Medical Education and Artificial Intelligence: a Web of Science-based bibliometric analysis (2013-2022)

Shuang Wang, Liuying Yang, Min Li

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Shuang Wang[1*]; Liuying Yang[1*]; Min Li[1*]

[1]Yunnan University of Chinese Medicine Kunming CN
[*]these authors contributed equally

Corresponding Author:
Liuying Yang
Yunnan University of Chinese Medicine
Yunnan University of Chinese Medicine
Kunming
CN

Abstract

Background: As an important driving force leading a new round of scientific and technological revolution and industrial transformation, Artificial Intelligence (AI) has spawned a large number of new products, new technologies, new formats and new models, and also brought more possibilities for the modernization of medical education. Looking into the future, we should work together to build a high-quality and warm AI medical education ecology. How to make human-machine collaboration smarter and human-machine dialogue more friendly is a long-term topic of "AI + medical education" Education is dynamic and evolving, thinking rationally about the relationship between people and technology. Further promoting the deep integration and innovative development of AI and medical education can better empower the modernization of education.

Objective: Use CiteSpace and VOSviewer to determine the current and emerging trends in Artificial Intelligence on medical education from 2013 to 2022.

Methods: Search the literatures related to Artificial Intelligence on medical education in Web of Science core database from 2013 to 2022. Use CiteSpace and VOS viewers to analyze countries, institutions, authors, references and keywords that meet the requirements.

Results: We identified 195 articles about Artificial Intelligence on medical education from 2013 to 2022 and found that the annual incidence rate increased over time. The most active country was the United States, the most active institution was the Harvard Med Sch and Univ Toronto. And Bissonnette, Vincent; Blacketer, Charlotte; Del Maestro, Rolando f; Ledows, Nicole; Mirchi, Nykan; Winkler-schwartz, Alexander; Yilamaz, Recai was the leading authors. Besides, “Medical students' attitude towards Artificial Intelligence: a multicentre survey” was the largest number of citation papers. References and keyword analysis showed that “radiology”, “medical physics” ,“ehealth” ,“surgery”,and “specialty” were the focus of these studies, while “big data”, and “management” were the frontiers of research.

Conclusions: The bibliometric study shows that the research of Artificial Intelligence on medical education is a promising research field. The current research is mainly focused on a few aspects of medical education, with the progress of technology, it is expected to broaden the direction in the future. At present, the urgent problem to be solved is to strengthen inter-regional cooperation and improve the quality of research. Our findings provide valuable information for researchers to determine a better perspective and develop future research directions.

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Medical Education and Artificial Intelligence: a Web of Science-based bibliometric analysis (2013-2022)

*Shuang Wang[1], Liuying Yang[1], Min Li, Xinghe Zhang, Xiantao Tai**
School of Second Clinical Medicine, Yunnan University of Chinese Medicine, Kunming, China
Corresponding Author:

Xiantao Tai

Yunnan University of Chinese Medicine
No 1076, Yuhua Road
Chenggong District
Kunming, 650500
China
Phone: 86 15025189569
E-mail: taixiantao@163.com.

Abstract

Background: Incremental advancements in Artificial Intelligence (AI) technology have facilitated its integration into various disciplines. In particular, the infusion of AI into medical education has emerged as a significant trend with noteworthy research findings. Consequently, a comprehensive review and analysis of the current research landscape of AI in medical education is warranted.

Objective: This study aims to conduct a bibliometric analysis of pertinent papers spanning the years 2013-2022 using CiteSpace and VOS viewer. The study visually represents the existing research status and trends of AI in medical education.

Methods: Articles related to AI and medical education, published between 2013 and 2022, were systematically searched in the Web of Science core database. Two reviewers scrutinized the initially retrieved papers based on their title and abstract to eliminate papers unrelated to the topic. The selected papers were then analyzed and visualized for country, institution, author, reference, and keywords using CiteSpace and VOS viewer.

Results: A total of 195 papers pertaining to AI in medical education were identified from 2013 to 2022. The annual publications demonstrated an increasing trend over time. The United States emerged as the most active country in this research arena, with Harvard Med Sch and Univ Toronto as the most active institutions. Prolific authors in this field include Bissonnette, Vincent; Blacketer, Charlotte; Del Maestro, Rolando f; Ledows, Nicole; Mirchi, Nykan; Winkler-schwartz, Alexander; Yilamaz, Recai. The paper with the highest citation was “Medical students’ attitude towards Artificial Intelligence: a multicentre survey.” Keyword analysis revealed that “radiology”, “medical physics”, “ehealth”, “surgery”, and “specialty” were the primary focus, while “big data”, and “management” emerged as research frontiers.

Conclusion: The study underscores the promising potential of AI in medical education research.

Present research directions encompass radiology, medical information management, and other aspects. Technological progress is expected to further broaden these directions. There is an urgent need to bolster inter-regional collaboration and enhance research quality. The findings offer valuable insights for researchers to identify perspectives and guide future research directions.

Keywords: Artificial Intelligence; Medical Education; Bibliometric Analysis; CiteSpace; VOS viewer

Introduction

The concept of artificial intelligence (AI)—referring to machines and systems capable of emulating human intelligence—was first introduced at an academic conference in 1956. Its extensive research fields encompass numerous domains including intelligent expert systems, language processing, intelligent data retrieval, and intelligent control. AI stands as one of the three groundbreaking technologies of the 21st century, sharing the pedestal with genetic engineering and nanoscience technologies [1-3]. The ultimate aim of AI is to facilitate the utilization of machines in replicating and expanding human intelligence. In doing so, machines are empowered to listen, see, speak, think, and make decisions in a manner akin to humans—thus elevating the quality of human life [4, 5].

The sustained evolution of AI has resulted in a paradigm shift in medical practice, transitioning from traditional methods to digital healthcare, with AI finding applications in diverse realms of medical and health care. AI can generate pathological diagnostic reports through integrated data analysis, aid psychologists in diagnosing mental disorders by simulating human thinking patterns, and perform imaging evaluations via deep learning. Moreover, AI can be employed to manage clinical patients and deliver doctor-prescribed treatment plans through records of patient history and treatment processes [6]. This seems to show a trend that AI can replace humans.It also reminds us that the healthcare industry, especially medical education, is undergoing changes, and it is time for medical students to be exposed to AI courses. Conversely, the advancement of AI holds the potential to serve as an invaluable instrument for enhancing the learning process for medical students: provisioning personalized and adaptive learning experiences, enhancing diagnostic precision, and facilitating data-driven decision-making [7]. Traditional medical education often adopts a one-size-fits-all approach, mandating students to memorize a vast amount of knowledge. However, AI has the capability to customize the learning experience to meet the specific needs of students, enabling them to concentrate on areas that necessitate more practice [8]. Additionally, AI can aid educators in formulating personalized learning plans, monitoring learner’s progress, and providing real-time

feedback [9].Research in AI has demonstrated that the output-input ratio in the medical field holds more promise than other disciplines [10]. Currently, there are several reports and studies on the future of medical education.The Institute of Medicine has held a multidisciplinary summit, emphasizing the integration of key competencies such as patient-centered care, interdisciplinary teams, evidence-based practice, quality improvement, and informatics into the education of health professionals. The institute recommends a hybrid approach encompassing supervisory processes, training environments, research, public reporting, and leadership [11]. Meanwhile, the Carnegie Foundation addresses related challenges, providing recommendations to achieve excellence in medical education. Four themes emerged: standardization and personalization, integration, habits of inquiry and improvement, and identity formation [12]. However, these reports abstractly propose goals and direction for the future of medical education, with researchers seldom conducting actual surveys to elucidate how medical educators worldwide are conceptualizing and implementing strategies in preparation for a future replete with advanced technologies and expanded knowledge.

