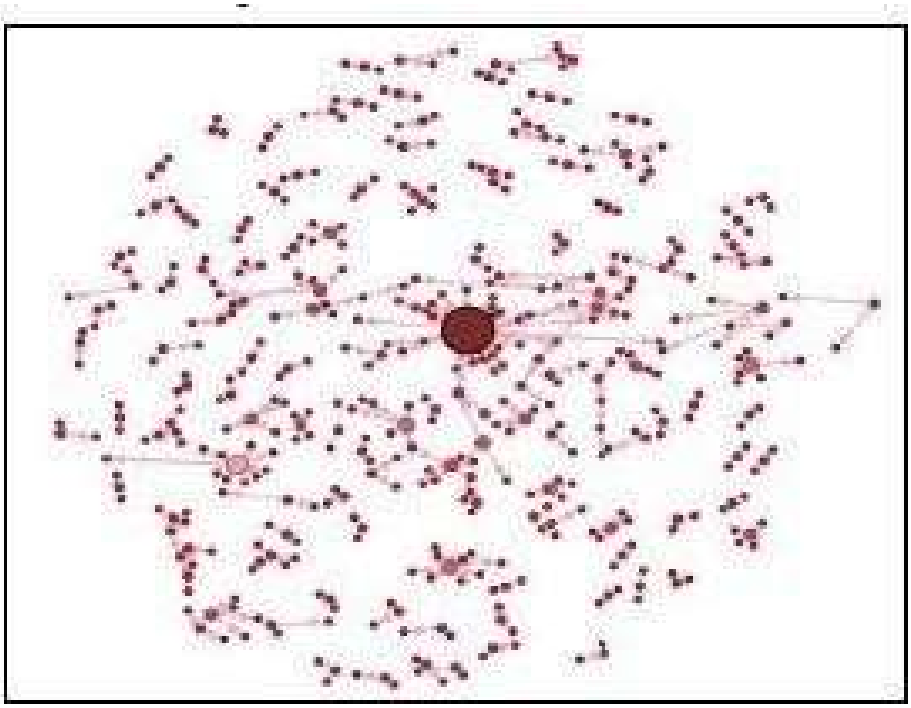

Figure 3.6 Relationship of keywords and source title

Figure 3.7 shows the cluster of publication year and title having 284 nodes and 342 edges.

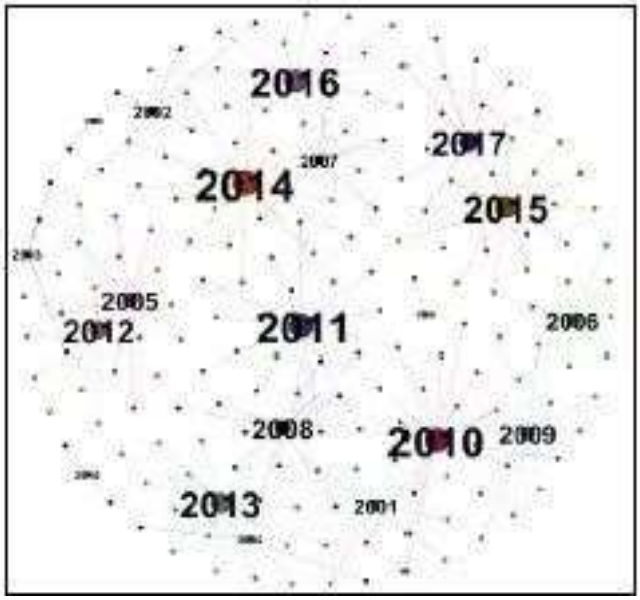

Figure 3.7 Cluster of Year-wise Publications

Figure 3.8 shows the relationship between the author and keywords co-appearing in the samepaper with 94 nodes and 84 edges.

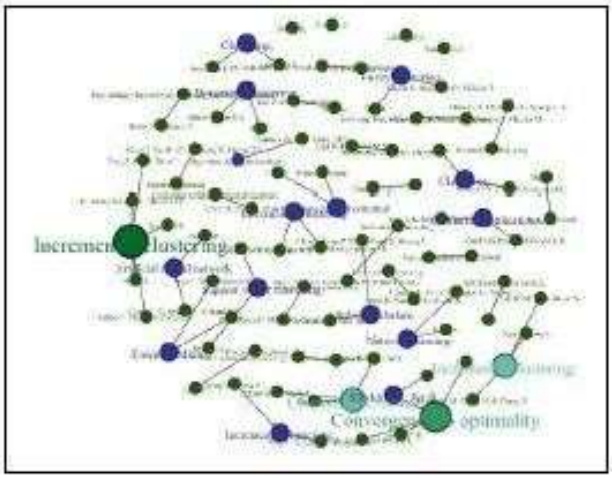

Figure 3.8 Relationship of keywords and authors appearing on the same topic

Figure 3.9 shows the data relationship between author keywords and source title with 184 nodesand 354 edges.

