3-2021

A Brief Bibliometric Analysis and Visualisation of Scopus and WoS databases on Blockchain Technology in Healthcare Domain

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ABSTRACT:

Background: The aim of this study is to analyse the work carried out in healthcare or medical domain using blockchain technology for privacy and security of patient's data, their healthcare records. The documents published in Scopus and Web of Science databases during the year 2016 to present (February 2021) have been considered for survey.

Methods:

Scopus and Web of Science(WoS), most popular databases are used to retrieve documents which were published between years 2016 to present. Scopus analyser and web of Science analyser are used for analysis of various parameters such as documents published per year, sources of documents, number of citations and so on. VOSviewer1.6.16 software tool is used for analysis of different units such as citations, co- authorship etc.

Results:

During our survey we have retrieved a total 598 documents related to blockchain technology in the healthcare domain which are published from year 2016 onwards from scopus database. Using a web of science database 594 documents has been retrieved for the same domain. Statistical analysis and network analysis shows that there is tremendous growth in publications from year 2019 and 2020 on blockchain technology. The United States, India and China are major contributors.

Conclusions: Databases are analyzed in terms of number of documents per year, sources of publications, authors correlation, documents per country, funding agencies etc parameters are statistically analysed. Using statistical and network analysis we can conclude that there is huge scope to work in the blockchain domain to achieve more privacy, security, and data integrity.

Keywords: Blockchain, Healthcare, data privacy, data security, healthcare records, citations, documents.

1. INTRODUCTION:

Blockchain technology came into picture in 2008 when Santoshi Nakamoto released the first white paper which demonstrates the crypto currency Bitcoin. From 2015 onwards blockchain came in many real applications to provide more security, data integrity, privacy. Blockchain is using a basic concept of peer to peer transaction so that anyone can enter and see the transaction details [2].

Every medical institution is having their own format of data storage and they have their own policies and strict restrictions on transferring or sharing their patient's data with others. Using the current process of medical data collection we can not assure the reliability and integrity of patients healthcare records [3]. Traditional healthcare systems have many problems such as storing the patient's data and transferring these data securely among the healthcare information networks[14]. Using a distributed framework of blockchain healthcare data integration can become easy and secure across all users and stakeholders [4]. To secure patient's data and make it available whenever required is one of the challenges for the medical community. Because of the distributed and immutable nature of blockchain technology, the above problem can be solved and data can be transferred securely without any tampering. Using various encryption techniques, consensus mechanisms , peer to peer network above problems can be solved by adding blockchain technology in medical healthcare systems.

1.1 Blockchain :

Technically Blockchain is defined as Distributed Decentralized peer to peer network of databases which allows any number of participants on whom we can't trust to do the transactions without interference of any third party and it is used to keep data unaltered. It's a distributed ledger which makes transactions and makes permanent and verifiable records of information. Peer to peer network, public key cryptography and distributed consensus are basically three key concepts which become the backbone of blockchain technology and transactions.

1.2 Block in A Blockchain:

The block is a record that contains the transaction data details as shown in Figure 1. It consists of the following details.

1. Hash of the block alphanumeric number to identify block.
2. Hash of the previous block.
3. Timestamp
4. Nonce random number used to vary the value of the hash.
5. Merkel root hash of all the hashes of all the transactions the block.
6. Transaction data which contains details of several transactions.

1.3 Characteristics of Blockchain:

As a peer to peer network any one can join the blockchain network without tampering the data is one of the basic characteristics of blockchain. Timestamp is used to prove the existence of records within a certain period of time which can be further helpful to identify any unauthenticated alteration. Data once written on the blockchain remains unaltered so blockchain is Immutable.

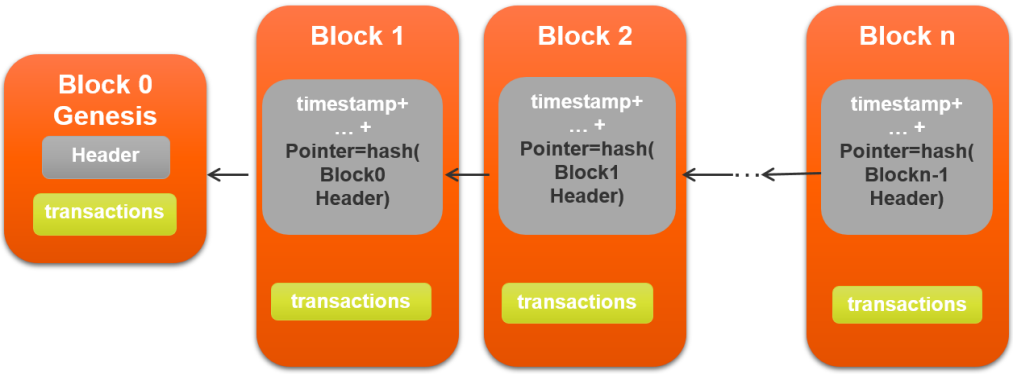

Figure 1: Representation of Block in Blockchain

As a decentralized and distributed nature of blockchain there is no failure of the network. Blockchain are irrevocable by the sender because implementing a revocation scheme is complex and because the blockchain is a public resource, complexity imposes costs on other users.

Due to all characteristics of blockchain technology, it is very much important to keep patients' healthcare records secure and transact it securely as per the need.

Currently blockchain and IoT devices also play an important role with more opportunities to secure patient's records in the healthcare system with wearable devices [12][13].

This bibliometric survey helps to understand till now work carried out in the medical domain using blockchain technology.

2. MATERIALS AND METHODS:

2.1 Database Collection:

Scopus, Web of Science, Google scholar, Scimago these are very popular databases worldwide having a variety of research articles in various domains. Out of all these we have referred most popular databases i.e. Scopus and web of science for our bibliometric survey analysis. We have done our analysis on the use of blockchain technology in the healthcare domain. The keywords used for search have retrieved a total of 598 documents from scopus and 594 documents from the web of science and their publication details. The different keywords are used for the searching of the databases, the retrieved data in terms of documents are from various countries, in different languages, restrictions are not added while searching data with given keywords. This information is used for the further bibliometric survey.

Table 1 shows the primary and secondary keyword used for the documents searching from Scopus database.

Table 1: Primary and Secondary Keywords

Fundamental Keywords	Blockchain Technology in Medical Healthcare systems
Primary Keywords	Blockchain AND in AND medical AND healthcare
	Blockchian AND medical OR healthcare
Secondary Keyword	Blockchain AND for AND patients AND data AND security

Source: Scopus database (accessed on 15th February 2021)

Web of Science Database (accessed on 25th February 2021)

Following are the queries for searching the documents in Scopus:

TITLE-ABS-KEY (blockchain AND in AND medical AND healthcare) OR TITLE-ABS-KEY (blockchain AND for AND patients AND data AND security))

(TITLE-ABS-KEY (blockchain AND in AND medical AND healthcare) OR TITLE-ABS-KEY (blockchain AND for AND patients AND data AND security)) AND PUBYEAR>2014

(TITLE-ABS-KEY (blockchain AND in AND medical AND healthcare) OR TITLE-ABS-KEY (blockchain AND for AND patients AND data AND security)) AND PUBYEAR>2014 AND PUBYEAR<2021

(TITLE-ABS-KEY (blockchain AND in AND medical AND healthcare) OR TITLE-ABS-KEY (blockchain AND for AND patients AND data AND security)) AND PUBYEAR>2014 AND PUBYEAR<2021 AND (LIMIT-TO (SUBJAREA,"COMP") OR LIMIT-TO (SUBJAREA,"ENGI"))

In web of science the keywords used for searching an articles on work of Blockchain technology in medical or healthcare domain are

TS: (“Blockchain” AND (“Healthcare” OR “Medical”)) Timespan = 2016-2021

2.2 Initial Search Outcomes:

On the Scopus database, using the different keywords related to our work, the publications are obtained. These are analysed according to the language. It is found that, English language has the

highest number of publications of 586, refer Table 2. While in WoS database 594 publications are retrieved out of them 541 are in English language followed by 43 in Korean language. Out of 594 records from WoS database, 542 records are from Web of Science core collection, 49 records are from KCI Korean Journal database, 2 records are from Russian Science Citation Index and 1 record is from SciELO science Citation Index.

Table 2: Publication analysis based on Language

Language of Published Document	Publication Count from scopus	Publication Count from WoS
English	587	541
Korean	-	43
Chinese	5	1
German	2	3
Russian	-	3
French	1	1
Greek	1	1
Italian	1	-
Portuguese	1	-
Spanish	-	1

Source: Scopus database (accessed on 15th February 2021)

Source: Web of Science database (accessed on 25th February 2021)

2.3 Publication outcome based on Top 10 Keywords:

During the search, many keywords are found in addition to the fundamental keywords. Top 15 keywords are listed here in Table 3. Disease is the keyword having the highest publications. Generally all these keywords are found to be related to health and technology.

2.3 Publication Outcome based on Funding Sponsor:

Using Scopus and WoS analyser, analysis of 598 and 594 documents Table 4 shows detailed analysis of number of publications sponsored by funding agencies. National Natural Science Foundation of China has funded 43 projects and 77 projects which are maximum among all scopus and WoS

databases respectively. Top 10 funding agencies from different countries who have supported to carry out healthcare research in blockchain technology are listed in Table 4.

Table 3: Publication Analysis based on Top 10 keyword Analysis

Sr. No.	Keyword	# Publications from Scopus Database
1	Blockchain	512
2	Health Care	243
3	Electronic Health Record	122
4	Healthcare	113
5	Data Privacy	112
6	Human	110
7	Privacy	97
8	Digital Storage	90
9	Security	85
10	Internet of Things	83

Source: Scopus database (accessed on 15th February 2021)

Table 4: Publications based on Funding Agencies

Sr. No.	Funding Agency	# Scopus Publications	# WoS Publications
1	National Natural Science Foundation of China	43	77
2	National Research Foundation of Korea	12	4
3	Fundamental Research Funds for the Central Universities	8	15
4	National Basic Research Program of China (973 Program)	8	-
5	Conselho Nacional de Desenvolvimento Científicoe Tecnológico	7	-
6	Institute for Information and Communications Technology Promotion	7	2
7	Ministry of Science and ICT, South Korea	7	3
8	Ministry of Science, ICT and Future Planning	7	
9	National Institutes of Health	7	11
10	United Arab Emirates University	7	4

Source: Scopus database (accessed on 15th February 2021

Source: Web of Science database (accessed on 25th February 2021)

3. PERFORMANCE ANALYSIS:

For Scopus and WoS database analysis we have used VOSviewer 1.6.16 [9][10] software which effectively gives us network analysis of co-citations, co-occurrences of authors, bibliographic coupling.

