Mapping Artificial Intelligence in Medical Diagnosis in India: A Bibliometric Analysis

[1]Dr. Ziaur Rahman, [2] Dr Akhtar Hussain, [3] Md. Safiqur Rahaman, [4]Khadeeja M N Ansari

[1]Department of Library and Information Science, Rabindra Bharati University
[2] Hamdard Institute of Medical Sciences and Research (HIMSR),
[3]Deanship of Library Affairs, King Fahd University of Petroleum and Minerals,
[4] Department of Library and Information Science

Abstract: The integration of Artificial Intelligence (AI) into medical diagnosis has immense potential to revolutionize healthcare practices. This bibliometric study explores the landscape of AI research in the field of medical science, focusing specifically on India's trajectory. This study employed bibliometric analysis to examine the landscape of Artificial Intelligence (AI) in medical science research from 2004 to 2023. A total of 2077 research papers authored by 9,982 individuals from 627 sources were analyzed, revealing a collaborative environment with an average of 7.25 co-authors per document, over half of which involved international collaboration. Fluctuations in researchers' productivity and citation impact are illustrated by the publication and citation trends. Highly productive authors, top journals, and contributing organizations were identified to provide insights into their publication records and scholarly prominence. Document categorization highlights the varying impacts of publication type. Co-citation analysis elucidated research themes, such as stroke risk stratification, diabetic retinopathy, and spectral data analysis. Key author keywords and their co-occurrence patterns revealed prevalent themes such as machine learning and COVID-19. Moreover, an analysis of citation bursts revealed topics that have experienced heightened scholarly attention over time. The landscape of international collaboration demonstrated India's significant engagement, particularly in countries such as the United States, United Kingdom, and Italy, indicating widespread global participation in AI-driven medical research. This

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comprehensive examination offers valuable insights into the evolution, trends, and collaborative dynamics of AI research in medical sciences, thereby facilitating further understanding and advancement in this critical domain.

Keywords: Bibliometric, Artificial Intelligence, Medical diagnosis, Co-Citation, Trend analysis.

Introduction

Artificial Intelligence (AI) has emerged as a transformative force across various domains including medical science.In India, amidst a dynamic healthcare landscape and burgeoning IT sector, exploring the applications of AI in medicine is paramount.This study employed a bibliometric approach to scrutinize AI research in medical science in India, offering a comprehensive overview of its current status, key contributors, and emerging trends (Bohr & Memarzadeh, 2020).Globally, significant efforts have been made to integrate AI into medical science, including diagnostic tools, predictive analytics, personalized treatment plans, and drug discovery, to enhance diagnostic accuracy and patient outcomes (Topol, 2019).Understanding India's trajectory in this context is vital, as nations worldwide embrace AI's potential in healthcare (Rajkomar et al., 2019).

India's healthcare system faces unique challenges such as a diverse population, inadequate infrastructure, and resource constraints. AI leveraging presents a promising opportunity to address these hurdles by facilitating effective disease management, early detection, and personalized treatment strategies (Mishra et al. 2017). The synergy between India's robust IT sector and healthcare fosters a conducive environment for AI-driven advancement (Al Kuwaiti et al. 2023).
Bibliometrics, as a quantitative analysis tool for scientific publications, patents, and collaborations, offers a systematic approach to mapping evolution and trends within specific fields (Bornmann & Leydesdorff, 2014).In the realm of AI in medical science, bibliometric analysis serves as an invaluable tool for comprehending the research landscape, identifying influential contributors, and identifying emerging areas of interest.

Literature review

The integration of artificial intelligence (AI) into medical diagnosis has marked a transformative shift in healthcare, promising enhanced accuracy and efficiency in diagnostic procedures. As AI converges and medicine progresses, it is crucial to assess the current state and trajectory of research. Through bibliometric analysis, the study titled 'Mapping out of Artificial Intelligence in Medical Diagnosis' offers a comprehensive overview of trends, key contributors, and emerging topics in AI-driven medical diagnosis.

Gao et al. (2021) conducted a study titled "Bibliometric Analysis of AI Trends Over the Past Decade," analyzing high-citation articles to discern AI research trends, collaborations, and key topics. Hussain and Ahmad (2023) provided similar insights into AI publications, revealing shifts in citation rates and geographic patterns.Trabelsi and Parambil (2023) investigated recent trends in AI-based suspicious activity recognition, highlighting dominant document types and geographic distribution.Additionally, Chen et al.. Li et al. (2021) and Zamit et al.(2022), Saheb et al. (2021), and Penteado et al. (2021) explored various aspects of AI in healthcare, from clinical trials to ethical considerations and medical informatics.Likewise, Tchuente Foguem and Teguede Keleko (2023) focused on AI applications in pulmonary hypertension, identifying significant publications and affiliations in this field.Bajpai and Wadhwa (2021) investigated AI in the Indian healthcare sector and outlined its potential benefits and challenges. Zhang et al. (2023) discussed the use of generative adversarial networks (GANs) in medicine, emphasizing ethical considerations and potential applications. Ma et al. (2023) conducted a bibliometric analysis on AI and deep learning in otorhinolaryngology, revealing evolving research trends and disease focuses.

Musa et al. (2022) examined the impact of AI and machine learning in cancer research, highlighting top-cited articles and key contributors. Lareyre et al. (2022) explored AI research output in non-cardiac vascular diseases, identifying prominent countries and fields within AI development. These studies collectively underscore the growing importance of AI in healthcare, and offer valuable insights into its applications and implications for future research and practice.In addition, the literature review conducted by Gurmessa and Jimma (2023) investigated the application of Explainable Artificial Intelligence (XAI) techniques in stroke diagnosis.This study aimed to examine the use of XAI in stroke diagnosis, its efficacy in elucidating machine-learning model outputs, the evaluation methods employed, and the prevalent categories of explainable approaches.Adhering to the PRISMA guidelines, this review scrutinized 17 primary studies published between January 1988 and June 2023.The key findings indicated that 94.1% of the studies employed XAI for model visualization, with 47.06% utilizing model inspection.However, none of the studies employed evaluation metrics such as D, R, F, or S to assess their XAI system performance.Additionally, none of the studies have evaluated human confidence in the use of XAI for stroke diagnosis.

Loan et al. (2021) presented a bibliometric analysis of the Journal of "Applied Artificial Intelligence (AAI)." The analysis delves into publication trends, authorship patterns, collaborative networks, citation behaviors, and research hotspots across authors, organizations, and countries. Data sourced from the Web of Science database were analyzed using the VOS viewer software.The main findings reveal the journal's growth in research productivity but a decline in citations.The authors from 74 countries contributed, with the USA leading in publications, followed by Italy, India, and England. These countries form a collaborative network, with the USA serving as the central collaborator. Common research topics include classification, optimization, algorithms, and neural networks.Similarly, J. Li's (2022) study discusses the advantages of implementing intelligent robot services in libraries to enhance efficiency and service levels. It identifies challenges, such as the need for core technology mastery, insufficient intelligent service, and corpus construction improvement.To optimize these benefits, libraries should adopt multipurpose intelligent robot systems that integrate library and robot technologies under the Internet of Things.These robots can offer various care services to readers, enhance the overall library experience, improve bookshelving efficiency, and expand reference services.The most suitable systems for library management include automatic book-access and consulting robot systems, particularly book autoaccess and IM consultation systems.The implementation of book auto-access robot technology can help libraries overcome technological bottlenecks and transition to smart libraries.

The study by Agac et al., (2023) aimed to provide a comprehensive systematic review using bibliometric analysis on the utilization of metaverse technology in health education. Analyzing 231 studies from 145 scientific journals, this study assessed trends, patterns, and collaboration networks in research on the metaverse in health education.Key findings identified trends and research hotspots in the use of metaverse technology in health education, showcasing its potential for creating new educational environments and experiences.In addition, this study sheds light on the current state of research and offers guidance for advancing the field.Furthermore, it identifies the leading countries in research on the metaverse in health education.Cobelli and Blasioli (2023) analyzed the adoption of eHealth services in healthcare management using bibliometric methods.By introducing new analytical tools for a more precise examination, this study provides an overview of the existing resources in healthcare management and education.Specifically, this study concentrates on the utilization of UTAUT and UTAUT2 research models in academic studies pertaining to healthcare.The primary findings indicate the increasing relevance of UTAUT and UTAUT2 models in the literature since 2016, particularly in understanding the reasons for the adoption and non-adoption of eHealth services.Additionally, the study underscores the necessity of a multidisciplinary approach to eHealth service implementation and notes the limited focus on the acceptance of healthcare professionals.