Bibliometrics serves as a tool for the quantitative analysis of published literature, determining the relationship between research statements and emerging research frontiers based on co-occurrence, citation, and co-citation [13]. Numerous global bibliometric analyses have been conducted using CiteSpace and VOS viewers in recent years. These analyses have focused on the comprehensive rehabilitation statuses and research trends of diseases like cancer, ankylosing spondylitis, motor and neuropathic pain, and osteoarthritis [10-13]. However, to the best of our knowledge, a bibliometric analysis of AI’s application in medical education has yet to be implemented.

Consequently, this study employs CiteSpace and VosViewer for the analysis of articles on artificial intelligence in medical education published from 2013 to 2022. The current research status and trends within this field are evaluated by examining facets such as region, institution, author, references, and keywords. This approach allows for the identification and assessment of emerging trends

Methods

Recruitment

All data for this research were procured from the Web of Science (WoS). The search parameters for data retrieval encompassed the topics “Artificial Intelligence” and “medical education” (Table 1), with a publication date range from 2013 to 2022.

Statistical Analysis

The search results were subsequently analyzed using CiteSpace and VOS viewer. CiteSpace, a visual analysis software developed by Chaomei Chen, was utilized to analyze the total quantity of papers related to the topic, the trend of changes over the years, the frequency of keywords, and centrality. This software allowed for a more convenient and intuitive analysis of the structure, rules, and distribution of subject knowledge. A scientific knowledge map facilitated the identification of research hotspots, progress, and the current situation within a specific field. VOS viewer, a software tool primarily oriented towards document data processing, enabled the analysis of the country, institution, author, journal, keywords, and co-occurrence knowledge graph of country, institution, journal, and document in the literature. Each node on the knowledge graph represented a unique element, with the connection width between nodes indicating collaboration strength, node size reflecting the number of publications, and larger nodes indicating more frequent releases.

Data inclusion

The papers for this study were downloaded in txt format from the Web of Science database. Two expert researchers examined the title, keywords, and abstract, and screened the papers based on inclusion and exclusion criteria. In cases of disagreement or difficulty in paper inclusion, a third reviewer made the final decision via discussion. Initially, a total of 580 papers were searched, of which 385 papers that did not meet the study's topic were excluded, resulting in the retention of 195 papers.

TABLE I. Search Queries

Set	Result	Search Query
#1	140447	(((TS=(generative AI)) OR TS=(AI)) OR TS=(Artificial Intelligence)) OR TS=(generative Artificial Intelligence) Indexes=Web of Science, Timespan=2013-2022
#2	93678	(TS=(medical education) Indexes=Web of Science, Timespan=2013-2022
#3	580	#1 AND #2

Results

Annual Publications

Over the past decade, a total of 195 papers were published on AI and medical education,

demonstrating an overall upward trend (Fig. 1). The publications saw a significant surge from 2020 to 2021, reaching a peak in 2021, although the number of related papers published in 2022 decreased.

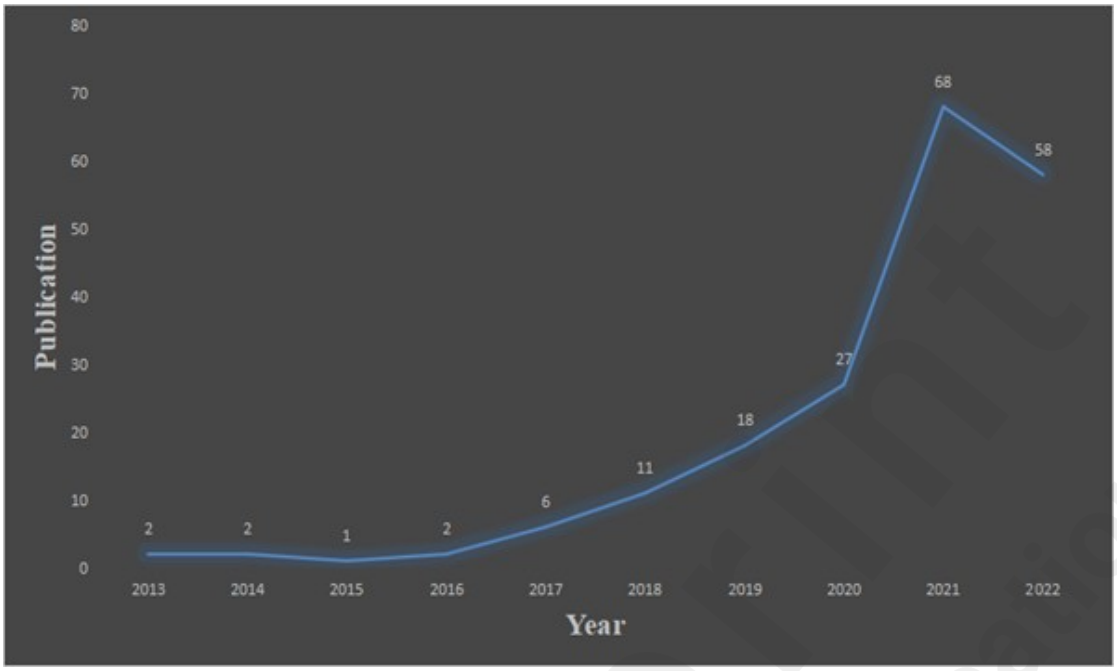

Figure 1. Taking the year of publication as the abscissa and the number of publications as the ordinate, a line chart shows the trend changes in the number of publications in this field in the ten years from 2013 to 2022.

National analysis

Based on a comprehensive national analysis, 57 countries globally contributed to the exploration of Artificial Intelligence (AI) within the field of medical education from the period of 2013 to 2022. The United States took the lead by publishing 66 papers, thereby establishing itself as the most actively engaged country in this domain. The subsequent countries, albeit with lesser contributions, were Canada (24 papers), China (17 papers), England (13 papers), Singapore (12 papers), Australia (12 papers), India (9 papers), Germany (8 papers), the Netherlands (8 papers), and Spain (7 papers). The most cited countries were the United States (845 citations), Singapore (489 citations), and China (435 citations). When evaluated in terms of total link strength, the United States (44), the Netherlands (29), and Belgium (26) emerged as the top three (Table 2).

TABLE 2. Top 10 Publications, Centrality, and Citations of Countries

Rank	Documents	Countries	Citations	Countries	Total link strength	Countries
1	66	USA	845	USA	44	USA

2	24	Canada	489	Singapore	29	Netherlands
3	17	peoples R China	435	peoples R China	26	Belgium
4	13	England	371	Canada	23	Germany
5	12	Australia	155	England	22	England
6	12	Singapore	108	Spain	20	France
7	9	India	101	Germany	19	Italy
8	8	Germany	94	Netherlands	19	Switzerland
9	8	Netherlands	94	Belgium	18	Spain
10	7	Spain	85	Iran	16	Greece

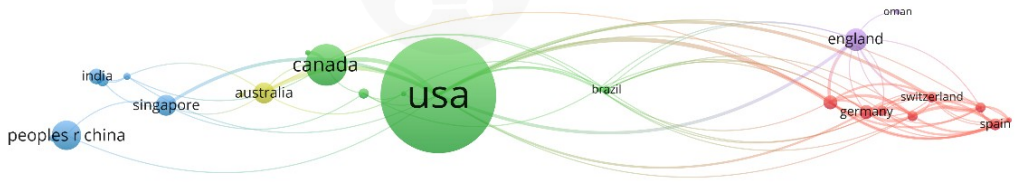

Figure 2. Use VOS software to analyze the countries that have published articles in this field. The circles show the countries that have published more than 3 articles. The curve represents the cooperative relationship between each country. The thicker the line, the closer the cooperation.

