Journal of Pioneering Medical Sciences
Received: February 26, 2026 | Accepted: April 08, 2026 | Published: June 05, 2026
Volume 15, Issue 05, Pages 144-152

DOI https://doi.org/10.47310/jpms2026150518

Global Research Trends in Artificial Intelligence for Healthcare and Education: A Bibliometric Analysis (2000-2025)

Anas Ali Alhur[1*], Muneef M. Alsahmmari[2] and Fahad Saud Alshammari[3]
[1,2]Department of Health Informatics, College of Public Health and Health Informatics, University of Hail, Hail, Saudi Arabia
[3]Department of Health Management, College of Public Health and Health Informatics, University of Hail, Hail, Saudi Arabia

Author Designation: [1]Lecturer, [2,3]Assistant Professor

*Corresponding author: Anas Ali Alhur (e-mail: anas.ali.alhur@gmail.com).

Abstract This study presents a comprehensive bibliometric analysis of global research trends in Artificial Intelligence (AI) in healthcare and education from 2000-2025. A total of 3,101 peer-reviewed publications retrieved from OpenAlex were analysed using VOSviewer to map co-authorship networks, keyword co-occurrence and institutional collaboration patterns. Five major thematic clusters were identified: technical foundations, learning theory, clinical applications, governance and ethics and point-of-care applications. Citation analysis highlighted the ten most highly cited articles, primarily focusing on challenges related to AI implementation and interpretability. Leading institutions included Harvard University, Stanford University and University College London. While North America and Western Europe dominate research output, contributions from emerging regions, particularly South Asia and the Gulf, have increased since 2020. The findings indicate a shift toward human-centered AI, interdisciplinary education and explainability. However, persistent challenges remain, including data interoperability, privacy concerns and algorithmic bias.

Key Words Artificial Intelligence, Healthcare, Medical Education, Bibliometric Analysis, Machine Learning, Digital Health, Research Trends, Ethics and Governance

INTRODUCTION

Artificial Intelligence (AI) has advanced out of the laboratory and is now an integral part of healthcare systems today. It enables advanced pattern recognition in diagnostic images, real-time predictive analytics from electronic health records and the use of intelligent conversational agents to augment clinical capacity [1,2]. AI, bringing together the strengths of human expertise and the accuracy of computational power, contributes to faster diagnosis, personalised treatment plans and improved management of population health [3]. Consequently, research at the intersection of AI and healthcare has been rapidly growing, with the number of publications on the topic increasing substantially over the last two decades, covering areas such as radiomics, genomics, clinical decision support, robotics and public health surveillance [4,5].

Although the field has grown rapidly, its structure and evolution are difficult to understand. While traditional narrative reviews provide useful insights into specific applications, they are often limited in scope and may miss the bigger picture of research trends, new collaborations or conceptual developments. In this regard bibliometric analysis provides a systematic and quantitative approach to mapping scientific output. Methodologies such as co-authorship analysis, co-citation mapping and keyword co-occurrence analysis allow for the detection of key authors, thematic clusters and worldwide research networks [6,7]. Tools for visualisation such as VOSviewer and CiteSpace improve this process by converting complex bibliographic data into interpretable maps, thus helping researchers and policymakers to make strategic decisions [8].

Existing bibliometric studies in AI and healthcare have provided valuable insights but are still fragmented. Many studies focus on specific areas, such as deep learning in radiology or clinical decision support systems or are limited to specific timeframes. As a result, there is limited information about the development of AI research in healthcare and education as related disciplines. Key questions remain on how to integrate technical, educational and ethical dimensions, the nature of global collaboration networks and the extent to which research output reflects disparities in digital health capacity across regions [9-11].

Addressing these gaps is crucial to inform evidence-based policy and future research directions. International efforts, such as the World Health Organization's framework on AI in healthcare, emphasise the need for comprehensive

analyses to guide investment strategies, workforce development and governance structures [12]. Moreover, the integration of AI in healthcare education requires a better understanding of how research trends align with curricular development and professional training needs [13,14].

