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ORIGINAL RESEARCH ARTICLE

An insight on the interventions of AI in healthcare—A bibliometric study

Vineed Kumar Vijayan*, Smiju IS, Jose John

School of Management Studies, Cochin University of Science and Technology, Kochi 682022, India

*** Corresponding author:** Vineed Kumar Vijayan, vineedkumar@cusat.ac.in

ABSTRACT

Background: The literature on artificial intelligence (AI) in healthcare is expanding quickly and is a key factor in healthcare promotion. **Objective:** This analysis's goal is to offer a dynamic and comprehensive bibliometric analysis of publications on artificial intelligence in the field of health care. **Methods:** All currently available and highly referenced healthcare-related AI research papers published in English up to April 2023 were found by searching the Web of Science (Clarivate PLC). A search technique was created based on bibliometric indications to evaluate the title's eligibility, using the abstract and full text as necessary. **Results:** 6254 items were found during the search, and 3107 of those papers were used in the analysis. USA was the country that published most research papers in the field of AI in healthcare. India stood in 4th place, with China and the United Kingdom in front of them. Relevant Affiliations were found in Stanford University, Harvard Med School, followed by King Abdul Aziz University. **Conclusion:** Future research should concentrate on bridging the gaps between clinical applications and AI healthcare research. More research should be done, especially in the areas of ethics, data governance, clarity of data, and additional inputs in the form of training that might be required for healthcare workers to update their skills in the world of AI-assisted healthcare.

Keywords: artificial intelligence; health care; bibliometric analysis; health information systems

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1. Introduction

In recent decades, extraordinary research focus has been drawn to the expanding significance of artificial intelligence (AI) in the fields of health and medicine. We are already using AI to develop pharmaceuticals, personalise therapies, and even modify genes to diagnose diseases more accurately. The study of artificial intelligence (AI) in medicine has been expanding quickly. In recent years, more budget was allocated to healthcare AI projects than AI initiatives in any other sector of the global economy. This article's objective is to review and analyse the role of AI in Healthcare Management that has been published in reviewed journals and has been indexed for the years 1992 to 2023 in the Web of Science database.The decision to commence our analysis from 1992 is because the first documented scholarly article pertaining to AI in Healthcare Management was published during that year in Web of Science database. Thus, we have chosen this publication year as the starting point in order to trace the evolution and development of AI applications in the healthcare management field over the subsequent decades.

The analysis looks at how the use of artificial intelligence has created new research areas by looking at the number of publications, the authors, and the cooperating nations. In addition, how digitizing and combining medical data might enable AI to discover beneficial patterns. Machine learning, Artificial Neural Networks, Artificial intelligence, and Deep Learning were highlighted as part of a global nexus of major methodologies that involved authors' keywords and content assessment of pertinent research publications.

AI-based healthcare systems enhance disease diagnosis, treatment, and prognosis for both patients and healthcare professionals[1]. Due to current computers' significantly increased computing power and the enormous quantum of digital data accessible for gathering and use, interest in and advancements in medical AI applications have risen recently. A few ways that using AI in healthcare can be advantageous to doctors, patients, and healthcare workers are as follows:

1) Determining the likelihood of treatment success and analysing the onset of the disease prior to treatment initiation;
2) Averting or handling complications;
3) Dynamically supporting patient care throughout the treatment;
4) Determining the pathology of the disease as well as the most effective diagnosis[2].

One of the most intriguing uses of AI in healthcare is the potential for improved diagnosis and treatment accuracy. Healthcare professionals may be able to diagnose ailments faster with its assistance. AI can increase the accuracy of diagnoses by simulating human doctors' predictive abilities by quickly scanning horizontally and vertically through patient electronic health records[3]. AI can also help patients better understand complex symptoms, improve their quality of life, and promote therapy compliance[4].

Medical practice is changing rapidly because of AI. Numerous AI applications could be helpful in a range of medical disciplines, including clinical, diagnostic, rehabilitative, surgical, and prognostic practical. Clinical decision-making and disease diagnostics are important areas of medicine where AI has an influence. To identify disease and direct clinical conclusions, AI systems could collect, analyse, and present massive volumes of data from several modalities[5].

2. Methodology

The methodology followed for conducting Bibliometric analysis is depicted in **Figure 1**.

