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Research Article

Bibliometrically Mapping Disruptive Technologies in Healthcare Infrastructure of Smart Cites-The Future Agenda

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ABSTRACT

Purpose – This study explores the impact of emerging healthcare technologies on the development of smart cities, aiming to understand how these technologies contribute to resilient and intelligent healthcare systems.
Research methodology – A bibliometric analysis was conducted using 656 studies from the Scopus database, covering the period from 2011 to 2024. This analysis identifies key authors, influential works, and prominent research areas within the field. It focuses on the utilization of disruptive technologies like Artificial Intelligence (AI), the Internet of Things (IoT), and Blockchain within smart city healthcare frameworks.
Findings – The analysis reveals a significant increase in research activity in this area over the past five years. While this growth is substantial, the research remains fragmented, with diverse focuses. The study highlights the current state of research regarding the application of AI, IoT, and Blockchain in smart city healthcare.
Research limitations – The study is limited by its reliance on the Scopus database. Furthermore, the bibliometric approach provides a quantitative overview of the research landscape but may not fully capture the nuances and complexities of the individual studies.
Practical implications – The findings can help policymakers, urban planners, and healthcare providers in developing and implementing effective strategies for integrating emerging technologies into smart city healthcare systems. By identifying key research trends and gaps, the study can also guide future research efforts.
Originality/Value – This study offers a comprehensive bibliometric analysis of the evolving field of smart city healthcare, specifically focusing on the role of disruptive technologies. It provides valuable insights into the current research landscape, highlighting key areas of investigation and potential future directions. The focus on AI, IoT, and Blockchain within this context adds to the existing body of knowledge and provides a timely contribution to the field.

Keywords: Disruptive Technologies, Bibliometric Analysis, Healthcare, Smart City, Scopus.

INTRODUCTION

The term "smart cities" has gained momentum recently as it demonstrates how investments in contemporary ICT infrastructure, e-services, social and human capital support sustainable growth and the standard of living. (Schaffers et.al, 2012). Smart Cities leverage on contemporary ICT infrastructure, electronic services, and human resources that help in their sustainable growth along with improving the quality of life. Information and communication technologies (ICT) serve as the foundation for smart cities. The primary intent of such a framework is to bring people and technology together and enhance the standard of living of the netizens. (Obinikpo & Kantarci, 2017). Smart cities' development has surged due to recent technological advancements (Rejeb et. al., 2022). They are required to be livable, guarantee the welfare of its residents, and provide continual information. (Liu et.al.,2017). As urban populations continue to grow, **healthcare demands are rising** at an unprecedented rate, placing immense pressure on existing medical infrastructure. Traditional healthcare systems often struggle to meet these demands due to **overburdened hospitals, inefficient patient management, limited accessibility, and high operational costs**. In response, smart healthcare systems provide **integrated digital solutions** that enable proactive disease prevention, early diagnosis, and continuous health monitoring, thereby **reducing hospital admissions and improving overall public health** (Corsi et al., 2022). ICT incorporates AI, IoT, cloud computing, big data analytics, and deep machine learning to transform traditional healthcare delivery into a modern healthcare delivery system that is more efficient, effective, convenient, and personalized. (Kelly et.al 2020). These new generations of Information technologies (IT) are playing a vital role in the advancement of society, specifically