While research is growing, there is still a lack of understanding of the global research landscape across healthcare and education as a whole. Previous bibliometric analyses have often lacked longitudinal depth and have failed to capture inter-disciplinary linkages and evolving patterns of collaboration. The present study aims to overcome these limitations by providing a comprehensive bibliometric analysis from the year 2000-2025. This study seeks to contribute to policy-making, research prioritisation and the integration of AI into education and healthcare systems by analysing publication trends, thematic structure and collaboration networks [15-17].

The objectives of this study are to:

- Map global research trends in artificial intelligence in healthcare and education
- Identify major thematic clusters and key research domains
- Analyse leading authors, institutions and collaboration networks
- Examine the geographic distribution of research output
- Evaluate highly cited publications and emerging research priorities

METHODS

Data Source and Retrieval Strategy

Articles were included if they (i) Addressed applications of artificial intelligence in healthcare and/or education, (ii) were published in peer-reviewed journals and (iii) were written in English. Articles were excluded if they were conference abstracts, editorials, letters or lacked sufficient bibliographic metadata for analysis.

All bibliographic records were collected from OpenAlex (https://openalex.org/) on 31 March 2025. OpenAlex was selected because it aggregates Crossref, PubMed, arXiv and institutional repositories. It also offers open APIs and provides persistent identifiers that integrate seamlessly with major bibliometric software.

A Boolean search query was executed in the title-and-abstract fields to capture work situated at the intersection of Artificial Intelligence (AI), healthcare and education. The following searching strategy was used to retrieve the relevant material; ("artificial intelligence" OR "machine learning" OR "deep learning" OR "neural network*") AND ("health*" OR "medicine" OR "clinical" OR "public health") AND ("education" OR "training" OR "curriculum" OR "learning" OR "teaching").

The search was restricted to peer-reviewed journal articles published in English between 1 January 2000 and 31 March 2025 and further filtered by the OpenAlex concept label "Artificial Intelligence in Healthcare and Education" (concept ID C98873066). In total, 3101 records were retrieved (Figure 1).

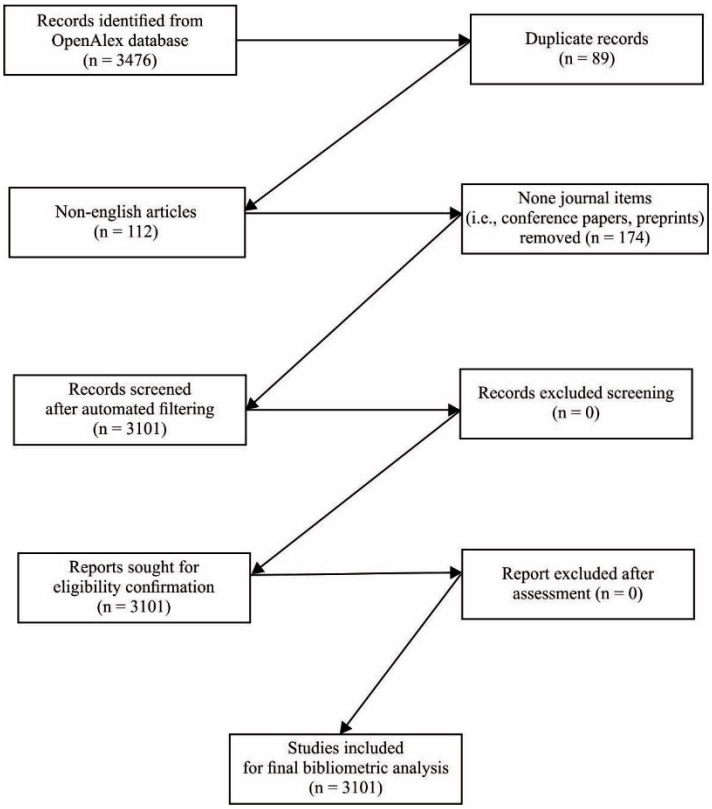

Figure 1: PRISMA Flow Diagram of Study Selection for Bibliometric Analysis on Artificial Intelligence in Healthcare and Education (2000-2025)