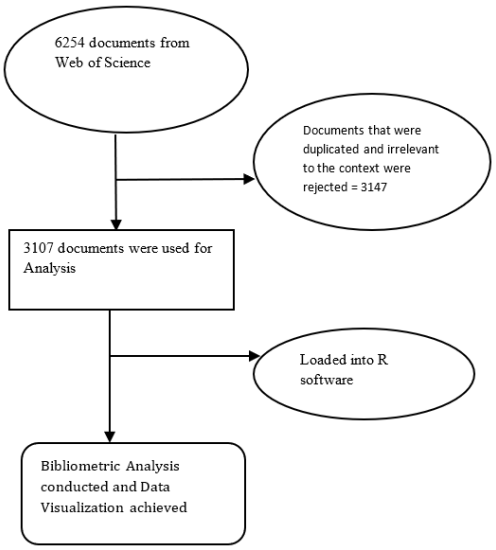

Figure 1. Methodology flowchart.

Identifying the primary quantitative research stream variables is made possible due to the incorporation of Bibliometrics in to the study. This strategy makes it easier to find the necessary information about a given

study topic, such as the number of publications, authors, policies, properties, governance, and country data[6]. Additionally, it permits the use of the science mapping technique.

This article used the Biblioshiny online interface and the Bibliometrix R package as analysis tools.

The study looked into the subsequent aspects for aspiring researchers and professionals:

1) Bibliometric data on 3107 English-language, peer-reviewed papers from the Web of Science database.
2) Identification of the top publications in this field, including Journal of Medical Systems, IEEE Access and Healthcare Journal.
3) Data on authors' keywords, citations, h-index, g-index.
4) Investigate specific nations to evaluate the effectiveness of AI in each region's healthcare delivery, quotes, and networks.
5) A thorough examination of the issues raised and the theoretical and practical implications for further research.

3. Results

After the Loading of the data into R software, the following data results were made in **Table 1**.

Table 1. Main information chart.

Description	Results
MAIN INFORMATION ABOUT DATA	-
Timespan	1992:2023
Sources (Journals, Books, etc.)	558
Documents	3107
Annual Growth Rate %	20.7
Document Average Age	2.6
Average citations per doc	17.27
References	141,773
Document contents	-
Keywords Plus (ID)	4232
Author's Keywords (DE)	7667
Authors	-
Authors	15,265
Authors collaboration	-
Single-authored docs	117
Co-Authors per doc	6.36
International co-authorships %	41.23
Document types	-
Article	2420
article; book chapter	7
article; data paper	1
article; early access	143
article; proceedings paper	58
Review	458
review; book chapter	1
review; early access	19

3.1. Main information

The time span of the study is from 1992 to 2023. The overall number of documents considered in the study is 3107. The average age of the documents was found to be 2.6. The citation per document was estimated to be 17.27. The author keyword was found to be 7667 during the bibliometrics analysis. **Figure 2**: Depicts the Annual Scientific production showing the details of articles produced across the years. Regarding author collaboration, the number of single-authored documents was 117and the number of co-authors per doc was 6.36. The percentage of international co-authorship of the articles was an astonishing 41.22%. The documents selected for this analysis were of different types. The number of articles was 2420. Book chapter articles were 7, whereas data paper was only one. The early access articles were 143, and the proceeding paper articles were 58. The number of reviews in the study was 458, one book was referred from chapter-review, and another 19 numbers from early access review.

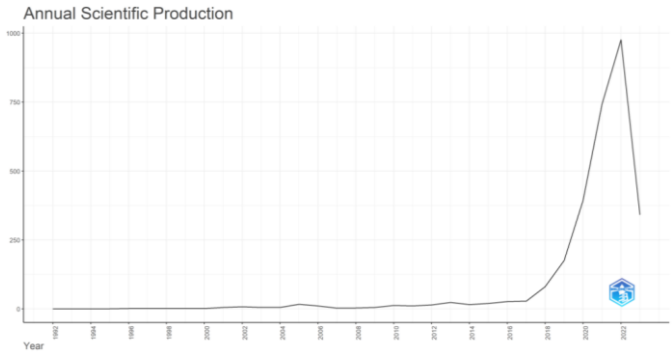

Figure 2. Annual scientific production.

3.2. Annual scientific production

The publishing and generation of articles from the early 90s to the late 2000s were found to be low. A slight improvement was seen from the early 2010s, and an upward trend began from 2017 onwards. From 2018 onwards, the total no of articles increased to around 500 papers per year around 2020 and by 2022, the number of articles published in 2022 reached 1000. The trend is seeing a decline after 2022, with the average number of papers being published dropping to 300 papers. As the year 2023 has not been completed, there is a possibility for the count to improve by the end of the year.