in the healthcare domain which is a core facility necessary for every city across the world. The recent evolution of medical infrastructure has increased attention and interest in smart healthcare services. (Li et.al 2021).The administration of health care services, a fundamental right under law, is a core component of smart cities, which is realized through the implementation of smart healthcare systems (Corsi et.al 2022). The conceptual framework of smart city requires the shift in the health care through medical device, communications, and decision support enabled by sensors and the Internet of Things. It contributes to a comprehensive overhaul of the current healthcare system, increasing its effectiveness, accessibility, and personalisation. Bibliometric analysis serves as a powerful tool that helps researchers for examining and documenting the nature, trends and patterns of the subject. (Block and Fisch 2020; Linnenluecke et al. 2019). It is a type of statistical analysis of publications that, utilizes citations data, authors information, keywords, or journals data used in analysis and helps to understand research trends, quantitative insight into expansion of the body of knowledge within a specified domain and time period. (Leung et.al 2017). Scopus is a comprehensive collection of abstracts and references of peer-reviewed research that covers wider subjects and topics than WoS database. (Kuntolaksono, S et.al, 2022). The bibliometric analysis provides an alternative approach for comprehensibly assessing literature when contrasted with narrative and meta-analysis methods. While the latter two approaches lean towards synthesis, bibliometric analysis uncovers significant points in time, patterns, and directions. Its purpose isn't to formulate novel theories but rather to illuminate ongoing subjects of study and their origins. Essentially, it serves as a foundational guide for individuals keen on undertaking research within a specific field. (Subramanian, Billsberry, and Barrett 2022) Previous research in smart healthcare exploring the use of digital technologies had limiting scope, focusing on one area or nation. (Li et.al 2021). An in-depth overview and analysis of the recent advances in smart healthcare is still in its nascent stage. In recent years, IoT applications in healthcare have gained significant scholarly attention from diverse disciplines, highlighting the need for an integrative approach to investigate and explore its present state, its potential, and future directions. Thus, using bibliometric visualisation, this paper attempts to map the current landscape of these disruptive technologies in smart healthcare research, providing a comprehensive overview of their applications. Further, the status of research contribution in terms of nations, organisations, publications authors is also being analysed. This paper presents a critical review of the major trends in the field of research, thereby offering insightful data for researchers, policymakers, and industry practitioners for future research directions. No prior research study has reviewed these disruptive technologies in the healthcare domain regarding smart cities. Most of the studies have reviewed either one or two of the emerging technologies. To bridge this knowledge gap, the present study thus offers a bibliometric review of disruptive technologies in the healthcare domain from the viewpoint of smart cities. This research systematically makes an effort to understand and provide an overview of the recent advances highlighting the need for and use of disruptive technologies in today's healthcare domain. It offers a detailed assessment of modern technologies as well as conventional technologies and methodologies.

More precisely, we seek to investigate the listed questions for research (RQs) in this study:

RQ1 How has disruptive technologies and smart city research evolvedover the years?

RQ2 What are the major growth trends in research in these new-generation information technologies regarding healthcare for smart cities?

RQ3 Which authors, documents, and countries in the literature had the greatest impact on the citation?

RQ4 What topics among these disruptive technologies have been studied with the greatest frequency and are currently attracting the greatest attention?

Starting with 656 published papers, the research narrows this pool to include more prestigious journals and scholars. After that, a thorough network analysis is finished, revealing several clusters. Finally, the potential directions for future research are discussed.

2. RESEARCH FRAMEWORK AND PRELIMINARY DATA ANALYTICS

Using bibliometric analysis, the study provides a critical evaluation of the Scopus-indexed publications on emerging technologies in the smart healthcare research domain. The bibliometric analysis uses statistical and mathematical methods for investigation of the dynamics of knowledge domains in any specific area. (Mora et.al 2017). Science mapping techniques are frequently used in conjunction with bibliometric study to visualise the intellectual framework of a certain research field.

The first step in the bibliometric assessment process is to find out the best database for the research study. The Scopus database was used because of its wide scope. Moreover 26 million of the over 84 million records in the citation database are associated with peer-reviewed publications (Scopus 2022). Scopus is commonly used by researchers in all fields because it's ability to manage and measure bibliographic citations and their impact. Scopus is a globally indexed, leading academic database that covers approximately 70% more references than Web of Science (Rejeb, et al., 2022). Therefore, it is considered more reliable database for peer-reviewed articles (Harzing and Alakangas2016).

A four-step methodological framework (identifying relevant keywords, cleaning and formatting the data and conducting a preliminary analysis and data analysis) based upon the work of Zhao and Strotmann (2015), on the Scopus platform is employed to look into the research topics and offer suggestions for further research in the domain.

