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Internet of Things in Medicine: a Bibliometric Review

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ABSTRACT

The Internet of Things (IoT) is a transformative technology that enhances various aspects of human life, significantly impacting fields such as healthcare, industry, transportation, agriculture, education, and commercial applications. In particular, IoT's role in smart healthcare systems has attracted considerable research attention due to its potential to improve patient monitoring, optimize treatments, and reduce costs. Therefore, a systematic assessment of the scientific output in this domain is essential for understanding current trends and future directions. Bibliometric approaches can describe, explain, and predict the scientific contributions of researchers, institutions, journals, and countries on an international scale while identifying emerging research areas. This analysis quantifies scientific output and evaluates its impact through concepts such as co-occurrence networks, collaboration networks, and co-citation networks, revealing trends within specific fields. Given the increasing significance of IoT in healthcare, this study examines trends in IoT applications in medicine using a bibliometric approach. The research analyzes 7,205 articles indexed in the Web of Science (WoS) database, covering the period from 2013 to August 2024. Data visualization was conducted using VOSviewer software. The findings indicate a likely future focus on integrating automated disease detection methods with IoT technologies. China, India, and the United States lead in scientific output, with Asian countries demonstrating a strong interest in healthcare applications. Additionally, security and privacy concerns remain significant challenges in the field.

Keywords*—*Internet of Things, IoT, Medicine, Bibliometric Analysis Article.

1. Introduction

The Internet of Things (IoT), as a network of physical objects connected through the Internet, is rapidly growing and has the potential to become a massive source of information [1], [2]. IoT involves various computing devices, machines, objects, humans, or animals with unique identifiers and the ability to transfer data within the network without human intervention [3]. As the number of IoT devices embedded in various objects increases, this technology is expanding rapidly. It is projected that by the year 2030, the quantity of intelligent devices with the capability to connect to the Internet is anticipated to approximate 500 billion [4]. This technology has created new opportunities in various sectors such as healthcare, transportation, agriculture, and industries [5-8]. The role of the Internet of Things in the healthcare field is vital and represents one of the most in-demand research areas. Projections indicate that by 2025, the use of IoT in healthcare will surpass other applications of this technology, potentially reaching 41% [9]. The Internet of Medical Things (IoMT), introduced by Joyia and et.al [10], plays a significant role in the healthcare industry by enhancing the precision, adaptability, and throughput of electronic devices [3]. IoMT is an information system built using advanced electronics, computers, and medical technologies. In this system, patient data and vital signs are collected and sent to emergency services or healthcare professionals for assessment and appropriate response. Advances in IoMT help patients receive better care and shift the focus of healthcare systems from hospital-centric to patient-centric care [11]. Although the rapid growth of IoT usage in medicine has led to various academic studies in recent years, a comprehensive understanding of both the explicit and implicit dimensions of the topic, as well as the current outlook, is necessary for future research. Consequently, regular assessment of scientific output is essential. As an objective metric for the appraisal of research efficacy in a field, bibliometric analysis has emerged as a crucial

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instrument for evaluating scientific merit and output [8]. Bibliometric is a set of methods used to study or measure research through scientific publications indexed in large databases such as Scopus or Web of Science (WoS) [12]. By examining the relationships between articles, journals, authors, keywords, and citations, bibliometrics method enables researchers to identify publication patterns, collaborative efforts, key topics, influential journals, and emerging trends in a scientific domain. This method is useful in identifying influential research directions and predicting future studies, making it a valuable resource for researchers seeking to assess the scientific performance of authors, articles, journals, institutions, and countries through analysis of keywords, citation metrics, and emerging trends in a specific field of science [13]. The bibliometric approach contributes to scientific advancement by allowing the extraction of information in various ways, such as evaluating progress, identifying the most reliable scientific sources, identifying key scientific actors, and assessing the output of universities and research institutions. As a result, bibliometrics has become an essential tool in many scientific fields [14].

While systematic literature reviews analyze smaller datasets qualitatively, bibliometric studies focus on quantitatively analyzing large datasets using statistical or visualization tools [15]. Bibliometric analysis has evolved into a vital statistical tool for assessing scientific output and mapping research trends. Its widespread acceptance has grown significantly in recent years, expanding its applications to fields such as pharmaceuticals, oncology, tourism management, human resource management, and business management [13]. Bibliometric, a branch of science, employs statistical and mathematical approaches to evaluate scientific activity [16]. Therefore, using bibliometric analysis is beneficial for understanding the foundational knowledge structure in a particular subject.