Data Cleaning and Normalisation

Bibliographic data-including authors, titles, abstracts, journal, publication year, citation counts, institutional affiliations and country codes-were exported in CSV format and processed in Python 3.11 with pandas 2.2 and pybliometrics 3.5. Duplicates were removed by matching DOI, PubMed ID and title strings. Author and institution names were disambiguated using ORCID identifiers where available and, when absent, by applying a Levenshtein-similarity threshold (>0.9) to surname-initial combinations. Because OpenAlex does not supply author keywords, unigrams and bigrams were tokenised from titles and abstracts, lemmatised with spaCy 3.7, stripped of stop-words and retained if they occurred ten or more times, yielding 714 high-frequency terms for co-occurrence analysis.

Bibliometric Mapping

Visual analytics were made with VOSviewer v1.6.20. Full counting was used and the similarity matrices were normalised using the association-strength index. Keyword co-occurrence maps (minimum term frequency = 10) were used to describe thematic structure. Author, institutional and country networks were created for entities with three or more publications, 300 publications and five publications respectively. Clusters were identified using the modularity algorithm of VOS viewer and the colour partitions represent clusters described in the Results section. All images were exported as high resolution SVG files (600 dpi) for submission to the journal.

Citation Metrics

Total citations and citations-per-year were drawn directly from the works_cited_by_count field returned by the OpenAlex API. Papers in the top decile of the distribution (≥379 citations) were designated "highly cited."

Methodological Limitations

OpenAlex does ingest PubMed but does not fully index EMBASE or Web of Science and so may under-represent discipline-specific output beyond its coverage. The language bias is due to the corpus being limited to English language articles. Finally, even with ORCID-assisted disambiguation, homonym and synonym errors may persist for authors lacking persistent identifiers.

RESULTS

A total of 3,101 peer-reviewed articles published between 2000 and 2025 were retrieved from OpenAlex on AI in healthcare and education. After data cleaning and normalization, bibliometric analyses were performed using VOS viewer to examine keyword co-occurrence, citation patterns, co-authorship, institutional networks and global collaborations. The keyword co-occurrence network (Figure 2) resolved five dominant thematic clusters indicated in Table 1.

The density map (Figure 3) shows the highest signal intensity around "computer science", "medicine", "machine learning", "medical education" and "psychology", illustrating the interdisciplinary Focus of the field.

High-frequency terms included computer science, medicine, machine learning and medical education, illustrating the interdisciplinary nature of the field (Figure 2-3). The prominence of governance-related terms indicates a growing concern with ethics and trust alongside technical progress.

Table 2 lists the top 10 most-cited papers, led by "The potential for artificial intelligence in healthcare" (2019, 2,576 citations) and "Key challenges for delivering clinical impact with AI" (2019, 1,556 citations). Most highly cited works emphasize implementation challenges, interpretability and ethical considerations, reflecting persistent barriers to real-world adoption.

The most prolific authors were Leo Anthony Celi (14 publications), Yindalon Aphinyanaphongs (12 publications) and Abdulqadir J. Nashwan (10 publications) (Table 3). Co-authorship networks (Figure 4-6) reveal dense collaboration clusters, with Celi, Magrabi and Shah bridging clinical, ethical and data-science domains. These figures highlight a transition from small, isolated teams before 2010 to globally connected research communities after 2017.