3.3. Three-field plot graph

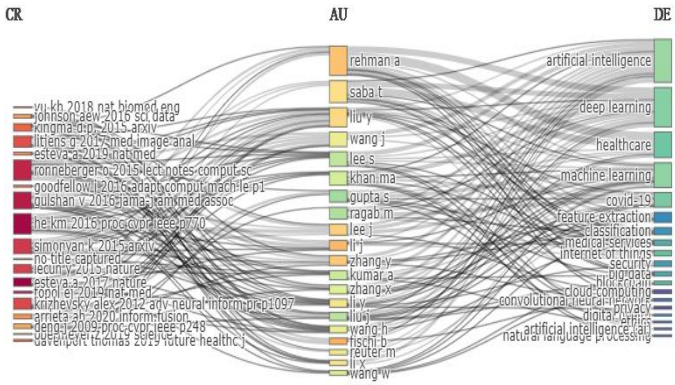

Figure 3. Three plot graph.

The 3-field plot shown in **Figure 3** depicts three elements, which mainly consist of cited references (CR), the authors (AU) and keywords (DE). The three elements are plotted with grey lines that show their relationship, beginning with the cited references, concerned author and each author linked to the keywords in the study. The size of the rectangle in particular lists shows the associated paper with the element. The

authors highlighted in the 3 field plot graph are Rehman A, Saba T and Liu Y, and they have the larger rectangle in the second element list. The keywords that stand out from the third element are artificial intelligence, Deep Learning, Healthcare, and Machine learning. The third element shows that the 4 top keywords mentioned have been used commonly by most authors in top journals on a high level.

3.4. Authors impact

The impact of authors is shown in **Table 2** with regards to the "h-index"[7] (that is, the output and impact of a researcher's citations), the "g-index"[8] (which is the dispersal of citations got for the publications of a researcher), the "m-index"[8] (i.e., the "h-index" value annually), the total number of citations, the total number of papers, and the years of scholarly publication. The "H-index" was first published in the literature as a tool for the impartial assessment of scientific findings and was based on the volume and significance of publications[9].

Table 2. Impact of authors.

Element	h-index	g-index	m-index	Total citations	NP	PY-start
FISCHL B	19	28	1.056	1852	28	2006
REUTER M	12	14	1.091	1318	14	2013
LI X	9	15	1.8	319	15	2019
OURSELIN S	9	10	2.25	2951	10	2020
KIKINIS R	8	8	0.364	1394	8	2002
LI J	8	20	1.333	501	20	2018
SABA T	8	16	1.6	321	16	2019
STEVES CJ	8	8	2	2608	8	2020
SUDRE CH	8	8	2	2608	8	2020
WANG W	8	13	1.6	523	13	2019

The Author's local impact measures as per h-index show that FISCHL B stands at the top of the list with 19, followed by Reuters M at 2nd position with h-index measure of 12. Authors LI X and OURSELIN S came 3rd with a measure of 9, and all remaining authors measured a score of 8 (**Figure 4**).

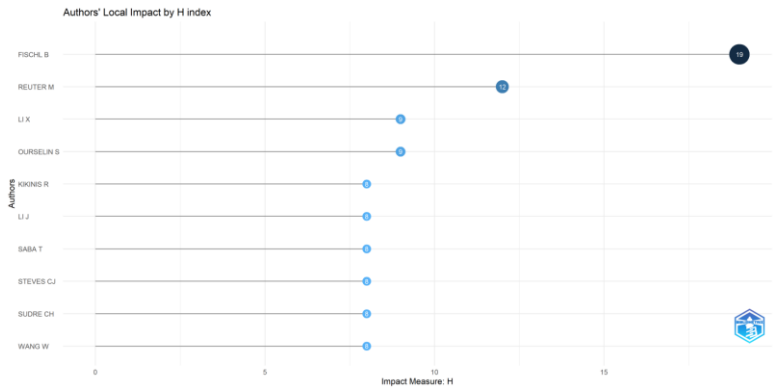

Figure 4. Author local impact as per H-Index.

3.5. Co-occurrence network of authors keywords

The top author keywords can indicate scientists' and researchers' scientific and research interests in terms of the total occurrences present in the 3 clusters. In **Figure 5**, there are 3 clusters, with cluster one having red colour, cluster 2 having blue colour and cluster 3 having green colour. Out of 7667 keywords from all the documents, the analysis has filtered the top 49 keywords and divided the same into 3 clusters based on their betweenness and closeness.

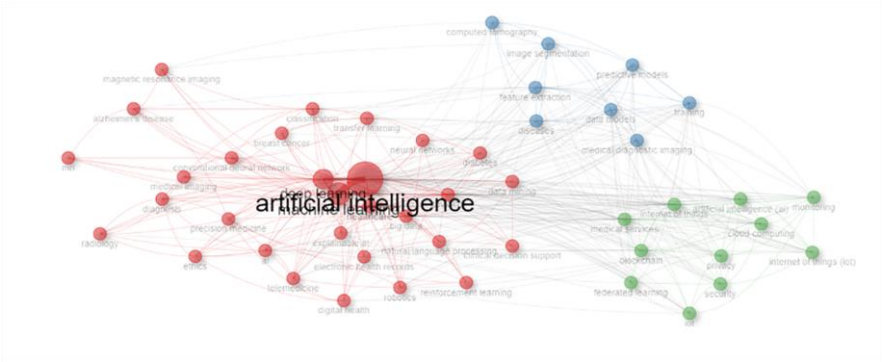

Figure 5. Co-occurrence network of author keywords graph.