Sweileh (2023) conducted a recent study examining global research publications on virtual and augmented reality (VR/AR) technologies for mental disorders.Utilizing the SciVerse Scopus database to collect pertinent documents from 1980 to 2021, 1, 233 research articles were identified, indicating a significant surge in research activity since 2017.Most of this research has been disseminated in journals associated with clinical psychology, neuroscience, psychiatry, and computer science.Scholars in high-income countries with advanced digital technology have led research endeavors, although collaboration between nations in this domain remains limited.The leading countries in this research field include the USA, Spain, and Italy.Articles that focused on anxiety and phobias received the highest number of citations.

Research objectives

- Identify and analyze publication and citation trends concerning artificial intelligence in medical science from 2004 to 2023.
- Investigate the most prolific authors and institutions that contribute to the field of AI in medical science.
- Evaluation of the most relevant sources of AI in Medical sciences.
- Examining authorship patterns within the realm of AI in medical science.
- Identify key research topics and themes within AI in medical diagnosis through co-occurrence of author keywords and word cloud analysis.
- Explore the most cited papers and assess the level of international collaboration in the domain of AI in medical diagnosis.
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Significance of AI in Medical Diagnosis

Literature underscores the significant role of artificial intelligence (AI) in revolutionizing medical diagnoses.AI's integration of AI into the medical field has brought about transformative changes, offering a wide array of diagnostic tools, predictive analytics, personalized treatment plans, and advancements in drug discovery.This study emphasizes AI's potential to enhance diagnostic accuracy and efficiency, thereby improving patient outcomes.Moreover, given India's evolving healthcare landscape and burgeoning IT ecosystem, exploring AI applications in medicine has become imperative.

Research Methodology

This study utilized bibliometric methods to analyze research productivity pertaining to Artificial Intelligence in medical science research in India from 2004 to 2023.Bibliometrics, a quantitative approach, was employed to examine various aspects of academic publications including journals, articles, authors, and citations.This method involves statistical analysis of bibliographic data to uncover patterns, trends, and connections within a particular study domain.
A literature search was conducted using the Web of Science database employing appropriate search phrases related to artificial intelligence and medical science publications.The retrieved papers were screened for relevance to the study topic based on the specific inclusion and exclusion criteria.Ultimately, 2077 publications were downloaded and analyzed using bibliometric software tools such as Biblioshiny, VOSviewer, and CiteSpace.

Search Query Formulation

To retrieve relevant bibliographic data, the following search query was executed on the Web of Science platform.

TS= "Artificial Intelligence" AND "Medical Science Research" AND India AND PUBYEAR > 2023 AND PUBYEAR < 2024

Refined by [excluding] document types: (early access, editorial materials, book reviews, meeting abstracts, books, letters, corrections, data papers, news items, reprints, art exhibition reviews).

Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI SSH, ESCI, CCR-EXPANDED, IC.

Data Extraction

The search query was executed on November 9, 2023, at Rabindra Bharati University, Kolkata, resulting in the retrieval of 2077 research publications.

Data analysis and results

Main information about the data

Table 1 presents key statistics regarding AI data in the field of Medical Science. The table encompasses 2077 research papers from 2004 to 2023.These papers were authored by 9,982 individuals and derived from 627 diverse sources, including journals and books.Notably, only 35 papers were authored by the individual authors.The data illustrate a notable annual growth rate of 30.24%, highlighting increasing interest in the convergence of AI and Medical Science research. On average, each paper receives approximately 14.81 citations, indicating the significance and recognition of the topics explored. The dataset was enriched with 4,426 "Keywords Plus (ID)" and 5,922 "author keywords (DE)," offering a diverse linguistic landscape that encapsulates AI in Medical Science research.The inclusion of various sources underscores the academic community’s broad engagement in disseminating AI-related insights.Furthermore, individual individuals authored 37 documents, emphasizing the individual contributions within this expansive field. Collaboration is a prominent feature, with each paper having an average of 7.25 co-authors, reflecting the collaborative nature of AI in Medical Science research. Notably, approximately 52.24% of the co-authorships transcended international borders, indicating robust global participation and knowledge exchange. Table 1 provides a comprehensive overview of the AI-MS research landscape, highlighting its growth, collaboration dynamics, and exploration of keywords, showcasing the dynamic interaction between artificial intelligence and medical science research.

Table 1. Main information about the data.

Description	Results
Timespan	2004:2023
Sources (Journals, Books, etc.)	627
Documents	2077
Total citation (TC)	30758
Annual Growth Rate %	30.24
Document Average Age	2.52
Average citations per doc	14.81
References	98093
Keywords Plus (ID)	4426
Author's Keywords (DE)	5922
Authors	9982
Authors of single-authored docs	35
Single-authored docs	37
Co-Authors per Doc	7.25
International co-authorships %	52.24

Yearly publication and citation trends

Figure 1 provides a detailed overview of a researcher's academic metrics from 2004 to 2023, including Total Publications (TP), Total Citations (TC), Citations Per Article (CPA), and h-index.Over the timeline, the researchers’ publication output exhibited noticeable fluctuations.Notably, the peak year for the total publications was 2022, with an impressive count of 660.Subsequent years have also demonstrated substantial productivity with 2021 (398), 2023 (303), and 2020 (156) showcasing noteworthy publication figures.In terms of citation impact, the researcher's work has garnered significant recognition.The highest total number of citations was 2021, accumulating an impressive count of 4870, closely followed by 2020 (4694), 2016 (4662), and 2019 (4173), indicating a consistent trajectory of accumulating citations.Assessing the impact of individual articles, the researcher attained the highest citations per article in the initial year of observation (2004) with an outstanding value of 152.50.Subsequent years, such as 2018 (87.96), 2005 (56.00), and 2013 (49.56), also demonstrated a substantial citation impact per article.The h-index, serving as a measure of both productivity and influence, peaked in 2020, with a score of 35, closely followed by 2019 (34), 2021 (31), and 2018 (30), underscoring the researcher's consistent and impactful contributions to their field.

In a broader context, the collective data presented in the figure highlight the researcher's sustained productivity, evident growth in citation counts, and consistently substantial h-index.These trends collectively signify the researchers' significant influence and contribution to their academic domains.

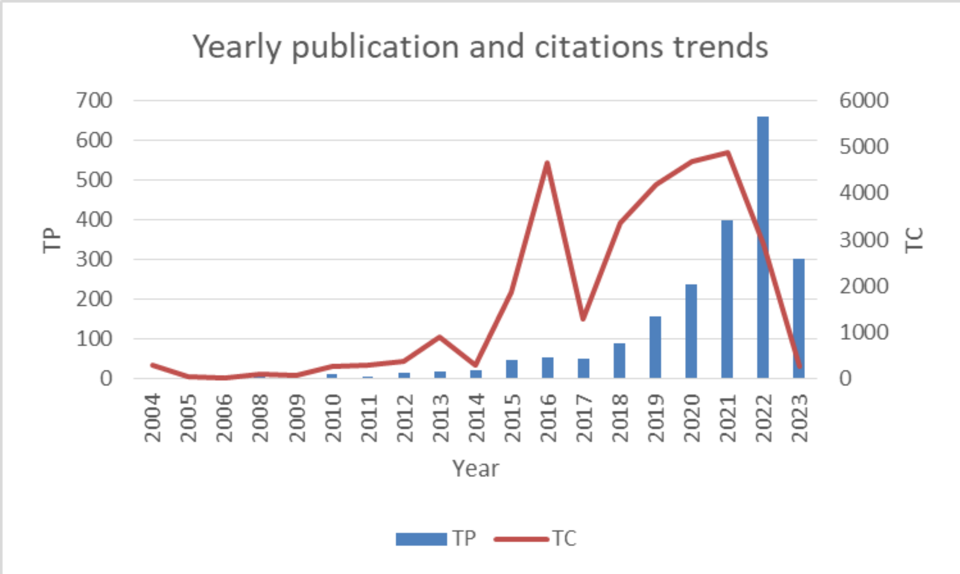


Figure 1. Yearly publication and citation trends.