Table 1: Thematic Clusters and Their Representative Terms and Focus Areas

Cluster	Representative terms	Topical focus
Red	Computer science, deep learning, data science	Technical foundations & algorithms
Green	Psychology, medical education, perception	Learning theory & cognitive science
Blue	Medicine, radiology, clinical AI	Applied clinical practice
Yellow	Equity, ethics, policy	Governance, fairness & trust
Purple	Nursing, medical emergency, communication	Point-of-care applications

Table 2: Top 10 Most Cited Articles in AI for Healthcare and Education (2000-2025)

Rank	Title	Year	Citations
1	The potential for artificial intelligence in healthcare	2019	2,576
2	Key challenges for delivering clinical impact with AI	2019	1,556
3	Implementing Machine Learning in Health Care	2018	1,149
4	Explainability for AI in healthcare: a multidisciplinary perspective	2020	1,050
5	Overview of artificial intelligence in medicine	2019	843
6	FDA-approved AI medical devices and algorithms: an online database	2020	823
7	Machine learning in medicine: addressing ethical challenges	2018	545
8	Synthetic data in machine learning for medicine and healthcare	2021	473
9	Deep learning in medicine — promise, progress and challenges	2019	401
10	The ethical implications of AI in healthcare	2020	379

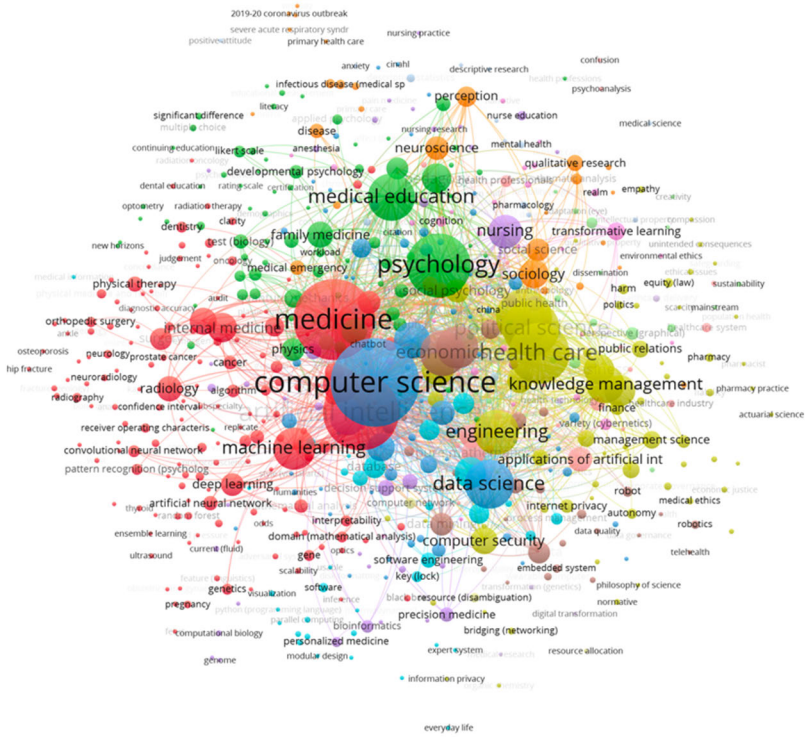

Figure 2: Keyword Co-Occurrence Network Showing Five Thematic Clusters in AI, Healthcare and Education Research