3.6. Country article production

From **Figure 6**, it can be seen that the production of documents increased from 2004 until 2023, among which the USA stood first with a significant increase in article production from 2017. Likewise, China stood second in the diagram with a substantial rise in articles publications from 2018. The United Kingdom came third with an accelerated rate in articles publishing from 2020, followed by India and Germany. Both India and Germany showed more results from 2021 onwards.

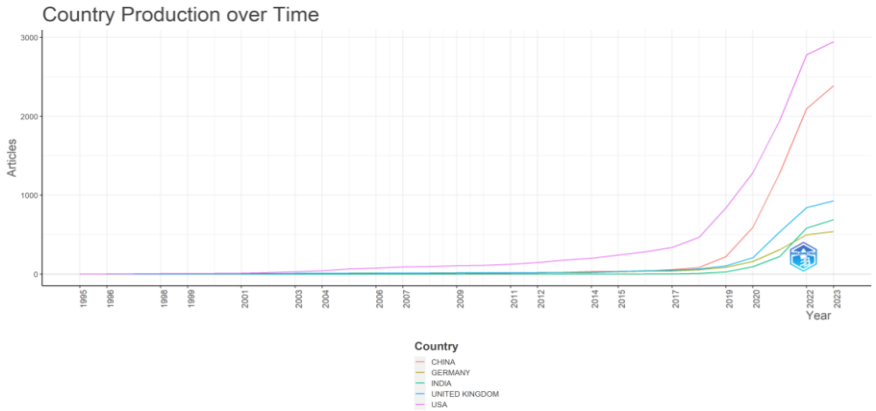

Figure 6. Country article production over time graph.

3.7. Country scientific production

Out of 3107 articles selected for this bibliometrics analysis,3029 came from the USA, CHINA, India, etc., marked in deep blue colours. The remaining 148 contributions are denoted in the lesser intensity of blue, and the corresponding countries are coloured accordingly. The contributions are well depicted in **Figure 7**.

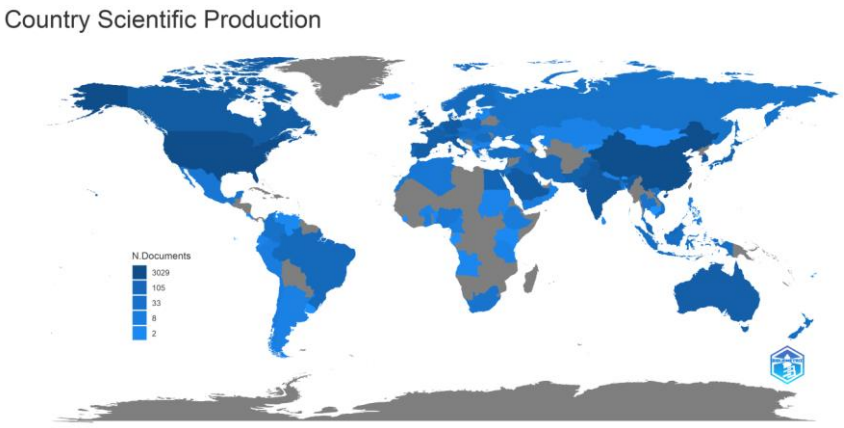

Figure 7. Country scientific production graph.

3.8. Contextual map structure

A contextual map structure was created with the most relevant words in the bibliometric analysis. The contextual structure of each word is shown in the form of a diagram. The main purpose is mapping the words within the Dim 1 and Dim 2 axis and each of the words is fixed on the graph depending on the corresponding values of DIM1 and DIM 2.DIM in bibliometry means diminutive particle, and there is a mapping of words with similar values. In **Figure 8**, there is a red area with interrelated words mapped, which means there are relations between the words in the research papers used in this bibliometrics analysis, and their variety in the research papers is also high.