VOSviewer 1.6.16 [9][10] is the software that is used for the database analysis in addition to the analysis form Scopus. It provides a very effective way to analyse the citations analysis in terms of sources, authors, organizations, countries, co-occurrences of keywords, bibliographic couplings etc. Following are the list of different types of analysis performed on Scopus database of Blockchain related papers in the medical / healthcare domain.

Statistical Analysis of Scopus and WoS Databases on use of Blockchain in the Medical domain.

1. Documents by Source
2. Documents by Year
3. Documents by Subject area
4. Documents by Type
5. Documents by Country
6. Documents by Author
7. Documents by Affiliation
8. Documents by top Funding Agencies

Network Analysis of Databases:

1. Co-authorship: Authors, organizations, country
2. Co-occurrence: All keywords, Author keywords, Index keywords
3. Citation Analysis: Sources, authors, organizations, country
4. Bibliographic coupling: Documents, Authors

4. RESULTS AND DISCUSSIONS:

Analysis performed on the database retrieved from Scopus is by two different ways, statistical analysis of database and network analysis.

Statistical analysis is done through Scopus while VOSviewer1.6.16 tool is used for network analysis.

4.1 Statistical Analysis:

4.1.1 Document Analysis by Sources and year wise publication:

The database of blockchain documents retrieved from Scopus includes different sources such as conferences, journals, book chapters, notes, articles, reviews and so on. Publications of different documents according to their year of publications are shown in the table. Figure shows the graphical representation of the different sources with the number of documents published year wise.

Table 5: Document analysis by year wise publication

Year of Publication	Number of Documents Published in Scopus	Number of Documents Published in WoS
2021	7	31
2020	258	293
2019	208	169
2018	75	79
2017	16	20
2016	4	2

Source: Scopus database (accessed on 15th February 2021)

Source: Web of Science database (accessed on 25th February 2021)

From Table 5, it is observed that day by day blockchain is becoming more popular technology as many are working on it. It is observed from the analysis that, highest number of publications is in the year of 2019 followed by 2020. From year 2019 it became more popular. As per the statistics further there is more scope to work in blockchain technology for resolving healthcare issues. Figure shows in detail analysis of publication of papers in different sources. In 2020 , 10 or more than 10 papers will be published in all different sources such as IEEE access, Advances in Intelligent Systems in Computing, Journal of Medical Internet research, ACM international conference proceedings etc. in this area. From the WoS database it was observed that , In 2020 47 papers are published in IEEE access, 10 papers are published in Journal of Medical Internet Research, 17 papers are published in Sensors Journal.

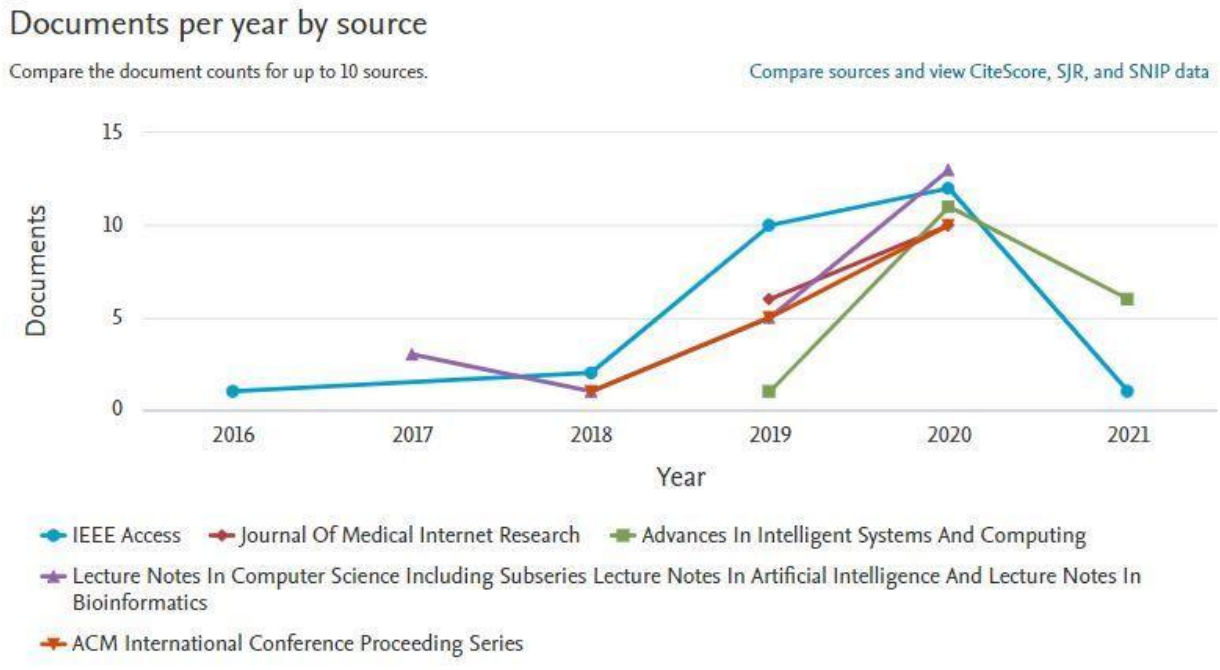

Figure 2a: Analysis of documents per year by sources (Scopus)

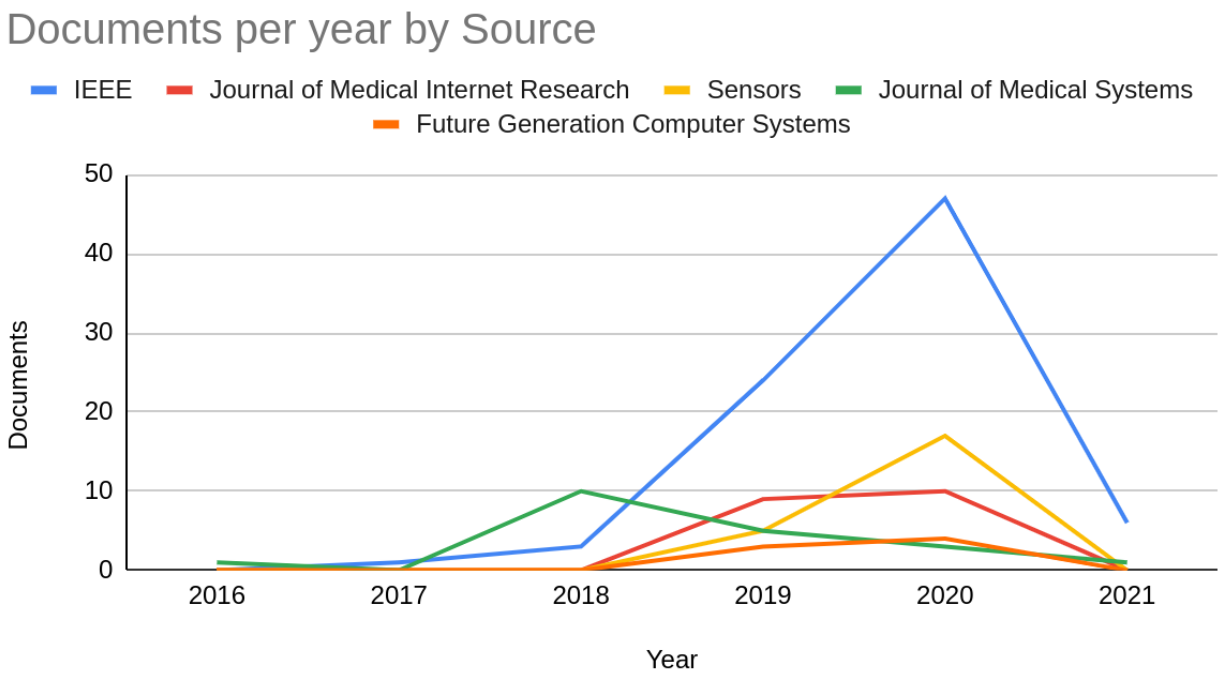

Figure 2b: Analysis of documents per year by sources (Scopus and WoS)

Source: Web of Science database (Data accessed on 25th February 2021)

4.1.2 Documents by Subject Area:

To keep a patient's healthcare record secure or for authentication of medical data blockchain technology is used. Maximum papers are coming under computer science (32.4 %) and engineering fields (20.3%). More than 50 % researchers in the Computer science and Engineering domain have been working on the Blockchain and medical domain. Remaining papers are from medicine, Decision science, biochemistry, social science etc.