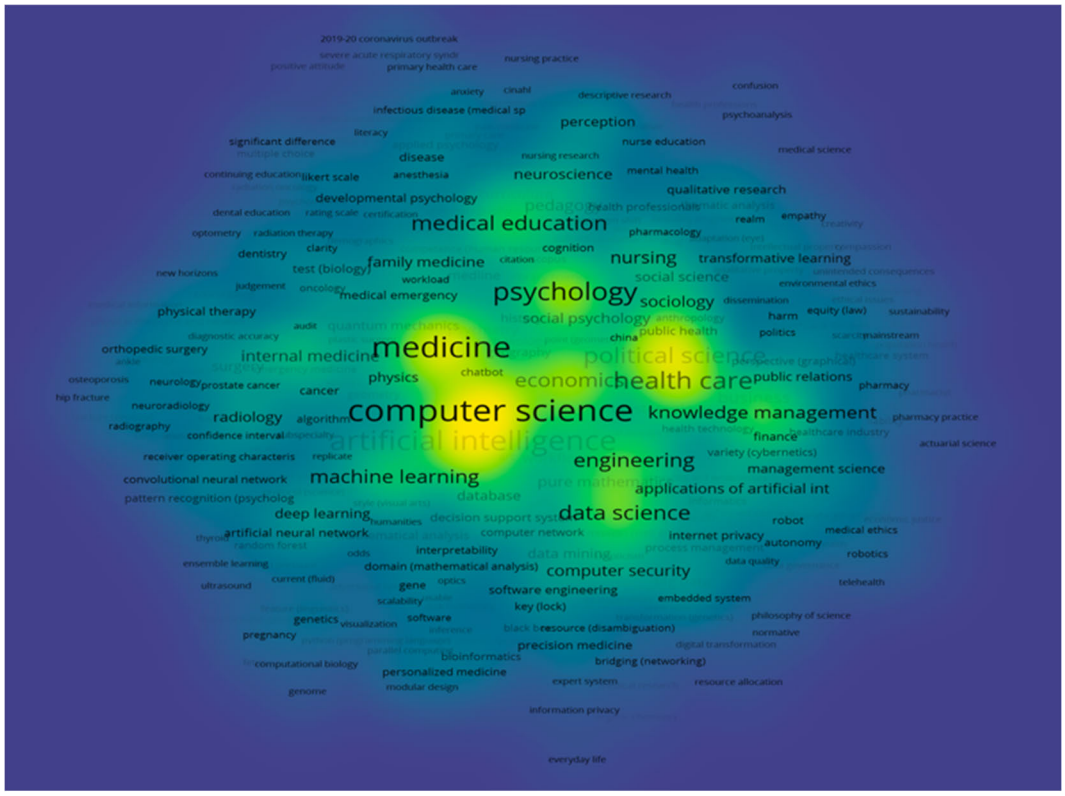

Figure 3: Keyword Density Visualisation Highlighting Areas of Greatest Conceptual Intensity

Source co-citation analysis (Figure 7-8) identified Cureus, BMC Medical Education and Digital Health as key outlets bridging technical AI and pedagogy. Cureus emerged as the most prolific journal, while PubMed-indexed education journals were increasingly represented, signaling a stronger integration of AI into health-professional education.