Productive authors

Table 2 presents a cohort of highly productive authors, highlighting their scholarly achievements, including Total Publications (TP), Total Citations (TC), Citations Per Article (CPA), and the h-index. The "TP" column denotes the number of publications attributed to each author, with Suri JS leading the pack at 79 publications, closely followed by Saba L with 70. The publication count of the remaining authors ranged from 32 to 50. In the "TC" column, Suri JS maintains a prominent position, accumulating 2506 citations, followed closely by Saba L with 2307 citations. The citation counts of other authors varied from 427 to 1634. The "CPA" column showcases the average citations per article for each author, ranging from 12.56 for Gupta S to 36.85 for Nicolaides A, illustrating varying levels of impact associated with their contributions. The h-index, indicative of research influence and productivity, peaked with Suri JS and Saba L, both attaining an h-index of 30, highlighting their significant impact.The h-indices of the remaining studies ranged from 13 to 26. On the lower end, Johri AM holds an h-index of 17, with 32 published papers, 651 citations, and a CPA of 20.34.

This table succinctly encapsulates the essence of the most prolific authors and delineates their publication records, citation impact, and scholarly prominence within their respective domains. The provided rankings and metrics offer valuable insights into the scholarly contributions and academic influence of each author.

Table 2. Top ten productive authors.

Rank	**Author**	**TP**	**TC**	**CPA**	**h_index**
1	Suri JS	79	2506	31.72	30
2	Saba L	70	2307	32.96	30
3	Sharma A	64	980	15.31	20
4	Laird Jr	50	1634	32.68	26
5	Khanna NN	41	1387	33.83	22
6	Nicolaides A	39	1437	36.85	23
7	Gupta A	34	752	22.12	14
8	Gupta S	34	427	12.56	13
9	Kitas GD	32	878	27.44	18
10	Johri Am	32	651	20.34	17

The table presents a compilation of highly productive authors based on their scholarly achievements, including Total Publications (TP), Total Citations (TC), Citations Per Article (CPA), and h-index.

Productive sources

Table 3 presents the ranking of the top ten journals in AI in Medical Sciences, along with the associated metrics. "Computers in Biology and Medicine" leads with 94 total publications (TP) and 1753 total citations (TC), boasting high citations per article (CPA) of 18.65, with significant g-index and h-index values.

Originating in the USA, the Journal Impact Factor (JIF) was 7.7."Computational Intelligence and Neuroscience" followed closely with 79 TP and 533 TC, demonstrating substantial impact, with a JIF of 3.1.
"Diagnostics" ranks third with 60 TP and 525 TC, showcasing significant influence from Switzerland, with a JIF of 3.6. The Journal of Healthcare Engineering" is fourth, with 56 TP and 605 TC, maintaining a moderate impact from the UK, with a JIF of 3.8.The Journal of Medical Systems" ranks fifth, with 54 TP and 1429 TC, exhibiting significant influence from the USA, with a JIF of 5.3.
"Computer Methods and Programs in Biomedicine" stands sixth with 36 TP and 1248 TC, originating from the Netherlands, with a JIF of 6.1. The Journal of Minimal Access Surgery" is seventh with 33 TP and 313 TC, originating from India, with a JIF of 0.8.The Journal of Robotic Surgery" holds the eighth position with 29 TP and 114 TC, originating from the USA, with a JIF of 2.3.
The IEEE Journal of Biomedical and Health Informatics" ranks ninth, with 27 TP and 413 TC, maintaining a moderate level of impact from the USA, with a JIF of 7.7. "Medical & Biological Engineering & Computing" holds the tenth position with 26 TP and 334 TC, originating from Germany, with a JIF of 3.2.
These metrics offer insights into the influence and impact of these journals on AI in the Medical Sciences domain, considering publication output, citations, and journal reputation (JIF).

Table 3. Productive sources.

Rank	**Source**	**TP**	**TC**	**CPA**	**g_index**	**h_index**	**JIF**	**Country**
1	Computers in Biology and Medicine	94	1753	18.65	37	26	7.7	USA
2	Computational Intelligence and Neuroscience	79	533	6.75	19	10	3.1	USA
3	Diagnostics	60	525	8.75	19	13	3.6	Switzerlan
4	Journal of Healthcare Engineering	56	605	10.80	21	13	3.8	UK
5	Journal of Medical Systems	54	1429	26.46	36	23	5.3	USA
6	Computer Methods and Programs in Biomedicine	36	1248	34.67	35	19	6.1	Netherlan
7	Journal Of Minimal Access Surgery	33	313	9.48	16	9	0.8	India
8	Journal of Robotic Surgery	29	114	3.93	8	5	2.3	USA

9	IEEE Journal of Biomedical and Health Informatics	27	413	15.30	19	12	7.7	USA
10	Medical & Biological Engineering & Computing	26	334	12.85	17	9	3.2	Germany

The ranking is based on the given parameters, such as the total publications (TP), total citations (TC), citations per article (CPA), journal impact factor (JIF)

Productive organization

Table 4 presents an analysis of the leading organizations in AI research in the medical sciences domain from 2004 to 2023.Topping the list is the All India Institute of Medical Science, which exhibits exceptional productivity with 87 publications, garnering 706 citations and achieving an average of 8.11 citations per article.Closely following is the Vellore Institute of Technology, securing the second position with 63 publications, 307 citations, and an average of 4.87 citations per article.The Indian Institute of Technology is noteworthy, claiming a third spot, boasting 60 publications, 926 citations, and an impressive average of 15.43 citations per article. Additionally, the National Institutes of Technology ranks fourth, contributing 37 publications, accumulating 825 citations, and attaining a high average of 22.30 citations per article. The SRM Institute of Science and Technology occupies the fifth position with 30 publications, 87 citations, and an average of 2.90 citations per article.

The organizations listed in the table demonstrate varying degrees of research productivity and impact. Following the top five, the Manipal Academy of Higher Education, Tata Memorial Hospital, Anna University, Indraprastha Apollo Hospital, and Indian Institute of Technology–Madras hold sixth to tenth positions, respectively.

Table 4. Productive organization.

Rank	**Productive organization**	**TP**	**TC**	**CPA**
1	All India Institute of Medical Science	87	706	8.11
2	Vellore Institute of Technology	63	307	4.87
3	Indian Institutes of Technology	60	926	15.43
4	National Institutes of Technology	37	825	22.30
5	SRM Institute of Science & Technology	30	87	2.90
6	Manipal Academy of Higher Education	28	306	10.93
7	Tata Memorial Hospital	28	245	8.75

8	Anna University	27	371	13.74
9	Indraprastha Apollo Hospital	27	660	24.44
10	Indian Institute of Technology–Madras	24	282	11.75

The table contains five key columns: Rank, Organization, Total Publications (TP), Total Citations (TC), and Citations Per Article (CPA).

Type of documents

Table 5 categorizes AI in MS research documents from 2004 to 2023, highlighting its varying impacts and prominence in the academic and research spheres.Articles lead to 1636 published documents (DT) and 24255 total citations (TC), boasting an average citations per article (CPA) of 14.83 and an h-index of 61, indicating a significant influence. Reviews follow with 428 DT and 6364 TC, with a CPA of 14.87 and an h-index of 41, showcasing their substantial contribution. Proceedings papers ranked third with 5 DT and 93 TC, exhibiting a CPA of 18.60 and an h-index of 4, indicating notable attention within conferences.The book chapters present 7 DT and 42 TC, with a CPA of 6.00 and an h-index of 4, indicating a moderate influence.Retracted publications, with only one DT and four TC, show minimal impact, with a CPA of 4.00 and an h-index of 1, reflecting their limited influence.This analysis highlights the diverse impacts across publication types, emphasizing the importance of considering multiple metrics for a comprehensive evaluation.

Table 5. Type of Documents.

Rank	**DT**	**TP**	**TC**	**CPA**	**h-index**
1	Article	1636	24255	14.83	61
2	Review	428	6364	14.87	41
3	Proceedings Paper	5	93	18.60	4
4	Book Chapter	7	42	6.00	4
5	Retracted Publication	1	4	4.00	1

This study examined five different types of publications based on various metrics, including the number of published documents (DT), total publications by type (TP), total citations (TC), average citations per article (CPA), and h-index.