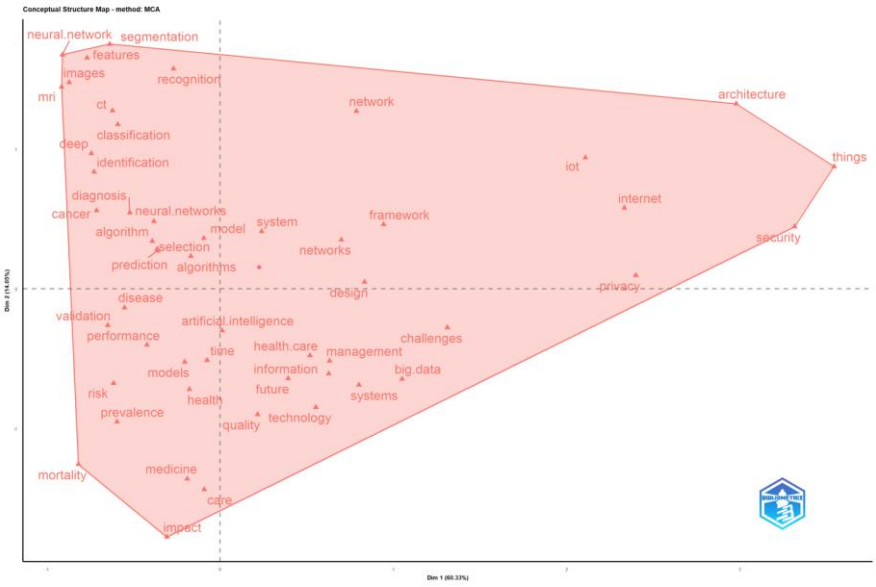

Figure 8. Contextual map structure.

3.9. Relevant affiliations

From all the articles listed in the WOS database, most affiliations relevant to the study are from Stanford University, with 169 articles. Harvard Med School is second on the list with 116 contributions, followed by King Abdul Aziz University, which has 98 articles. Taipei Med University comes in 4th place with 91 contributions, and Harvard University, which has contributed 75 articles, comes fifth in the list (**Figure 9**).

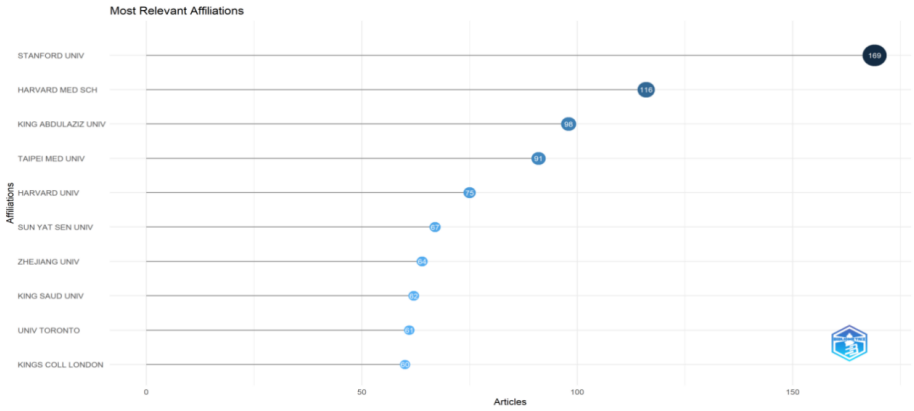

Figure 9. Relevant affiliations of universities graph.

3.10. Relevant authors

After the bibliometric analysis of the papers, it is found that the author FISCHL B is the most relevant author with 26 documents. The author LIJ J comes next with 20 documents, followed by Rehman A closely

behind with a tally of 19 documents. The details are visible in the figure, showing the details of the relevant authors in this study (**Figure 10**).

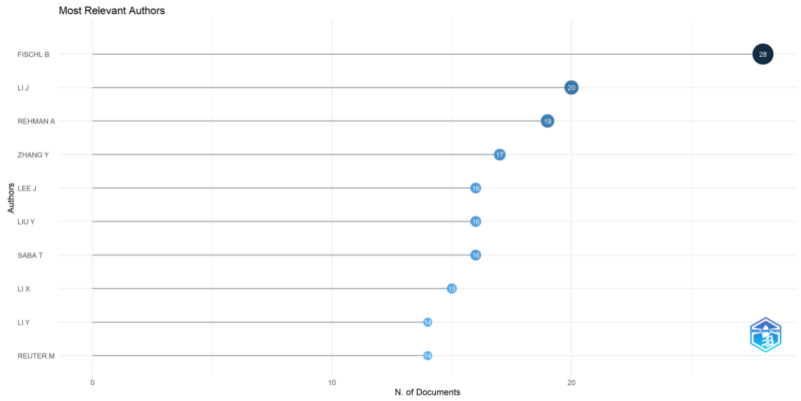

Figure 10. Graph showing relevant authors.

3.11. Author countries

The countries from which the authors contributed to the analysis were mainly from China. There are mainly two kinds of contributions, i.e., Single Country Publications (SCP) as well as multiple country publications (MCP). China led the chart, where SCP and MCP had over 600 contributions, and the USA came in Second position with approximately 570 contributions. The remaining appreciable contributions came from the United Kingdom, India and Korea (**Figure 11**).