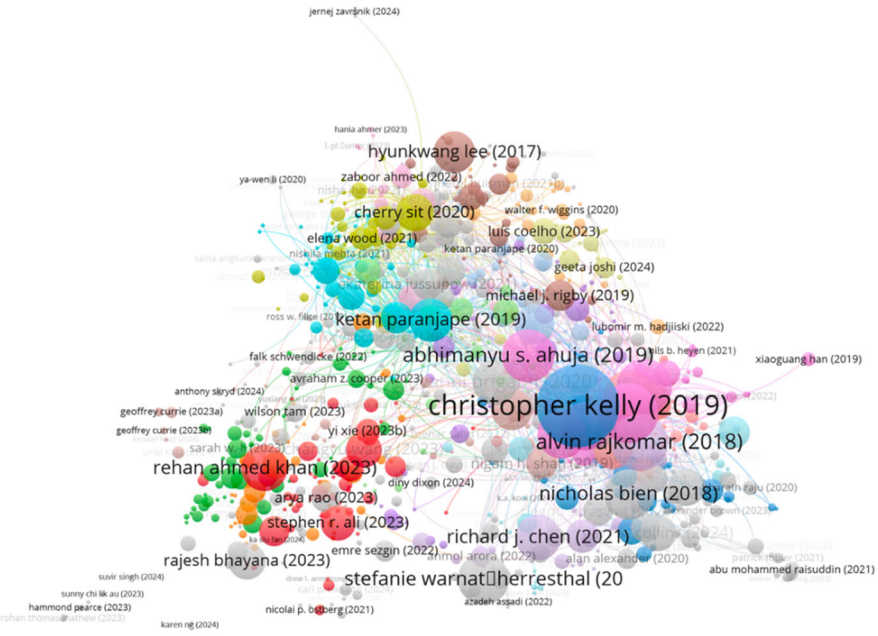

Figure 4: Overlay Co-Authorship Map Coloured by First-Publication Year

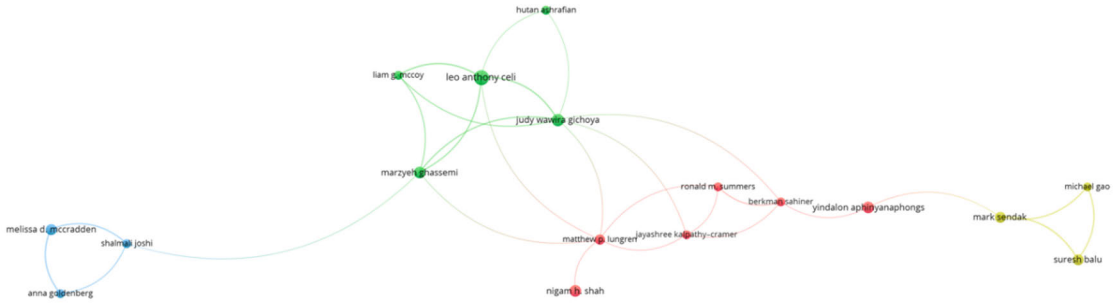

Figure 5: Focused Co-Authorship Network Highlighting High-Density Collaboration Clusters

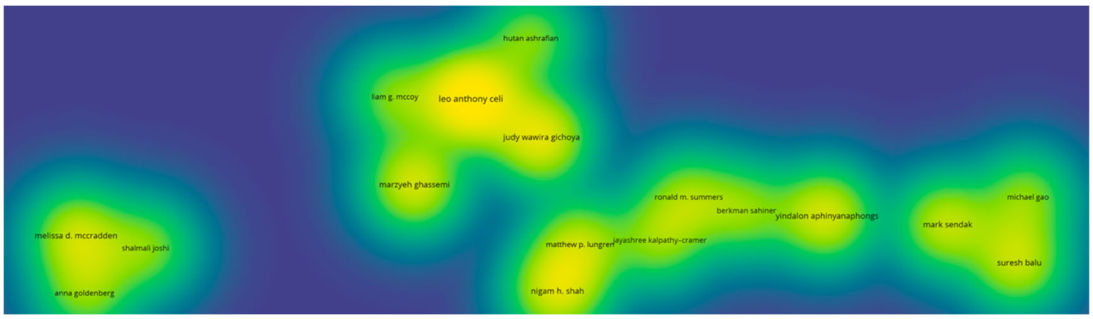

Figure 6: Author Collaboration Density Heat-Map

Table 3: Most Prolific Authors in AI for Healthcare and Education (2000-2025)

Rank	Author	Publications
1	Leo Anthony Celi	14
2	Yindalon Aphinyanaphongs	12
3	Abdulqadir J. Nashwan	10
4	Farah Magrabi	9
5	Thomas Grote	9
6	Christina Malamateniou	8
7	Joseph J. Y. Sung	8
8	Judy Wawira Gichoya	8
9	Ian Scott	7
10	Nigam H. Shah	7