Pattern of authorship

Figure 2 provides a detailed overview of authorship dynamics and presents the publication counts, total citations (TC), and average citations per article (CPA) for different authors.Each row represents an author who offers insights into research productivity and influence.The authors at the top demonstrate significant productivity, with the leading author (1) having 37 publications, 230 citations, and an average of 6.22 citations per article (CPA).Conversely, authors with lower rankings may have fewer publications, but higher citation counts and CPAs, indicating a concentrated impact.Notably, Author 15 had a modest publication count (TP: 14) but a high total citation count (TC: 3498), resulting in an exceptionally high CPA of 249.86, reflecting a significant impact.Authors 13, 20, and 22 also exhibited notable CPAs, indicating a potent influence despite their lower document tallies.Conversely, authors 35, 37, 61, and 75 have a CPA of 0.00, indicating no citations for their work.Authors 34 and 87 had CPAs that matched their total citation counts, suggesting that each publication earned a single citation.Several authors have reported mid-range CPAs (approximately 10-20), indicating a moderate level of impact.Additionally, author 145, despite modest TP and TC, maintains a relatively high CPA of 5.00, denoting a commendable impact given the limited document count.Overall, the figure highlights the diverse research productivity and impact of the authors.

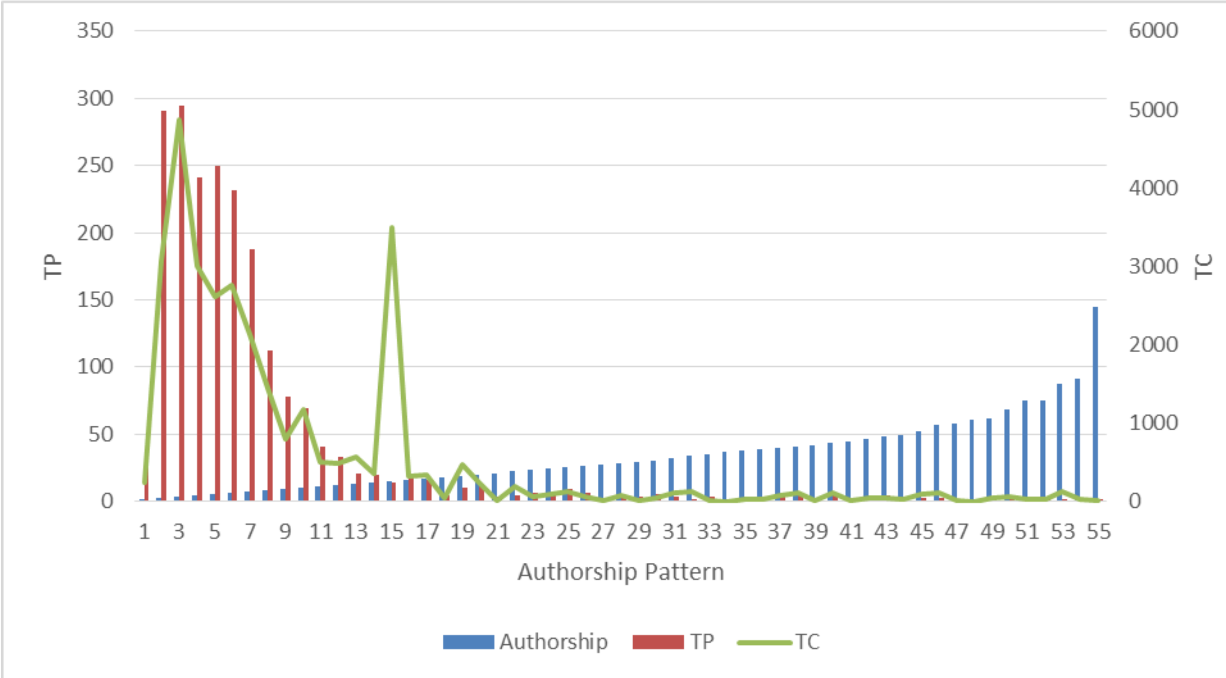


Figure 2. Pattern of authorship**.**

Co-occurrence of author keywords

Figure 3 shows a dataset comprising "types of analysis" and author keywords selected as a "unit of analysis," unit of analysis. unit of analysis A Co-occurrence analysis was conducted using both the full counting and fractional counting methods.Keywords appearing at least ten times were considered for the analysis, resulting in 83 qualifying keywords out of 5922. For each of these 83 keywords, the total strength of co-occurrence links with other keywords was calculated. The keywords with the highest total link strength were selected.The analysis revealed 83 items organized into seven clusters, with 710 links and a combined total link strength of 2255.

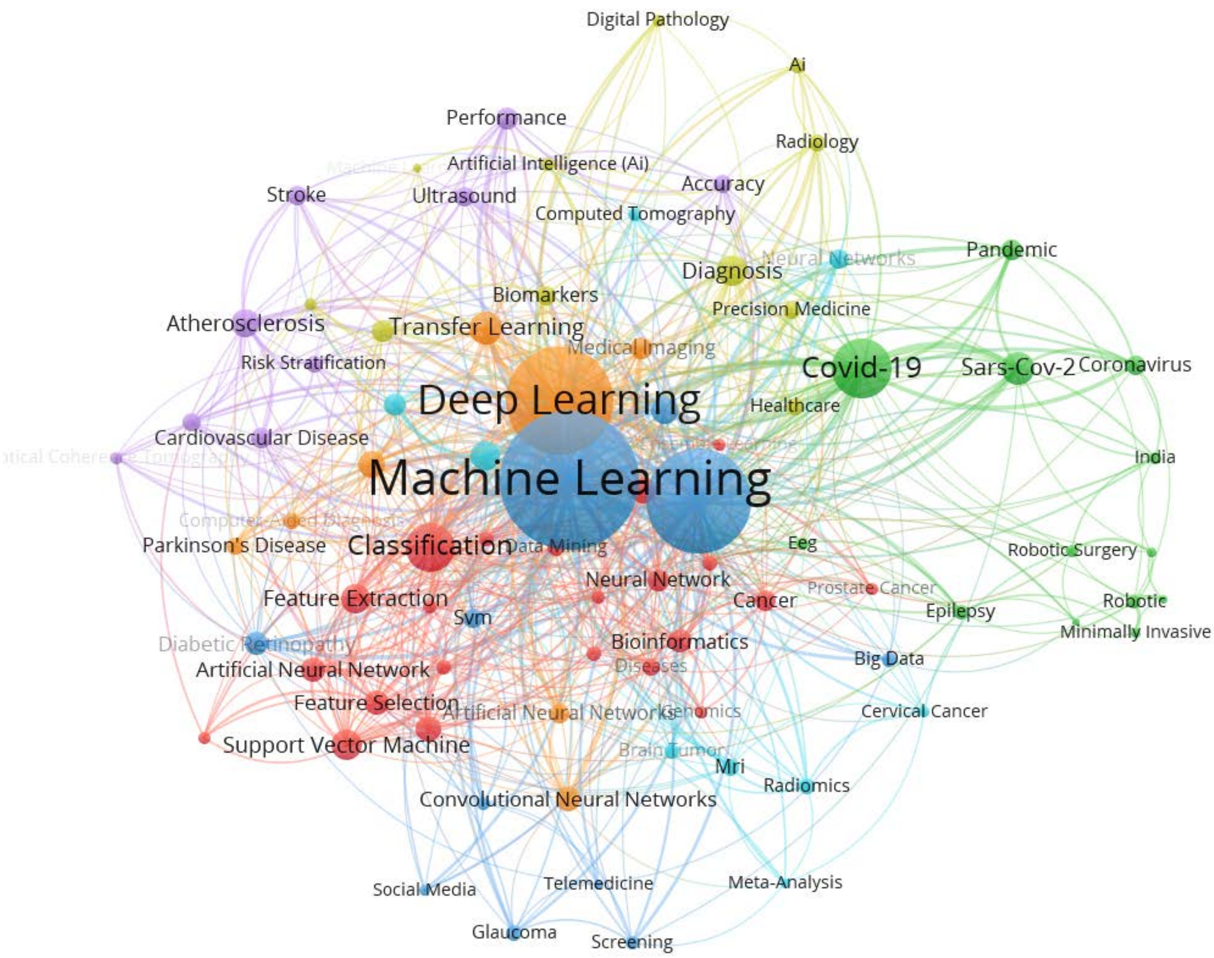


Figure 3. Co-occurrence of author keywords using VOSviewer software.