2.1 Selecting the relevant search criteria

Several search criteria's were used for collection of data namely "smart city", "healthcare", "AI", "Artificial Intelligence", "Blockchain", "IoT". or "Internet of things", ("AI") OR ("artificial intelligence"), ("internet of things") OR ("IoT"), ("blockchain") OR ("smart contract") , ("smartcity") AND ("healthcare")

2.2 Preliminary Findings

The keywords, titles, and abstracts were searched in Scopus in accordance with Fahimnia et al. (2015). Scopus is a commonly used database for research analysis in diverse fields since it can measure citations and manage bibliographic references.

Using defined search terms of "keywords, title and abstract," articles were retrieved from Scopus. Chapters of books, conference papers, proceedings, and books, and were excluded. The preliminary findings showed a total of 13981 articles. ***Table 1*** provides the snapshot of the search findings for the given sets of keywords. To include all the key information's like title of the paper, name of the author, affiliating association of the authors, keywords, abstracts and references the results were then exported to .csv format. The analysis was confined to articles published in the English languageonly. The disruptive technologies database consists of 656 articles from 2011 to 2024 published in nearly300 sources. The collected papers have 14.78 average citations per article. Among the retrieved articles from the Scopus database with 2030 authors' contributions 79 articles were written by a single author.

Table 1. Initial data search findings

Important Data Information	
Duration	2011:2024
Bibliographical Sources (Journals, Books, etc)	299
Articles	655
YearlyRate of Growth %	9.59
Average citations per article	14.81
References Used	24677
Content of the Documents	
Keywords of Authors	2010
Keywords Plus	2932
Contributors	
Authors	2030
Single-authored articles	79
Collaborations	
Single-author Publications	82
Joint Authors per Articles	3.37
Percentage of International Collaborations	24.73

2.3 Data Cleaning and Formatting

To further refine the outcomes, fields were confined to business management and accounting; economics, finance and econometrics; Psychology; health; and nursing. All articles were checked for their significance by reviewing the keywords, titles and abstracts. Non-relevant fields were removed from the dataset and eventually, 656 were finalised for review and analysis.

2.4 Preliminary Statistics

Fig. 1 highlights the trajectory of articles published in the related field from the year 2011 to 2024. The initial analysis showed that the field is still in its nascent stage and therefore is predicted to attract more interest until it reaches its maturity phase. The results depict a geometric growth in publications. Focussing on publications, nearly 25 journals/repositories have published 266 studies, which are almost 40% of all publications under study. The major publications were done in the year 2021, followed by 2019 and 2020, respectively. An advantage of utilizing bibliometric analysis is its ability to showcase the researchers with journals that have a substantial impact on the related research areas. The articles included in the study were found to be published in 300 sources out of which the

top 10 productive journals are provided in ***Fig 2***. Internet of Things (Netherlands) was the most productive journal for publishing the relevant study (31 articles), then the International Journal of Recent Technologies and Engineering (28) and the Journal of Cleaner Production (17), respectively.

Fig 1 Publication pattern/trend Disruptive Technologies in smart healthcare

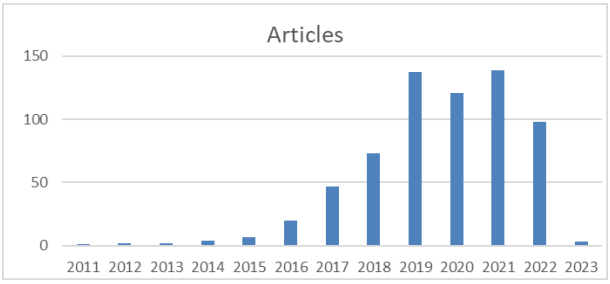

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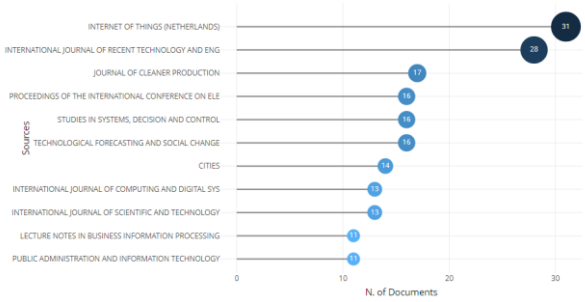
Fig 2 Top 10 high impact journals in Disruptive Technologies in smart healthcare