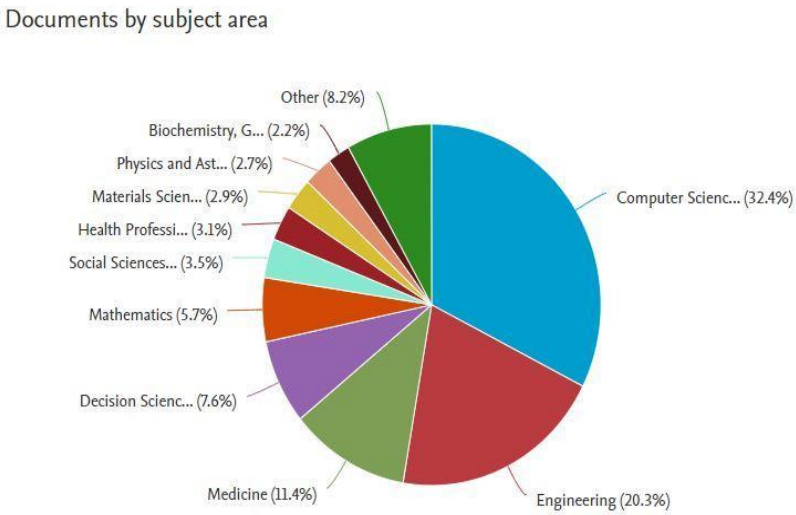

Figure 3a: Analysis of documents by search area

Source: Scopus Database (assessed on 15th February 2021)

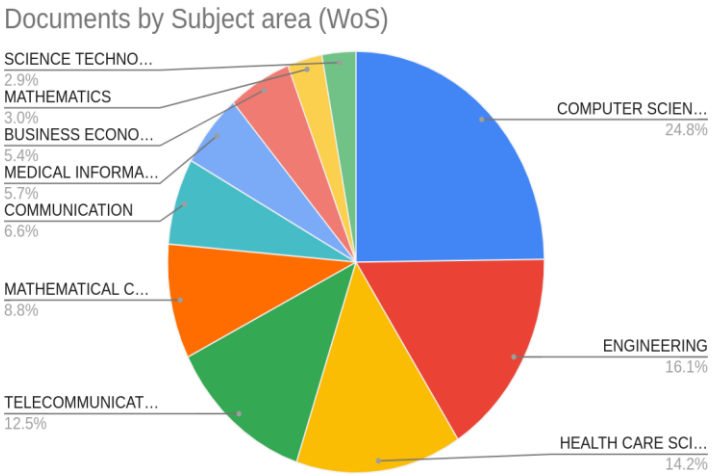

Figure 3b: Analysis of documents by search area

Source: Web of Science Database (accessed on 25th February 2021)

4.1.4. Documents by Type:

Analysis of documents by Type indicates, most of the publications are from conferences (45.3 %) followed by journal articles (38.8%). Around 15 to 16 % articles are from other sources such as book chapters, conference review, surveys etc. In WoS databases 70% documents are articles.

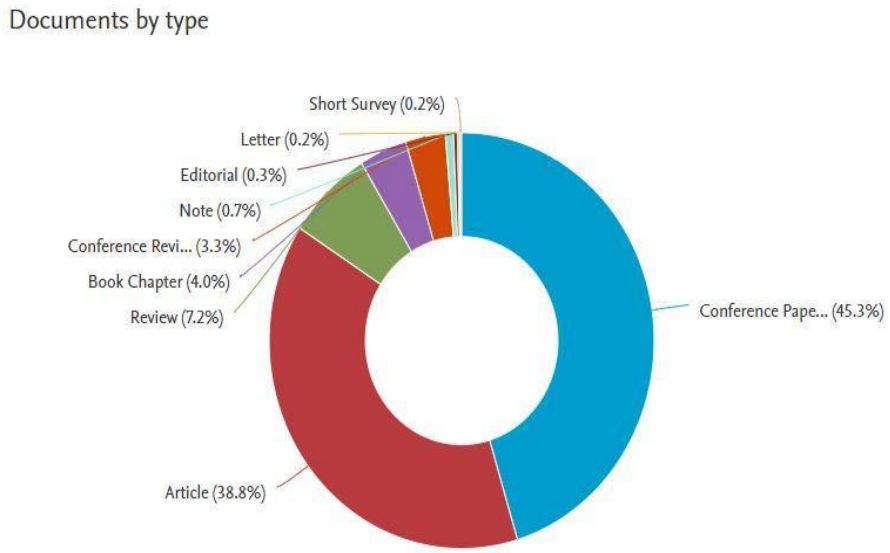

Figure 4a: Analysis of documents by type

Source: Scopus Database (assessed on 15th February 2021)

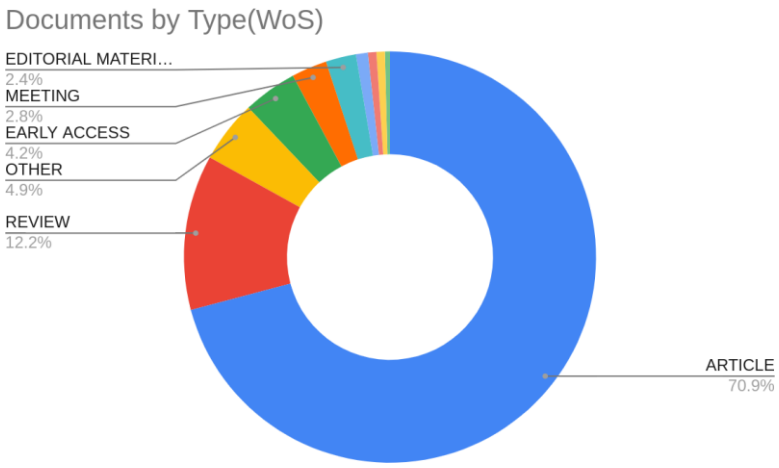

Figure 4b: Analysis of documents by type

Source: Web of Science Database (accessed on 25th February 2021)

4.1.5 Analysis of Publications by Country or Territory:

Scopus database is analysed for countries by considering the number of documents published. It shows that the USA has the highest number of documents published between the elected timeline followed by India and then China. USA and INDIA have published more than 110 papers during the specified period. In WoS databases the highest publication count i.e. 144 from the United States followed by China and India.

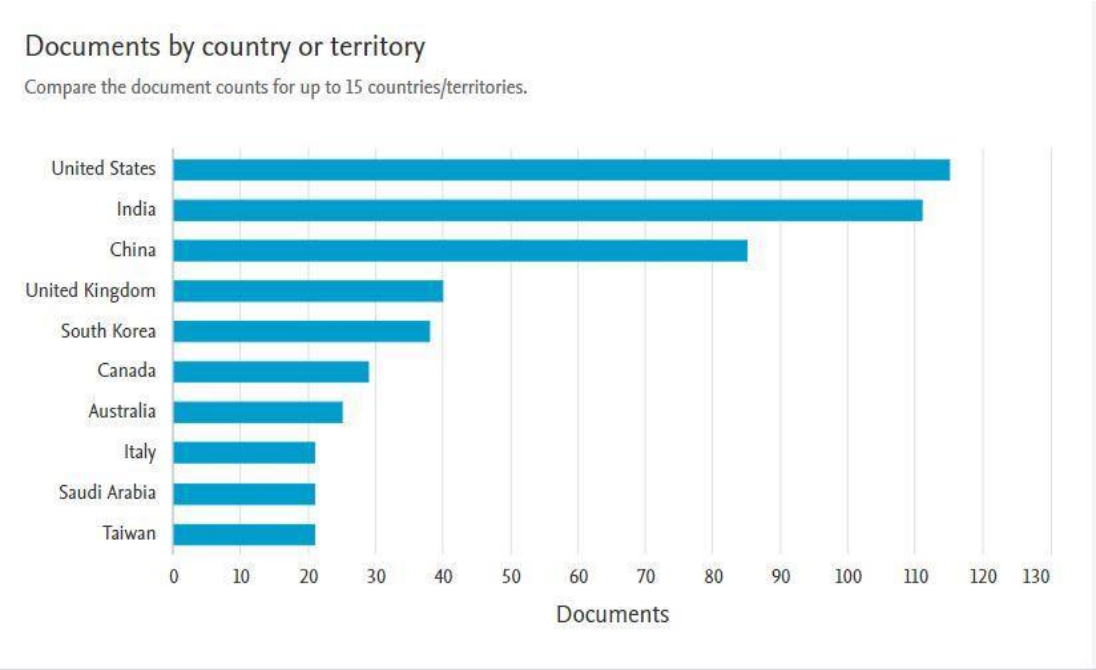

Figure 5a: Analysis of publications by Country

Source: Scopus Database (assessed on 15th February 2021)

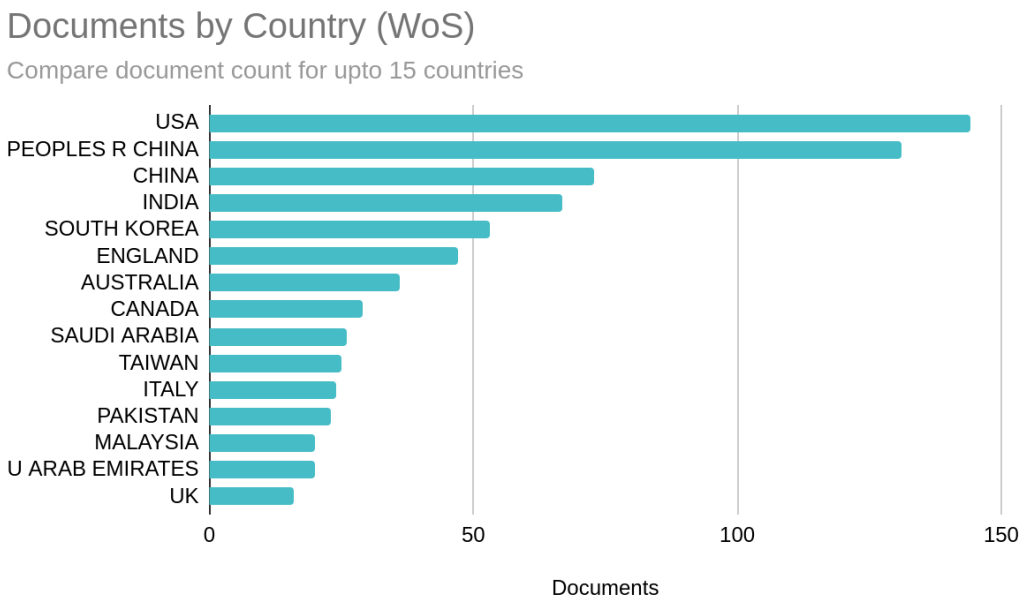

Figure 5b: Analysis of publications by Country

Source: Web of Science Database (accessed on 25th February 2021)

4.1.6 Documents by Author: In this analysis, authors with the number of publications are considered. Graphs of Top 10 authors who have published papers in Scopus and WoS databases with this comparison are shown here. It is found that author Jayaraman R having the highest publication

count of 10 in web of science databases and author Tanwar S. has the highest number of publications in Scopus databases. i.e. 8 and also has 7 publications in web of science databases in healthcare and blockchain domain. Maximum authors have an approximate average publication count 4-6