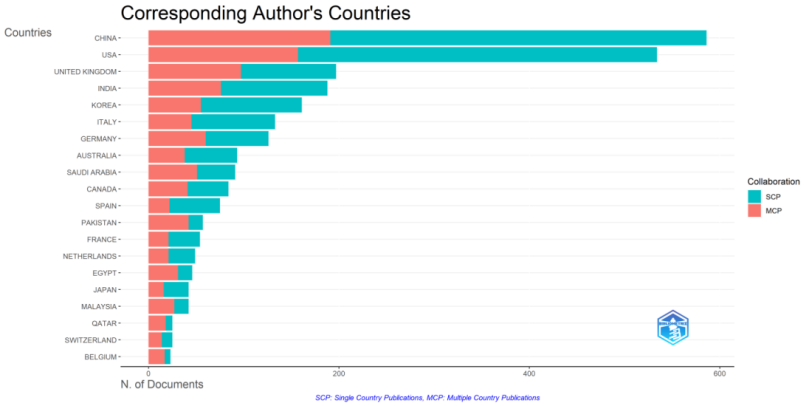

Figure 11. Graph showing corresponding authors and countries.

3.12. Relevant sources

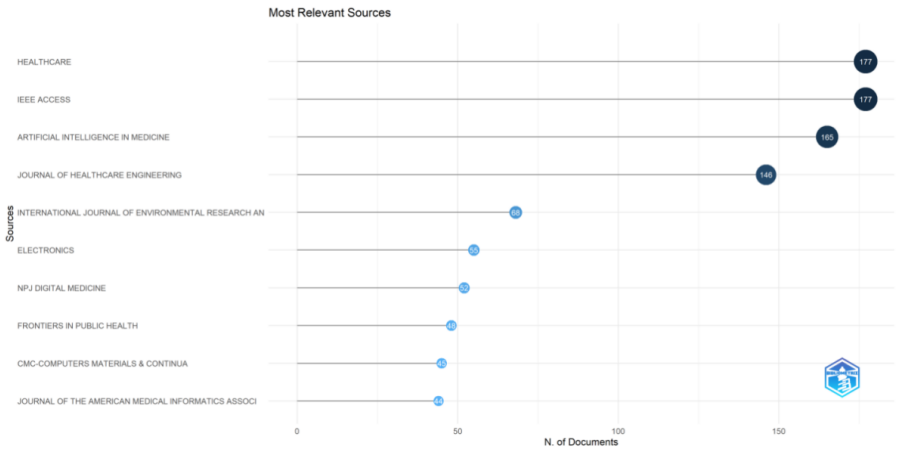

Figure 12. Figure depicting relevant sources.

From **Figure 12** it can be seen that Healthcare journals, as well as IEEE Access journals, have been the leading relevant sources with 177 contributions each for the bibliometric analysis. Followed by this, Artificial Intelligence in Medicine came 3rd with 165 contributions, and the Journal of Healthcare Engineering came with 146 contributions.

3.13. Relevant words

From **Figure 13**, the most relevant words from the study are classification in 1st place, which has accounted for 244 times, followed by Artificial Intelligence, which has accounted for 233 times. In third place is the diagnosis, which accounts for 199 times, followed by the word System 186 times.

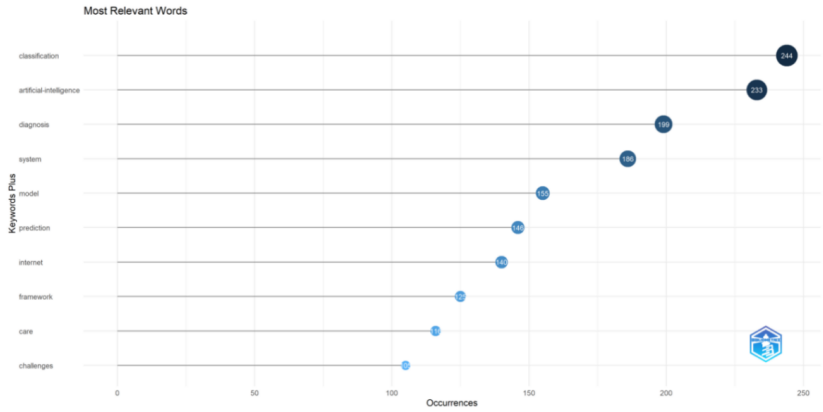

Figure 13. Most relevant words graph.

