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Artificial Intelligence and Medicine 2014-2024: Bibliometric Analysis and Global Impacts

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ABSTRACT

Artificial intelligence (AI) has radically transformed the field of medicine in the last decade, with a significant increase in academic publications. Based on 1783 English-language articles analyzed with Biblioshiny and VOSviewer tools, the findings highlight an annual growth rate of 30.38% and a significant increase from 2018 onwards. Each article received an average of 17.54 citations. The studies had contributions from 11678 authors and an international collaboration rate of 29%. There were single-author (118) and single-country (129) articles. Prominent contributing authors include Forestiero A, Mazzuca D and Zinno F. Harvard Medical School (104 papers) and the University of Toronto (83 papers) have played important roles in the advancement of AI applications in medicine. The USA stands out with both publication volume (3241 articles) and number of citations (9176). Journals such as Journal of Medical Internet Research (26 articles) and Frontiers in Medicine (25 articles) stand out as the leading publication venues in the field. The most cited articles were published in journals such as Jama, Radiology and Nature. This study highlights the wide-ranging applications of AI in areas such as machine learning, deep learning, natural language processing and computer vision, demonstrating its potential in medical imaging, genetic analysis and clinical decision support systems. Future research needs to focus on maintaining collaboration, increasing methodological rigor and finding solutions to emerging challenges.

1. Introduction

Artificial intelligence (AI) has become popular today thanks to deep learning models that can produce anything from art to term papers with minimal human intervention [1]. AI algorithms have recently emerged as a promising technology that can potentially benefit from recent advances in 'big data' and provide more efficient and precise results, with the ability to automatically recognise and learn processes in terms of healthcare [2].

The use of AI in medicine has the potential to revolutionise the delivery of healthcare services. For example, AI can improve early detection, diagnosis, treatment and outcome prediction in various diseases, including cancer, neurology and cardiology [3]. Furthermore, AI technologies, especially

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through deep learning and neural networks, can revolutionise health and pharmaceutical research, improving personalised treatment, drug discovery and epidemic prediction [4].

However, its practical applications are still in the development stage and more research and development on the use of artificial intelligence is needed for better healthcare delivery [5]. In this context, AI can transform healthcare, but it also requires careful management and research on its capabilities and limitations [6].

AI also plays an important role in medical decision-making processes, especially in predictive analyses, improving diagnosis, treatment and overall health management. However, considering accountability, transparency, potential harms, and the professional roles and integrity of clinicians, AI-assisted decision-making in healthcare can be implemented ethically and responsibly [7]. In addition to supporting physicians in diagnosis, disease prediction and treatment customisation, AI also requires skills and data quality awareness for data-intensive analysis and knowledge-based management [8]. Specifically, this requires not only specialised knowledge of the personnel in their field, but also knowledge of artificial intelligence and data processes.

With all these different aspects and effects of artificial intelligence, it necessitates the reinterpretation of some fundamentals and dynamics in the field of health and medicine. Artificial intelligence, which will come to the fore as the most important variable in the future, should be revealed with its different views. This study endeavours to provide both sector employees and academicians with a different perspective and framework for the future by presenting academic studies on the use of artificial intelligence, especially in the field of medicine.

2. Conceptual Framework

The development of artificial intelligence in medicine covers a wide range from the use of artificial intelligence in image analysis, identification of disease outbreaks and diagnosis to the use of chatbots [9]. It is predicted that artificial intelligence applications in the health sector have a great potential today and this potential has the power to create a serious transformation in the future. There are positive and negative evaluations, opportunities and challenges, as well as ethical debates regarding the use of artificial intelligence applications in the field of health in general and medicine in particular. These discussions include not only the related disciplines but also the technological integration and use of artificial intelligence systems. For example, the challenges of using artificial intelligence include data security and privacy concerns and regulatory barriers [10]. In terms of integration, the main challenges faced include the inherent challenges of machine learning, logistical implementation challenges, adoption barriers and sociocultural changes [11].

In healthcare, artificial intelligence improves early detection, diagnosis, treatment and outcome prediction in various disease areas by using machine learning, deep learning and natural language processing techniques for structured and unstructured data [3]. Miller and Brown [12] stated in their research that artificial intelligence can increase the speed, accuracy and efficiency of diagnosis in image analysis, radiology, pathology and dermatology in medicine and reduce medical errors. It is emphasised by researchers that artificial intelligence technologies in medicine can improve diagnostic procedures, treatment protocol development, patient follow-up, drug development, personalised medicine and epidemic predictions in global health [13]. Artificial intelligence technologies in the field of medicine can revolutionise healthcare by generating insights, enabling

decision-making through augmented intelligence, and also facilitating personalised diagnosis and predictions [14].

Concerns about the use of artificial intelligence in the medical field have also emerged in parallel with these developments. These include concerns about data sharing and privacy, transparency of algorithms, data standardisation, interoperability across multiple platforms, and patient safety [15]. They also include early adoption, patient privacy and patient autonomy rights [16], and accountability, potential group harms from algorithmic bias, and clinicians' professional roles and integrity [7].

As the information age gives way to the age of artificial intelligence, some professions, including the medical field, may be disproportionately affected by this situation with its pros and cons [17]. Employees may even find themselves in a post-luddisim-like tendency and structure with the fear of losing their jobs due to artificial intelligence [18]. In this respect, it is necessary to determine serious procedures for the use of artificial intelligence for the future by evaluating the positive and negative aspects well. This is important even in terms of public health. Because, it seems that digital assistance systems based on chatbots regarding the use of artificial intelligence (AI) in medicine will play an increasingly important role in the doctor-patient communication of the future [19]. However, AI is an algorithm that has the capacity to improve the physician's decision-making process [20] while enabling the system to reason and learn by providing insights through advanced computation and inference. In this respect, it can assume a role that supports the physician, accelerates the process and contributes.

In this context, in this article, in order to understand the studies, perspectives and evaluations on artificial intelligence in the field of medicine, the literature on the field was reviewed through a bibliometric analysis.

3. Methodology

In this study, articles published in academic journals from 2014 to 2024 (July) in the world on the use of artificial intelligence in the field of medicine were analysed. The data used in the analyses made through Biblioshiny and VOSviewer were obtained from Scopus, one of the largest databases. As a result of the search in the field of medicine with the keywords ‘medicine’ and ‘AI’ from the database, 1783 articles published in English were included in the analysis.

The aim of this article is to identify and analyse the scientific literature with a bibliometric analysis to find the main topics, authors, sources, most cited articles and countries in the literature on the use of artificial intelligence in medicine. Thus, it is aimed to provide a different perspective and framework for the sector and academicians for the future by revealing academic studies on the use of artificial intelligence, especially in the field of medicine.

3.1 Bibliometric Analysis

Combining different frameworks, tools and methods for examining and analysing citations of scientific publications [21], bibliometric analysis is also used to identify the most frequently cited articles in a researcher's area of interest and to identify author networks on a global scale [22]. As an analytical technique frequently used in systematic literature reviews [23], it has become an area of increasing research interest [24], especially in the last decade. There are many different scientific databases to collect data for bibliometric analysis and various software to analyse these data [25].