Top ten author keywords

Table 6 displays the frequencies of the various keywords in the dataset. "Machine Learning" tops the list with 541 occurrences, followed by "Artificial Intelligence" at 307. "Deep Learning" appears 245 times, while "COVID-19" is mentioned 99 times. Other keywords such as "Classification," "Robotic Surgery," "Diagnosis," and "Support Vector Machine" had counts ranging from 81 to 41 occurrences. "Breast Cancer" and "Robotic" have 38 and 36 occurrences, respectively.

Table 6. Top ten author keywords.

Rank	**Keyword**	**Occurrences**
1	Machine Learning	541
2	Artificial Intelligence	307
3	Deep Learning	245
4	Covid-19	99
5	Classification	81
6	Robotic Surgery	46
7	Diagnosis	43
8	Support Vector Machine	41
9	Breast Cancer	38
10	Robotic	36

Word cloud analysis

Word clouds visually depict word frequency, with the size of each word determined by how frequently it appears in the analyzed material. They highlight the central themes or most common terms within the printed text.The word cloud in Figure 4 illustrates keywords related to AI in medical science. It reveals a diverse research landscape, with prominent terms like "classification" (n=271), indicating extensive study on classification methods. Additionally, terms like "diagnosis" (n=157), "prediction" (n=105), and "system" (n=97) suggest efforts to advance AI for anticipatory medical diagnosis. The high occurrence of "cancer" reflects a significant focus on oncology applications. Terms like "features" and "segmentation" imply the exploration of feature extraction and picture segmentation techniques essential for precise diagnosis. "Validation" underscores the importance of testing AI models for reliability in therapy. The repeated mention of "risk" indicates a growing interest in evaluating and categorizing risks in medical contexts. The prevalence of "neural network" emphasizes the use of neural network-based methodologies. Overall, this analysis provides valuable insights into the diverse research directions that shape the use of AI in medical diagnostics.

Figure 4. Analysis of the word Cloud.

Top 13 Keywords with the strongest citation burst

Figure 5 indicates that CiteSpace incorporates a burst detection functionality to identify significant fluctuations in citation activity over a specified timeframe, which is essential for uncovering emerging and declining research topics. Analyzing the 627 publications from 2004 to 2023, Figure 5 shows the top 13 publications with the most pronounced citation bursts.

The "year" column denotes the publication year of keywords, while "begin" and "end" indicate the start and end dates of each burst occurrence. Visualized as a blue timeline spanning 2004 to 2023, the red segments overlay periods of keyword bursts, with endpoints illustrating the duration of each burst event.

In 2005, "classification" exhibited the highest burst strength of 7.49, spanning from 2012 to 2017. Similarly, in 2004, the SVM had the second-highest burst strength at 7.33, running from 2015 to 2019. Finally, "outcome" recorded a burst strength of 7.49 from 2012 to 2017, ranking third.

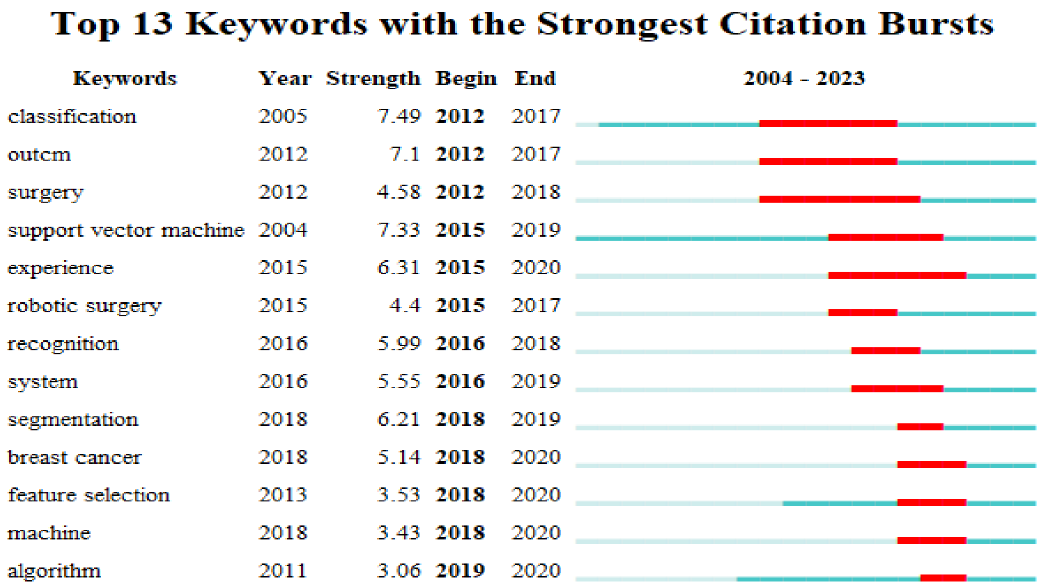


Figure 5. Keywords Burst Detection using CiteSpace: Red depicts the burst period, while blue depicts the beginning of publication.

Exploring research themes by analysis of co-citation of references

In Figure 6, research themes are explored by analyzing the co-citations of the cited references.Among the 32 clusters, 10 were discussed, offering insights into various aspects of medical diagnostics utilizing artificial intelligence (AI).

Cluster #0, focusing on "Stroke Risk Stratification," delves into algorithms for assessing stroke likelihood, featuring notable references such as Khanna et al.'s work on stratifying cardiovascular/stroke risk in diabetic foot infection patients.
Cluster #1, centered on "Diabetic Retinopathy," emphasizes the detection of this diabetes consequence, prominently featuring Raman et al.'s research on deep learning algorithms for diabetic retinopathy detection.
Cluster #2, labeled "Framework," investigates AI approaches for probabilistically anticipating protein-protein interactions, enhancing understanding of molecular biology.

Cluster #3, titled "Spectral Data," explores spectrum data and relevance vector machines in optical cancer detection, demonstrated by Majumder et al.'s research on relevance vector machines for cancer diagnosis.

Cluster #4, "Death," focuses on predicting death in critical care units, highlighting developments in predictive modeling for clinical outcomes.

Cluster #5, "Method," centers on predicting CTL epitopes using computational methodologies, advancing immunoinformatic.

Cluster #6, "Near Wall," evaluates categorization precision in medical AI applications, particularly assessing stroke risk based on plaque tissue shape using carotid ultrasonography.

Cluster #7, "Breast Cancer," utilizes AI for breast cancer detection and diagnosis, exemplified by Kumar et al.'s work on explainable AI discovering biomarkers from peripheral blood mononuclear cells.

Cluster #8, "RKT," examined robotic kidney transplantation progress enabled by AI in surgical methods.

Cluster #9, "CVD Risk Assessment," explores AI in evaluating cardiovascular disease risk, integrating risk assessment with COVID-19, exemplified by Suri et al.'s study on AI assessing cardiovascular risk in COVID-19 individuals.

These clusters highlight a broad spectrum of AI-based medical diagnosis research, from disease-specific algorithms to surgical technique improvements and risk-assessment models. This underscores the interdisciplinary nature and significant potential of AI-driven innovations in health care.