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3. STATISTICAL ANALYSIS

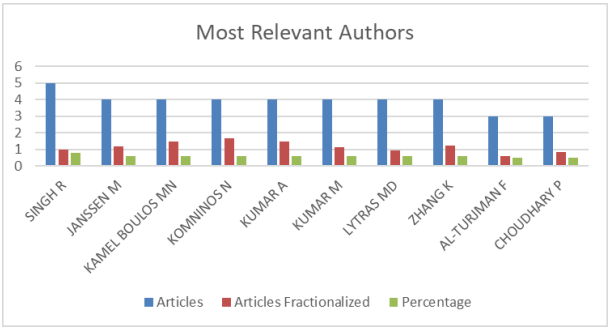
3.1Bibliometric Analysis

Bibliometric analysis has previously been performed using a number of software programs, each with unique features and restrictions. Building up on the preliminary evaluation of the retrieved papers, a more in-depth look at the content was done (i.e., keywords) then the connections between the research was conducted to gather more information. Network analysis based on the bibliometric data was conducted with the use of VOSviewer version 1.6.15 (Van Eck and Waltman 2010) and the Bibliometrix R package with the Biblioshiny application. This helped to map the collaborative network studies done in the field of disruptive technologies in smart healthcare infrastructure. (Aria and Cuccurullo 2017).The main focus of the analysis was on details like title, journal, name of the authors, publication year, keywords used, author's affiliations, and references.

3.2 Author Impact

Biblioshiny application is utilised to check how frequently a particular text appears in various categories of bibliographic information available. Upon retrieving the author field frequency of occurrences of all authors was then documented. ***Fig 3 outlines*** the most impactful ten authors in terms of their contributions in the form of articles and corresponding percentage contributions. Out of the publications output from 2030 entries, Singh R was the most prolific author with 5 publications (0.8%). Janssen, Kamel Boulos, Kumar A, Kumar M, Lytras, and Zhang K with 4 publications each. (0.6%).

Fig 3 Top 10 authors in terms of their publications



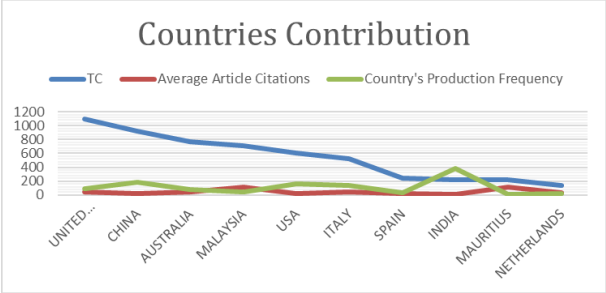
Source: Author's Development

3.3 Affiliation Analysis

Initial analysis depicts the geographical locations of the organizations that have contributed in IoT-based smart healthcare literature. Albeit the first publication on smart healthcare originated in the Kingdom. ***Fig 4*** shows the distribution of all the publications covered in 60 countries. The top 10 countries with their total citations and average article citations, along with the country's production frequency, are demonstrated. The highest in publications output was the United Kingdom (1097 citations and a production frequency of 90) followed by China (927 citations and a production frequency of 185), and Australia (774 citations and a production frequency of 78) respectively. India is the 8th among publications in terms of total citations i.e. 225, but with the highest production frequency of 387

articles. Similarly, Malaysia ranks 4th in terms of the total number of citations but exhibits top position in average citations per article with 118.17 citations

Fig 4 Top 10 Countries by Citation



Source: Author's Development

Out of the total 593 entries from 1193 articles the top five premier institutions in terms of published articles were found to be the University of Messina (1.4% with 17 publications), National Chegchi University (1.17 % with 14 publications), Edith Cowan University (1.08% with 13 publications), University of Cambridge (0.92 % with 11 publications) and Okayama University (0.83 % with 10 publications) respectively.