This research uses bibliometric analysis to answer the following research questions. The objective of this study is to provide a comprehensive overview of the research conducted in the field of IoT in medicine. Consequently, this paper offers direction for researchers to better understand the key advancements and gaps in the literature. To achieve this objective, several fundamental questions are addressed:

1. What is the trend of scientific publications on the use of IoT in medicine?

2. Which countries and authors have produced the most scientific output?

3. What are the global keyword networks, and how do countries, institutions, and authors collaborate?

4. How have the keyword networks and Cooperation networks between countries evolved over the 12 years studied?

5. What are the research topics for the present and future concerning IoT in medicine?

The subsequent sections of this paper are structured as follows: Section 2 examines relevant literature. Section 3 delineates the research methodology employed. Section 4 presents the findings and their analysis. Ultimately, Section 5 provides the conclusion and suggestions for future research.

2. Literature Review

This section highlights several studies conducted on the use of Internet of Things technology in the field of medicine and healthcare. In the study by Islam et al. [17], the authors explored the applications, platforms, and commercial trends of IoT usage in healthcare, as well as issues related to IoT security and privacy in this sector. Additionally, the study discussed how advancements in various IoT technologies, such as wearable devices and ambient intelligence, are utilized in healthcare. Another study focused on analyzing smart healthcare systems based on IoT by reviewing literature published between 2014 and 2020. The authors covered multiple research areas related to IoT, edge and cloud computing, artificial intelligence, security, and the integration of medical signals [18].

In [19] security and privacy technologies in healthcare, smart communities, and smart homes within IoT applications are explored. The results emphasized that IoT security remains a significant concern for users of this technology. In a separate study [20], a comprehensive review of embedded healthcare systems based on IoT was conducted. The findings demonstrated that the use of IoT can be beneficial for governments in improving public health and economic relations. Furthermore, the study highlighted the serious need for safety infrastructures due to the new capabilities of IoT technology. Yang et al. [21] conducted a review of smart health monitoring technologies and various sensors used in IoT for health. The study also discussed how different combinations of signal processing and classification techniques can aid IoT networks in health monitoring. Another study examined strategies to encourage physicians to adopt IoT in smart healthcare. This research, grounded in analyses disseminated across nine esteemed academic databases from 2015 to 2021, elucidated that social influence, individual attitude, and personal inattention constituted the three principal perceived determinants for the adoption of the Internet of Things within the healthcare sector at the individual level. Furthermore, perceived privacy risk emerged

as an additional pivotal factor concerning security considerations [22]. Another study examined the use of the Internet of Things in modern healthcare monitoring systems, highlighting their advantages. It also reviewed IoT systems utilizing wireless and wearable sensors, addressing key issues related to security, privacy, and Quality of Service (QoS). Finally, the study discussed recommendations and future directions for advancing IoT technologies in healthcare [23]. Sadoughi et al. have conducted a systematic review in the area of identifying and mapping the advancements of the Internet of Things in medicine. This study examined literature published between 2000 and 2018 across major scientific databases, including IEEE Xplore, Web of Science, Scopus, and PubMed. The results indicated that neurology, cardiology, and psychiatry were the medical subfields receiving the most attention in terms of IoT applications [1]. Ullah et al. reviewed recent research activities on the role of IoT in healthcare, presenting an integrated and simplified bibliometric analysis approach. Their method combined data from seven major databases using various tools to avoid manual tasks. The study, based on data collected from 2012 to 2022, focused on IoT in healthcare and its applications [24].

Also, in [25-27] studies have been conducted on the use of Internet of Things technology during the outbreak of the Covid-19 epidemic.

3. Methodology

This applied research was conducted in three phases: data collection, data preprocessing, and finally, visualization and analysis of results. Each phase is briefly explained below.

3.1. Data Collection

The data for this research was collected from the Web of Science (WoS) database, comprising 7,205 articles published between 2013 and 2024. Among the seven document types available in WoS, four types were selected for this study: Articles (4,416; 59.6%), Proceeding Papers (2,299; 31.2%), Review Articles (523; 7.1%), and Early Access documents (157; 2.1%). The specifics of the data collection phase are summarized in Table 1.

3.2. Data Preprocessing

Given the lack of a specific standard for keyword selection, different authors may use different keywords to represent the same concept, such as "internet-of-things," "internet of things," "internet of thing," and "IoT." These terms refer to the same concept but may appear differently across articles. Such variations can lead to the creation of small clusters with only a few nodes, causing errors in the analysis. To overcome this issue, all keywords were carefully reviewed in terms of spelling and meaning, ensuring that synonyms were treated as a single node.

Table 1. Summary of the Data Collection Phase

Attribute	*Value*
Search terms	("internet of things" OR "IoT") AND ("medical"))
Fields mined	Topic (title, abstract, author keywords)
Database	Web of Science
Year	2013-2024
Search date	August 4, 2024
Document NO.	7205
Type of Document	Article, Proceeding Paper, Review Article, Early Access

3.3. Data Visualization and Analysis

After standardizing synonymous keywords through preprocessing, the selected related articles were analyzed using bibliometric network methods such as co-occurrence analysis, cooperation analysis, and co-authorship analysis. VOSviewer software (version 1.6.18) was used for visualizing the thematic areas of IoT in medicine and mapping co-occurrence networks and scientific cooperation between countries. Figure 1 illustrates the main stages of this study.