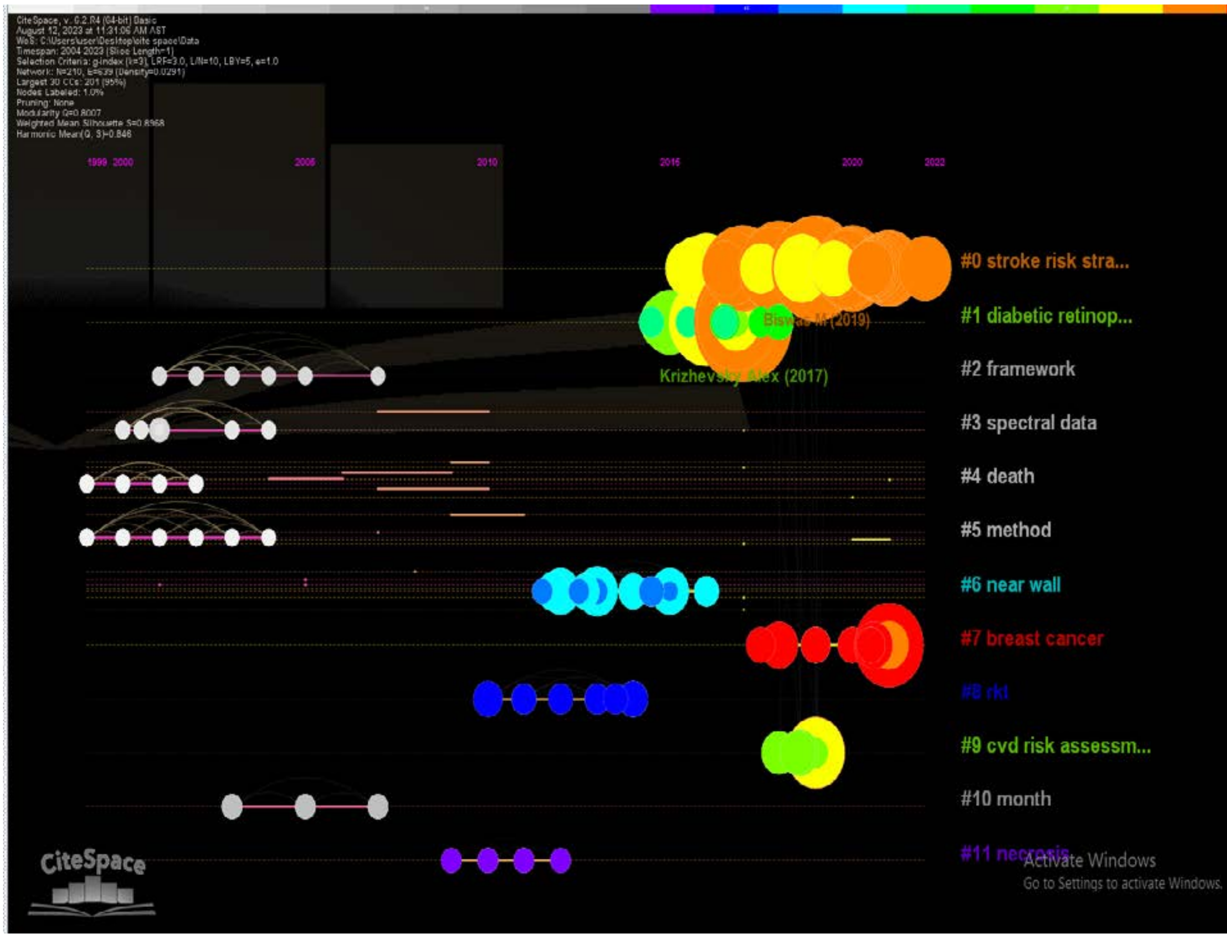


Figure 6.Co-citation of cited references: Each circle represents a document and the circle size represents the number of citations. The larger the circle, the higher the number of citations.

Co-citation of cited authors

In Figure 7, the co-citations were extracted from 'types of analysis,' and cited authors were selected from a 'unit of analysis,' using a full calculation method. Authors with a minimum of 20 citations were considered for analysis, resulting in 246 qualifying authors out of 39665. For each of these 246 authors, the total strength of the co-citation links with other authors was calculated. The authors with the highest total link strengths were selected. The analysis revealed a total of 246 items organized into three clusters, with 12264 links and a combined total link strength of 107137.

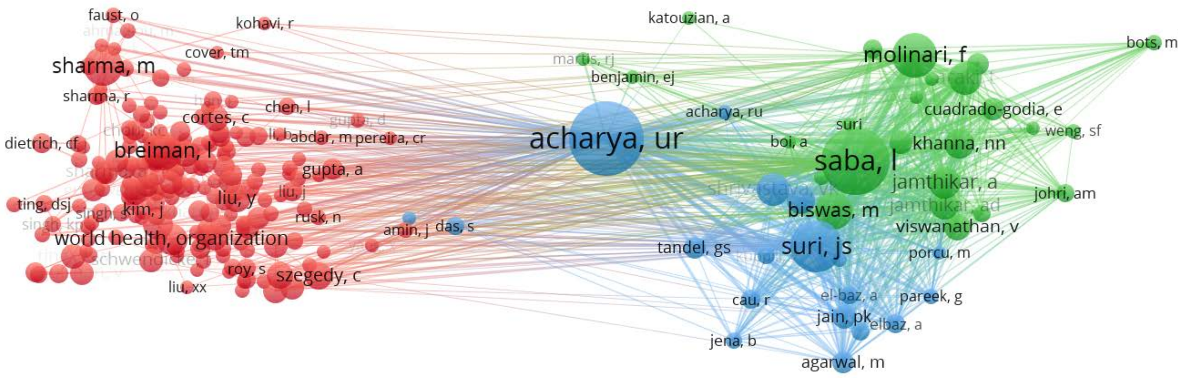


Figure 7. Visualizing co-citations of cited authors.

Top 10 co-citations of the cited author

Table 7 provides an overview of the authors' academic impact, focusing on their citation counts and total link strength. "Acharya, UR" leads with 564 citations and a total link strength of 19689, followed closely by "Saba, L" with 463 citations and a link strength of 20949. "Suri, 0JS" holds 276 citations and a total link strength of 13781, while "Molinari, F" is credited with 209 citations and a link strength of 9876. "Sharma, M," "Breiman, L," and "Biswas, M" have 160, 156, and 147 citations respectively, contributing to their respective link strengths. Completing the list, "Shrivastava, VK," "Araki, T," and "Jamthikar, A" have 113, 111, and 105 citations, respectively, along with their corresponding link strengths.These data provide valuable insights into the scholarly influence of these authors on the academic community.

Table 7. Top 10 co-citations of cited authors.

Rank	Author	Citations	Total Link Strength
1	Acharya, UR	564	19689
2	Saba, L	463	20949
3	Suri, 0JS	276	13781
4	Molinari, F	209	9876
5	Sharma, M	160	865
6	Breiman, L	156	803
7	Biswas, M	147	7466
8	Shrivastava, VK	113	4369
9	Araki, T	111	4990
10	Jamthikar, A	105	5511

Co-citation of cited Sources

Figure 8 shows that co-citations were identified from 'types of analysis,' with cited sources selected from a 'unit of analysis,' utilizing a full calculation method. Sources with a minimum of 20 citations were included in the analysis, resulting in 976 out of 23082. For each of these 976 sources, the total strength of the co-citation links with other sources was computed. The sources with the highest total link strength were selected. The analysis yielded a total of 976 items clustered into nine groups, with 193859 links and a combined total link strength of 2222104.