In this study, the reason for using bibliometric analysis to analyse artificial intelligence publications in the field of medicine in the world is to determine the weights in the field and to reveal the most effective studies.

3.2 Research Gaps and Research Questions

A worldwide review of academic studies on artificial intelligence in the field of medicine reveals three critical research gaps for the bibliometric analysis method.

- There is a need for a bibliometric analysis study in which studies on artificial intelligence in the field of medicine are comprehensively evaluated and analysed.
- In the field of social sciences, there is a need for studies that enable the evaluation of articles and other publications using bibliometric analysis from many different perspectives.
- The number of studies conducted with different analysis techniques of bibliometric method in social sciences is not sufficient.

This study is among the few examples that use the bibliometric method to analyse articles on artificial intelligence in the field of medicine. This study seeks to answer the following questions:

- What is the growth trend of AI-related articles in the field of medicine?
- What is the citation status of AI-related articles in medicine?
- Who are the most cited authors in the field of medicine?
- Which are the most cited documents, journals, organisations and countries in the field of medicine?
- What is the most cited publication in the field of medicine?

4. Findings

The data obtained from the search results were cleaned by removing duplicate records and irrelevant publications. In this process, titles, abstracts and keywords were reviewed and appropriate publications were selected for analysis. The information obtained and general information about the publications are given in Table 1.

Table 1: Main Information

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2014:2024
Sources (Journals, Books, etc)	875
Documents	1783
Annual Growth Rate %	30,38
Document Average Age	2,33
Average citations per doc	17,54
References	73736
DOCUMENT CONTENTS	

Keywords Plus (ID)	10885
Author's Keywords (DE)	4699
AUTHORS	
Authors	11678
Authors of single-authored docs	118
AUTHORS COLLABORATION	
Single-authored docs	129
Co-Authors per Doc	7,79
International co-authorships %	29
DOCUMENT TYPES	
Article	1783

Table 1 contains basic information on academic publications between 2014 and 2024. Timespan: 2014-2024, References (Journals): 875, Documents: 1783, Annual Growth Rate %: 30.38, Average Age of Documents: 2.33 years, Average Citations per Document: 17.54, References: 73736, Authors: 11678, Author of Single Authored Documents: 118.Single Authored Documents: 129, Number of Co-authors per Document: 7.79. International Collaboration Rate %: 29. Article 1783.

These data show that the number of academic publications is increasing rapidly and co-operation between authors is widespread. In particular, the annual growth rate of 30.38% indicates the rapid expansion in the academic field. The average number of citations per document is 17.54, indicating that the studies in this field generally have high impact. The average document age of 2.33 years indicates that the studies in the field are relatively new and up-to-date. The high rate of collaboration between authors (7.79 co-authors per document) and the international collaboration rate of 29% indicate that the studies are generally carried out with multicentre and diverse perspectives. The fact that the number of single-authored documents is 118 and the number of single-authored documents is 129 reveals that there are fewer individual studies in this field.

Various bibliometric indicators were used to analyse the quantitative and qualitative characteristics of publications. These indicators are designed as number of publications, number of citations, author institution analysis, country analysis, journal analysis.

4.1 Number of Publications and Citations

Research trends were determined by analysing the distribution of the number of publications by years. The distribution of publications by years is given in Figure 1.

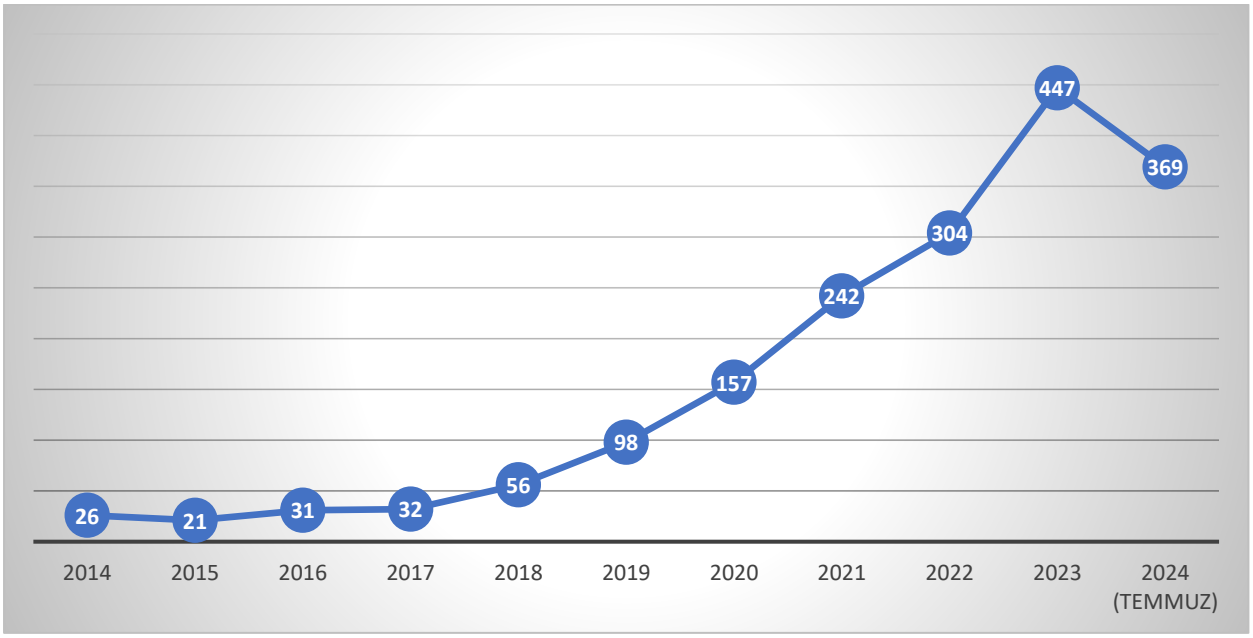

Fig. 1. The distribution of publications by years

Figure 1 shows a clear upward trend in the number of articles from 2014 to 2024. Especially since 2018, there is a sharp increase in the number of articles. In 2015, the lowest number of articles is observed (21 articles). In 2023, the highest number of articles (447 articles) was reached. As of 2020, a sharp increase in the number of articles is observed. This increase continues until 2023, and although it decreases slightly in 2024, it still remains at a very high level. These data show that there has been a significant increase in academic publications in recent years. Especially in 2020 and beyond, there has been a significant increase in research and publications, possibly due to the impact of the COVID-19 pandemic. 2023 stands out as the year with the highest number of articles. Although 2024 saw a slight decline, the general trend points to a significant increase in the number of academic publications.

The status of annual citations in the bibliometric analysis of studies on 'medicine' and 'artificial intelligence' is shown in Figure 2.