4. Analysis and Evaluation of Results

4.1. Distribution of Publications

Figure 2 illustrates the distribution trend of published articles from 2013 to 2024, which shows a growing trajectory. A slight decline is observed in 2023, likely due to the time lag for articles to be indexed in the WOS database. The significant increase in articles from 2013 to 2022 reflects the continuous growth of research in the studied field.

4.2. Scientific Contributions

Figure 3 presents an overview of the top ten countries with the highest number of published articles. As can be seen, China has the largest number of publications, followed by India and the United States. Notably, six Asian countries are among the top ten, indicating a strong focus on this research area in Asia.

Figure 4 shows the contributions of the top ten countries in the studied years. India and Saudi Arabia have experienced significant growth since 2020 compared to others. Table 2 shows the top ten countries with the highest citation rates per document. Vietnam ranks highest in citation rates, followed by Singapore and Finland.

Figure 5 shows the percentage of publications by continent, with Europe having the highest number of published articles, followed by Asia.

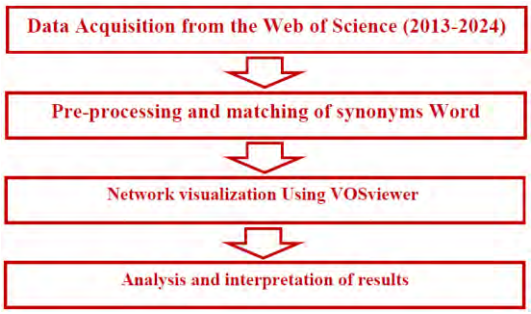


Figure. 1. Research Process

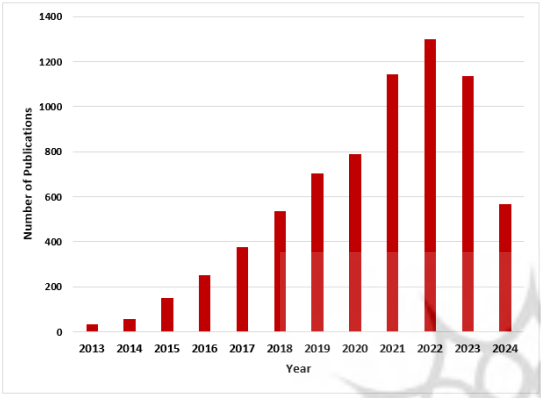


Figure. 2. Distribution of Publications by Year

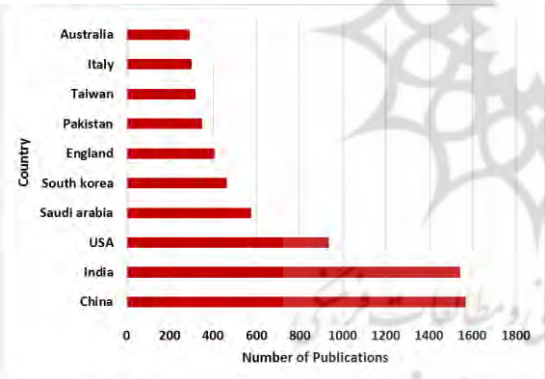


Figure. 3. Top Countries by Number of Articles

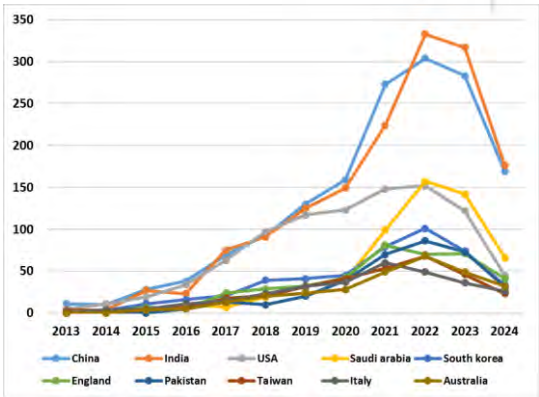


Figure. 4. Distribution of Publications for the Top 10 Countries by Year

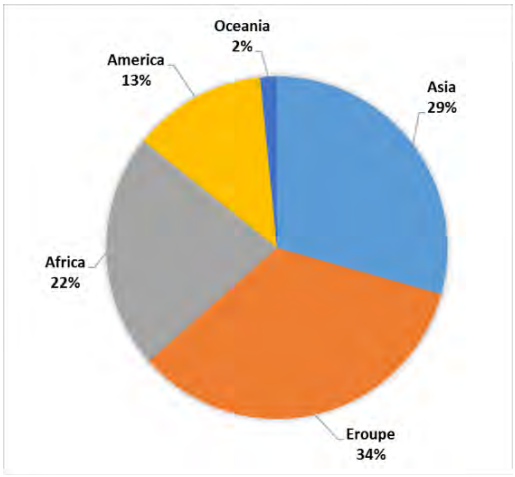