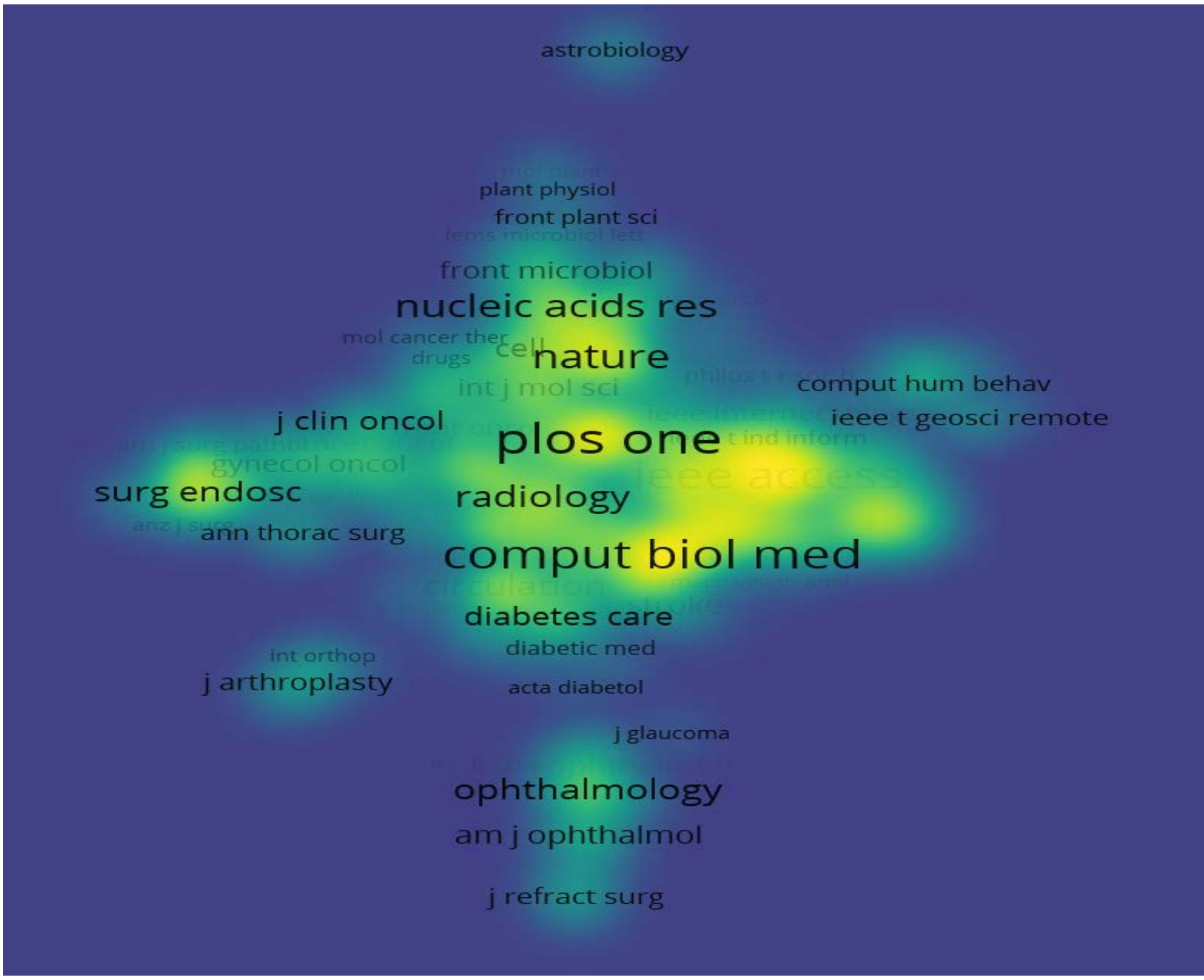


Figure 8. Visualization of the co-citation of cited sources.

Top 10 co-citations of cited sources

Table 8 offers insights into the impact and prominence of various sources within the academic domain using metrics such as citation counts and total link strength." PLOS One" leads with 1394 citations and a total link strength of 85897, followed closely by "Sci Rep-UK" with 1172 citations and a link strength of 74698. “Comput Biol Med” has accrued 1144 citations and a link strength of 86950, while “IEEE Access” is recognized for its 982 citations and total link strength of 50995. Additionally, “Comput Meth Prog Bio,” “Expert Syst Appl,” and “Lect Notes Comput Sc” have citation counts of 897, 790, and 774 respectively, contributing to their corresponding link strengths.“Nature” has garnered 679 citations and a link strength of 44777, while “IEEE T Med Imaging” and “arXiv” complete the table with 659 and 617 citations respectively, along with their associated link strengths. These data provided a snapshot of the scholarly impact and engagement associated with each source.

Table 8. Top ten co-citations of cited sources.

Rank	Source	Citations	Total Link Strength
1	PLOS One	1394	85897
2	Sci Rep-UK	1172	74698
3	Comput Biol Med	1144	86950
4	IEEE Access	982	50995
5	Comput Meth Prog Bio	897	65487
6	Expert Syst Appl	790	41182
7	Lect Notes Comput Sc	774	48501
8	Nature	679	44777
9	IEEE T Med Imaging	659	41960
10	arXiv	617	31233

Most cited papers

The analysis of Table 9 reveals that the paper with the highest total citation (TC) count is "Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs" by Gulshan et al. (2016). This paper has accumulated 3232 citations, with an average of 404

citations per year. A normalized TC of 36.74, signifies that this paper has received more citations annually than any other in the field of medical imaging since its publication.
The paper with the second highest TC is "Recommendations for Laparoscopic Liver Resection: A Report from the Second International Consensus Conference Held in Morioka" by Wakabayashi et al. (2015), which has been cited 912 times, with an average of 101.33 citations per year. The normalized TC value was 22.36.
Similarly, the paper with the third highest TC is "Artificial Intelligence and Deep Learning in Ophthalmology" by Ting et al. (2019), also cited 912 times, averaging 101.33 citations per year, with a normalized TC of 22.36.

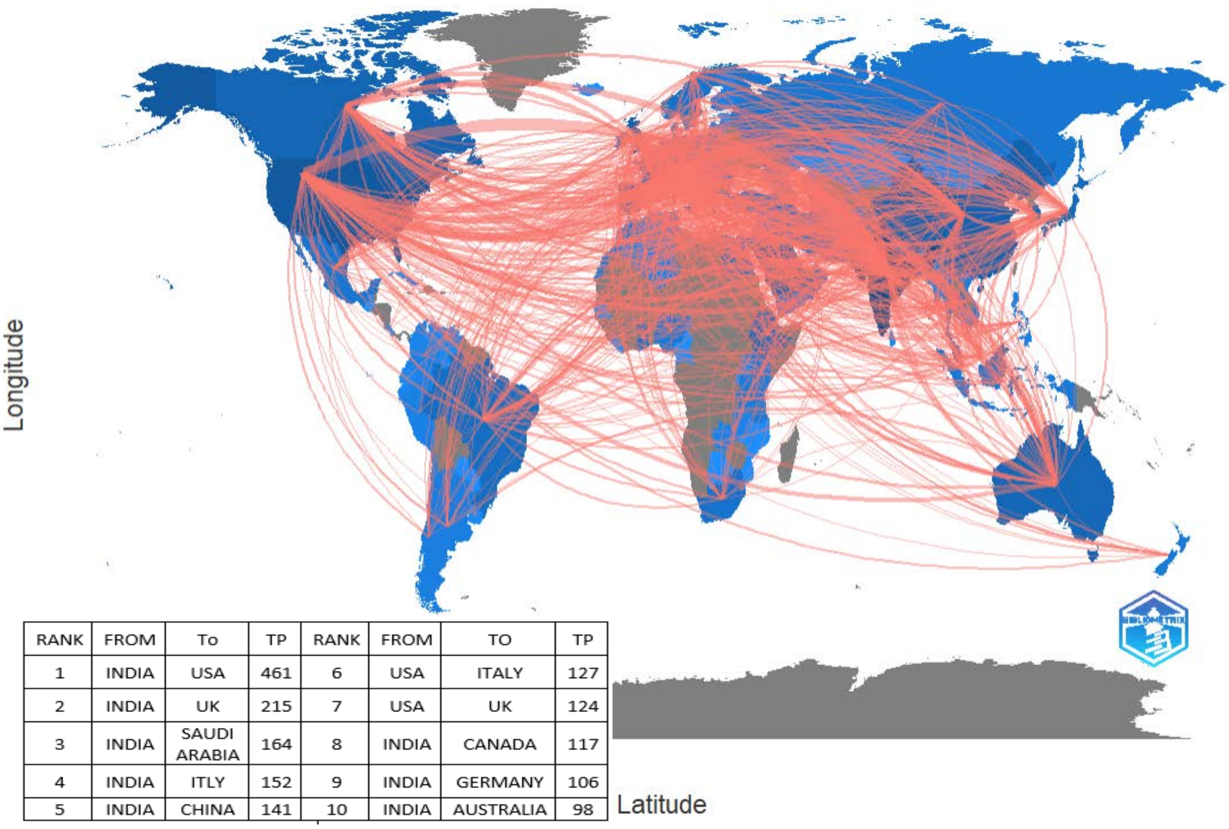
Table 9. Top 10 most-cited papers.

Rank	Title	Author, Year, and Source	TC	TC per Year	Normalized TC
1	Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs	Gulshan V, 2016, JAMA J Am Med Assoc	3232	404	36.74
2	Recommendations for laparoscopic liver resection: a report from the second international consensus conference held in Morioka	Wakabayashi G, 2015, Ann Surg	912	101.33	22.36
3	Artificial intelligence and deep learning in ophthalmology	Ting DSW, 2019, Brit J Ophthalmol.	450	90	16.82
4	A Dataset and a Technique for Generalized Nuclear Segmentation for Computational Pathology	Kumar N, 2017, IEEE T Med Imaging	389	55.57	15.45
5	Classification of COVID-19 patients from chest CT images using multi-objective differential evolution–based convolutional neural networks	Singh D, 2020, Eur J Clin Microbiol	312	78	15.69
6	Automated EEG-based screening of depression using deep convolutional neural network	Acharya UR, 2018, Comput Meth Prog Bio	293	48.83	7.79

7	Designing of interferon-gamma inducing MHC class-II binders	Dhanda SK, 2013, Biol Direct	273	24.82	5.51
8	Prediction of CTL epitopes using QM, SVM, and ANN techniques	Bhasin M, 2004, Vaccine	264	13.2	1.73
9	Brain and blood metabolite signatures of pathology and progression in Alzheimer's disease: A targeted metabolomics study	Varma VR, 2018, PlOS Med	242	40.33	6.44

Country collaboration map

Figure 9 provides an overview of international collaboration in AI research within the medical science domain. India and the United States led the collaboration, with a total publication (TP) count of 461. The following are closely related to India and the United Kingdom, with 215 publications: Another significant collaboration includes India and Saudi Arabia, amassing a TP of 164, as well as India and Italy, with a TP of 152. Further down the list, India's collaboration with China resulted in a TP of 141, whereas the partnership between the USA and Italy yielded a TP of 127. Finally, rounding out the top ten ranks on the country collaboration map is the partnership between India and Australia, with a total of 98 publications.