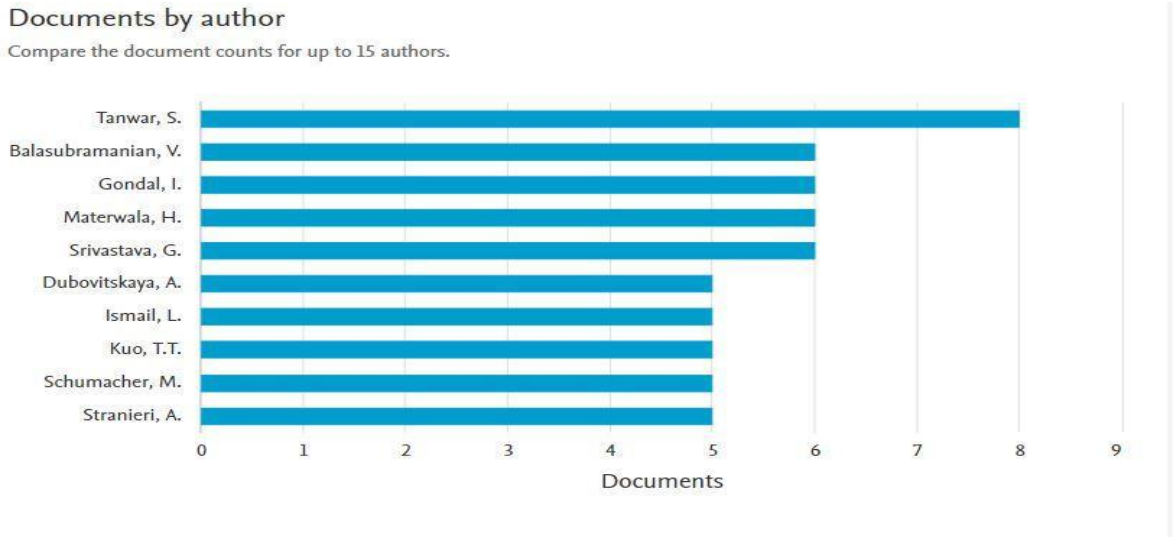

Figure 6a: Analysis of number of documents by Author

Source: Scopus Database (assessed on 15th February 2021)

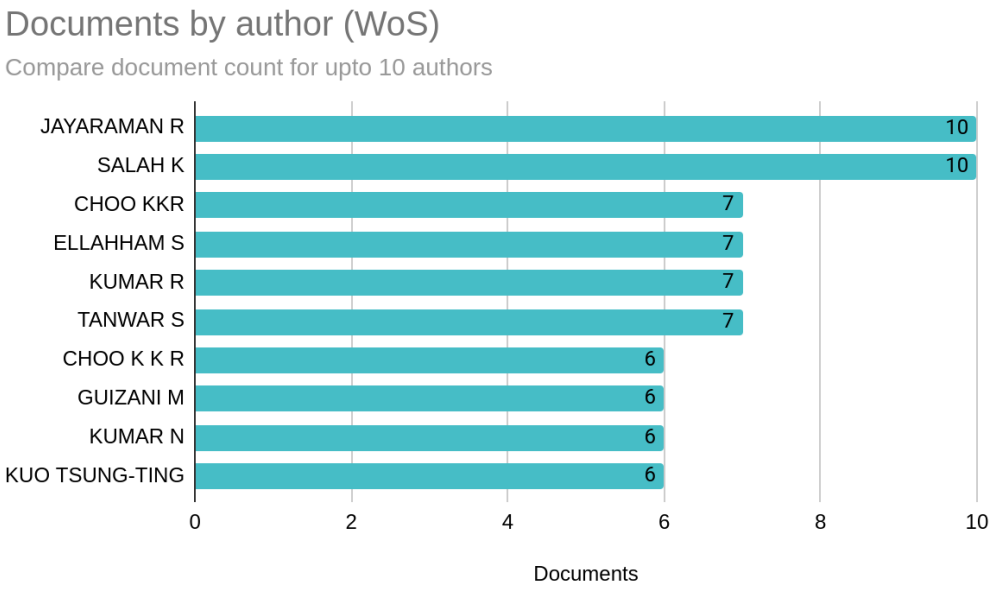

Figure 6b: Analysis of number of documents by Author

Source: Web of Science Database (accessed on 25th February 2021)

4.1.7Documents by Affiliations:

In this analysis, top 10 affiliations are considered. It is found that, United Arab Emirates University has 10 publications on this area. Most of the affiliations are having 5 or more than 5 papers published on this domain.

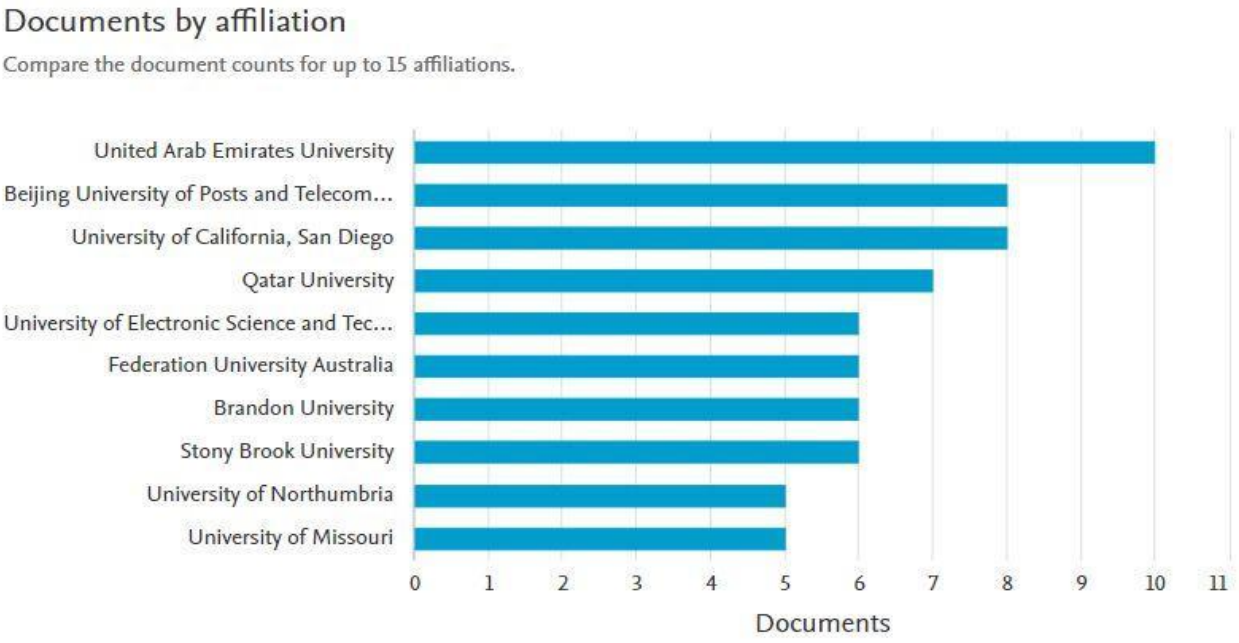

Figure 7a: Analysis of publications by Affiliation

Source: Scopus Database (assessed on 15th February 2021)

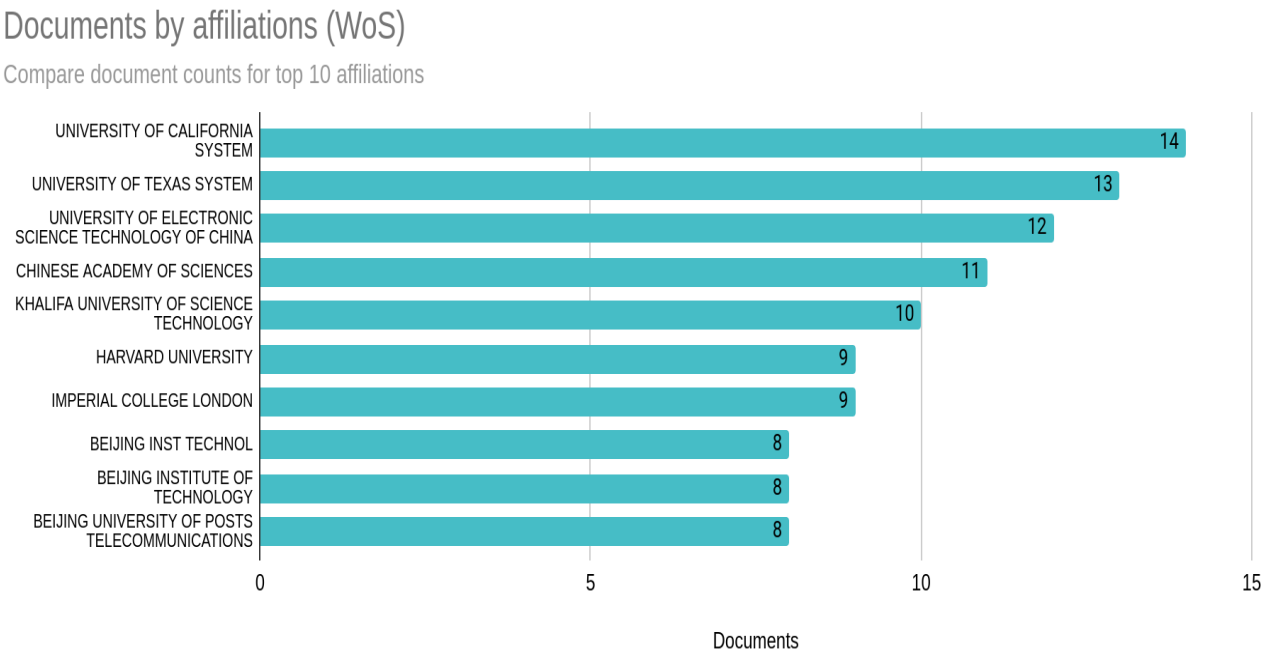

Figure 7b: Analysis of publications by Affiliation

Source: Web of Science Database (accessed on 25th February 2021)