Institutional analysis

Shifting the focus to an institutional analysis reveals that from 2013 to 2022, 77 institutions were engaged in research on AI in medical education. The two institutions that topped the list in terms of a number of publications were Harvard Medical School and the University of Toronto, each with 7 contributions, followed by McGill University and the National University of California, San Francisco (5 contributions each). The institutions receiving the most citations were Nanyang Technological University (396 citations), McGill University (149 citations), and the University of Chicago (127 citations).

TABLE 3. Top 10 Publications, Centrality, and Citations of Organizations

Rank	Documents	Organization	Citations	Organization	Total link strength	Organization
1	7	Harvard Medical School	396	Nanyang Technological University	15	Leiden University
2	7	University Toronto	149	McGill University	15	Harvard Medicine School
3	5	McGill University	127	University Chicago	11	Oregon Health and Science University
4	5	National University Singapore	104	University British Columbia	10	University Toronto
5	5	Oregon Health and Science University	86	Guys & St Thomas NHS Foundation Trust	9	University British Columbia
6	5	Queens University	83	Kings College London	9	Stanford University

7	5	Stanford University	68	University California San Francisco	9	Queens University
8	5	University California San Francisco	67	National University Singapore	8	Imperial College London
9	4	Emory University	66	Sultan Qaboos University	8	Johns Hopkins University
10	4	Leiden University	60	University Maryland	7	Ludwig Maximilians University Munchen

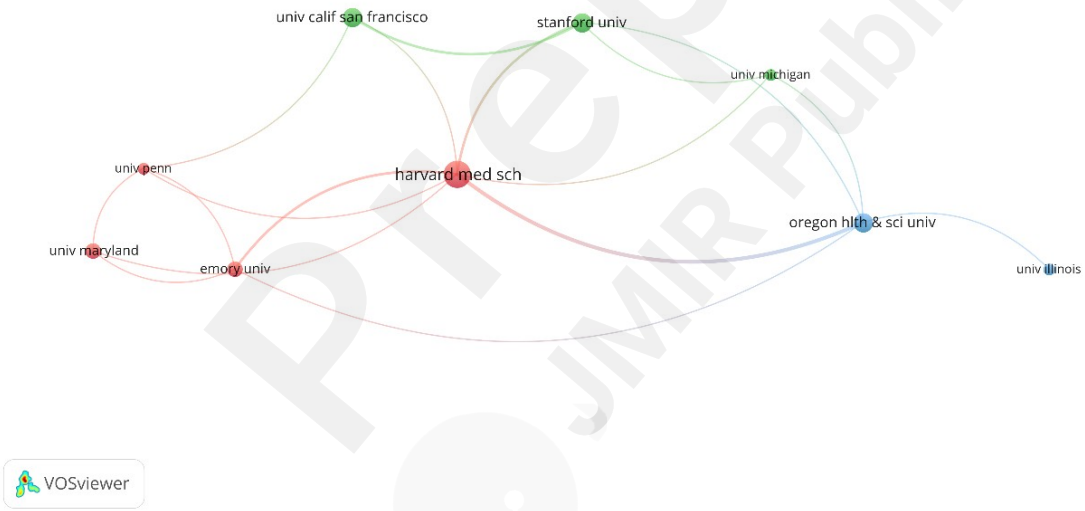

Figure 3. Use VOS software to analyze the institutions that publish articles in this field. The circles show the institutions that have published more than 3 articles. The curves represent the cooperative relationships between various institutions. The thicker the lines, the closer the cooperation.

Author analysis

In the span of the last decade, research on Artificial Intelligence (AI) and medical education has seen the involvement of a total of 53 authors. The authors most frequently contributing to the documents included Vincent Bissonnette, Charlotte Blacketer, Rolando F. Del Maestro, Nicole Ledwos, Nykan Mirchi, Alexander Winkler-Schwartz, and Recai Yilmaz, each penning three papers. The authors garnering the highest citations encompassed the same group, with each achieving 143 citations

(Table 4).

TABLE 4. Top 10 Publications, Centrality, and Citations of Authors

Rank	Documents	Author	Citations	Author	Total link strength	Author
1	3	Bissonnette, Vincent	143	Bissonnette, Vincent	22	Bacchi, Stephen
2	3	Blacketer, Charlotte	143	Del maestro, Rolando f.	22	Duggan, Paul
3	3	Del maestro, Rolando f.	143	Ledwos, Nicole	22	Gallagher, Steve
4	3	Ledwos, Nicole	143	Mirchi, Nykan	22	Licinio, Julio
5	3	Mirchi, Nykan	143	Winkler-schwartz, Alexander	22	Parnis, Roger
6	3	Winkler-schwartz, Alexander	143	Yilmaz, Recai	22	Perry, Seth w.
7	3	Yilmaz, Recai	56	Culp, Melissa p.	22	Symonds, Ian
8	2	Bacchi, Stephen	56	Mollura, Daniel j.	22	Tan, Yiran
9	2	Bulatov, Sergey	47	Sapci, a. hasan	22	Thomas, Josephine
10	2	Caliskan, s. ayhan	47	Sapci, h. aylin	22	Wagner, Morganne

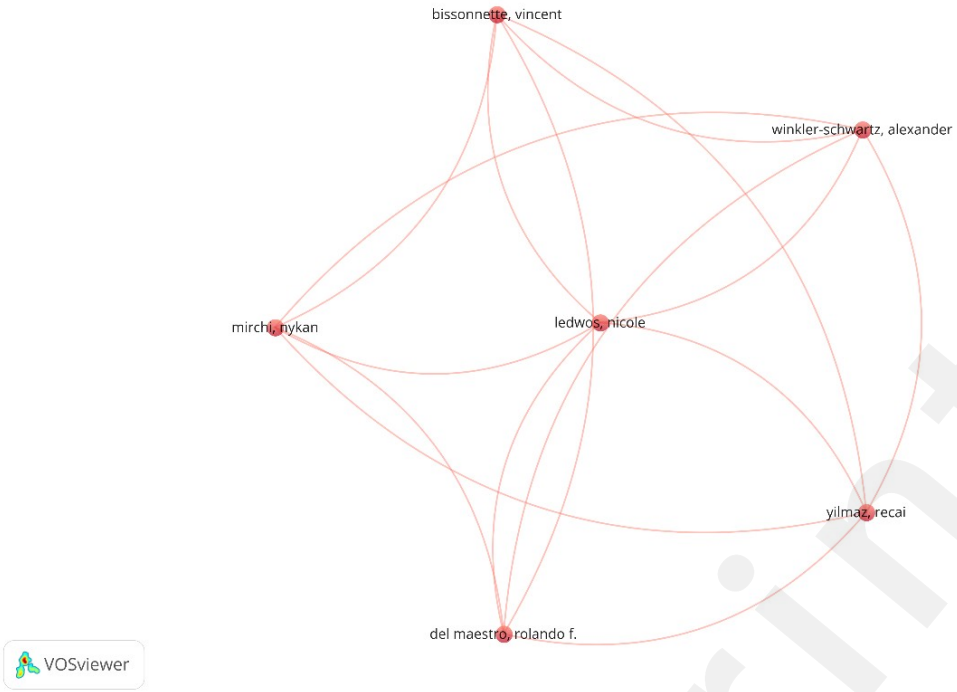

Figure 4. VOS software was utilized to analyze the authors of articles published in this domain. Given the limited collaboration between authors within this field, the circles in this diagram represent authors who have published more than three articles and maintain collaborative relationships. The curves delineate the cooperative relationships between various institutions, with the thickness of the line indicative of the closeness of the cooperation

Reference analysis

In accordance with Table 5, there are 15 papers which serve as primary references in the research of AI and medical education. The document entitled “Medical students’ attitude towards artificial intelligence: a multicenter survey” emerged as the most frequently cited and most pertinent literature, garnering 36 and 109 citations respectively. It primarily evaluates the attitudes of undergraduate medical students towards radiology and medical AI.