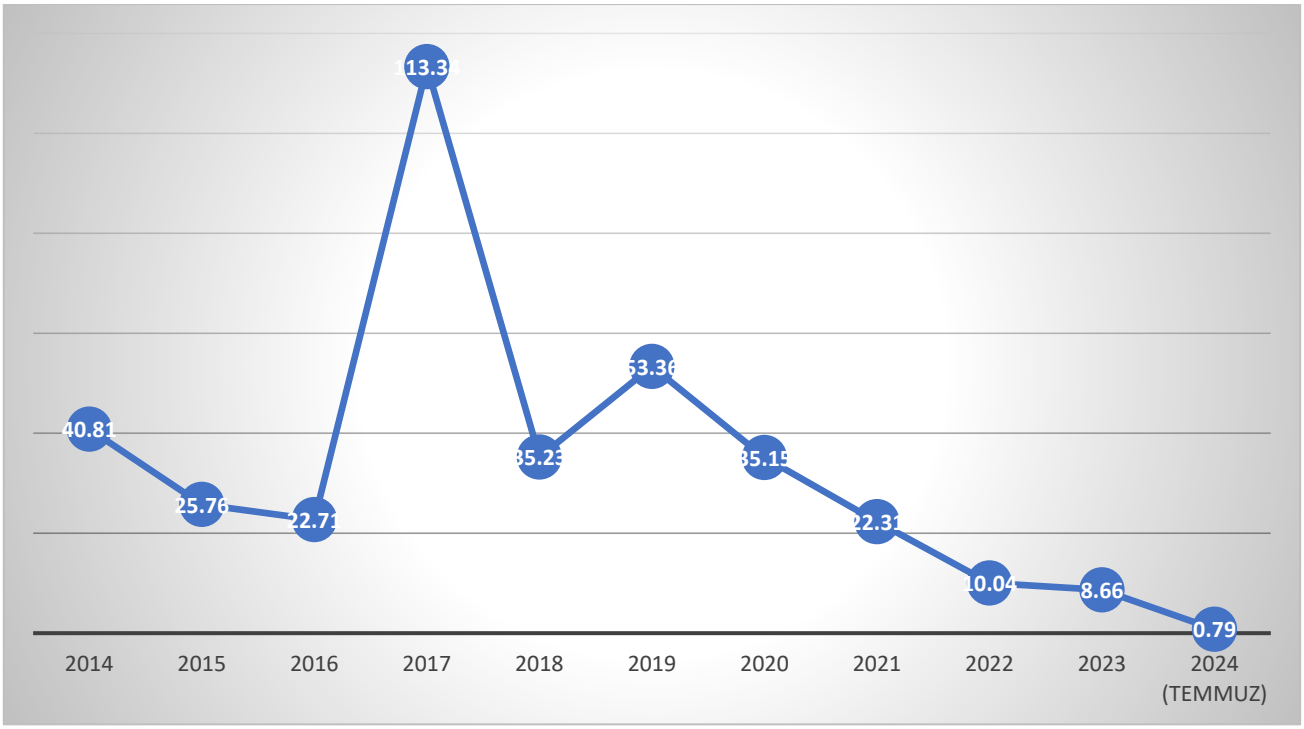

Fig. 2. Annual average citation trend of publications

Figure 2 shows a significant fluctuation in the number of citations. The number of citations, which was relatively high between 2014-2024, entered a serious downward trend as of 2019. 2017 has the highest number of citations with an average of 113.34 citations per article. 2024 is the year with the lowest number of citations with an average of 0.79 citations per article as of July. These data show that the average total number of citations per article has experienced serious fluctuations over the years. Especially 2017 draws attention with its very high number of citations. However, from 2021 onwards, there is a significant downward trend in the number of citations. By 2024, the average number of citations per article is at a very low level as of July.

4.2 Citation Analysis

The most cited articles and authors were determined by analysing the number of citations received by the publications. The most cited article is the one with the highest cumulative number of citations [26]. Accordingly, the most cited articles on 'medicine' and 'artificial intelligence' are presented in Table 2.

Table 2: Most Efficient Publications

Paper	DOI	Total Citations	Total Citation per Year
COLLOCA L, 2017, NAT REV DISEASE PRIM	10.1038/nrdp.2017.2	1407	175,88
HAMET P, 2017, METAB CLIN EXP	10.1016/j.metabol.2017.01.011	1195	149,38
BERA K, 2019, NAT REV CLIN ONCOL	10.1038/s41571-019-0252-y	803	133,83

ABRÀMOFF MD, 2018, NPJ DIGIT MED	10.1038/s41746-018-0040-6	793	113,29
AMANN J, 2020, BMC MED INFORMATICS DECIS MAK	10.1186/s12911-020-01332-6	544	108,80
BENJAMENS S, 2020, NPJ DIGIT MED	10.1038/s41746-020-00324-0	514	102,80
LEE P, 2023, NEW ENGL J MED	10.1056/NEJMsr2214184	469	234,50
CASCELLA M, 2023, J MED SYST	10.1007/s10916-023-01925-4	323	161,50
COLLINS GS, 2021, BMJ OPEN	10.1136/bmjopen-2020-048008	323	80,75
DILSIZIAN SE, 2014, CURR CARDIOL REP	10.1007/s11886-013-0441-8	318	28,91

Table 2 shows the total number of citations of articles written in the field of artificial intelligence and medicine. Articles published in 2017, especially the works of COLLOCA L and HAMET P, attract attention with their high citation numbers. This shows that these articles have made a great impact in the field of artificial intelligence and medicine and are referenced by a wide range of readers. Articles published in 2018, 2019 and 2020 were also highly cited. This shows that the studies conducted in these periods are important. The fact that even articles published in 2023 are rapidly cited emphasises the timeliness and importance of these studies. The high number of citations indicates that the articles have an important place in the scientific community and have a wide impact. The fact that even articles published in 2023 are rapidly cited shows that new studies are rapidly contributing to the scientific literature and being referenced. This table provides an overview of the impact of articles written in the field of artificial intelligence and medicine and the number of citations received by studies conducted in different years. The rapid citation of studies in this field shows how important and up-to-date the subject is in the scientific world.

The most cited authors are given in Figure 3.