4.1.8 Analysis by Funding Sponsors:

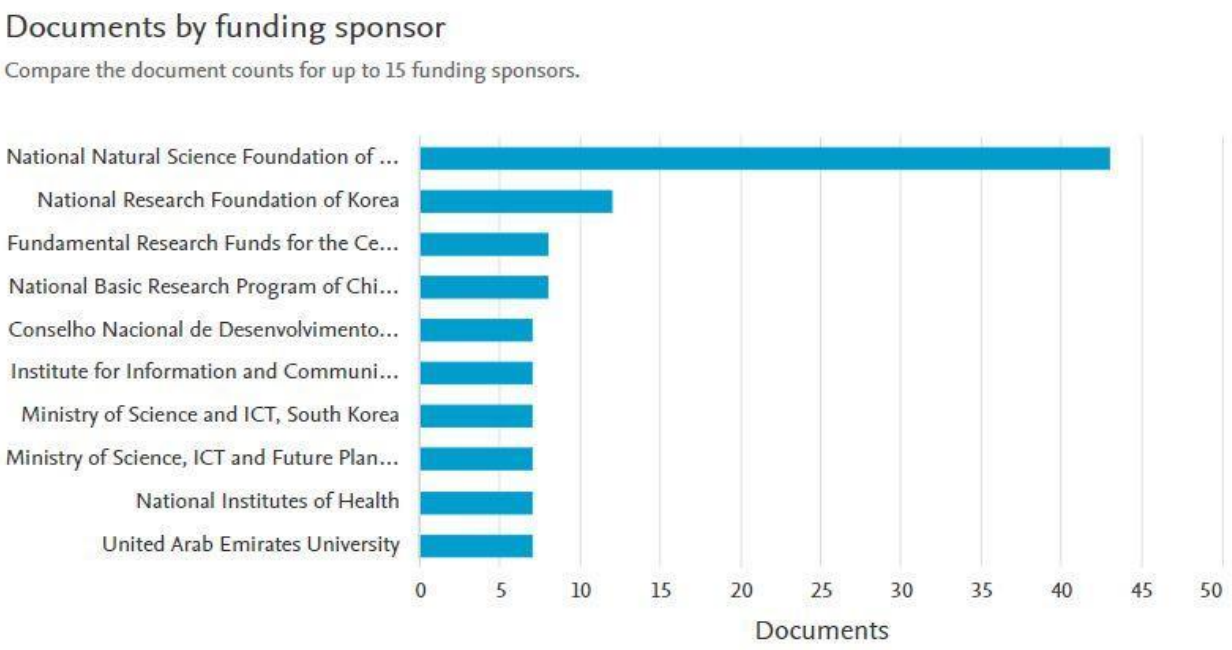

Figure 8a: Analysis of documents by funding sponsor

Source: Scopus Database (assessed on 15th February 2021)

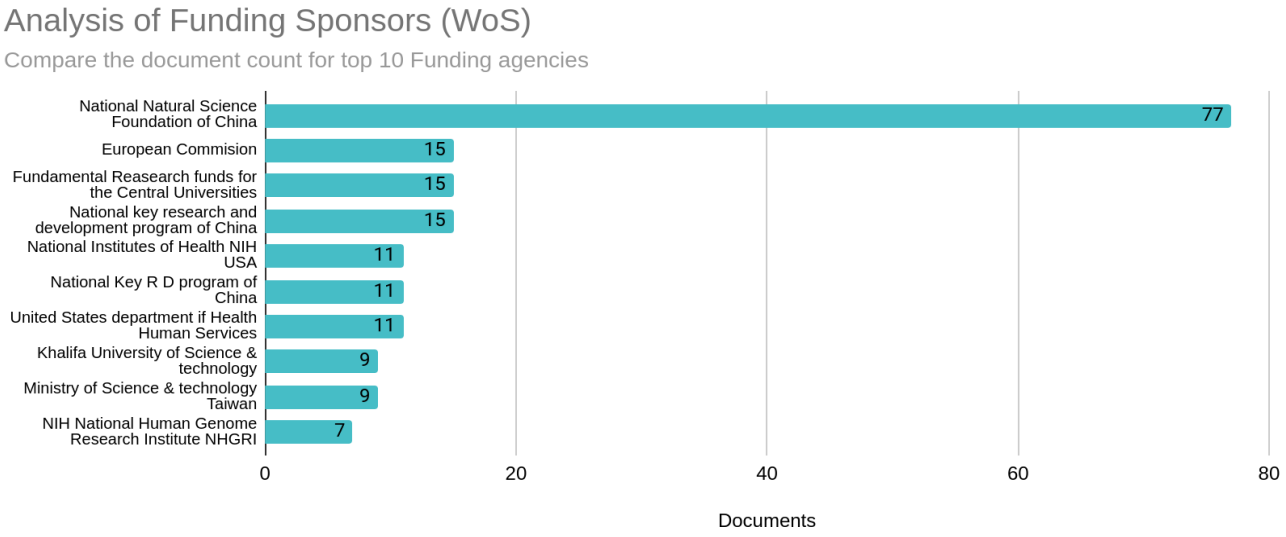

Figure 8b: Analysis of documents by funding sponsor

Source: Web of Science Database (accessed on 25th February 2021)

In this case, China is ahead amongst all, with highest funding. The National Nature Science Foundation China funded 43 projects which are published in Scopus database and 77 documents of funded projects in the web of science database.

4.2 Network Analysis:

For network analysis of Scopus database all retrieved 598 documents and for the web of science database 598 documents are analysed using VOSviewer 1.6.16 software tool[9][10].

4.2.1 Co-authorship Analysis:

A) Co-authorship in terms of Authors:

This parameter of analysis is considered with 03 different parameters related to it. The authors, organizations, and countries are considered for analysing this parameter. Documents with a very large number of authors are ignored in this analysis. This number is considered as 10. Threshold is considered as 2 for the minimum number of documents of an author. It is seen that out of 1731 authors, 279 authors met the criteria from the scopus database and from the web of science database out of 1640 authors , 185 met the criteria.

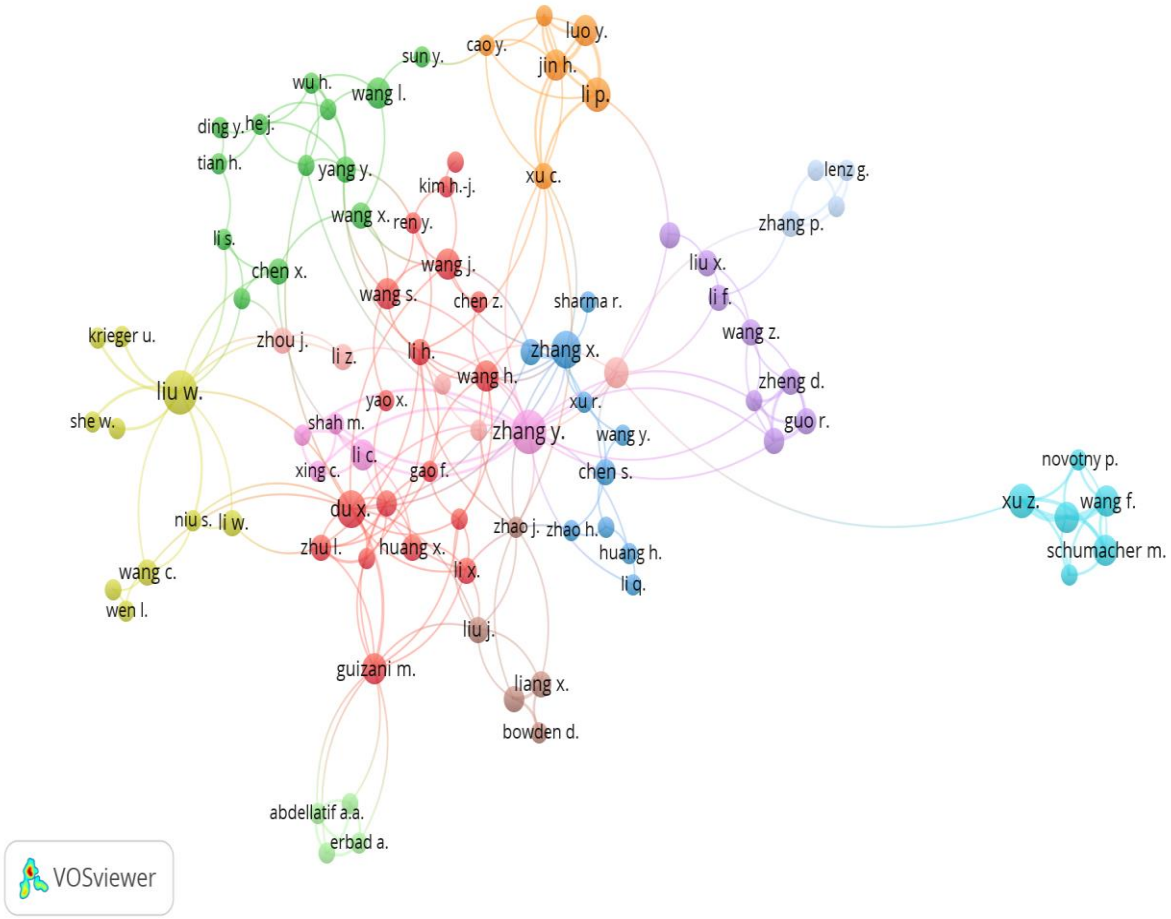

Figure 9a: Network Analysis of Co-authorship in terms of authors(Scopus)

Source: Scopus Database (assessed on 15th February 2021)

The total strength of the co-authorship is calculated with other authors. By this method, the link strengths are obtained. Zhang Y. found with the highest link strength of 23 with the total number of citations to be 19 for 8 different documents. Here a total of 60 authors found to have the relation in

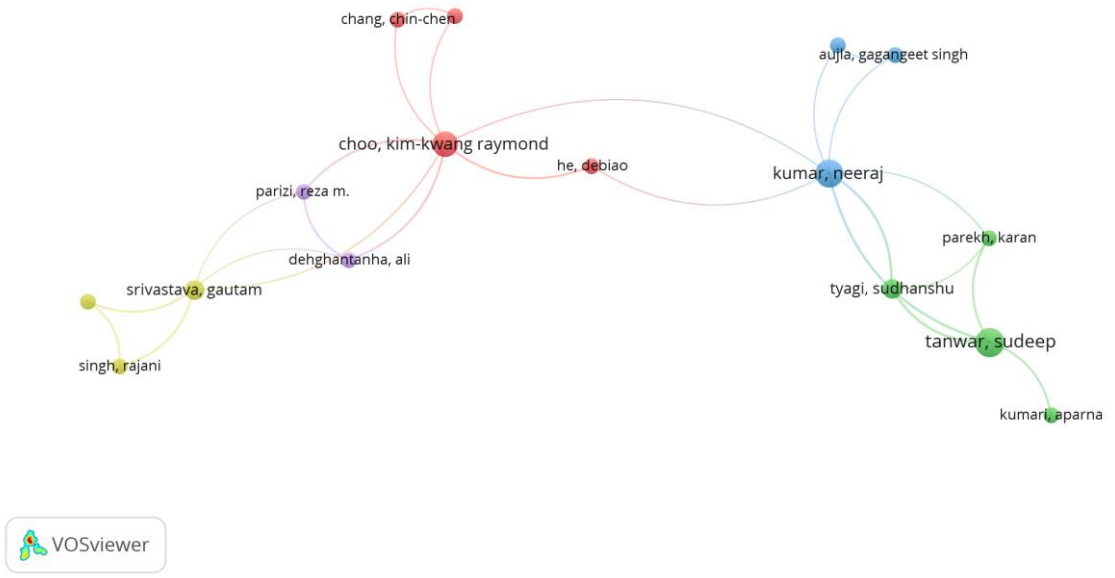

Figure 9b: Network Analysis of Co-authorship in terms of authors(Web of Science)

Source: Web of Science Database (accessed on 15th February 2021)

terms of co-authorship with 10 or more than 10 link strengths. Out of 279, the largest set of connected authors includes 94 items which are shown in the figure. In WoS author Jayaraman found the highest link strength of 37 with total citations 13 for 10 different documents. The largest set of connected items consists of 16 itesm out of 185.