TABLE 5. Top 10 Publications, Centrality, and Citations of Cited reference

Rank	Citations	Cited reference	Total link strength	Cited reference
1	36	Dos Santos Dp, 2019, Eur radiol, v29, p1640, [https://doi.org/10.1007/s00330-018-5601-1]	109	Dos Santos Dp, 2019, Eur radiol, v29, p1640,[https://doi.org/10.1007/s00330-018-5601-1]
2	23	Kolachalama Vb, 2018, Npj digit Med, v1, p0,. [https://doi.org/10.1038/s41746-018-0061-1]	103	Wartman Sa, 2018, Acad Med, v93, p1107, [https://doi.org/10.1097/acm.0000000000002044]

3	23	Sit c, 2020, Insights Imaging, v11, p0,[https://doi.org/10.1186/s13244-019-0830-7]	98	Kolachalama Vb, 2018, Npj Digit Med, v1, p0, .[https://doi.org/10.1038/s41746-018-0061-1]
4	21	Gong b, 2019, Acad Radiol, v26, p566, [https://doi.org/10.1016/j.acra.2018.10.007]	96	Sit c, 2020, Insights Imaging, v11, p0, [https://doi.org/10.1186/s13244-019-0830-7]
5	21	Wartman Sa, 2018, Acad Med, v93, p1107, [https://doi.org/10.1097/acm.0000000000002044]	85	Masters k, 2019, Med Teach, v41, p976, [https://doi.org/10.1080/0142159x.2019.1595557]
6	19	Paranjape Ketan, 2019, Jmir Med Educ, v5, pe16048, [https://doi.org/10.2196/16048]	81	Paranjape Ketan, 2019, Jmir Med Educ, v5, pe16048, [https://doi.org/10.2196/16048]
7	19	Topol ej, 2019, Nat Med, v25, p44, [https://doi.org/10.1038/s41591-018-0300-7]	78	Topol ej, 2019, Nat Med, v25, p44, [https://doi.org/10.1038/s41591-018-0300-7]
8	16	Chan Kai Siang, 2019, Jmir Med Educ, v5, pe13930, [https://doi.org/10.2196/13930]	78	Wartman Steven a, 2019, Ama j ethics, v21, pe146, [https://doi.org/10.1001/amajethics.2019.146]
9	16	Masters k, 2019, Med Teach, v41, p976, [https://doi.org/10.1080/0142159x.2019.1595557]	78	Mccoy lg, 2020, Npj Digit Med, v3, p0, [https://doi.org/10.1038/s41746-020-0294-7]
10	15	Wartman Steven a, 2019, Ama j ethics, v21, pe146, [https://doi.org/10.1001/amajethics.2019.146]	75	Park Sh, 2019, J Educ Eval Health p, v16, p0, [https://doi.org/10.3352/jeehp.2019.16.18]

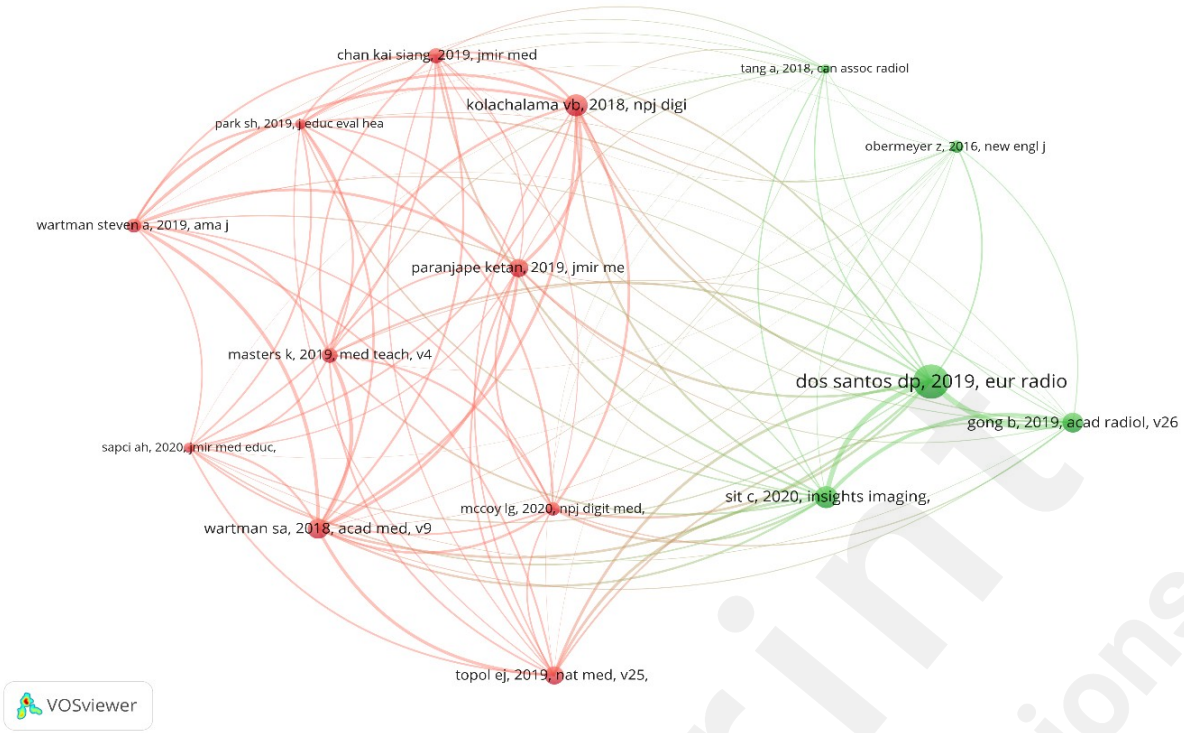

Figure 5. The VOS software was employed to analyze the cited references within this domain. The circles in the diagram denote references that have been cited more than ten times. The curves illustrate the relationships between the cited references, with the thickness of the line serving as an indicator of the closeness of the relationship

Keywords analysis

The study examining Artificial Intelligence (AI) and medical education from 2013 to 2022 concentrates on 39 primary keywords (detailed in Table 6), with AI (100), education (47), and medical education (45) generating the highest frequency of occurrences and the most substantial linked strength as shown in Figure 6.