Figure. 5. Distribution of Publications by Continent

Table 2. Top ten countries with the highest citation rate

Country	*Articles*	*Citations*	*Article/Cite*
Vietnam	45	1751	38.9
Singapore	87	2984	34.2
Finland	77	2430	31.5
Kazakhstan	14	421	30.0
Sweden	75	2207	29.4
Australia	292	8236	28.2
Austria	45	1265	28.1
Ireland	48	1334	27.7
USA	936	24556	26.2
Qatar	66	1607	24.3

4.3. Distribution of Publications by Journals

Analyzing the extracted articles from the WOS database revealed the top ten journals with the highest number of published articles in the research area, as shown in Table 3. The IEEE Internet of Things Journal ranks first with 379 articles, followed by IEEE Access and Sensors.

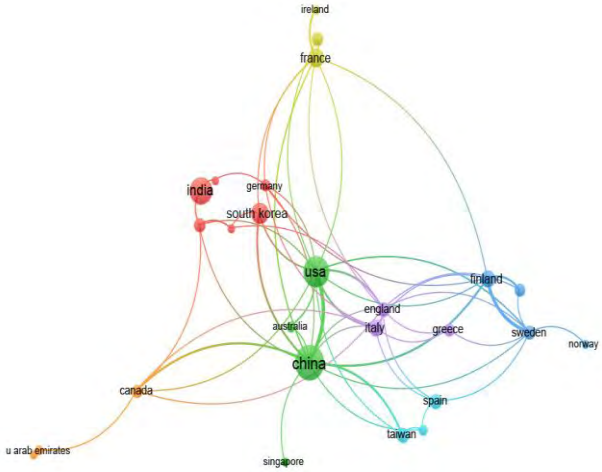
Table 4 lists the top five institutions with the highest number of documents and citations. King Saud University in Saudi Arabia, Vellore Institute of Technology in India, and the Chinese Academy of Sciences in China are among the most active institutions.

4.4. Cooperation Network of Countries

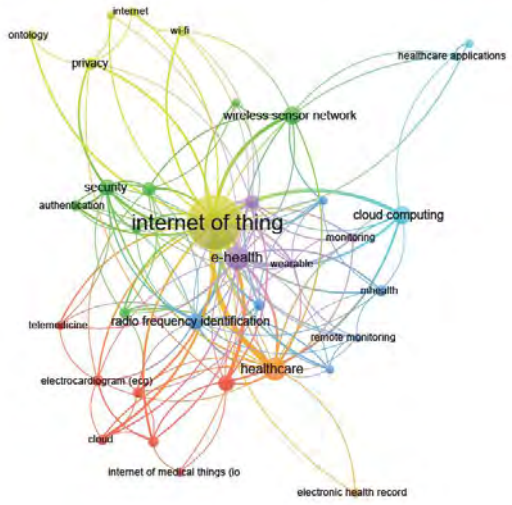
Figure 6 illustrates international cooperation between countries. The evolution of cooperation networks over time, from 2013 to 2024, shows that while China and the USA led in the 2013–2016 period, India has risen to second place in more recent years. There is also significant growth in collaboration among Asian countries, especially Saudi Arabia and Pakistan.

4.5. Co-occurrence Networks of Keywords

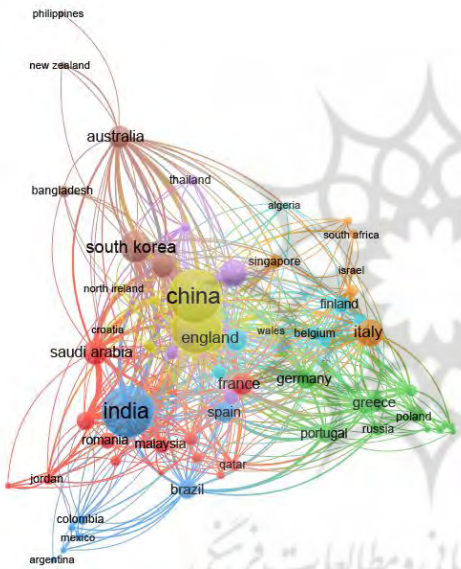
Figure 6 also shows the evolution of keyword co-occurrence networks over the period from 2013 to