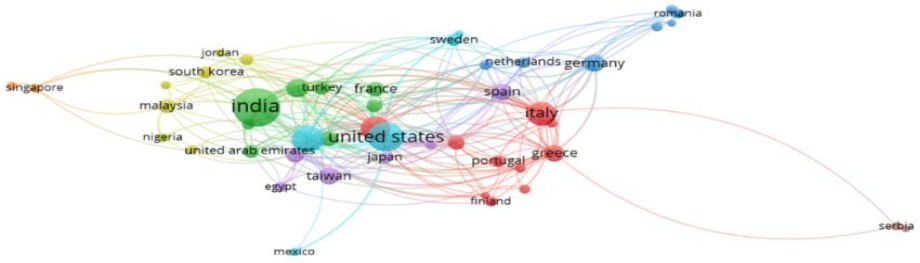
Table 2 shows the top 10 contributing Institutions

	Affiliations	Articles
1	University of Messina	17
2	National Chengchi University	14
3	Edith Cowan University	13
4	University of Cambridge	11
5	Okayama University	10
6	University of Belgrade	10
7	KIIT Deemed To Be University	9
8	The Bucharest University of Economic Studies	8
9	University of Johannesburg	8
10	American University of Sharjah	7

3.4Analysis of Collaborations

All 108 countries with 2024 authors were included in the analysis of co-authorship. Figure 5 displays the collaborative relationship. The authors are represented by the nodes while their collaboration relationship is represented by the lines between them.The dimension of each node in the collaboration network represents the total number of published articles by that country.So with the number of publications, the dimension of the node also increases. Further, the map also highlights the linkage of the international affiliations. Eight clusters were revealed in total. United Kingdom (cluster 1, 10 items, red) had the most publications, followed by India (Cluster 2, 8 items). Cluster 7 (Indonesia and Singapore) and Cluster 8 (Bulgaria and Serbia) had fewer connections denoting a weak cooperative research relationship in the smart healthcare academic field.

Figure 5 Relationships in the collaboration network



Source: Author's Development

Table 3 provides information about the 10 highest productive countries concerning SCP single-country and a MCP multiple-country publication wherein MCP refers to at least one co-author is from a foreign country. The MCP Ratio is calculated by dividing the number of multiple-country publications (MCP) by the total number of publications

Table 3 Top 10 highest productive countries

	Country	Articles/ Documents	SCP	MC	Freq	MCP_Ratio	TC	Avg Articles Citations
1	China	40	29	11	0.061	0.275	927	23.18
2	India	40	38	2	0.061	0.05	225	5.63
3	USA	23	18	5	0.035	0.217	605	26.30
4	United Kingdom	22	13	9	0.034	0.409	1097	49.86
5	Australia	18	10	8	0.027	0.444	774	43.00
6	Italy	13	6	7	0.02	0.538	519	39.92
7	Spain	10	6	4	0.015	0.4	241	24.10
8	France	9	3	6	0.014	0.667	63	7.00
9	Germany	9	7	2	0.014	0.222	80	8.89
10	Portugal	7	6	1	0.011	0.143	82	11.71

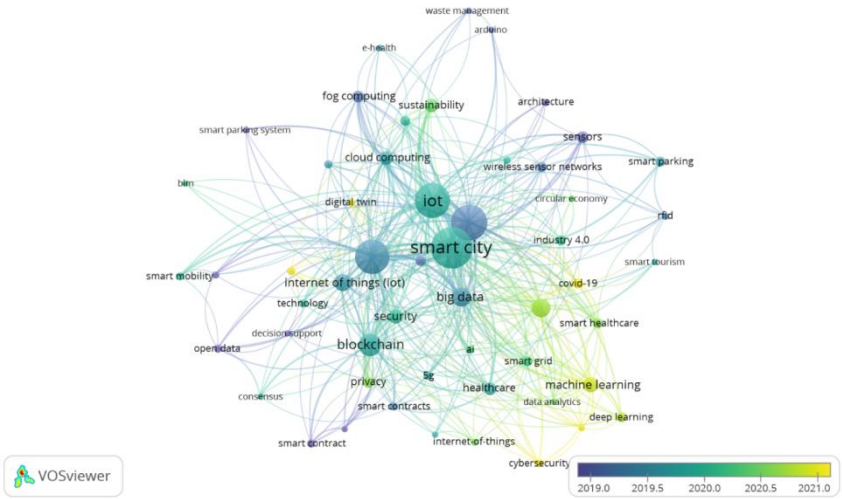
China (11) was found to be the country with highest rate of collaborations globally followed by the United Kingdom (9) and Australia (8). However, India scores high in intra-country collaborations with 38 articles