TABLE 6. Top 10 Keywords Related to AI in medical education

Rank	Occurrences	Keywords	Total link strength	Keywords
1	100	AI	259	AI
2	47	education	131	education
3	45	medical education	114	medical education
4	33	machine learning	107	machine learning
5	23	technology	94	technology

6	15	radiology	56	curriculum
7	14	artificial-intelligence	43	radiology
8	13	curriculum	43	artificial-intelligence
9	12	health	41	performance
10	12	medical students	38	health

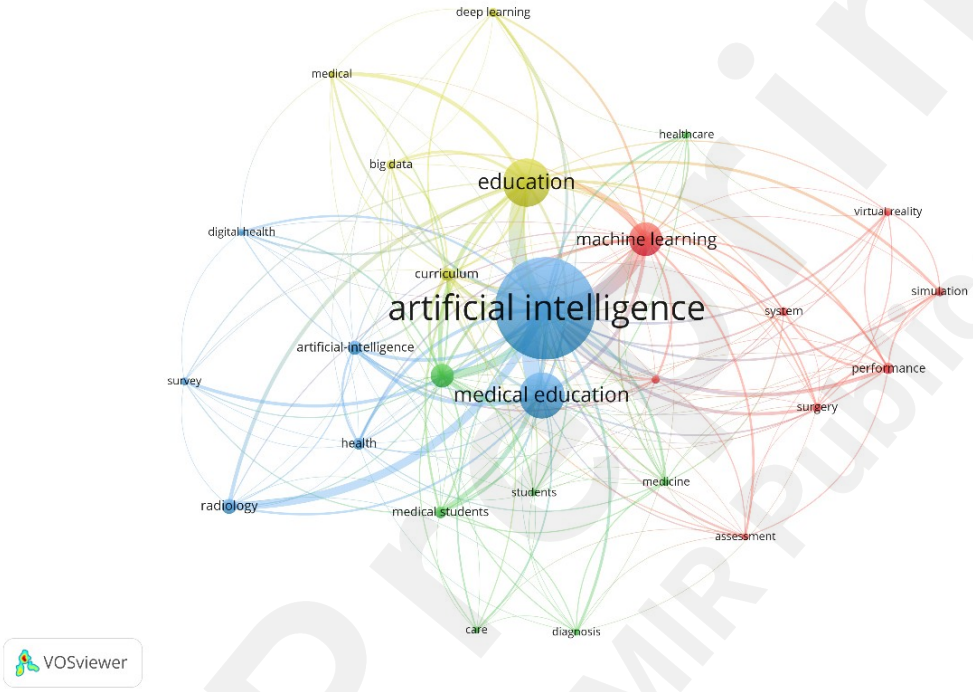

Figure 6.VOS software was used to analyze keywords mentioned in articles published in the field. The circles in the figure represent keywords that were mentioned more than seven times. The curve illustrates the relationship between keywords, and the thickness of the line can be used as an indicator of the closeness of the relationship.

References analysis

Through the analysis of references with high citation frequency and centrality, and the utilization of CiteSpace software to generate several clusters concentrated in specific research fields, it is possible to discern the highly esteemed research outcomes in the application of artificial intelligence within medical education. As depicted in Figure 7, five primary research fields have emerged: radiology, medical physics, ehealth, surgery, and specialty.

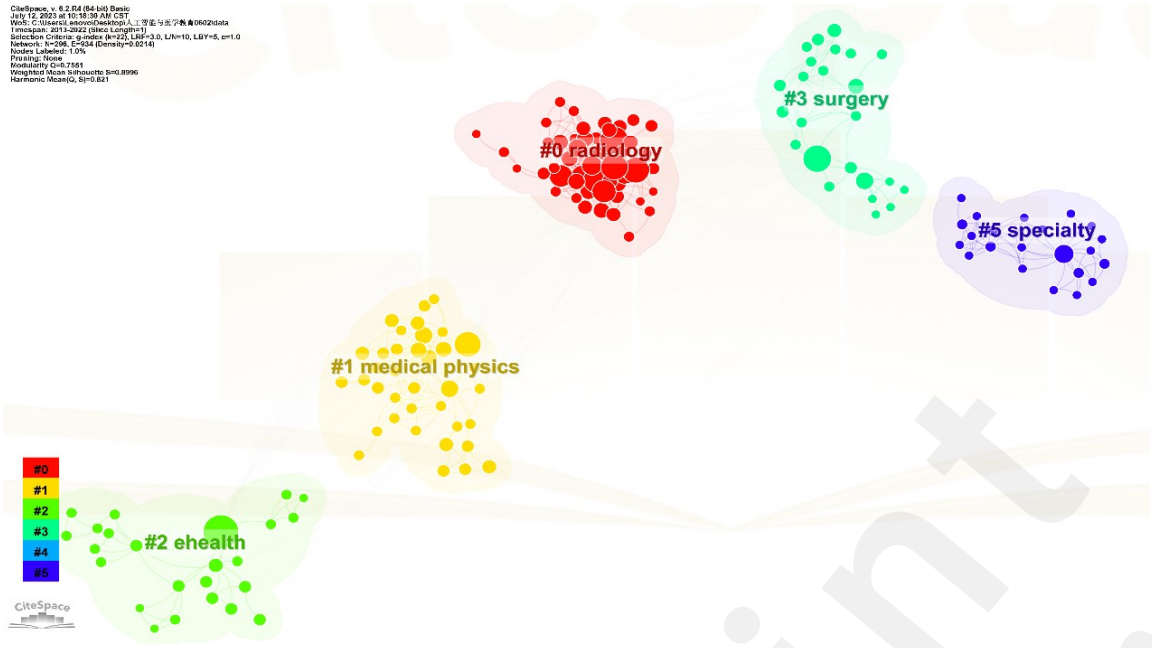

Figure 7. Research status map

Discussion

In this study, a bibliometric evaluation of 195 pertinent papers over the preceding decade was meticulously executed using Citespace and Vos viewer software. This research illustrates the findings related to countries, institutions, authors, citations, and keywords employing tables and diagrams.The United States stands out as the leading country in terms of the number of publications in this field, with Harvard University being the institution contributing the most significant volume of articles. Presently, there are no individual authors who have notably distinguished themselves through their publication output in this area. An analysis of references clusters has revealed five principal research clusters.

Annual number of publications, countries, institutions and authors

Figure 1 clearly indicates a recent substantial increase in the number of publications within this domain. The advent of AI has brought forth unprecedented opportunities and challenges for the medical and healthcare industry. As a foundational pillar for the development of the medical industry, medical education can greatly benefit from the incorporation of AI, thereby encouraging continuous innovation. An examination of the VOS viewer images reveals a distinct trend among North American and European countries towards the application of AI in medical education, likely attributable to their technological advancement. The United States has been a leading force in this field, having published a plethora of pertinent papers and fostered collaborative research relationships with numerous countries. From the perspective of total link strength between institutions, both Leiden University and Harvard Medical School have shown a higher degree of

collaboration with other institutions, each exhibiting a link strength of 15. According to the VOS viewer image, no researchers have an exceptionally high number of publications, indicating that the volume of published papers remains relatively low. These observations suggest that research in this field remains in its infancy, with none of the research teams significantly outperforming others.

References

References serve a crucial role in gauging the hotspots of the research area. In Cluster 0 and Cluster 1, the swift advancement of AI has led to its application across all medical sectors, notably radiology[14-16]. Despite radiologists, residents, and medical students increasingly recognizing the importance of understanding AI, medical education that targets future radiologists is only just commencing[17-19]. Current investigations fall into three categories: 1. Methods to facilitate medical students in learning AI knowledge, 2. Utilizing AI technology to augment radiology teaching efficiency and assist medical students in identifying clinical images, 3. Medical students' attitudes towards AI application in radiology. An AI curriculum (AI-RADS) has been devised to equip residents devoid of computing backgrounds with basic AI knowledge and its radiology application. The curriculum was highly rated (9.8 out of 10) by residents for overall satisfaction and significantly increased students' confidence in interpreting AI-related journal papers. There was a marked improvement in residents' comprehension of AI's fundamental concepts[20]. Some institutions stress an integrated AI framework to enhance radiology education, as illustrated in the subsequent figure[21]. As this framework continues to evolve, it may be possible to achieve "precise medical education" tailored to students' individual learning styles and needs[21]. A multi-centre survey assessing UK medical students' attitudes and perceptions of AI and radiology revealed that students recognize the significance of AI and are eager to engage[22]. This prompts the need to integrate relevant AI courses into medical education to acquaint students with practical AI applications and constraints, thereby maintaining their learning enthusiasm and preventing AI-related panic.