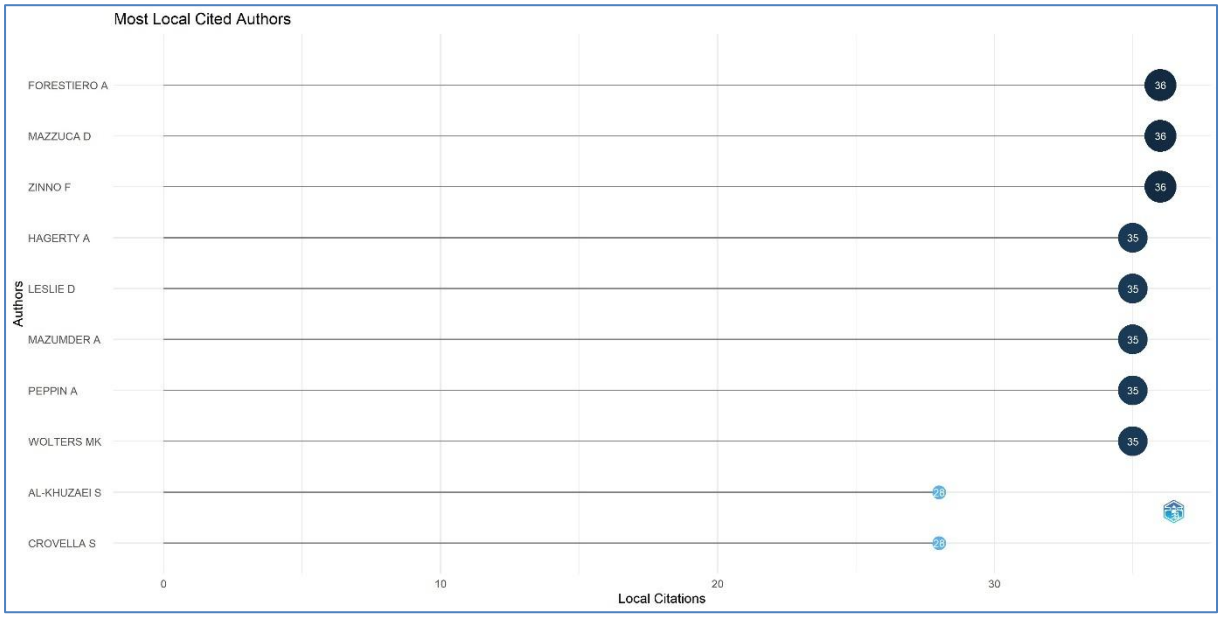

Fig. 3. Annual average citation trend of publications

Figure 3 shows the distribution of authors with the most local citations in publications related to ‘medicine’ and ‘artificial intelligence’. Forestiero A, Mazzuca D and Zinno F have the highest number of local citations, indicating that they have had a significant impact in this field. The other authors are

cited in the academic environment with similar levels of impact. This type of analysis is an important indicator to assess which authors and studies are more influential in studies with 'medicine' and 'artificial intelligence'.

4.3 Author and Organisation (Institution) Analysis

The leading names and institutions in this field were identified by analysing the authors and institutions that publish. Table 3 highlights the most important authors worldwide in terms of number of publications.

Table 3: Most Productive Authors

Author	Number of Articles
WANG Y	28
ZHANG Y	26
ZHANG X	21
LI J	19
LIU Y	19
ZHANG J	18
LIU X	16
LI Y	14
CHEN J	13
WANG S	13

Most Prolific Authors According to Table 3, WANG Y is the most prolific author with 28 articles. It shows that this author has a wide range of research in the field of artificial intelligence and medicine. ZHANG Y ranks second with 26 articles. It is seen that this author is also very productive and has made significant contributions in the field. ZHANG X, 21 papers, LI J, 19 papers, LIU Y, 19 papers, these authors have also published a significant number of papers and have made a remarkable impact in the field. Authors such as WANG Y and ZHANG Y stand out as the most prolific authors in the field. The high number of articles by these authors shows that they have made significant contributions to the field of AI and medicine. The fact that these authors work in the field of artificial intelligence and medicine shows that the subject is a wide research area and many researchers have contributed to this field. The fact that prolific authors published more than one article shows that there is a continuous and intensive research effort in this field and that these researches have made significant contributions to the scientific literature. This table shows the most prolific authors in the field of AI and medicine and their contributions to the field. The high number of articles of the authors emphasises the active research activities in the field and the importance of these authors in the field.

The publication outputs of the institutions or organisations to which the authors who contribute to 'medicine' and 'artificial intelligence' based research are affiliated are given in Table 4.

Table 4: Relevant Organisations Contributing to the Research

Affiliation	Articles
HARVARD MEDICAL SCHOOL	104
UNIVERSITY OF TORONTO	83
MAYO CLINIC	68
SUN YAT-SEN UNIVERSITY	67
UNIVERSITY OF OXFORD	67
STANFORD UNIVERSITY	66
HUAZHONG UNIVERSITY OF SCIENCE AND TECHNOLOGY	65
UNIVERSITY OF MINNESOTA	57
STANFORD UNIVERSITY SCHOOL OF MEDICINE	53
UNIVERSITY OF PENNSYLVANIA	52

Table 4 shows the number of articles published by specific universities and research institutions in the field of AI and medicine. Ranking institutions by the number of articles can help identify the most active and productive institutions in this field. Harvard Medical School is the most productive institution with 104 articles. This shows that this institution plays a leading role in the field of artificial intelligence and medicine. University of Toronto ranks second with 83 articles. This institution is also very active and has made significant contributions in the field. The fact that these institutions work in the field of artificial intelligence and medicine shows that the subject is a wide research area and many institutions contribute to this field. The fact that productive institutions have published more than one article shows that there is a continuous and intensive research effort in this field and that these researches have made significant contributions to the scientific literature. This table shows the most active and productive institutions in the field of artificial intelligence and medicine and their contributions to the field. The high number of articles of the institutions emphasises the active research activities in the field and the importance of these institutions in the field.

4.4 Country Analysis

By analysing the geographical distribution of publications, the countries with the highest number of publications and citations were determined. The dark blue, blue and grey colours on the world map represent the countries with publications, countries with few publications and countries with no publications respectively. Figure 4 shows the most productive countries in terms of the number of publications.