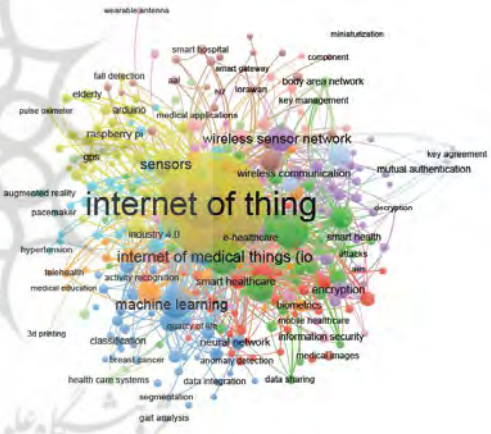
Cooperation network (2013-2016)



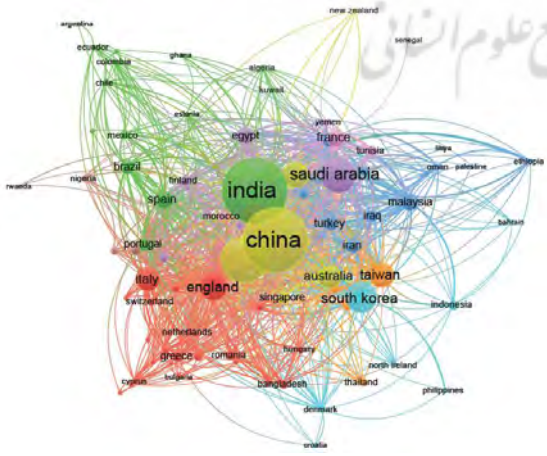
Co-occurrence network (2013-2016)



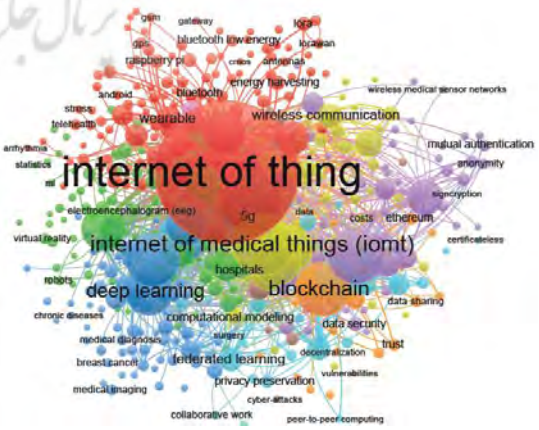
Cooperation network (2013-2020)



Co-occurrence network (2013-2020)



Cooperation network (2013-2024)



Co-occurrence network (2013-2024)

Figure. 6. The evolution of the Cooperation network of countries and Co-occurrence networks of keywords for the years 2013 to 2024

2024. As can be seen in this figure, since 2016, machine learning has entered as an important topic in IoT research in medicine. In addition, in the period leading to 2024, the concepts of deep learning and blockchain have been seriously considered by researchers in this field.

4.6. Top Keywords

Table 5 presents the most frequent keywords found in the articles reviewed for this study. Notably, in the years leading up to 2024, security and blockchain technology have emerged as prominent research topics. Additionally, the frequent use of the term 'deep learning' in recent studies reflects a growing trend toward integrating the Internet of Things with diagnostic systems in medicine.

4.7. Cooperation Network between Universities and Research Institutes

Figure 7 shows the cooperation network among universities and research institutions from 2013 to 2024. The most active participants include King Saud University, Vellore Institute of Technology, and the Chinese Academy of Sciences.

4.8. Co-Authorship Networks

One factor influencing a researcher's specialization is their interaction with fellow researchers. Collaborative research and its subsequent publication require both intellectual and social engagement among participants, which is often represented through co-authorship networks. These networks are among the most common social structures, where researchers are linked to one another based on shared authorship in one or more publications. In other words, when two or more researchers co-author a paper, it indicates an intellectual and social connection between them. Figure 8 illustrates the co-authorship network during the study period. As shown, Kumar, Rodrigues, and Guizani stand out as key figures who have collaborated extensively with other authors in this field, making them the most active members of the co-authorship network.

4.9. Top Ten Authors

Table 6 shows the top ten authors with the highest number of published articles. Al-turjman has the most papers, while Srivastava has the highest citation count.

4.10. Top Authors with Highest Citations per Document

Table 7 shows the top ten authors with the highest citations per document, considering only those who have published at least 10 articles between 2013 and 2024.