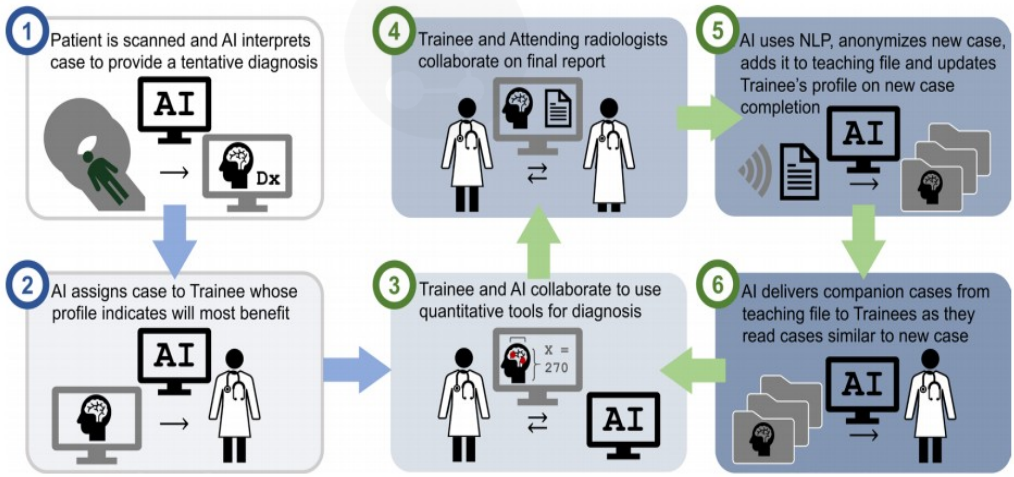

Figure 8. Framework of AI.

Natural Language Processing (NLP) is an important direction in the fields of computer science and artificial intelligence. It studies various theories and methods that enable effective communication between humans and computers using natural language. Its main function here is to distinguish rare cases

In Cluster 2, e-health refers to the utilization of information and communication technologies to fulfill healthcare needs in various domains, including AI, telemedicine, Internet of Things (IoT), connected devices, and mobile health (mHealth)[23]. E-health technologies provide access to healthcare in rural areas and support the management of numerous health conditions[24-28]. Following the release of the World Health Organization's national e-health strategy tool in 2012, it is imperative for future medical students to receive e-health education and training. Current medical education primarily includes conceptual courses while neglecting practical training[29]. While emphasizing the inclusion of e-health in medical education, it is also important to recognize the potential adverse outcomes of over-reliance on AI technology[30]. Hence, identifying the optimal e-health application areas in healthcare is necessitous[31].

In Cluster 3, the integration of medical education and AI holds significant value and potential beyond radiology, extending into surgical education and surgery. AI's earliest medical applications were in image-based specialties like radiology, pathology, ophthalmology, and dermatology. However, its application in procedural professions like surgery may require more time[32, 33]. The benefits of AI application in surgery mainly include: integrating preoperative, intraoperative, and postoperative data to improve the accuracy of the clinical decision-making system and predict postoperative complications more efficiently; applying surgical knowledge and education to interact with surgeons and patients through virtual or augmented reality. For instance, virtual reality (VR) simulators were initially used in laparoscopic surgery training[34]. A study involving 176 medical students was conducted to assess the accuracy of robot-assisted virtual surgical simulations after integrated deep learning, showing improved accuracy[35]. In 2022 and 2023, AI application breakthroughs were achieved in oral and maxillofacial surgery education[36] and orthopedic surgery[37]. While AI proves beneficial in surgery and surgical education, especially in surgical ability assessment, it raises questions regarding whether AI can ever match human educators' intelligence and audacity. Although advanced AI teaching tools can be incorporated into surgical education, current technology cannot fully replace multifaceted surgeons or surgical educators. Addressing the transparency and responsibility of AI application in medical education and resolving ethical issues may require more time and effort.

In Cluster 5, the rapid AI development profoundly impacts medical education. Modern medical education must accommodate various healthcare systems, including digital health systems and big data generation in a highly connected world[38]. A Canadian survey of medical students' perceptions of AI's impact on radiology in 2018 showed that anxiety induced by the prospect of AI replacing radiologists deterred many students from considering radiology[39]. The radiology community should appreciate AI's potential impact on the profession, educate students appropriately about AI's role, and ensure radiology's viability as a long-term career option. While AI's benefits in medicine include eliminating human bias and enhancing pattern recognition and decision-making, its drawbacks, such as the inability to provide warmth and empathy to patients and absorb human educators' wisdom, should not be underestimated. The confusion about whether AI's role in medical education is supplementary or replacement-based is another concern[40]. In summary, while AI promises great advances and changes in medicine, it also poses numerous challenges and problems. The medical community needs to proactively address these challenges, leverage AI technology benefits, and promote continuous innovation and improvement in medical services.

Limitation

The search strategies employed can potentially yield divergent results, and the strategy opted for in this study might not encompass all pertinent literature. With the swift advancement of AI, a number of papers in this domain were brought to light in 2023. However, the temporal span of this study extends from 2013 to 2022, thus excluding the contributions from 2023.

Conclusions

Initially, examining the annual publication count, authors, institutions, and countries, it was identified that from 2019 onwards, global interest and recognition of AI's applicability in medical education experienced an upswing. Secondly, superficially, collaboration in this arena might appear limited, an aspect that can be attributed to this field's unique nature and the diverse modalities of medical education across different regions. For future progress, it is recommended that countries focus on harmonizing their approaches while acknowledging their differences, fostering collective advancement, and advocating for a mutual elevation of medical education standards.

Further, an evaluation of the current research status and prevalent research themes highlighted that the extent of AI technology integration in medical education is significantly inadequate, with a rather limited focus area. Consequently, it is advocated that future efforts should aim at active exploration

to unearth novel advancements.

Lastly, AI, being inherently enigmatic, evokes uncertainty among both educators and learners about its future potentialities. Therefore, the immediate concern should be to strategically leverage its potential while mitigating its drawbacks, which, indeed, becomes the highest priority for future advancement.

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Professor Tai (taixiantao@163.com)and Dr. Zhang are cocorresponding authors for this manuscript.

Data Availability

The data sets generated or analyzed in this study will not be publicly available. Consent and ethical approve not include a provision for the sharing of data from this study.

Authors’ Contributions

XT and XZ are the main investigators, mainly responsible for the overall framework and design of the paper, SW is mainly responsible for data processing and mapping, LY and ML are mainly responsible for the article writing and table design. All authors participate in the revision and approved the final manuscript.

Conflicts of Interest

None declared.