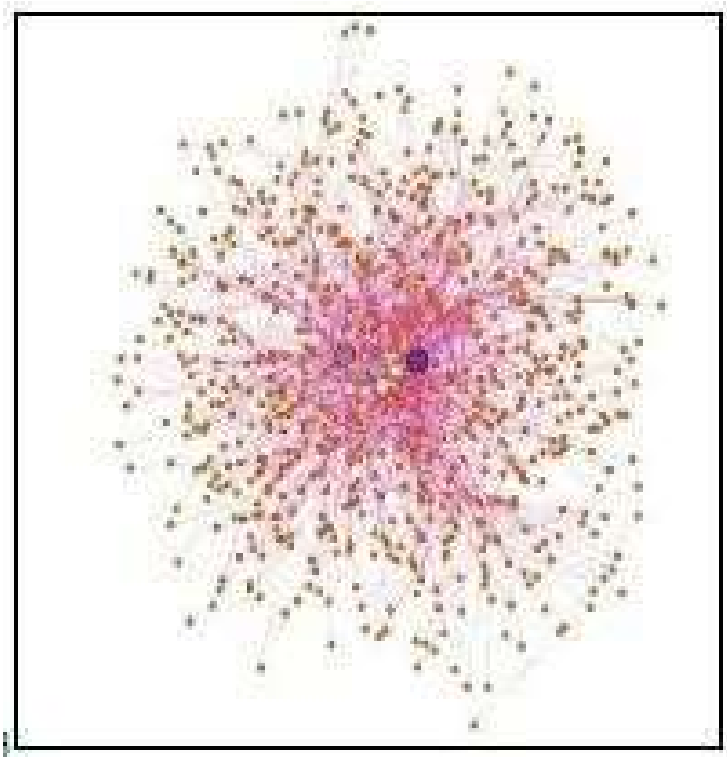

Figure 3.9 Relationship of keywords and authors in the same topic

Figure 3.10 shows the affiliation, language, and type cluster with 28 nodes and 45edges.

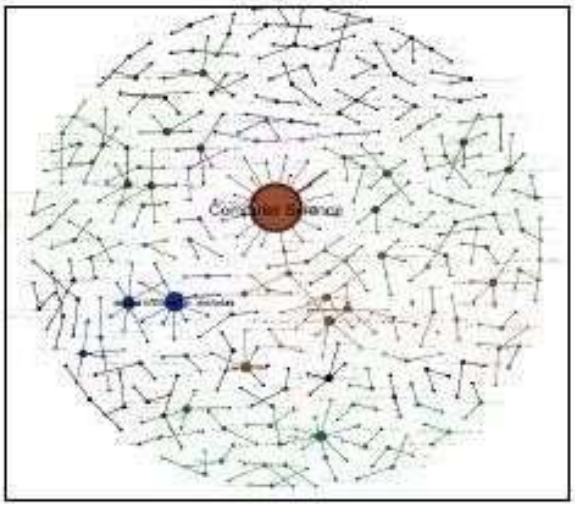

Figure 3.10 A constellation of affiliation, language, and type

3.10 PUBLICATION IN DIFFERENT DISCIPLINES

Figure 3.11 shows data publication in different subject areas i.e., computer engineering, science, technology, arts, etc. From the figure, it is concluded that computer science has been the primary area of research, with 28.2% of the total publication (2080), followed by engineering, with 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.