RANK	FROM	To	TP	RANK	FROM	TO	TP
1	INDIA	USA	461	6	USA	ITALY	127
2	INDIA	UK	215	7	USA	UK	124
3	INDIA	SAUDI ARABIA	164	8	INDIA	CANADA	117
4	INDIA	ITLY	152	9	INDIA	GERMANY	106
5	INDIA	CHINA	141	10	INDIA	AUSTRALIA	98

Figure 9. Country-collaboration map.

Discussion

This study employed bibliometric analysis to examine AI's evolution of AI in Indian medical research. Table 1 shows 2,077 papers (2004–2023) reflecting growing academic interest. The 30.24% annual growth rate underscores AI's expanding role of AI in diagnostic and treatment planning(Senthil et al., 2024). The high average citation rate of 14.81 per paper underscores the impact of these studies. The dataset also highlights strong collaboration, with an average of 7.25 co-authors per paper and 52.24% involving international partnerships, which is essential for advancing AI-driven healthcare (Saha, 2024). Furthermore, the yearly publication and citation trends in Figure 1 indicate a dynamic research trajectory, with noticeable fluctuations in both output and impact. The peak publication year, 2022, saw an extraordinary 660 publications, 2021 (398) and 2023 (303) also demonstrated high productivity. The citation impact peaked in 2021 (4870 citations), reinforcing the influence of scholars (Garfield, 2006). The highest h-index was recorded in 2020 (h = 35), reflecting sustained academic significance (Hirsch, 2005a).

The analysis of highly productive authors (Table 2) revealed a concentration of scholarly influence among a few selected authors. Suri JS and Saba L emerge as the most prolific, with 79 and 70 publications, respectively. Their citation counts (2506 and 2307) and h-indices (30 each) reflect a significant research impact. Nicolaides A led to the CPA (36.85), highlighting its high-impact contributions. These metrics align with prior studies on author productivity (Bornmann & Daniel, 2007; Hirsch, 2005b). Furthermore, another analysis revealed the dominance of Computers in Biology and Medicine, which led to 94 total publications and a high citation per article (CPA) of 18.65, indicating a substantial impact (JIF 7.7). Other high-impact journals include Computational Intelligence and Neuroscience and Journal of Medical Systems (JIF 3.1 and 5.3, respectively). Such rankings highlight the global distribution and influence of AI research on healthcare (Mishra et al., 2022).

This analysis highlights the dominance of leading institutions in AI research in the medical sciences. The All India Institute of Medical Sciences has emerged as the most productive organization, followed by the Vellore Institute of

Technology, and the Indian Institute of Technology, which demonstrates the highest citation impact.The National Institutes of Technology also exhibits a strong influence, whereas the SRM Institute of Science and Technology contributes only moderately. These findings underscore the pivotal role of top institutions in advancing AI-driven medical research(Guo et al., 2020; Wang et al., 2023).In addition, authorship patterns revealed variations in research productivity and impacts (Figure 2). High-output authors (e.g., Author 1:37 publications, CPA 6.22) contrast with low-output, yet high-impact authors (e.g., Author 15: CPA 249.86), emphasizing quality over quantity (Seetharam et al., 2018). Authors with zero CPA indicate uncited work, while mid-range CPAs suggest a moderate influence(Sarli et al., 2010). Such trends align with previous bibliometric studies of citation distribution (Hirsch, 2005b).

Co-occurrence analysis of author keywords identified 83 frequently appearing keywords, forming seven clusters with 710 links and a total link strength of 2255 (Figure 3). This approach, which uses both full and fractional counting, highlights key research themes and their interconnections (Van Eck & Waltman, 2017). Such clustering helps map the intellectual structure of a domain(Zupic & Čater, 2015).

Keyword frequency analysis (Table 6) revealed a strong emphasis on machine learning (ML) and artificial intelligence (AI) in medical research. "Machine Learning" (n=541) and "Artificial Intelligence" (n=307) demonstrate the growing integration of these technologies in healthcare. The prominence of "Deep Learning" (n=245) underscores its increasing adoption in complex data analysis, particularly in medical imaging and diagnostics (LeCun et al., 2015). The presence of "COVID-19" (n=99) reflects the pandemic-driven surge in AI applications for disease detection and monitoring (Vaishya et al., 2020). Other frequently occurring terms, such as "Classification" (n=81), "Robotic Surgery" (n=64), and "Support Vector Machine" (n=41), indicate research trends in automated medical decision-making (Vapnik, 2013). As well, the word cloud analysis (Figure 4) visually supports these findings, highlighting "classification" (n=271), "diagnosis" (n=157), and "prediction" (n=105), showcasing AI's role in enhancing medical diagnostics and forecasting outcomes (Esteva et al., 2017). The high occurrence of "cancer" suggests a strong research focus on oncology applications. Terms like "segmentation" and "features" indicate advancements in medical image analysis (Litjens et al., 2017). The significance of "risk" in the dataset suggests a growing interest in predictive analytics for disease prognosis (Kourou et al., 2015).

Citation burst analysis (Figure 5) further corroborated these trends. "Classification" exhibited the highest burst strength (7.49) from 2012 to 2017, reflecting its foundational role in AI-based diagnostics. "Support Vector Machine" (burst strength: 7.33, 2015-2019) demonstrates its continued relevance in medical classification tasks (Cortes & Vapnik, 1995). Co-citation analysis (Figure 7) identified the key contributors to AI research. "Acharya, UR" leads with 564 citations, followed by "Saba, L" (463) and "Suri, OJS" (276). Scholars have significantly influenced AI’s application of AI in healthcare, particularly in medical imaging and pattern recognition (Lu et al., 2017). Similarly, the co-citation of sources (Figure 8) highlights the foundational studies that have shaped AI’s role of AI in medicine.

Table 9 lists the most cited paper, "Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs" by Ghulshan(Gulshan et al., 2016), leading to 3,232 citations. This underscores the importance of AI in ophthalmology and disease screenings. Another influential work, "Recommendations for Laparoscopic Liver Resection" by Wakabayashi et al. (2015) emphasized AI’s role of AI in surgical advancements. The country collaboration map (Figure 9) demonstrates strong research partnerships, with India and the USA leading (TP=461), followed by collaborations between India and the UK (TP=215). These partnerships indicate global efforts to advance AI in medical applications (Sarker, 2021).

Overall, this discussion highlighted the evolving impact of AI on healthcare, particularly in diagnostics, predictive analytics, and surgical interventions, thereby shaping future medical research.

Conclusions

This bibliometric study provides a comprehensive analysis of AI’s evolution of AI in Indian medical research over the past two decades. The steady increase in publications with a notable annual growth rate of 30.24% underscores the importance of AI in diagnostics, treatment planning, and predictive analytics. The high citation impact (14.81 citations per paper) reflects the field's academic significance, whereas strong international collaboration (52.24%) highlights global efforts to advance AI-driven healthcare. Key trends identified in the keyword frequency analysis and co-occurrence mapping revealed the dominance of machine learning, deep learning, and AI in medical imaging, disease detection, and automated decision-making. The COVID-19 pandemic has further accelerated AI applications in healthcare. In addition, the prominence of leading authors, institutions, and high-impact journals suggests a concentrated research influence that continues to shape the field. This study highlights AI's transformative potential of AI in medical research and practice. As AI technologies evolve, future research should focus on addressing ethical considerations, regulatory frameworks, and real-world implementation challenges to ensure their responsible and effective integration into health care.

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Conflict of interest

The authors declare no conflict of interest.

ORCID

Ziaur Rahman(https://orcid.org/0000-0002-3393-8690)
Akhtar Hussain (http://orcid.org/0000-0002-4215-9306)
Md. Safiqur Rahaman (https://orcid.org/0000-0003-1367-2618)
Khadeeja M N Ansari(https://orcid.org/0000-0002-1451-3822)

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