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Table of Abbreviations

Full name	Abbreviations
Artificial Intelligence	AI
Chronic Obstructive Pulmonary Disease	COPD
Diabetic Retinopathy	DR
Harvard Medical School	Harvard Med Sch
Leiden University	Leiden Univ
Machine Learning	ML
Mcgill University	Mcgill Univ
Nanyang Technol University	Nanyang Technol Univ
People's Republic of China	Peoples R China
University Chicago	Univ Chicago
University of California	Natl Univ Sniv Calif San Francisco
United Kingdom	UK
United States of America	USA
University of Toronto	Univ Toronto
Virtual reality	VR
Web of Science	WOS

Supplementary Files

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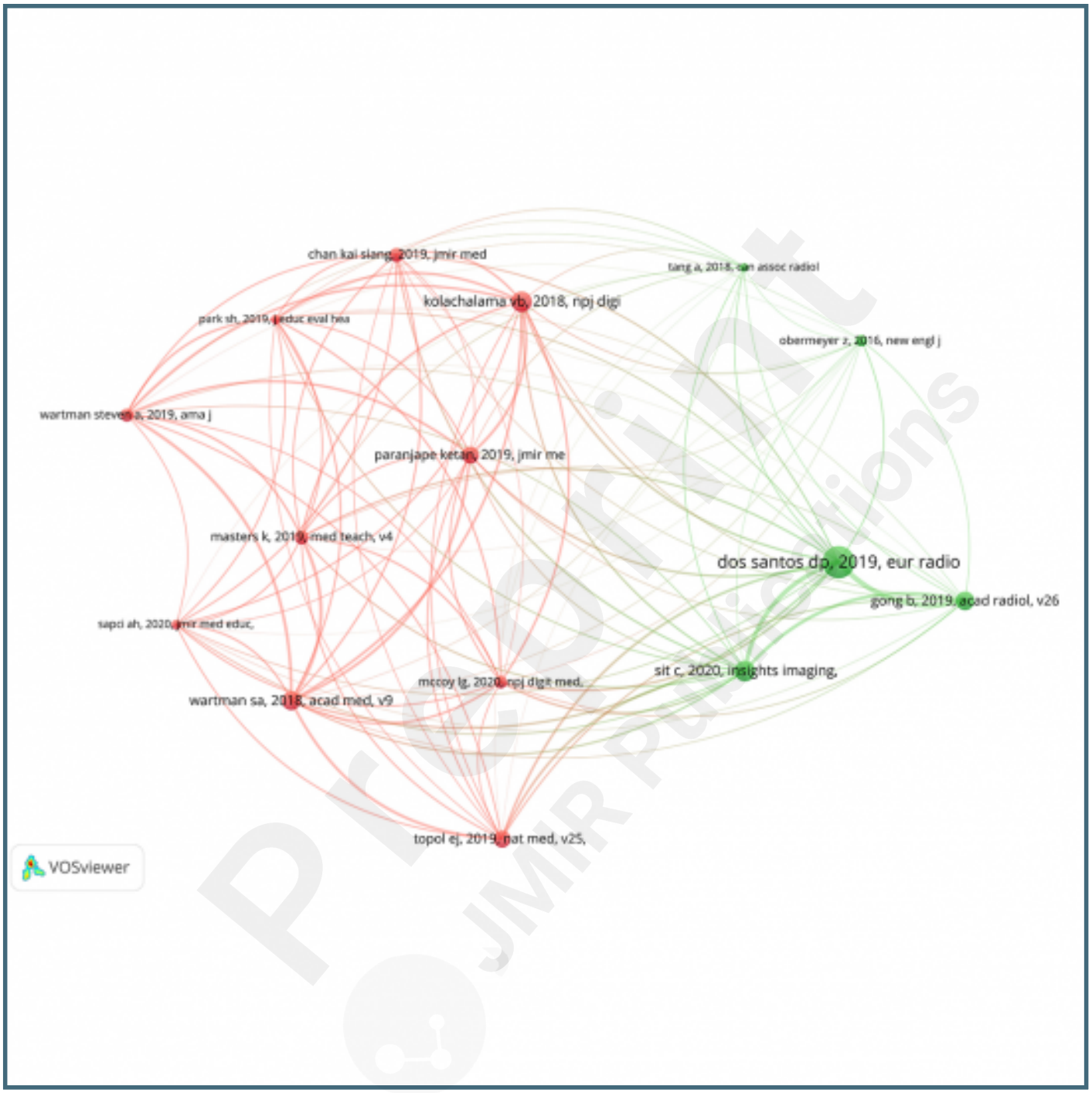
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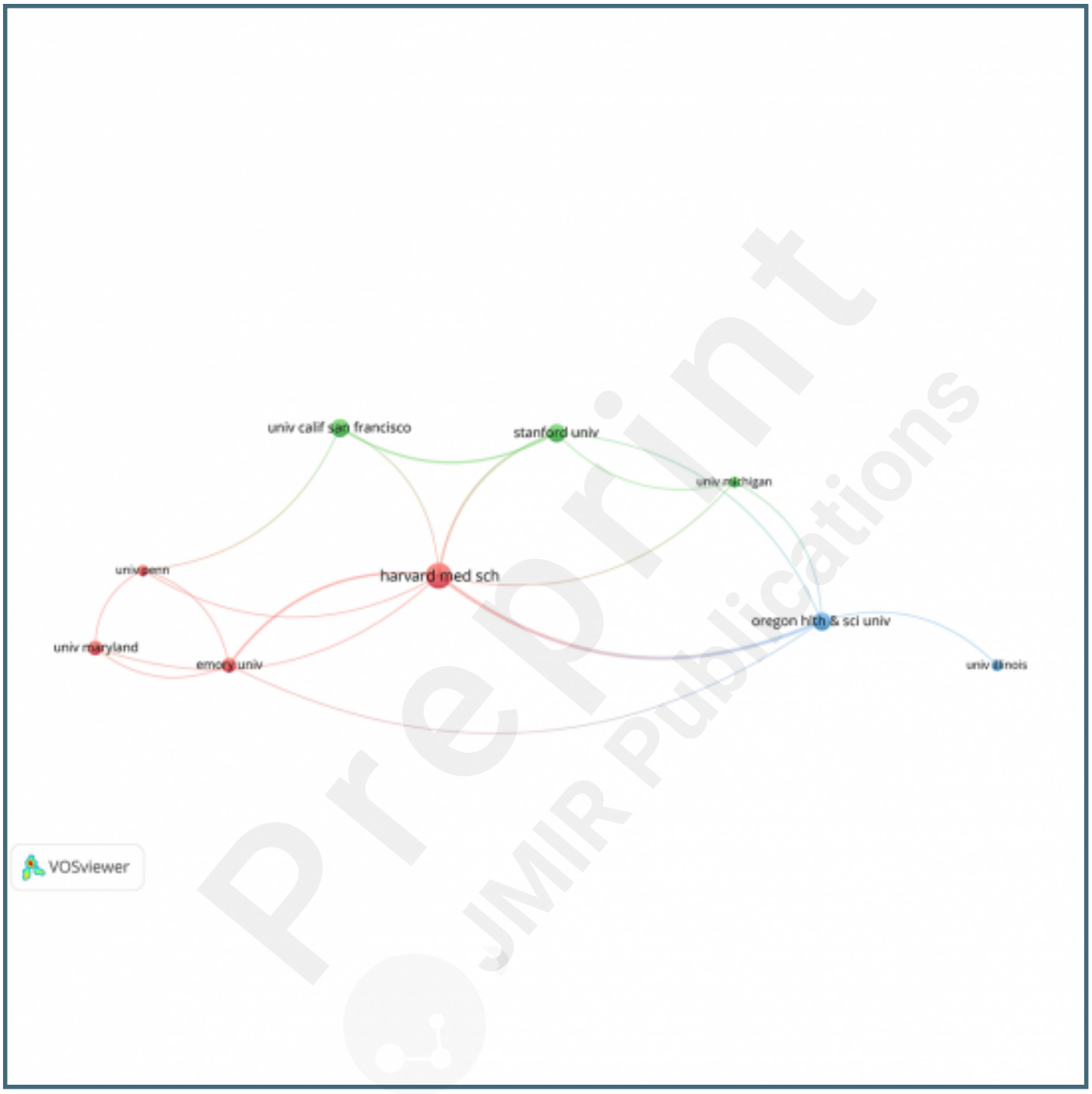