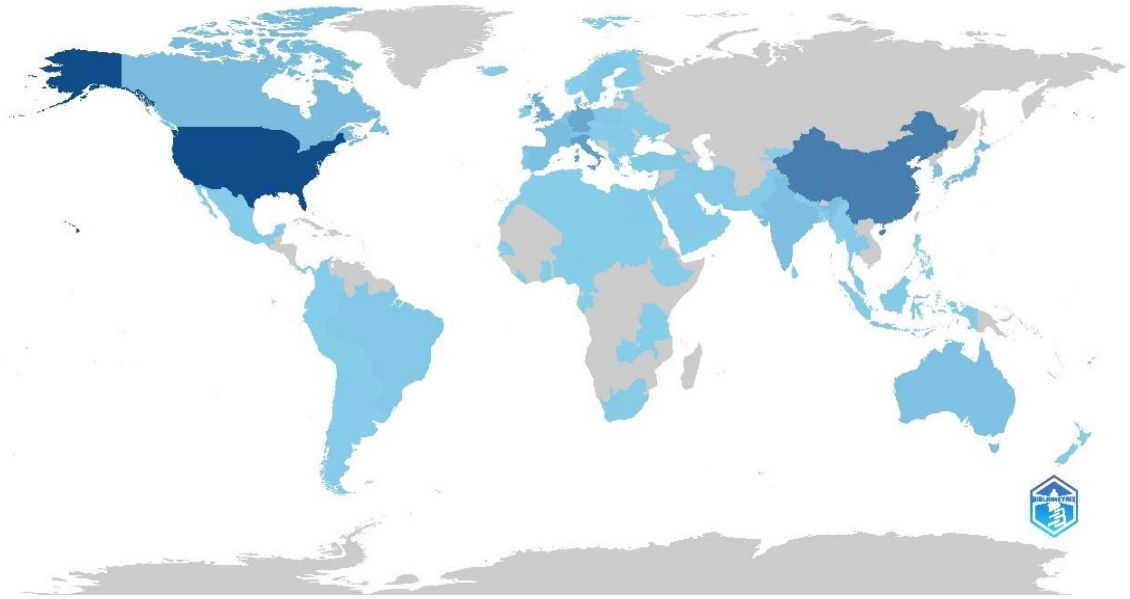

Fig. 4. The Most Productive Countries

Ranking countries according to the number of articles can help identify the most active and productive countries in this field [27]. USA (3241): The United States of America stands out as the region with the highest contribution by far. This shows that the USA is a leader in research and development activities, especially in advanced technology fields such as artificial intelligence and medicine. The large network of universities, research centres and high funding opportunities in the USA are among the reasons for this high contribution. CHINA (1941): China has the second highest contribution. China has invested heavily in artificial intelligence and medical research in recent years. State-sponsored projects and intensive R&D activities have enabled China to rise rapidly in this field. ITALY (1087): Italy is one of the countries making a significant contribution in Europe. Italy's interest in research in the fields of medicine, biotechnology and artificial intelligence has led to this high contribution. GERMANY (914): Germany is a major player in this field with strong universities and research institutes. It is recognised for its engineering capabilities and investments in artificial intelligence and medical research. The fact that the USA has by far the highest contribution emphasises its leading position in this field and its influence on global research. The high contributions of Asian countries such as China and Japan show that this region is rapidly rising in AI and medical research. European countries such as Italy, Germany, the United Kingdom, France and the Netherlands have a strong presence in research and development activities. This table shows the distribution of global research activities and how specific regions are leading the way in these fields. This diversity in AI and medicine also emphasises the importance of global collaborations and knowledge sharing.

Table 5 shows the most productive countries in terms of the number of citations to studies on medicine and artificial intelligence.

Table 5: Most Cited Countries

Country	Total Number of Citations
USA	9176
CHINA	2863
CANADA	1986
ITALY	1911
GERMANY	1759
UNITED KINGDOM	1102
AUSTRALIA	1059
JAPAN	995
SWITZERLAND	852
BELGIUM	591

Table 5 shows the total number of citations of papers from specific countries in the field of AI and medicine. Ranking countries according to their total number of citations can help to assess the influence of these countries in the field and the extent to which their contributions are recognised by the scientific community. USA: The most highly cited country with 9176 citations. This shows that the United States has a huge influence in the field of artificial intelligence and medicine. The published papers have received a large number of citations, indicating that their work is widely recognised and appreciated by the scientific community. CHINA: In second place with 2863 citations. China also has a significant impact in this field, but there is a big gap with the USA. The high citation counts of other countries show that research in these countries is recognised and appreciated by the scientific community. There is a big difference between countries, especially between the USA and other countries. This shows that the USA plays a leading role in publications on AI and medicine, with other countries also making significant contributions. This table shows the most highly cited countries in AI and medicine and their influence in the field. The countries' high citation counts highlight that their research in the field is widely recognised and appreciated by the scientific community.

4.5 Journal Analysis

The journals in which the publications were published were analysed and the most influential journals in this field were determined. The ranking of the sources of publications on medicine and artificial intelligence according to the number of publications is given in Table 6.

Table 6: Most Published Journals

Journal	Number of Articles
JOURNAL OF MEDICAL INTERNET RESEARCH	26
FRONTIERS IN MEDICINE	25
BMJ OPEN	24
NPJ DIGITAL MEDICINE	20
JOURNAL OF CLINICAL MEDICINE	19
ARTIFICIAL INTELLIGENCE IN MEDICINE	18
EUROPEAN RADIOLOGY	18

JMIR MEDICAL INFORMATICS	16
FRONTIERS IN DIGITAL HEALTH	15
FRONTIERS IN PHARMACOLOGY	15

Table 6 shows the academic journals that publish the most articles in the field of artificial intelligence and medicine and the number of articles published in these journals. This data can help to assess which journals are the most active and productive in this field and the importance of these journals in the field. Journal of Medical Internet Research is the most productive journal with 26 articles. This journal has published many articles in the field of artificial intelligence and medicine and plays an important role in the field. Frontiers in Medicine ranks second with 25 articles. This journal is also very active in the field and has published many researches. The work of these journals in the field of artificial intelligence and medicine shows how wide a research area the subject is and that many journals contribute to this field. The fact that productive journals publish more than one article indicates that there is a continuous and intensive research effort in this field and that these researches make important contributions to the scientific literature. This table shows the most active and productive academic journals in the field of artificial intelligence and medicine and their contributions to the field. The high number of articles of the journals emphasises the active research activities in the field and the importance of these journals in the field.

The ranking of publications on medicine and artificial intelligence according to the number of citations to their sources is given in Table 7.

Table 7: Most Cited Journals

Journal	**Articles**
JAMA	676
RADIOLOGY	661
NATURE	627
N ENGL J MED	493
PLOS ONE	472
SCI REP	443
NAT MED	433
LANCET	390
NPJ DIGIT MED	318
J MED INTERNET RES	302

According to Table 7, “Jama” ranks first with 676 citations. “Radiology” ranks second with 661 citations, and “Nature” ranks third with 627 citations.

4.6 Keyword Analysis

Titles, abstracts, and keywords of publications were analyzed to identify frequently used terms and topics. This analysis was performed using bibliometric analysis software such as VOSviewer and Biblishiny [28,29]. These software helped visualize the main themes and research areas in the literature by creating word clouds and conceptual maps [26]. The word cloud for studies related to medicine and artificial intelligence is given in Figure 5.

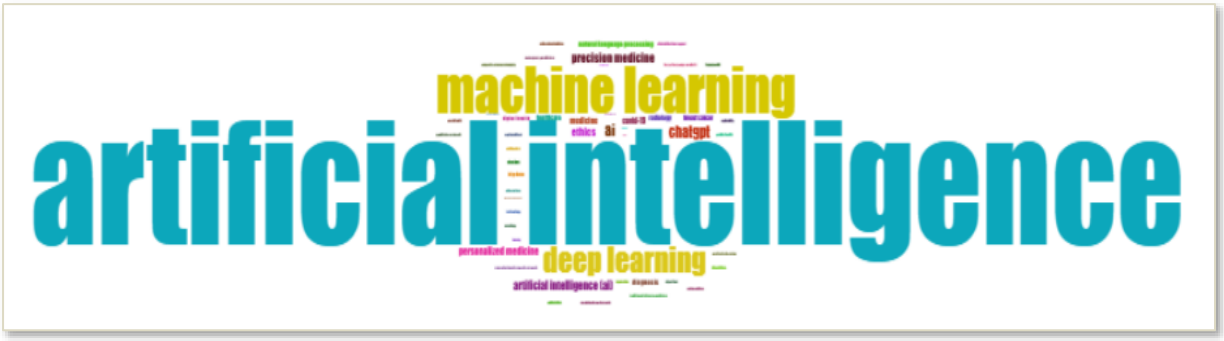

Fig. 5. Author Keyword Cloud

This word cloud of author keywords is organized with the frequencies of related terms and categorized to more clearly show general trends in research areas. Artificial Intelligence and Machine Learning: Artificial intelligence (712), machine learning (267), deep learning (154), ai (75), artificial intelligence (ai) (52), natural language processing (34), big data (26), convolutional neural networks (19), large language models (19), explainable ai (16), algorithms (15), convolutional neural networks (13), explainability (12), language model (12), neural network (11), generative ai (11). This category reflects the broad interest in artificial intelligence and machine learning. It is also seen that there is interest in specific subfields such as natural language processing (NLP), big data, convolutional neural networks (CNN), and explainable artificial intelligence. Recent technologies such as ChatGPT and large language models are also included in this category. Medicine and Health: Precision medicine (56), personalized medicine (46), medicine (39), covid-19 (36), diagnosis (35), radiology (31), healthcare (29), breast cancer (28), digital health (27), emergency medicine (18), radiomics (18), medical education (17), traditional chinese medicine (17), oncology (16), public health (16), clinical decision support (15), magnetic resonance imaging (15), telemedicine (14), nuclear medicine (12), segmentation (12), cancer (11), health care (11).