3.5 Analysis of Co-occurrence Collaborations

A Structural analysis of keywords facilitates the identification of key research themes in the area of the study. Keyword visualisation and co-occurrence analysis serves as an efficient tool that provides insight into trending topics in publications and variations in frequency over time in a specific research field. (Huang, N., & Wu, Y. 2022). Analysis of co-occurrence of author keywords involved 2012 keywords from 656 articles.

Figure 6 depicts *the* overlay visualization. The map shows the network links from the year 2019 to 2021. The frequency of occurrence of a particular research paper is positively correlated and is shown through different colors and sizes of the circles. The visual encoding of an item is done by aligning its color value with the assigned year in the color overlay file. It can be seen that the keywords Internet of Things and smart cities had comparatively higher frequency of co-occurrence in the healthcare domain concerning smart cities research in 2019.Later by the beginning of 2020 the keywords IoT, blockchain, and the smart city appeared more frequently. However, from 2020 to 2021, the keywords smart healthcare, artificial intelligence, machine learning sustainability, data analytics, and data science had high frequencies and received more research attention.

Fig 6 Keywords Co-occurrence Overlay visualization



Source: Author's Development

3.6 Analysis of Keywords

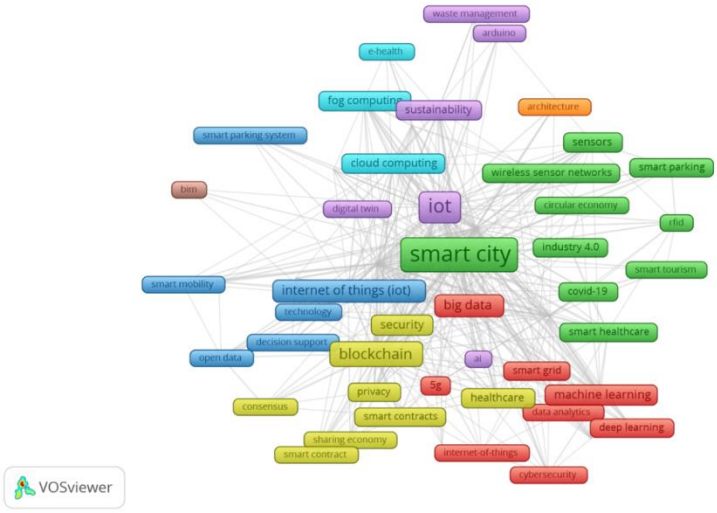
2010 keywords were retrieved from an overall of 656 articles. In accordance with the standard VOSviewer setting, the least occurrences for a keyword are set at 5 and that resulted to 54 keywords fulfilling that condition. Both ***Table***

4 and Figure 7consistently show that the top keywords are smart city (occurrence 179) and Internet of Things (occurrence 136).

Table 4 Top 20 frequent Keywords in publications

Word	Occurrence	Word	Occurrence
Smart City	179	Sustainability	20
Internet of Things	136	Cloud Computing	19
IoT	130	Healthcare	17
Smart cities	119	Sensors	15
Block Chain	52	Fog Computing	14
Big Data	38	Privacy	13
Artificial Intelligence	36	Covid-19	11
Internet of Things (IoT)	30	Smart Healthcare	11
Machine Learning	25	Deep Learning	10
Security	21	Edge Computing	10

Fig 7 Network visualisation of keywords co-occurrence



Source: Author's Development

4. PUBLICATION NETWORK ANALYSES

Publication Network analysis, along with graphical investigation, was done using VOSviewer for creating and visualising bibliometric results. The VOSviewer is a powerful tool fruitful for depicting complex bibliometric data in a comprehensive way. (Jan, N., & Ludo, V. E. 2010).