B) CO-authorship in terms of Organizations:

Co-authorship in the unit of organizations is calculated considering minimum 02 documents in organizations with neglecting the citation of the same, 59 organizations meet the criteria out of 1276 number of total organizations that are shown in the figure. A total of 4 organizations have the highest link strength of 6 with the highest citations of 154 Stony Brook University (SBU),NY,United States (with 2 documents).

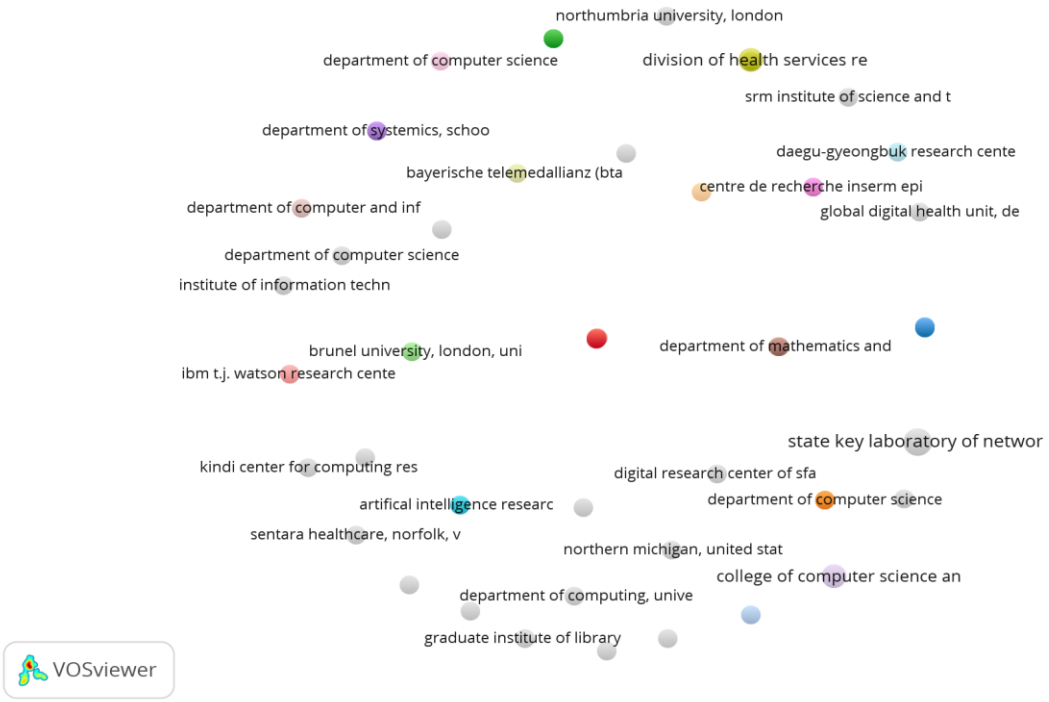

Figure 10: Network Analysis of Co-authorship in terms of organizations

Source: Scopus Database (assessed on 15th February 2021)

C) Co-authorship in terms of Country:

Co-authorship can also be obtained in relation to the country. A total of 63 countries are there, in which these databases are present. After considering the threshold of minimum 5 documents in a country, 34 countries met the threshold. Here, the United States found to have the highest citations of 2884 for 116 documents, and the link strength of 80, that is also highest amongst all. As far as the number of documents are concerned, India is at second highest of all with 654 citations for 112 documents with total link strength of 50. Out of 34 , 10 countries are having citations above 100.

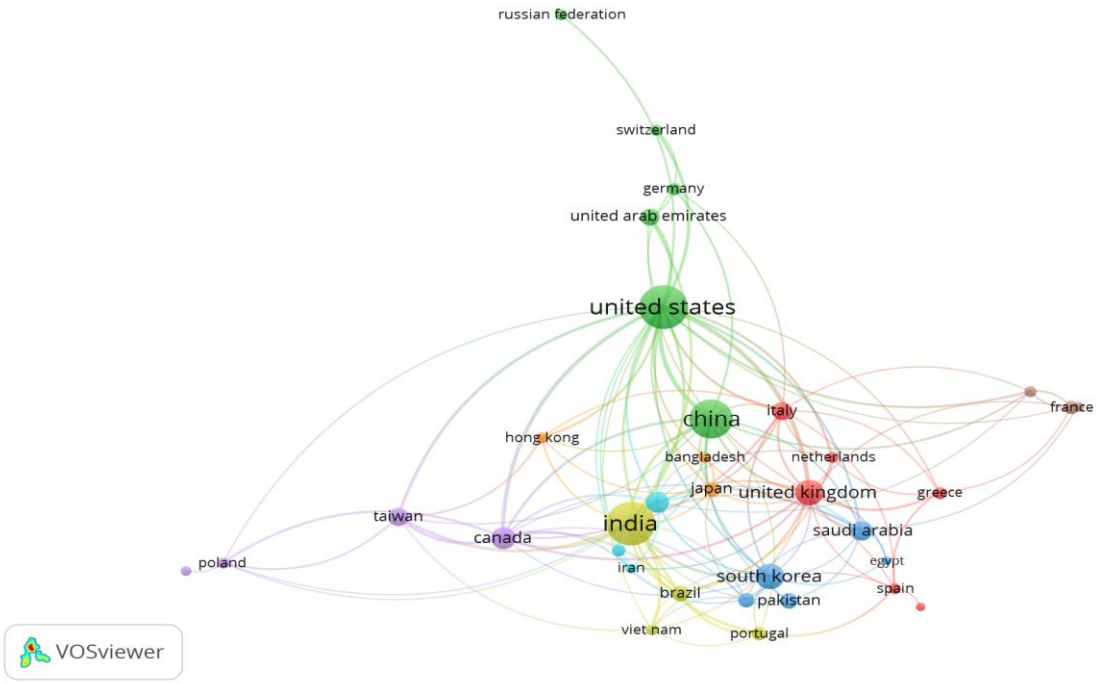

Figure 11: Network Analysis of Co-authorship in terms of country

Source: Scopus Database (assessed on 15th February 2021)

4.2.2. Network Analysis of Co-occurrences:

A) Co-occurrence analysis in terms of all keywords:

For the analysis of co-occurrences, different keywords are considered. Minimum number of occurrences in the keywords is considered to be 5. Out of 3321 keywords, 312 keywords met the threshold. Occurrence of Blockchain keyword is 514 and total link strength is 4980.

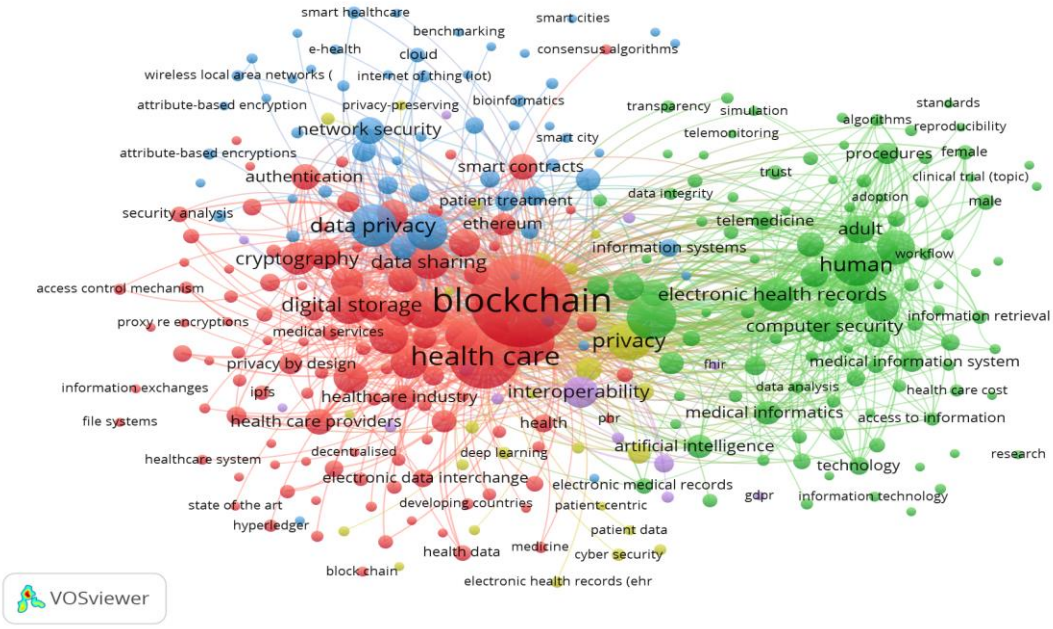

Figure 12: Network Analysis of Co-occurrences in terms of all keywords Source:

Source: Scopus Database (assessed on 15th February 2021)

B) Co-occurrence analysis in terms of Author keywords:

Co-occurrence of author keywords is analysed with the minimum threshold of 5 per author. Out of 1219 keywords by the authors, 87 keywords met the threshold.