This category covers interest in medicine and health and the various topics in that area. Topics such as personalized medicine, diagnostics, radiology, and digital health highlight the importance of technology in medical practice. Topics such as COVID-19, emergency medicine, oncology, and public health reflect a focus on broad health issues. Ethical and Societal Implications: Ethics (51), bias (11), medical ethics (12). The category of ethics and societal impacts reflects interest in the ethical dimensions of AI and medical applications. Ethical issues emphasize the importance of fair and responsible use in AI applications and medical practices. Education and Research Methods: Education (19), medical education (17), qualitative research (16), survey (16). The category of education and research methods reflects interest in both general education topics and medical education. Methods such as qualitative research and surveys indicate that research focuses on in-depth data collection and analysis techniques. Other Technological Applications: Chatgpt (70), chatbot (21), technology (17). This category reflects the wide range of use of AI and other technological applications. Applications such as ChatGPT and chatbot represent practical uses of AI in everyday life. These headings demonstrate the intersections between AI and medical applications and the diversity of studies conducted in these areas.

A keyword is a term or expression used to describe an article. The presence of a keyword in the article determines the prevalence of any expression [25]. VOSviewer was used to highlight the

common results of the study with keywords and the study knowledge base. Based on the indexed keywords of the article, 4787 keywords were found. As shown in Figure 6, 18 different clusters were evaluated for review after the threshold setting in the VOSviewer application was increased to 3.

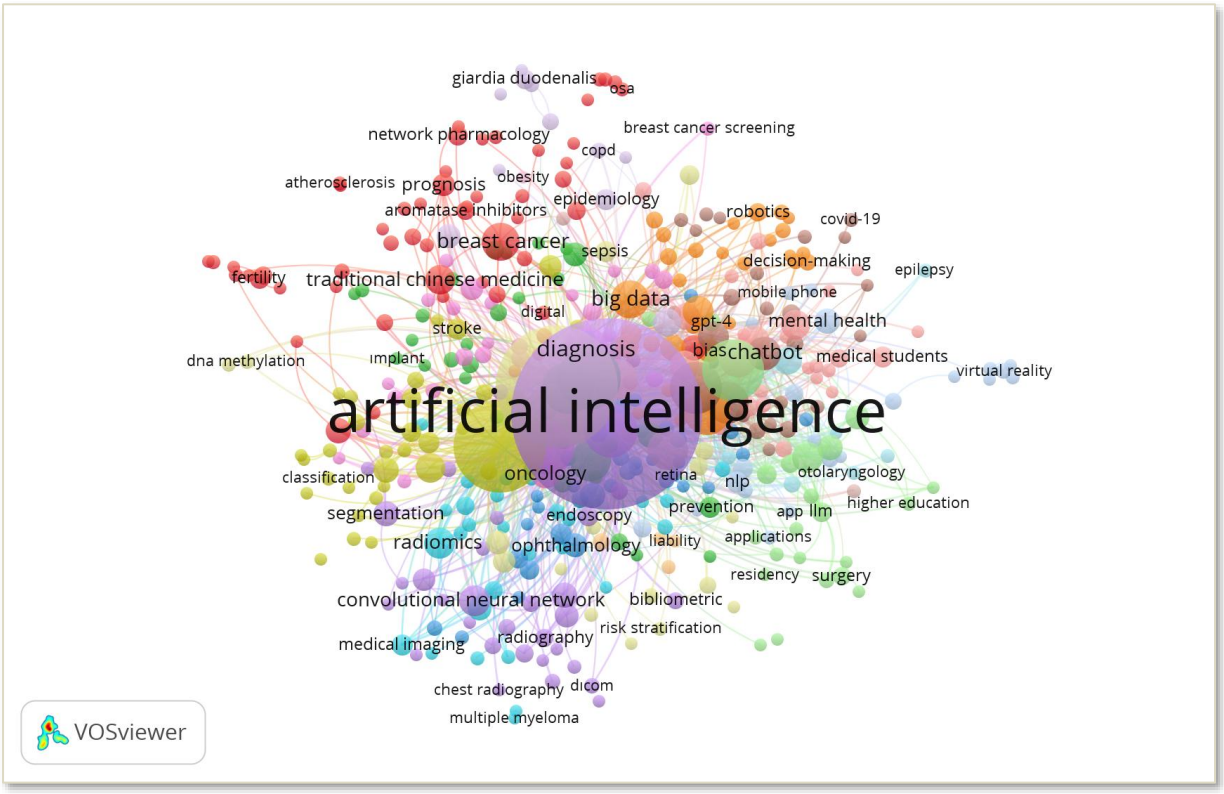

Fig. 6. Author Keyword Network Map

Each colour represents a different keyword cluster. In Figure 6, each circle represents the presence of a specific term and subfield of medical and artificial intelligence topics. A circle of similar colour represents the distribution in a comparative region. The largest cluster by number of elements is called "artificial intelligence". Artificial intelligence is a broad field and includes subfields such as machine learning, deep learning, natural language processing and computer vision. The second largest cluster is called "Machine Learning". This cluster focuses on machine learning techniques and applications. Machine learning is crucial for extracting meaningful information from large data sets, making predictions and developing models. In medicine, machine learning can be used for a variety of purposes, such as diagnosis, treatment planning, disease prediction and improving patient outcomes. Studies in this cluster can cover both theoretical and applied machine learning methods. The third largest cluster is called 'deep learning'. This cluster focuses on deep learning algorithms and models. Deep learning has been particularly successful in areas such as image and audio processing, natural language processing, and big data analytics. In areas such as medical imaging (radiology, tomography, etc.) and genetic analysis, deep learning models can help make more accurate and faster diagnoses. This cluster may include studies on convolutional neural networks (CNN), recurrent neural networks (RNN) and other deep learning structures.

Again, using the VOSviewer software, the keywords "overlay visualisation" were coloured differently according to the year of publication and the time periods in which they appeared in the literature were determined. In our case, the average (yellow) publication year for the newly introduced terminology is 2023. The colours of the articles were determined according to the time

elapsed since their publication. The period from 2020 to 2023 (blue-green-yellow colour) is shown in Figure 7.