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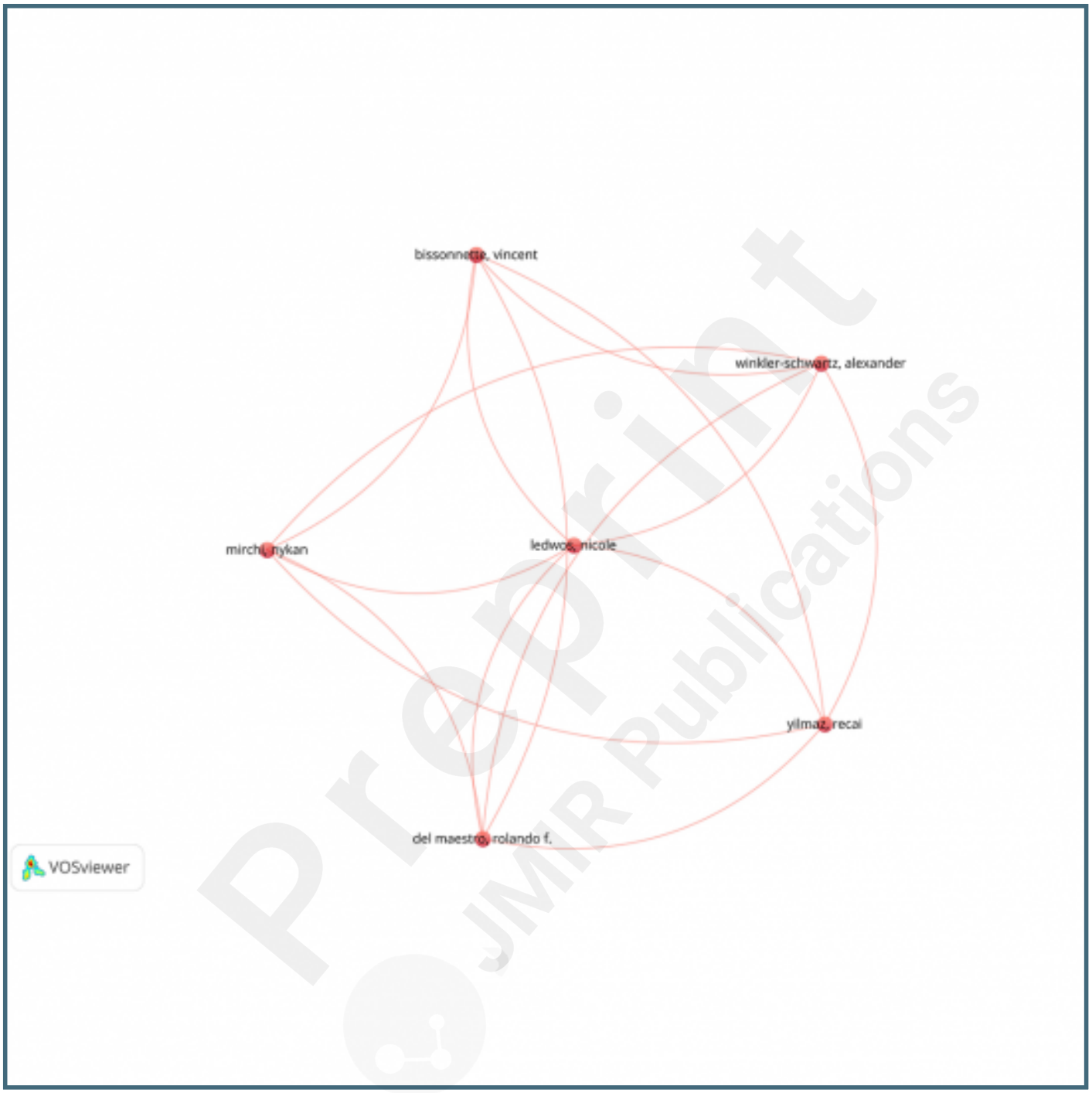
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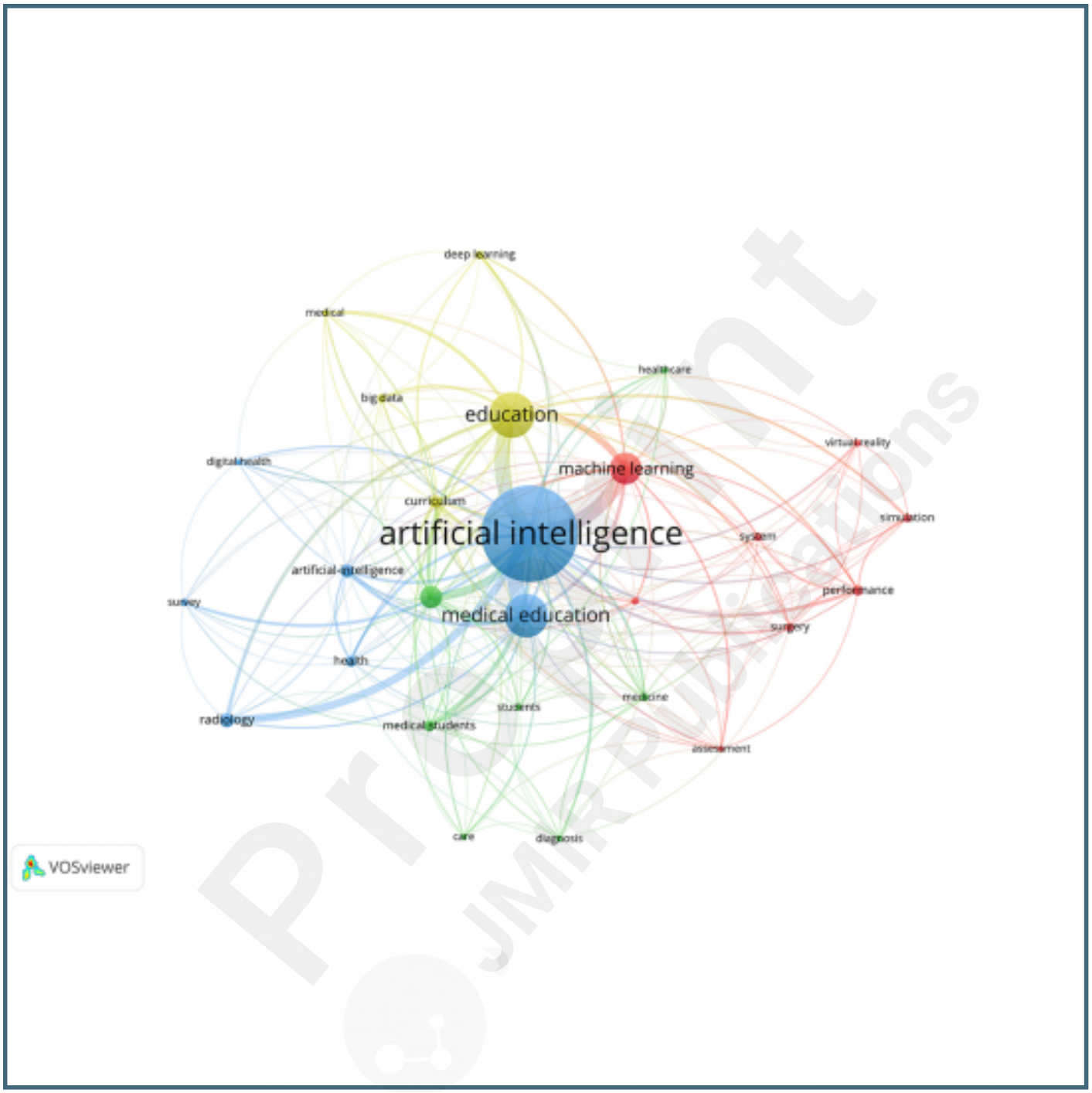
deep learning
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