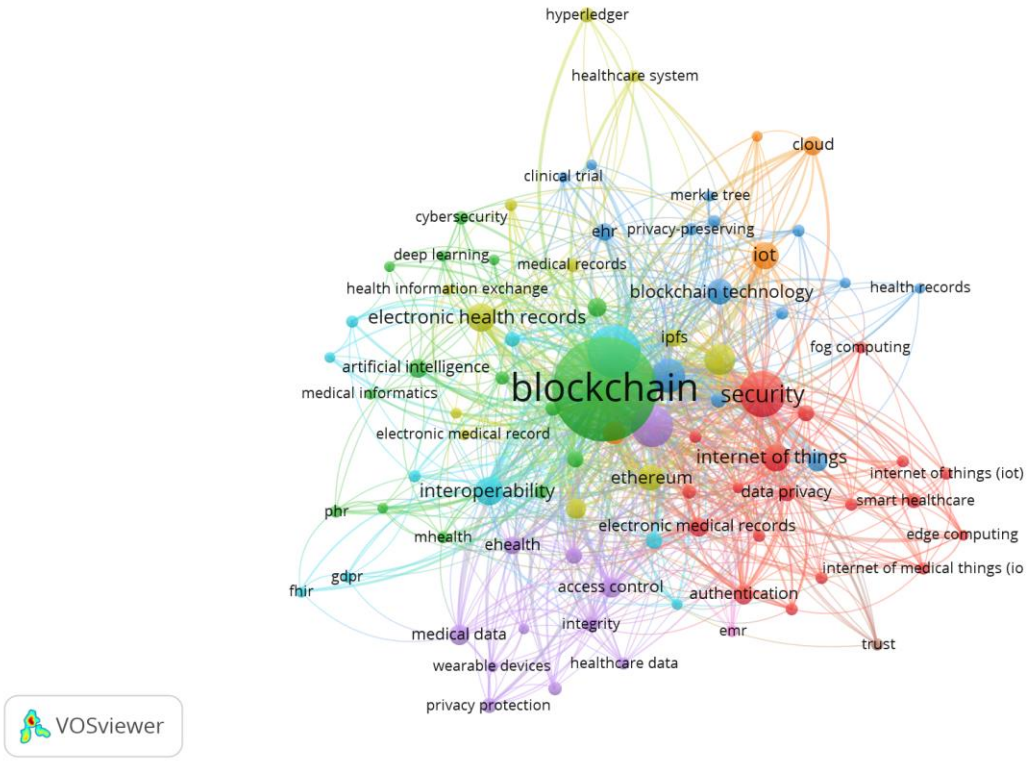

Figure 13: Network Analysis of Co-occurrences in terms of author keywords

Source: Scopus Database (assessed on 15th February 2021)

C) Co-occurrence analysis in terms of index keywords

Co-concurrence is also considered by index keywords of 2480, only 257 met the threshold which is shown in Figure 14.

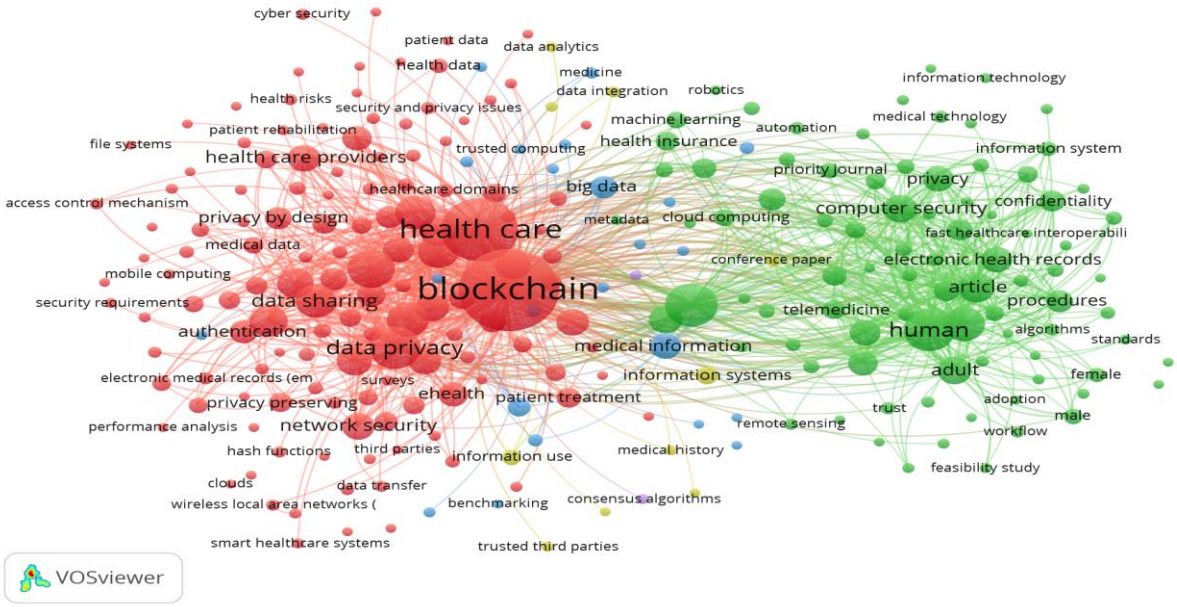

Figure 14: Co-occurrence analysis in terms of index keywords

Source: Scopus Database (assessed on 15th February 2021)

4.2.3. Network Analysis of Citations:

This analysis is done with the units of analysis including documents, sources, authors, country and organization.

A) Citation Analysis of Documents:

Out of a total of 598 documents, minimum 5 citations are considered as a threshold per document. So 178 documents met the threshold. Yue x (2016) has the highest number of citations 399 and the link strength is 48.Refer figure 15.

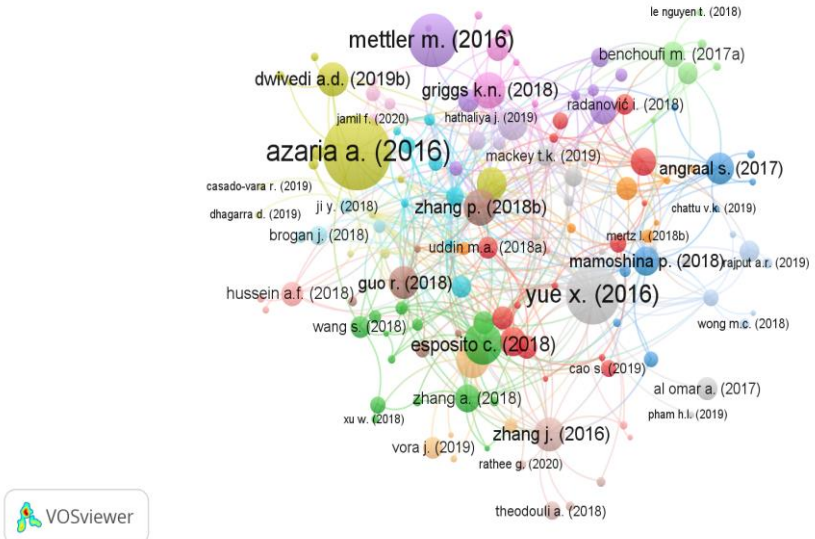

Figure 15: Network Analysis of citations in terms of documents

Source: Scopus Database (assessed on 15th February 2021)

B) Citation Analysis of Sources:

Citation analysis of sources is obtained by considering the threshold of 5 citations per source. Out of the 326 sources only 16 met the threshold which is shown in Figure 16. Journal of Medical Systems has got maximum citations of 1073 for 15 different documents.

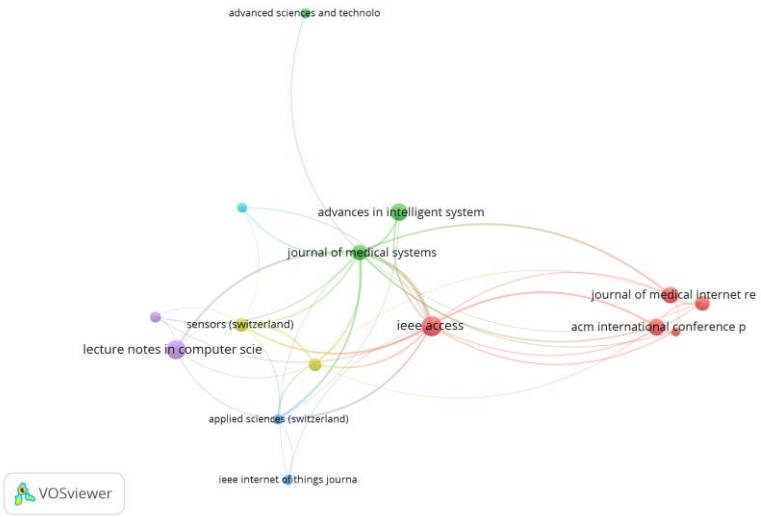

Figure 16: Network Analysis of citations in terms of sources

Source: Scopus Database (assessed on 15th February 2021)

C) Citation analysis by Authors:

Threshold considered here is 3 citations per author. A total of 109 authors met the threshold amongst the total of 1795 authors. Wang h. has maximum citations of 406 for 4 documents with total link strength as 83. Total 28 authors have more than 100 citations for their documents. Refer figure 17.

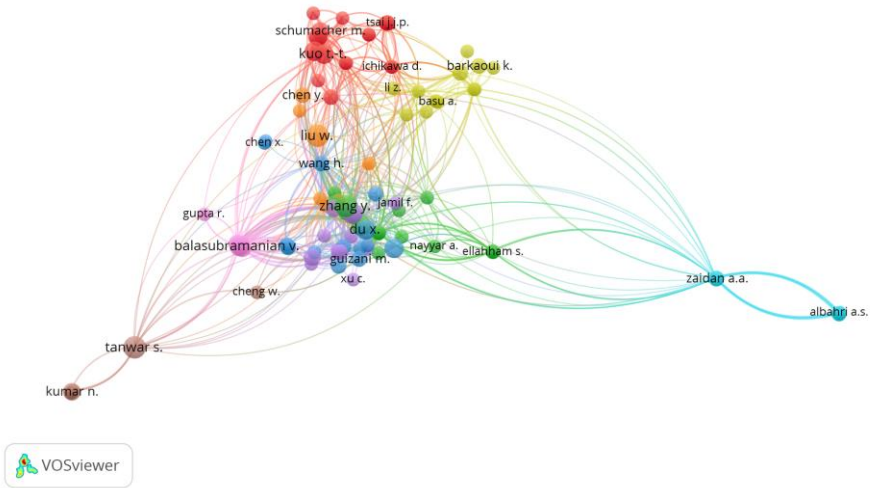

Figure 17: Network Analysis of citations in terms of authors

Source: Scopus Database (assessed on 15th February 2021)

D) Citation analysis by organization:

Considering minimum documents of 2 per organization as threshold, 69 organizations met the threshold out of 1305 organizations as per shown in figure 18. State key laboratory of networking and switching technology, Beijing University of posts and telecommunications, Beijing, China has Maximum citations of 176.