4.1Citation Analysis

By establishing a threshold at 3 for a given count of citations per author and a minimum citation of the author at 0 the authors were sorted to identify the most impactful among them. Of the 2022 authors, 31 met the threshold.

Results of our citation analysis (table 6) reflect that **Kamel Boulos** is the most popular author as he ranks 1 in the author category with h-index=4, g-index=3, and m-index of 0.4, also his article is among the 10 most cited papers. The next popular author in most cited authors and document categories is **Komninos N** with a 4 h-index 3 g-index and .3 m-index.

Table 5 10 most influential authors using citation measures

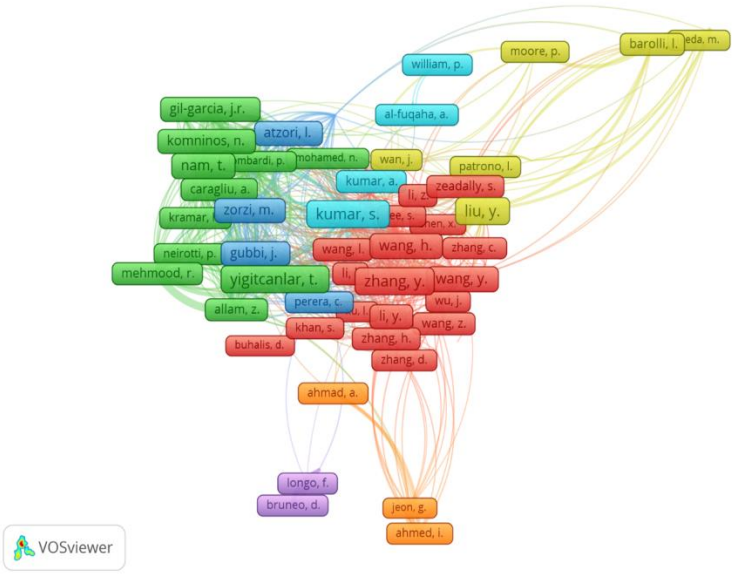
	Authors	h_index	g_index	m_index	TC	NP	PY start
1	Kamel Boulos M N	4	4	0.4	299	4	2014
2	Komninos N	4	4	0.333	83	4	2012
3	Papa A	3	3	0.5	261	3	2018
4	Janssen M	3	4	0.333	181	4	2015
5	Marsal-LIacuna M-L	3	3	0.5	127	3	2018
6	Al-Turjman F	3	3	0.6	96	3	2019

7	Singh R	3	5	0.6	93	5	2019
8	Li L	3	3	0.375	66	3	2016
9	Rhee S	3	3	0.375	62	3	2016
10	Peng G	3	3	0.6	56	3	2019

4.2 Co-citation Analysis

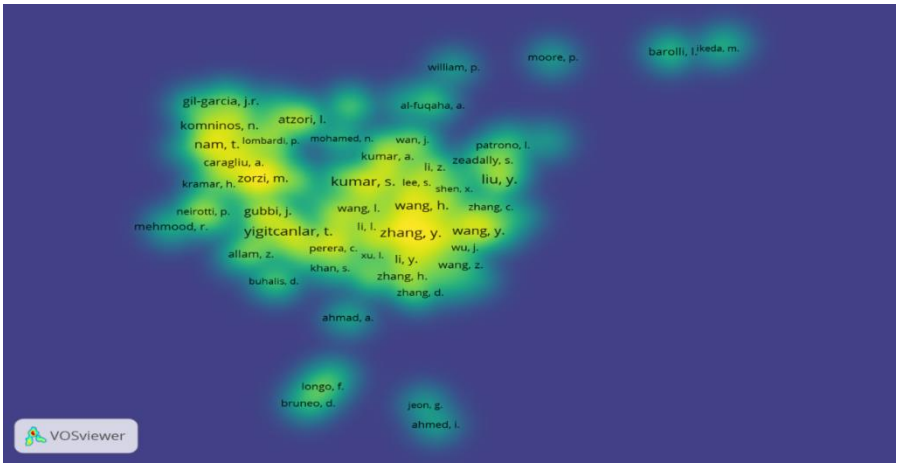
Co-citation network of authors was depicted and analysed with the help ofVOSViewer in Fig 8 (a) where authors are clustered based on their co-citation patterns; authors of the same color have the chances of having joint citation in a particular paper. Fig 8 (b) depicts co-citation density for authors, as the size of the label increases so is the frequency of citation.