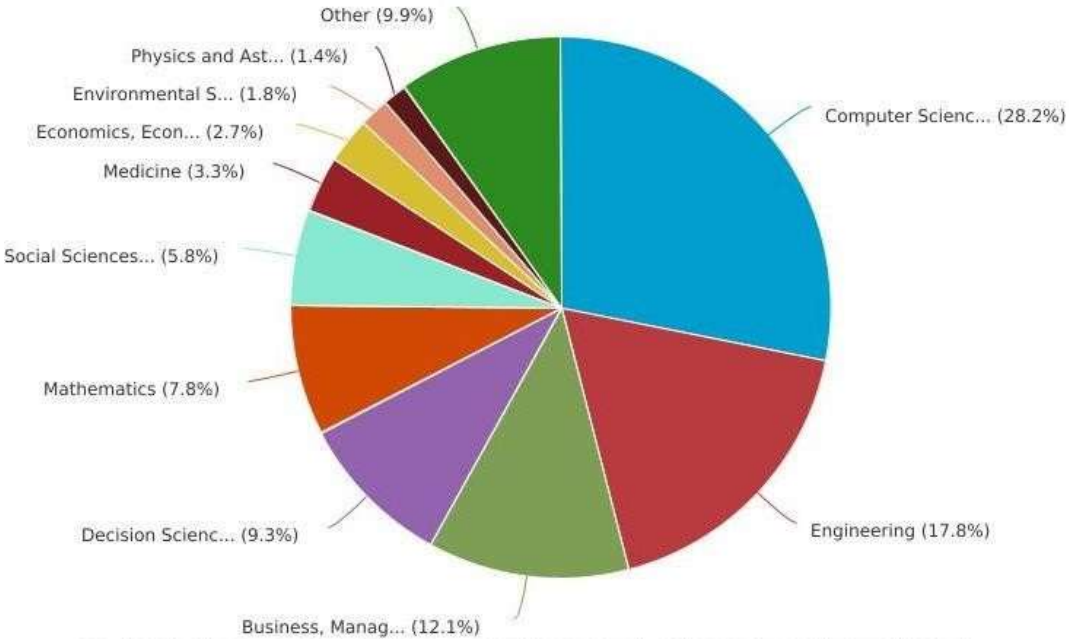

Figure 3.11 Publication percentage in different Disciplines

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

3.11 AFFILIATION STATISTICS

Figure 3.12 describes the affiliations of publications in the healthcare supply chain using artificialintelligence. As already discussed, the US focuses on supply chain and healthcare.Researchers in a university of the United States are exploring more in this

field more than in China. The old dominion university of Virginia, US, has a maximum affiliation with a statistic number of 26 than Hong Kong Polytechnic University, China, with 24 in number. It is interesting to note that researchers from different regions of the country, i.e., the US, China, the Middle East, Asia,etc., are working in the supply chain field.

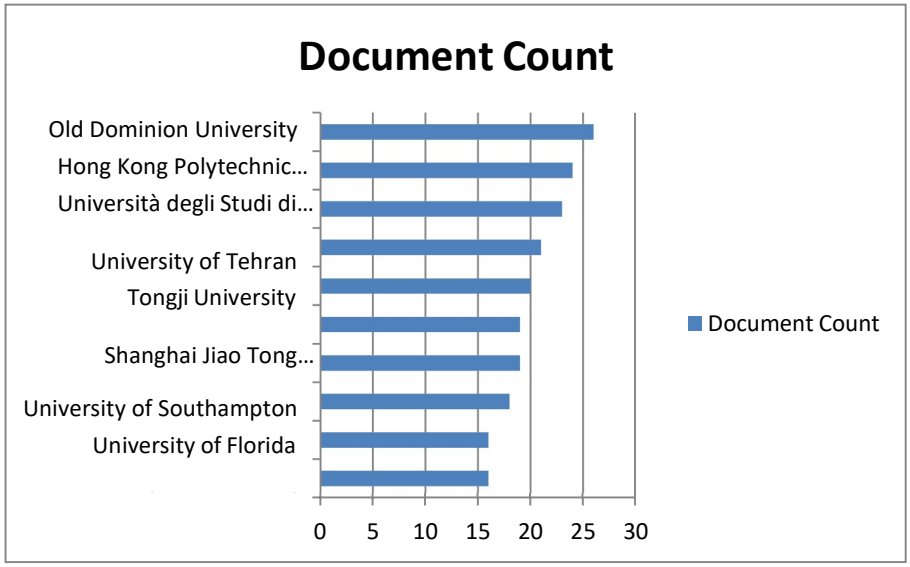

Figure 3.12 Number of Publications based on the affiliation of universities

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

3.12 AUTHOR STATISTICS

Figure 3.13 represents the data of the number of authors that have worked in the area of the supplychain or healthcare or artificial intelligence technique.