Table 3. Top Journals

Journal	*Articles*	*Citations*	*Article/Cite*	*IF*
IEEE Internet Of Things Journal	379	11106	29.3	8.2
IEEE access	352	9211	26.1	3.4
Sensors	240	4128	17.2	3.4
Electronics Switzerland	103	1431	13.8	2.6
internet of thing	86	997	11.5	6.0
Applied Sciences	74	894	12.1	2.5
future generation computer systems	63	3535	56.1	6.2
IEEE transaction on Industrial informatics	59	3001	50.8	11.7
Wireless Personal Communications	57	506	8.8	1.9
IEEE Sensor Journal	56	1006	17.9	4.3

Table 4. Top Institutions

Organization	*Country*	*Articles*	*Citations*	*Article/Cite*
King Saud University	Saudi Arabia	111	3335	30.0
Vellore Institute of Technology	India	105	1887	17.9
Chinese Academy of Sciences	China	92	5165	56.1
University of Electronic Science and Technology of China	China	75	2570	34.2
King Abdulaziz University	Saudi Arabia	68	1037	15.25

Table 5. Top Keywords

2013-2016	*2017-2020*	*2021-2024*
Internet of thing	Internet of thing	Internet of thing
E-health	Healthcare	Internet of medical things
Healthcare	Security	Blockchain
Wireless sensor network	Internet of medical things	Security
Cloud computing	Cloud computing	Healthcare
Big data	Machine learning	Machine learning
Security	Sensors	Medical services
RFID	Blockchain	Deep learning
Sensors	Big data	Covid-19
Wireless body area network	Privacy	Artificial intelligence

4.11. Evaluation and Analysis of Results

The results of this research indicate that the most significant use of the Internet of Things in medicine has been in the continuous monitoring of heart diseases and diabetes. Furthermore, since 2020 and following the COVID-19 pandemic, the use of IoT for disease control and monitoring has significantly expanded. The results also show a shift in research

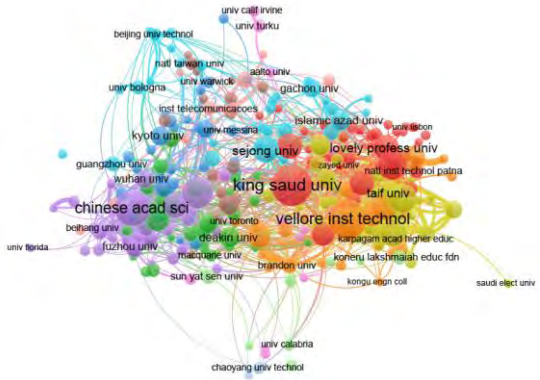


Figure. 7. Cooperation Network between Institutes (2013-2024)

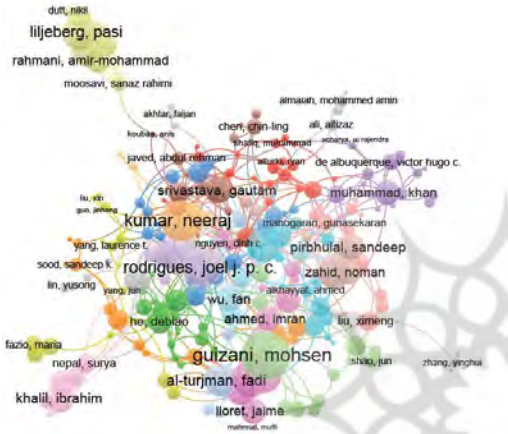


Figure. 8. Co-Authorship Network (2013-2024)

focus towards remote healthcare systems and patient-centered approaches. Additionally, from 2021 to 2024, there has been a notable increase in the use of IoT alongside automatic disease diagnosis. In particular, machine learning techniques, especially deep learning methods in recent years, have seen considerable growth. Traditional machine learning models such as Support Vector Machines (SVM) and deep learning models like Convolutional Neural Networks (CNN) have been prominently used. The findings also highlight that recent research has increasingly focused on security and privacy issues, marking them as significant challenges in this field. Consequently, blockchain technology has gained significant attention in recent research. Given the expanding use of IoT, especially in medicine and the need to maintain the confidentiality of medical data, security and privacy will likely be a central theme in future research. Recent studies have also given special attention to concepts like edge computing, fog computing, and federated learning, which may gain further prominence in the coming years.

5. Conclusion

This study analyzed articles published on the use of IoT in medicine from 2013 to 2024 using bibliometric analysis. The findings reveal that research in this field is currently at a midpoint, with a significant portion of studies aimed at reducing healthcare system costs. Recent articles suggest that future research will likely focus on automatic disease diagnosis methods in conjunction with IoT technology. Additionally, monitoring diseases with patient-centered approaches and using smart devices for remote control and monitoring via IoT are strategies being pursued by researchers. This approach not only saves costs and reduces the burden on medical facilities but ultimately enhances community health and well-being. The study also found that IoT applications are primarily focused on heart diseases and diabetes. Expanding IoT applications to specialized medical fields, other diseases such as various cancers, and medical imaging could significantly aid in early disease detection and serve as future research areas. Security and privacy issues in IoT are identified as critical challenges. Blockchain technology, as an emerging field, could play a vital role in securing IoT research and applications. The study, based on Web of Science data, suggests that similar studies on other databases, such as Scopus or a combination of multiple databases, could provide additional insights and facilitate comparisons with this study's findings.