Fig 8 (a) Author's network Visualisation



Source: Author's Development

Fig 8 (b) Author's Density Mapping



Source: Author's Development

5. CONCLUSION

A bibliometric analysis was done systematically to identify key insights on IoT and other emerging technologies-based healthcare infrastructure Artificial Intelligence (AI), the Internet of Things (IoT), and Blockchain for Smart Cities. The exploration tactic directed the assortment of 656 research pieces of literature in the Scopus repository.

Last five years, have witnessed a substantial growth in publication, and the trend in the trajectory is predicted to continue as highlighted in the significant rise in citations of the articles, even though the number publications have

declined in the previous year. The citation analysis results revealed that the most productive and leading article on IoT-based applications is by **Kamel Boulos** (2014) titled "On the Internet of Things, Smart Cities and the WHO Healthy Cities" in "The *International Journal of Health Geographics*". The most prevalent and significant cited source is the "Internet of Things (Netherlands)", followed by the "International Journal of Recent Technologies and Engineering Singh R is the most prolific author in the research domain. The University of Messina emerges as the topmost organization. The most upstanding country is China, followed by India and then the USA. The "Smart City" author keyword has the maximum occurrence being followed by "Internet of Things." Alarge number of publications and a strong international collaboration in countries (e.g., the United Kingdom) were discovered.

6. LIMITATIONS

The present study, like many others has certain limitations. The bibliometric analyses have many shortcomings. The data preparation stage is a crucial one in a bibliometric investigation. Despite the fact that there are many available databases a major limitation of most of the technology-oriented analyses is that they only select one database as a source. (Suominen and Seppänen 2014). The analysis relies exclusively on publications indexed in the **Scopus** database, which, although comprehensive, excludes research from other major academic sources such as **Web of Science, IEEE Xplore, and PubMed**. VOSviewer bibliometric software does not have the ability to combine data from multiple sources and only read data from a single database. (Yeung et al. 2019). As a result, upcoming researchers are suggested to integrate multiple databases to provide a more holistic perspective.

The bibliometric approach primarily offers a **quantitative assessment of research trends**, focusing on publication patterns, co-authorship networks, and keyword co-occurrence. However, it does not provide an in-depth qualitative evaluation of how AI, IoT, and Blockchain have been implemented in real-world healthcare settings. A systematic literature review or meta-analysis could complement this study by synthesizing empirical findings from various case studies.

Since the paper only included articles published in the English language, chances are that some high-impact papers published in non-English journals might be excluded.

7. FUTURE RESEARCH DIRECTIONS

Further studies can address the dearth of studies and expanded understanding in the subject by building on the foundation of this study. The enormous body of cumulative information that has been gathered so far and that is still accumulating might be necessary for research to be developed, incorporating previous findings into a more comprehensive normative framework with smart healthcare as a fundamental requirement for smart cities. This may also provide the groundwork and pave the way for future investigations on the adoption of IoT-based applications for creating reliable healthcare models. Researchers in the field of AI, healthcare providers, policy makers and urban planners can collaborate and explore how they can work synergistically to develop more sustainable smart healthcare infrastructures. Based on the findings of the present study future researchers could also examine some successful cases worldwide.

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