3.14. Thematic map

A semi-automatic algorithm scanning the references analysed in the study generated a thematic map based on relevance degree and development degree (**Figure 14**). The Map is divided into four topological areas. The Upper right quadrant represents high density and centrality. The topics in this quadrant system, internet and framework need to be researched further for future applications. The quadrant in the top left reveals topics that are areas of importance and rapid development. Sadly, there is no topic in that region. Likewise, there is no topic in the lower right quadrant as well. The lower left quadrant has keywords used but has a diminishing trend indicated by low centrality and low density. The topics in this region are classification, artificial intelligence.

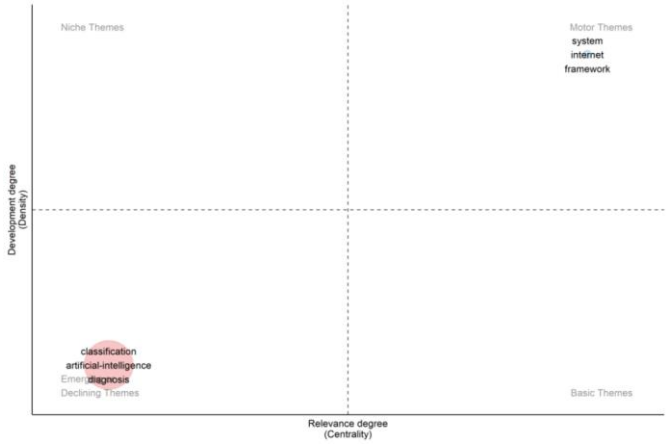

Figure 14. Thematic map graph.

3.15. Words cloud

It is seen from **Figure 15** that the frequency of usage of the words began to improve from 2004 and substantially rose from 2016 onwards. It displays almost all the keywords that appeared during the

bibliometrics analysis of all the data used for this study. The top word that has increased frequency was classification, followed by Artificial Intelligence in Second place and diagnosis in 3rd place. A few other keywords found were system, model, prediction, internet, framework and care.

Figure 15. Visualisations of the word that was found on articles used for bibliometrics analysis.

4. Discussion

The articles were studied closely, and the following findings were seen. The study was conducted on the literature available from 1992 to 2023. To start with; it was found that 41% of the co-authorships were of international authors. Though the real rush in paper publishing started in 2017, there were quite good papers after 2007. With the data revolution in the late 2000s, digitalisation began to gain ground, and many initiatives were brought into AI to the Healthcare Industry. Nearly 1000 papers have been published from 2018 onwards, and it only seems to go upwards as more and more countries are preparing their scientific and research community to conduct research in the healthcare field.

The USA keeps producing the greatest number of articles and is closely followed by the Chinese with a huge number of papers, especially in the recent past. The United Kingdom comes third, with India and Germany closely behind it. The most relevant affiliations were from Stanford University, followed by Harward Medical School and King Abdul Aziz University in 3rd place.

4.1. Role of AI in healthcare treatment

The worry of the healthcare sector workers is primarily around whether the machines with AI algorithms would de-skill the healthcare workers or not. With the usage of Machine learning and continuous data availability, it needs to be understood that AI would be able to assist doctors by providing better diagnosis of medical scans and better personalized outcome for patients[10]. The Administration team in Hospitals and smaller healthcare centres would greatly benefit as the resources allocation and efficient records management could be ensured with the support of AI in Healthcare management information systems[11]. The traditional methods of health record file management are in the process of being completely digitalised and with the support of AI, these records could be personalized such that innovations like finger print scanning, face recognition and wearable sensor bands[12] will be used for data management in healthcare sector and it would become the mandate for the administration of patient records in the near future.

AI would be able to provide data consolidation in the clinical setting and thus medications could be provided on a personalized manner for each patient by giving them precision medicines[13] for their illness depending their genes and environment factors. The chances of making mistakes are rare, and this could lead to automation in diagnosing diseases. While the chances of AI replacing doctors and nurses might not be

possible in its literal sense, the doctors, and other paramedical staff need to understand the rapid strides that AI in making in the Healthcare sector and need to update themselves to get familiar with the rapid changes expected to influence the healthcare sector in the near future. The Information systems[14] in Healthcare sector would act as a support mechanism for the doctors to diagnose effectively and paramedical staff to provide personalized care to the patients once they have support of the Data management systems with digital technological support.