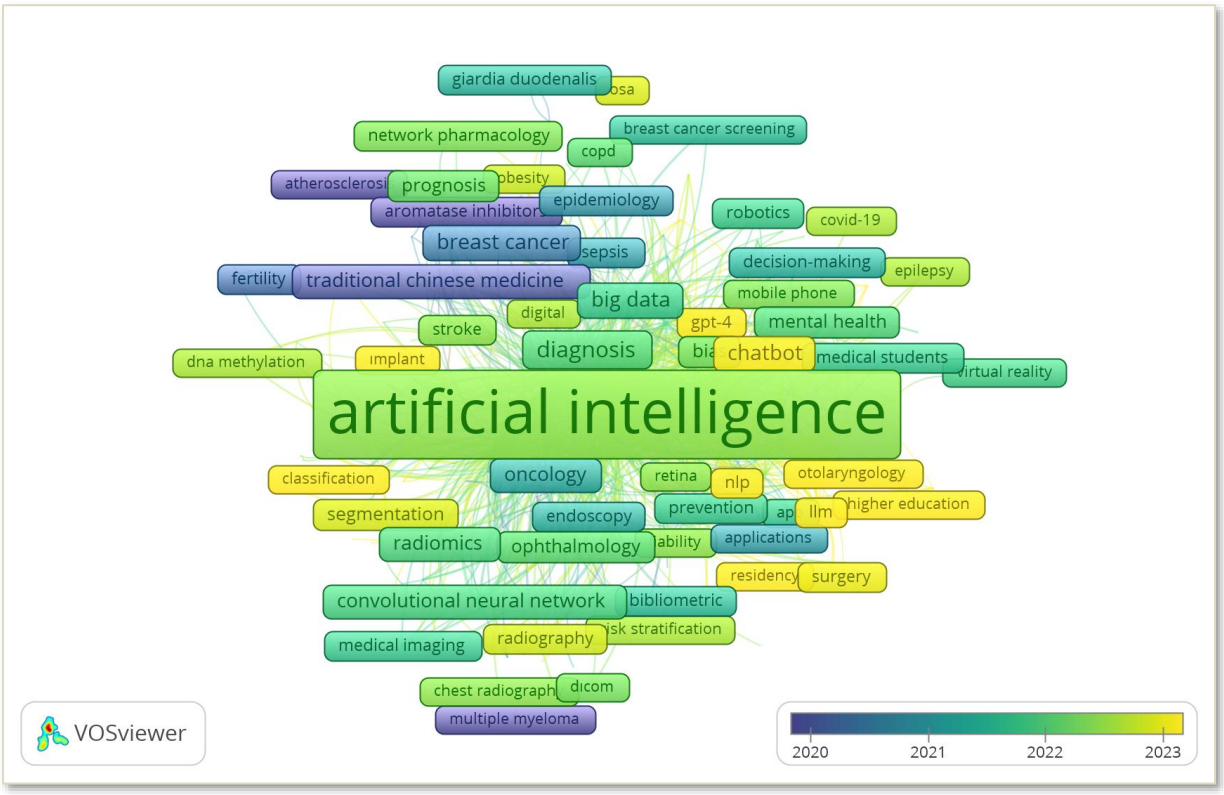

Fig. 7. Keyword Timeline

This information provides a summary of the most researched topics related to medicine and artificial intelligence during specific time periods. 2020-2021: Medical and biological research. Multiple myeloma, traditional Chinese medicine, aromatase inhibitors, atherosclerosis, biofilm. During this period, the focus will be on basic medical issues such as cancer, traditional medicine, hormone therapy and biological processes. In particular, the interest in specific treatments and diseases such as multiple myeloma and aromatase inhibitors shows that there are in-depth studies in this area. In addition, biological processes such as biofilms and atherosclerosis are also in the spotlight. 2021-2022: Data science and artificial intelligence. Big data, diagnostics, radiomics, convolutional neural networks, ophthalmology, deep learning, machine learning, decision making, artificial intelligence. During this period, there has been a shift towards the application of data science and artificial intelligence in the field of medicine. Techniques such as convolutional neural networks and deep learning are particularly important in image analysis and diagnostic processes. In addition, interest in AI applications in specific medical fields, such as ophthalmology, reflects the diversity and depth of research in this period. 2023 and beyond: Advanced AI and medical education. ChatGPT, medical education, generative AI, chest x-ray, heart failure, computed tomography, computer-aided detection. Recent focus has been on large language models and AI-based educational tools. Technologies such as ChatGPT and generative AI offer revolutionary innovations in medical education. In addition, studies into the detection and analysis of serious health problems such as heart failure using imaging techniques such as chest X-rays and CT scans show that the role of AI in medical diagnosis and treatment processes is being explored.

4.7 Trend Analysis

By analysing the distribution and main themes of publications over time, research trends in medicine and artificial intelligence were identified. In addition, prominent topics and methodologies in specific time periods were analysed. Table 8 shows the trending topics in the literature related to medicine and artificial intelligence by year from 2014 to 2024 (July).

Table 8: Yearly Trending Topics

Keywords	Frequency	Q1	Q2	Q3
artificial intelligence	1940	2021	2023	2023
human	1442	2021	2022	2023
article	1367	2021	2022	2023
humans	958	2020	2022	2023
deep learning	352	2021	2023	2024
middle aged	291	2018	2021	2023
retrospective study	194	2021	2023	2023
priority journal	138	2017	2019	2020
united states	124	2019	2021	2023
nonhuman	120	2019	2021	2022

Table 8 provides important information on the use of certain terms in AI and medicine and their distribution by year. These data show the periods in which these terms received more attention and the development of research in these fields over time. Terms related to artificial intelligence: artificial intelligence (1940): Frequently used in 2021, peaking in 2023. It shows that there is a strong interest in the field of artificial intelligence. deep learning (352): Appeared in 2021 and its use increased until 2024. Deep learning has an important place as a subfield of artificial intelligence. chatgpt (76): Increases in 2023 and continues in 2024. Shows an increasing interest in large language models. large language model (28): Launched in 2023 and intensified in 2024. It shows that studies of large language models are increasing. Human and Demographic Groups: Human (1442) and Human (958): Used regularly between 2020-2023, indicating that human-focused research will continue. middle-aged (291): Used between 2018-2023. young adult (105): Used between 2018-2022. aged 80 and over (36): It was the subject of research between 2018-2021. Medical research and diseases: retrospective study (194): It increased between 2021-2023. breast neoplasms (64): It was used intensively between 2017 and 2022. coronary artery disease (27): It appeared in 2023 and continued in 2024.Aromatase inhibitors (46): It attracted attention between 2016 and 2021. physiology (43): It was the subject of research between 2018-2022. psychology (35): It attracted attention between 2016-2020. Regional and special groups: American Indians (60), Alaska Natives (37), North American Indians (35): There have been regular studies on these groups between 2015-2021. United States (124): Intensive use since 2019. The data in the table show how research in AI and medicine has evolved and how certain terms have become popular over time. It is clear that topics such as artificial intelligence, deep learning and large language models have attracted a lot of interest in recent years, and that a wide range of topics have been explored in medical research. These trends are important for understanding the future directions of both technological advances and medical research.

5. Discussion and Conclusion

Between 2014 and 2024, academic studies on the use of artificial intelligence in medicine show a significant increase and a widespread trend towards collaboration. This analysis covers 1783 English language articles retrieved from the Scopus database and examined using the Biblioshiny and VOSviewer tools. In total, 1783 documents from 875 different sources were published during this period. The annual growth rate was calculated to be 30.38%, which clearly shows the rapid expansion of academic publications. Especially since 2018, a strong increase in the number of publications has been observed. An average of 17.54 citations per article indicates that the studies published during this period generally have a high impact area. However, there have been fluctuations in the number of citations over the years. While 2017 had the highest number of citations with an average of 113.34 citations per article, the average number of citations per article decreased to a very low level of 0.79 as of July 2024. This decrease also suggests that articles published in recent years may not have had enough time to receive sufficient citations. A total of 11,678 authors contributed to publications in artificial intelligence and medicine. The average number of co-authors per paper is 7.79 and the international collaboration rate is 29%, indicating that research in this field is generally multi-centred and collaborative. The low number of single-authored documents (118) and single-authored documents (129) indicates that there are fewer individual studies and that collaboration is more prevalent.