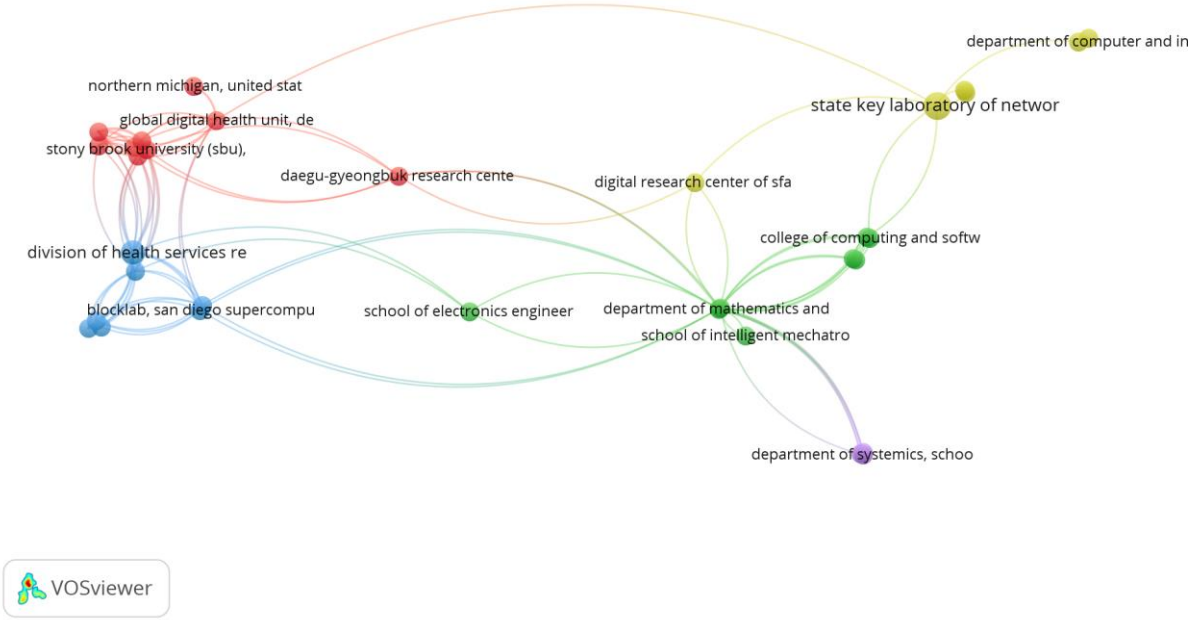

Figure 18: Network Analysis of citations in terms organizations

Source: Scopus Database (assessed on 15th February 2021)

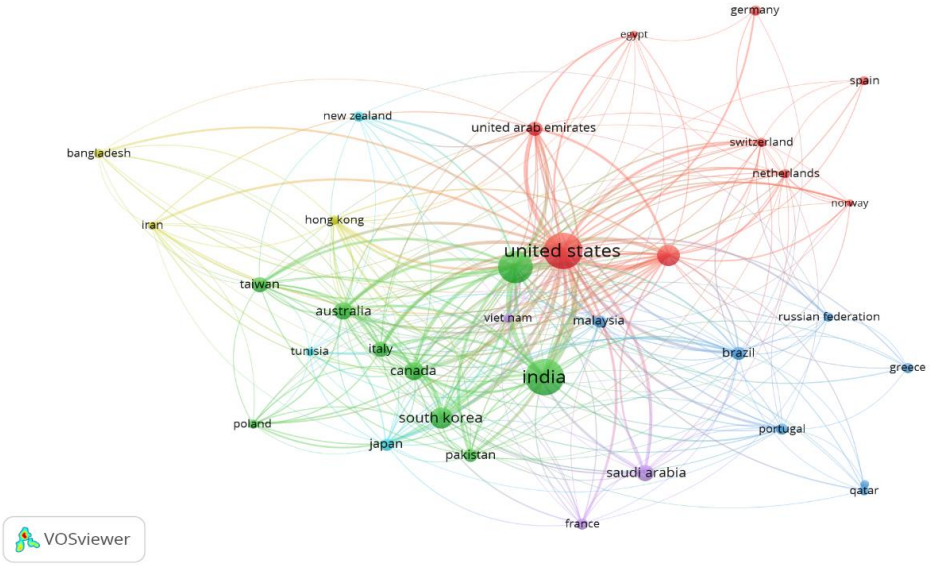

Figure 19: Network Analysis of citations in terms of Countries

Source: Scopus Database (assessed on 15th February 2021)

E) Citation analysis by country:

Total of 104 countries 34 met the citation criteria considering a threshold of minimum 5 citations per country. The United States has the maximum number of citations as 2884, followed by China 1761, followed by India 654 number of citations. Network analysis is shown in figure 19.

4.2.4. Network Analysis of Bibliographic Coupling:

A) Bibliographic Coupling of Documents:

Bibliographic Coupling of Documents by considering minimum 5 citations per document, out of 598 documents 178 met the threshold. Azaria A. (2016) has 641 as highest citations.

Figure 20: Network Analysis of bibliographic coupling of documents

Source: Scopus Database (assessed on 15th February 2021)

B) Bibliographic coupling of Authors:

Considering, 3 documents per author as a minimum threshold value. Out of total 1795 authors, 109 authors met the threshold criteria. Wang H. has highest citations as 406 while Zaidan A.A. and Zaidan B.B. has the highest link strength as 6301 among all authors. Network analysis diagram is shown in figure 21.

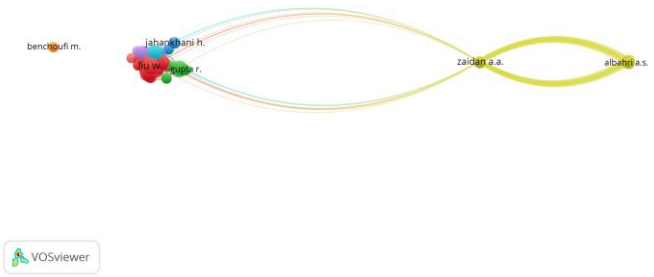

Figure 21: Network Analysis of bibliographic coupling of authors

Source: Scopus Database (assessed on 15th February 2021)

4.2.5 Network Analysis by Co-Citations using cited Authors:

Considering the minimum number of citations of an author as 20, out of 19826 authors 655 met the threshold. Out of total 1795 authors, 109 authors met the threshold criteria. Wang H. has highest citations as 406 while Zaidan A.A. and Zaidan B.B. has the highest link strength as 6301 among all authors. Refer Figure 22.

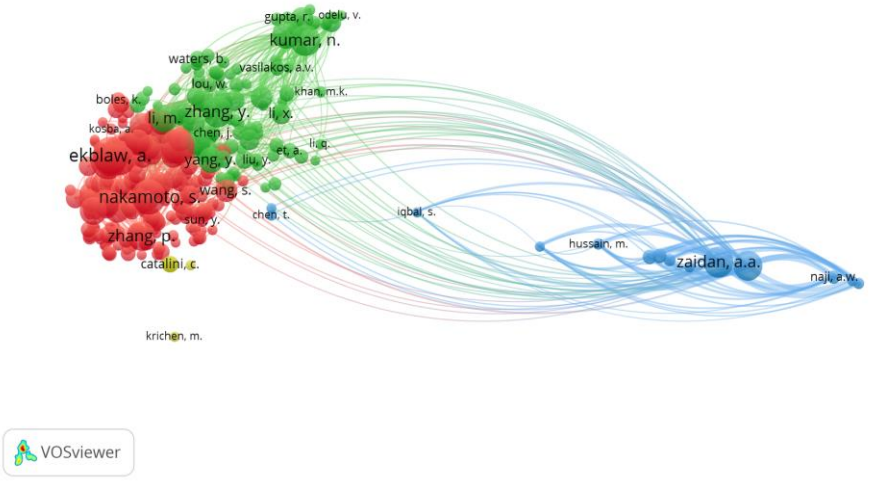

Figure 22: Network Analysis of Co-citations using cited authors

Source: Scopus Database (assessed on 15th February 2021)

5. CONCLUSION:

Scopus and web of science one of the world's largest databases are considered for Bibliometric survey of work done till now using blockchain technology in the field of healthcare. We have considered all the documents published from the year 2016 to 2021 (15th February 2021) from scopus and web of science(25th February 2021). By using the keyword search with

AND operator and OR operator the database searching is done. A total of 598 documents are obtained as the outcome of the search from Scopus while 594 documents are retrieved from the web of science database. The different parameters are considered for analysis of this database. It is seen that almost all the articles are written in English language. The outcome of Keyword search indicates that maximum publications are with the keyword “Blockchain”, followed by “healthcare”. Maximum documents are published in the year 2019 followed by the year 2020. The subject area Computer Science and Engineering covered more than 50% of the documents. As far as the type of document is considered, almost 45% papers are published through various conferences and 39% papers are from journals. The analysis of countries proved, USA and India are having maximum number of documents, more than 110 papers. Documents by different authors also analyzed and maximum authors average Publications account 4 to 6. It is found that, United Arab Emirates University has the highest 10 publications in this area and China is the highest funding sponsor in this area. The network analysis is also done by VOSViewer 1.6.16 version software. The different analysis types such as co-authorship analysis co-occurrence analysis citation analysis and bibliographic coupling are done with the same database. All these different network analyses indicate quite significant information about the differences mentioned above. It could also be seen that the major work in securing medical healthcare records using blockchain is done in 2019 and 2020. In upcoming years a very vast and major work is expected in this area.

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