Table 6. Top Ten Authors

Author	*Articles*	*Citations*	*Article/Cite*
al-turjman, fadi	46	1031	22.4
guizani, mohsen	32	982	30.6
matsuda, fumihiko	31	173	5.5
tabara, yasuharu	30	159	5.3
kumar, neeraj	29	1535	52.9
srivastava, gautam	23	1875	81.5
choo, kim-kwang raymond	21	964	45.9
das, ashok kumar	20	554	27.7
rodrigues, joel j. p. c.	20	429	21.4
kumari, saru	16	617	38.5

Table 7. Top Ten Authors with the most citations

Author	*Articles*	*Citations*	*Article/Cite*
wu, fan	11	978	88.9
sangaiah, arun kumar	10	861	86.1
elhoseny, mohamed	11	928	84.3
muhammad, ghulam	13	1067	82.0
srivastava, gautam	23	1875	81.5
hossain, m. shamim	15	1122	74.8
zeadally, sherali	10	701	70.1
liljeberg, pasi	13	884	68
he, debiao	10	659	65.9
muhammad, khan	13	811	62.3

Decleration

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Authors' contributions

[MA]: Study design, acquisition of data, Statistical analysis, drafting the manuscript;
[MD]: Supervision, Interpretation of the results, revision of the manuscript.

Conflict of interest

The authors declare that no conflicts of interest exist.

References

[1] F. Sadoughi, A. Behmanesh, and N. Sayfouri, "Internet of things in medicine: A systematic mapping study," *J. Biomed. Inform.*, vol. 103, p. 103383, Mar. 2020, doi: 10.1016/j.jbi.2020.103383.

[2] H. Zahmatkesh and F. Al-Turjman, "Fog computing for sustainable smart cities in the IoT era: Caching techniques and enabling technologies - an overview," *Sustain. Cities Soc.*, vol. 59, p. 102139, Aug. 2020, doi: 10.1016/j.scs.2020.102139.

[3] J. Srivastava, S. Routray, S. Ahmad, and M. M. Waris, "Internet of Medical Things (IoMT)-Based Smart Healthcare System: Trends and Progress," *Comput. Intell. Neurosci.*, vol. 2022, pp. 1–17, Jul. 2022, doi: 10.1155/2022/7218113.

[4] K. Khalil, K. Elgazzar, M. Seliem, and M. Bayoumi, "Resource discovery techniques in the internet of things: A review," *Internet of Things*, vol. 12, p. 100293, Dec. 2020, doi: 10.1016/j.iot.2020.100293.

[5] H. HaddadPajouh, A. Dehghantanha, R. M. Parizi, M. Aledhari, and H. Karimipour, "A survey on internet of things security: Requirements, challenges, and solutions," *Internet of Things*, vol. 14, p. 100129, Jun. 2021, doi: 10.1016/j.iot.2019.100129.

[6] R. Duan and L. Guo, "Application of Blockchain for Internet of Things: A Bibliometric Analysis," *Math. Probl. Eng.*, vol. 2021, pp. 1–16, Apr. 2021, doi: 10.1155/2021/5547530.

[7] F. Al-Turjman and S. Alturjman, "Context-Sensitive Access in Industrial Internet of Things (IIoT) Healthcare Applications," *IEEE Trans. Ind. Informatics*, vol. 14, no. 6, pp. 2736–2744, Jun. 2018, doi: 10.1109/TII.2018.2808190.

[8] P. K. Sethy, S. K. Behera, N. Kannan, S. Narayanan, and C. Pandey, "Smart paddy field monitoring system using deep learning and IoT," *Concurr. Eng.*, vol. 29, no. 1, pp. 16–24, Mar. 2021, doi: 10.1177/1063293X21988944.

[9] A. Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari, and M. Ayyash, "Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications," *IEEE Commun. Surv. Tutorials*, vol. 17, no. 4, pp. 2347–2376, 2015, doi: 10.1109/COMST.2015.2444095.

[10] G. J. Joyia, R. M. Liaqat, A. Farooq, and S. Rehman, "Internet of Medical Things (IOMT): Applications, Benefits and Future Challenges in Healthcare Domain," *J. Commun.*, 2017, doi: 10.12720/jcm.12.4.240-247.

[11] W. Liu, B. Li, and Z. Ji, "Research Overview of Internet of Things Technology in Medical Engineering," Zhongguo Yi Liao Qi Xie Za Zhi, vol. 47, no. 5, p. 576—581, 2023, doi: 10.3969/j.issn.1671-7104.2023.05.021.