4.2. Shortcomings of AI in healthcare

AI in healthcare relies on quality of medical data that is generated during diagnosis of patients and uploaded into the information systems. Biased data, incomplete and low-quality data can result in AI algorithms that make suggestions that are unreliable or unfair[15]. Data from specific patient population are used as data for training AI systems, which may lead to poor generalization to larger patient populations. Dealing with patient data and AI decision-making also raises ethical issues[16]. AI models frequently lack thorough clinical validation and might not have a solid body of data to back up their application in clinical settings. Most of the medical studies conducted involve proper data from the healthcare fraternity and the sample size might not be a true representation of the actual real life cases. The results obtained in such researches needs to be revalidated after conducting repeated trails and tests for final validity. It might be difficult and expensive to integrate AI into currently used healthcare IT systems. Another grave concern is the lack of clarity from authorities and regulators regarding privacy of the patients and their records management. Though many statutory norms have been laid down from time to time, there is no final rule of law regarding the privacy laws in the medical data protection section. To ensure the appropriate and ethical use of AI in healthcare, it is necessary for healthcare professionals, AI developers, regulators, and ethics subject experts to work together to address these issues.

4.3. Future of AI in healthcare

Many features have been discussed in the healthcare world with the integration of AI into its working sphere. To begin with quick disease detection and diagnosis is the first feature expected to happen once AI is introduced into the sector. It is expected to assist millions of healthcare professionals to make accurate diagnosis within exceptional speed. As AI would be able to analyse loads of data set and medical history of patients, personalised care[17] would be achievable as data will be readily available which would help doctors to provide better treatment for patients is expected to accelerate the process of discovering drugs for disease where cure has not been developed, as conducting experiments would be faster with better analysis of available date and simulation of molecular interactions. Medical students across the world would be encouraged to take up medical projects along with the various engineering laboratories and conduct research to make use of the emerging technologies to make their diagnosis easier, efficient and less time consuming. More patients could be catered to if such emerging technologies are added to the medical curriculum[18] if the doctors and paramedical staff. Telehealth is another application that is showing huge promise to treat patients living in remote places of the country like village. The patient will be connected with the support of wearable IOT devices[19] and connected to the healthcare professional with the support of internet connection, which inturn can access ambulances and doctors during emergency situations. Monitoring of the patient is made possible at all times. The data of the patients as well as the electronic health record data needs to be integrated[20] smoothly so that continuity of care could be ensured for all the patients coming to the healthcentres and tertiary hospitals. Overall management of resources, records management, and management of inventory and scheduling of appointments could be efficiently carried out faster reducing the burden of the administrative in healthcare management. Virtual chatbots and assistants are expected to provide round the clock service to the customers especially in matters like providing information to patients, appointment status and in some cases offering basic medical help as well.AI powered wearables and sensors

would help in monitoring health of the patients and would provide real time data to the hospital staff. Patients with chronic conditions could be given better treatment with the support of these innovations. Availability of large data sets would help to trigger good research in the medical field and various AI tools would help to provide state of art training to the medical professionals all across the world. By facilitating the above, AI and allied technologies will support doctors and other health department staff would get support for clinical decision making[21], which will help to improve diagnosis and provide better quality of healthcare to the patients. Health Information Management professionals[22] would be required in good numbers in order to monitor and collect quality data and support the process of effective data management especially in the healthcare field. These specialists would help to bridge the gap between the system requirements and hospital industry, in order to develop robust Healthcare management Information systems while carefully adhering to all the laws and regulations in the country.

4.4. Limitations

The study was conducted considering articles from the Web of Science. If further study can be done using Scopus, PubMed or the IEEE platform, better results and insights could be obtained.

5. Conclusions

This analysis thoroughly reviews the AI-related research that has been done in the healthcare industry, assisting researchers, policymakers, and practitioners in better understanding the evolution of this field of Artificial intelligence research and its potential application in practice. Forthcoming research should emphasize filling up the gaps between clinical applications and AI healthcare research. Importance should be given to provide privacy protection and security[23] to the medical data of the patients so that the stakeholders would use these cutting technologies to improve the treatment in their healthcare settings. Quantitative research has been given more importance, and more studies should be conducted primarily in regions of ethics, governance data clarity and data security in the form of training that may be needed for the healthcare workers in updating their skills in the AI-assisted Healthcare world[24]. Further research could be conducted between the countries where AI has been employed in the healthcare systems and also with those countries where no Information systems have been established. This would also provide an insight on the actual presence AI in Healthcare systems and an analysis could be conducted to understand the current situation in the world with respect to the integration of digital technologies in the Healthcare sector. Technologies like Explainable Artificial Intelligence (XAI) in the healthcare sector would support to develop a state of art cloud server system[25] where all the digital data requirements, communications and SMART hospital functions could be carried out. Integration of emerging technologies would help the health care sector to be ready to tackle pandemics like Covid-19 in the years to come.

Author contributions

Conceptualization, VKV, SIS and JJ; methodology, VKV; software, VKV; validation, VKV, SIS and JJ; formal analysis, VKV; investigation, VKV; resources, SIS; data curation, JJ; writing—original draft preparation, VKV; writing—review and editing, VKV, SIS and JJ; visualization, VKV; supervision, SIS. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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