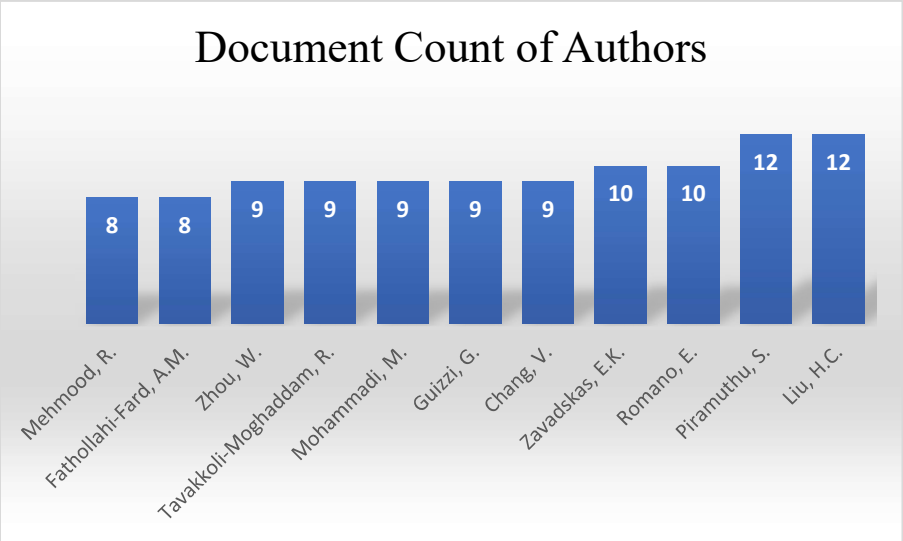

Figure 3.13 Number of Publication Count by different authors

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

3.13 STATISTICS OF DIFFERENT TYPES OF PUBLICATIONS

Figure 3.14 describes the different types of Publication Count in Journals, Articles, Conference Paper, Proceedings, etc. The statistics demonstrate that 80% of the publications are 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.

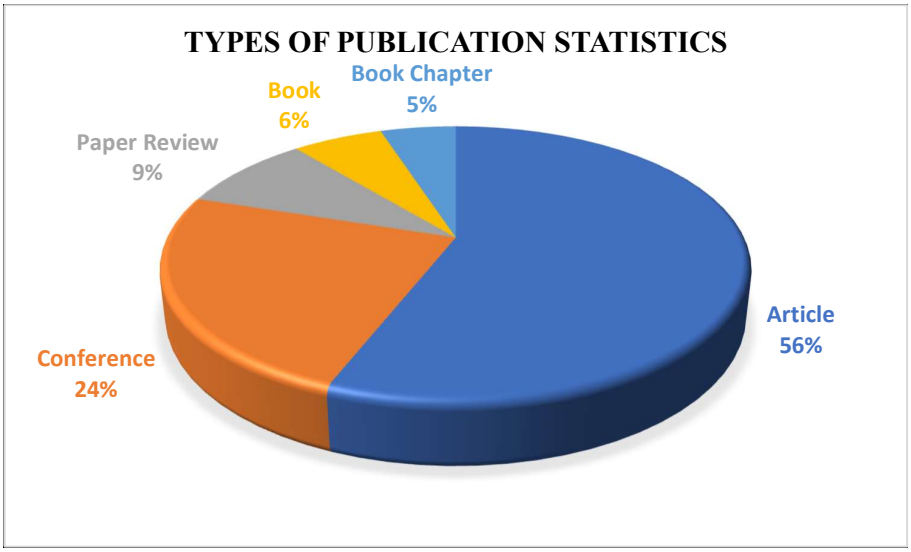

Figure 3.14 Statistics of different types of Publications.

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

3.14 ANALYSIS OF CITATIONS

Table 3.7 shows the citations of the first 2000 documents published from 2010 to 2019. The total citations for these 200 publications are 27829. The data is individually for keyword supply chain, healthcare, and artificial intelligence.

Table 3.7: Statistics report for citations of publication from the year 2010 to 2019 for the 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

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

3.15 STATISTICS ON SOURCE TITLE

Table 3.8 represents the different source titles and their publication count. It is seen from the table that the maximum numbers of publications are in the field of Computer Science.

Table 3.8: Statistics report for a number of publications from different sources

Source Title	Document Count
Lecture transcripts In Computer Science (Including Subseries); ArtificialIntelligence; 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)

3.16 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 doneso far. It focuses on the research scope that can develop interest among the researchers.

The core keywords utilised in table 1 for the analysis led to the discovery of a few new words, such as "blockchain technology," which reveals further areas that can be

investigated. The United States and China are increasing the pace at which they research this area. For India, many opportunities exist in the same field asit is one of the developing countries. The demand for the supply chain can never diminish as itis one of the core areas of practice in every industry, whether a product or service sector of thesupply chain.

3.17 CONCLUSION AND FUTURE SCOPE

The bibliometric analysis is done in the paper using SCOPUS, Google Scholar, etc., on significant keywords such as "artificial intelligence," "healthcare," and "supply chain". The variousanalyses represent the data count of journals with open access and others. The paper also represents the different types of publications in the field of the supply chain. It gives a fairidea of publication statistics by the different funding agencies, affiliations, 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 subjectareas. 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 is less, which still gives the researchers a new scope area. Also, the study fromvarious sources like the Web of Science and others can be considered for better analysis of the keyword areas.