[12] M. Gutiérrez-Salcedo, M. Á. Martínez, J. A. Moral-Munoz, E. Herrera-Viedma, and M. J. Cobo, "Some bibliometric procedures for analyzing and evaluating research fields," *Appl. Intell.*, Dec. 2017, doi: 10.1007/s10489-017-1105-y.

[13] M. Alavi, A. Valiollahi, and M. Pakravan, "Bibliometric Analysis of research trends on Graph Neural Networks," *in 2024 20th CSI International Symposium on Artificial Intelligence and Signal Processing (AISP)*, Feb. 2024, pp. 1–8, doi: 10.1109/AISP61396.2024.10475285.

[14] M. A. Martínez, M. J. Cobo, M. Herrera, and E. Herrera-Viedma, "Analyzing the Scientific Evolution of Social Work Using Science Mapping," *Res. Soc. Work Pract.*, vol. 25, no. 2, pp. 257–277, Mar. 2015, doi: 10.1177/1049731514522101.

[15] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, pp. 285–296, Sep. 2021, doi: 10.1016/j.jbusres.2021.04.070.

[16] O. Ellegaard and J. A. Wallin, "The bibliometric analysis of scholarly production: How great is the impact?," *Scientometrics*, vol. 105, no. 3, pp. 1809–1831, Dec. 2015, doi: 10.1007/s11192-015-1645-z.

[17] S. M. Riazul Islam, Daehan Kwak, M. Humaun Kabir, M. Hossain, and Kyung-Sup Kwak, "The Internet of Things for Health Care: A Comprehensive Survey," *IEEE Access*, vol. 3, pp. 678–708, 2015, doi: 10.1109/ACCESS.2015.2437951.

[18] F. Alshehri and G. Muhammad, "A Comprehensive Survey of the Internet of Things (IoT) and AI-Based Smart Healthcare*," IEEE Access*, vol. 9, pp. 3660–3678, 2021, doi: 10.1109/ACCESS.2020.3047960.

[19] A. Raghuvanshi, U. K. Singh, and C. Joshi, "A Review of Various Security and Privacy Innovations for IoT Applications in Healthcare," *in Advanced Healthcare Systems*, Wiley, 2022, pp. 43–58.

[20] W. Bovenizer and P. Chetthamrongchai, "A comprehensive systematic and bibliometric review of the IoT-based healthcare systems," *Cluster Comput.*, vol. 26, no. 5, pp. 3291–3317, Oct. 2023, doi: 10.1007/s10586-023-04047-1.

[21] Y. Yang, H. Wang, R. Jiang, X. Guo, J. Cheng, and Y. Chen, "A Review of IoT-Enabled Mobile Healthcare: Technologies, Challenges, and Future Trends," *IEEE Internet Things J.*, vol. 9, no. 12, pp. 9478–9502, Jun. 2022, doi: 10.1109/JIOT.2022.3144400.

[22] M. Al-rawashdeh, P. Keikhosrokiani, B. Belaton, M. Alawida, and A. Zwiri, "IoT Adoption and Application for Smart Healthcare: A Systematic Review," *Sensors*, vol. 22, no. 14, p. 5377, Jul. 2022, doi: 10.3390/s22145377.

[23] S. Abdulmalek et al., "IoT-Based Healthcare-Monitoring System towards Improving Quality of Life: A Review," *Healthcare*, vol. 10, no. 10, p. 1993, Oct. 2022, doi: 10.3390/healthcare10101993.

[24] R. Ullah, I. Asghar, and M. G. Griffiths, "An Integrated Methodology for Bibliometric Analysis: A Case Study of Internet of Things in Healthcare Applications," *Sensors*, vol. 23, no. 1, p. 67, Dec. 2022, doi: 10.3390/s23010067.

[25] M. Javaid and I. H. Khan, "Internet of Things (IoT) enabled healthcare helps to take the challenges of COVID-19 Pandemic," *J. Oral Biol. Craniofacial Res.*, vol. 11, no. 2, pp. 209–214, Apr. 2021, doi: 10.1016/j.jobcr.2021.01.015.

[26] S. Tuli, S. Tuli, R. Tuli, and S. S. Gill, "Predicting the growth and trend of COVID-19 pandemic using machine learning and cloud computing," *Internet of Things*, vol. 11, p. 100222, Sep. 2020, doi: 10.1016/j.iot.2020.100222.

[27] R. P. Singh, M. Javaid, A. Haleem, and R. Suman, "Internet of things (IoT) applications to fight against COVID-19 pandemic," *Diabetes Metab. Syndr. Clin. Res. Rev.*, vol. 14, no. 4, pp. 521–524, Jul. 2020, doi: 10.1016/j.dsx.2020.04.041.

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