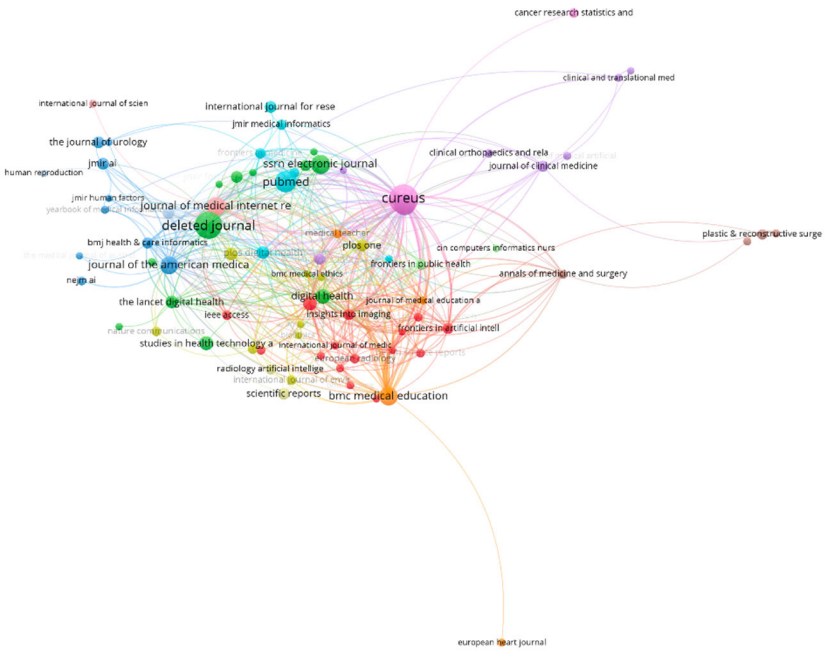

Figure 7: Co-Citation Network of Highly Cited Journals in AI-Health-Education Research

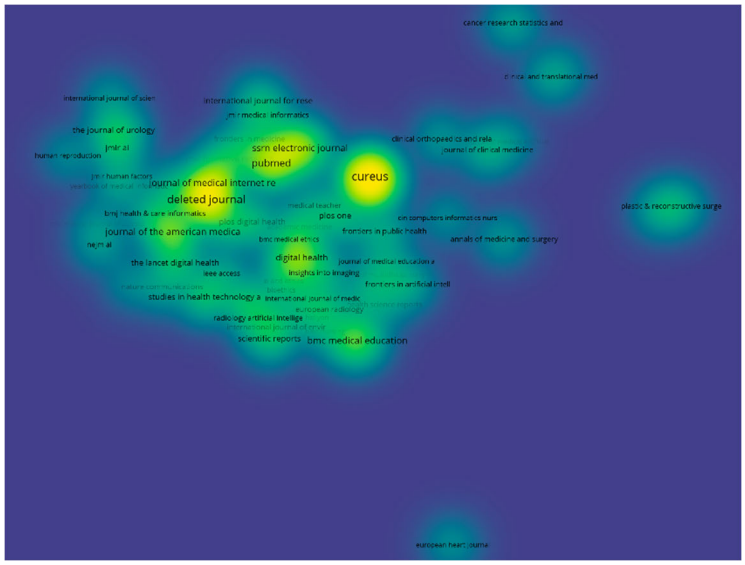

Figure 8: Source-Journal Density Map Indicating Publication Intensity

Institutional mapping (Figure 9) showed Harvard University, Stanford University, University College London and University of Toronto as central hubs of collaboration. Country-level analysis (Figure 10-11) placed the United States, United Kingdom, India, Australia and China at the forefront, with North America and Western Europe dominating output. Notably, contributions from South Asia and the Gulf region have grown since 2020, reflecting increased policy investment.

DISCUSSION

This bibliometric study offers a comprehensive overview of the research conducted at the intersection of artificial intelligence, healthcare and education. The results show a rapidly growing and more diverse field, with most research activity occurring in North America and Western Europe. However, a significant change is observed from early technology-oriented explorations to a wider focus on ethics, workforce readiness and interdisciplinary educational frameworks, which reflects the field's progression and its increasing societal importance [18].