When we look at the total number of citations of articles written in the field of artificial intelligence and medicine, the articles published in 2017 (in particular the studies by Colloca L and Hamet P) stand out with their high citation numbers. These articles have had a major impact in their fields and have been referenced by a wide range of readers. Articles published in 2018, 2019 and 2020 also have high citation numbers, demonstrating the importance of the studies carried out during this period. The fact that articles published in 2023 are also rapidly cited emphasises the timeliness and importance of these studies.

Among the authors who have made significant contributions to the field of artificial intelligence and medicine, prominent names include Forestiero A, Mazzuca D and Zinno F. These authors have high local citation counts and have made a significant impact in the field. In particular, Wang Y stands out as the most productive author with 28 articles. Wang Y's wide range of research in this field shows that he has made significant contributions to the field of artificial intelligence and medicine. Similarly, Zhang Y ranks second with 26 articles, while Zhang X, Li J and Liu Y have also made significant contributions to the field with 21 and 19 articles respectively. The high number of articles by these authors indicates that they have conducted extensive and in-depth research in the field of artificial intelligence and medicine. This suggests that research in this area is constantly evolving and expanding.

Harvard Medical School stands out as the most productive institution with 104 articles. This shows that Harvard Medical School plays a leading role in the field of artificial intelligence and medicine. Similarly, the University of Toronto ranks second with 83 articles, showing that this institution is also active in this field and has made significant contributions.

With 3241 articles, the United States is by far the country with the highest contribution in the field of Artificial Intelligence and Medicine. This shows that the USA is a leader in research and development activities, especially in high-tech fields such as artificial intelligence and medicine. The extensive network of universities, research centres and high funding opportunities in the US are the main reasons for this high contribution. China is in second place with 1941 articles and has attracted attention in recent years for its large investments in artificial intelligence and medical research. Italy,

with 1087 articles, is one of the main contributors in Europe. The USA has a major impact in the field of AI and medicine, being the country with the highest number of citations with 9176 citations. This shows that research in the USA is widely recognised and appreciated by the scientific community. China is in second place with 2863 citations and has a significant impact in this field, but there is a big difference between it and the USA.

Journal of Medical Internet Research stands out as the most productive journal with 26 articles. This journal has published many articles in the field of artificial intelligence and medicine and plays an important role in the field. Frontiers in Medicine ranks second with 25 articles, this journal is also very active in the field and has published many research papers. "Jama" is in first place with 676 citations, "Radiology" is in second place with 661 citations and "Nature" is in third place with 627 citations. The articles published in these journals are widely referenced and appreciated by the scientific community.

Classifying academic studies in the field of artificial intelligence and medicine is an important tool for understanding the broad scope and evolution of this field. The largest cluster by number of elements is called 'Artificial Intelligence'. This cluster includes several sub-clusters such as machine learning, deep learning, natural language processing and computer vision. This broad scope of artificial intelligence shows its versatile potential for use in medical research and applications. The second largest cluster is called "Machine Learning". Machine learning plays a crucial role in extracting meaningful information from large data sets, making predictions and developing models. In the medical field, machine learning is used for various purposes such as diagnosis, treatment planning, disease prediction and improving patient outcomes. Studies in this cluster cover both theoretical and applied machine learning methods. The third largest cluster is called 'deep learning'. Deep learning has been particularly successful in areas such as image and audio processing, natural language processing and big data analytics. In areas such as medical imaging (radiology, tomography, etc.) and genetic analysis, deep learning models can help make more accurate and faster diagnoses. This cluster includes work on convolutional neural networks (CNN), recurrent neural networks (RNN) and other deep learning frameworks.

In 2020-2021, the focus was on basic medical topics such as multiple myeloma, traditional Chinese medicine, aromatase inhibitors, atherosclerosis and biofilms. In particular, the interest in specific treatments and diseases such as multiple myeloma and aromatase inhibitors shows that in-depth studies have been carried out in this area. Biological processes such as biofilm and atherosclerosis have also been the focus of attention. The 2021-2022 period saw a shift towards data science and artificial intelligence applications in medicine. The focus was on topics such as big data, diagnostics, radiomics, convolutional neural networks, ophthalmology, deep learning, machine learning, decision making and artificial intelligence. Techniques such as convolutional neural networks and deep learning have an important place, especially in image analysis and diagnostic processes. In addition, the interest in AI applications in specific medical fields, such as ophthalmology, reflects the diversity and depth of research in this period. In 2023 and beyond, the focus is on large language models and AI-based training tools. Technologies such as ChatGPT and generative AI are revolutionising medical education. In addition, studies on imaging techniques such as chest X-rays and CT scans, and the use of AI to detect and analyse serious health problems such as heart failure, are exploring the role of AI in medical diagnosis and treatment processes.

6. Research Gaps, Future Directions, and Limitations

The aim of the study is to identify research trends, academic interest, and key authors and institutions in the field of medicine and artificial intelligence. Such data can be an important guide for researchers in related fields and can direct future research. The results of the analysis show the impact of scientific publications on medicine and artificial intelligence over the years and the level of academic interest, and can be a guide for evaluating the importance and impact level of research in this field in the academic community.

- *Research gaps*

1. Precision and reliability: The level of precision and reliability of artificial intelligence applications in medical diagnosis and treatment processes has not yet been fully achieved. In particular, it is important to improve the transparency and accuracy rates of the decision mechanisms of deep learning models.
2. The gap between training and application: To transfer artificial intelligence algorithms to clinical applications, training of healthcare professionals and guidance on how to use these technologies in daily practice are needed.
3. Data security and privacy: The use of large data sets poses potential risks to patient privacy and data security. How artificial intelligence systems manage these risks and how data security standards are implemented should be explored.

- *Future directions*

1. Expanded areas of application: Artificial intelligence technologies are expected to be applied to more medical fields and diseases. It is important to develop customised treatment approaches based on artificial intelligence, especially for rare diseases and personalised medicine.
2. Biomedical imaging and diagnosis: The use of deep learning models in biomedical imaging (e.g. MRI, CT, PET) enables the development of more sensitive and early diagnostic methods.
3. Improving patient outcomes and care: The use of AI to improve patient outcomes and increase the efficiency of healthcare will be a focus of future research.

- *Limitations*

1. Data access and quality: Limited access to and quality of datasets used to train AI models can affect the generalisability and accuracy of algorithms.
2. Inadequate training and resources: Adequate resources and programmes need to be created to train AI experts and healthcare professionals in accordance with these technologies.
3. Ethical and legal issues: Ethical and legal issues of AI applications require more research and guidelines, especially on transparency, accountability and patient rights in decision-making processes.

These issues will guide future studies in the field of AI and medicine and contribute to the safer and more effective use of these technologies in clinical applications.

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