The field's intellectual landscape is structured around five major clusters: medical education, clinical decision support, machine learning methodologies, AI ethics and health policy. Emerging themes of explainability, equity, trust, etc. across these clusters signal a definite shift to

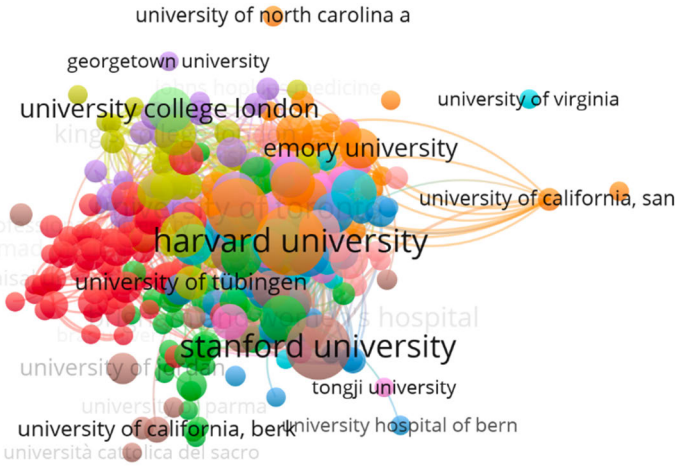

Figure 9: Institutional Collaboration Network Illustrating Global Research Hubs

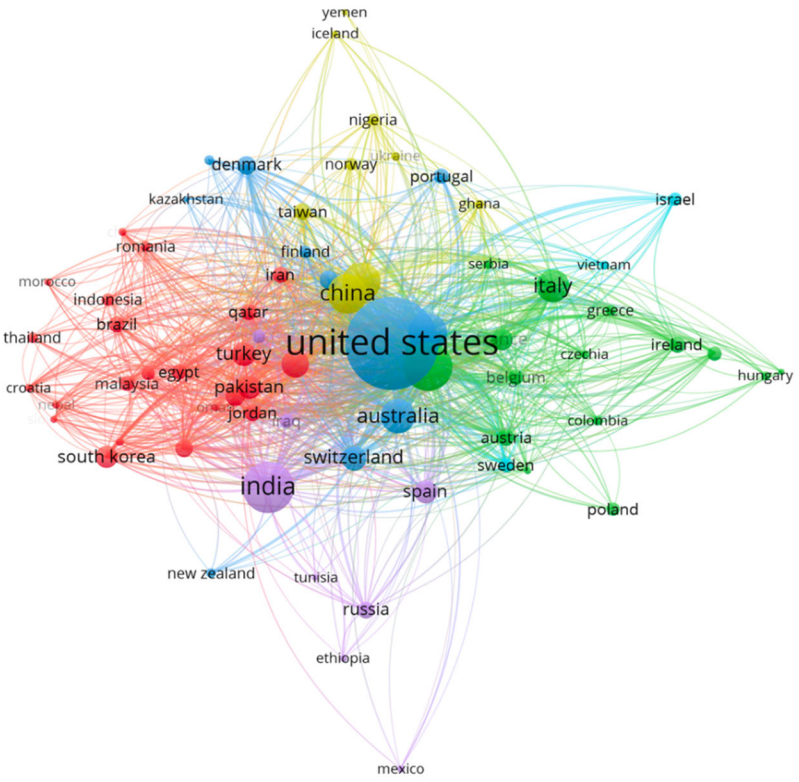

Figure 10: Country Collaboration Network Showing International Connectivity

human-centered AI design. This development raises the need to balance technical innovation with the considerations of transparency, usability and fairness in real-world applications [19,20]. Moreover, the growing significance of competency-based education and transformative learning approaches indicates that pedagogical developments are also progressing in tandem with the advancement of AI technologies [21].

Analyses of citations confirm the central role of foundational studies that address the challenges of implementation and the interpretability of models. Influential works still shape current research priorities, especially in terms of the safe and effective integration of AI in clinical practice [22,23]. Key contributors like Leo Anthony Celi, Nigam H. Shah and Farah Magrabi provide important links between data science, clinical application and ethics, emphasising the interdisciplinary character of the field. This is consistent with the general idea of augmented intelligence, in which AI systems are intended to assist, not replace, healthcare professionals in making clinical decisions [24].

Patterns of institutional collaboration further illustrate the dominance of leading academic centres such as Harvard University, Stanford University and University College

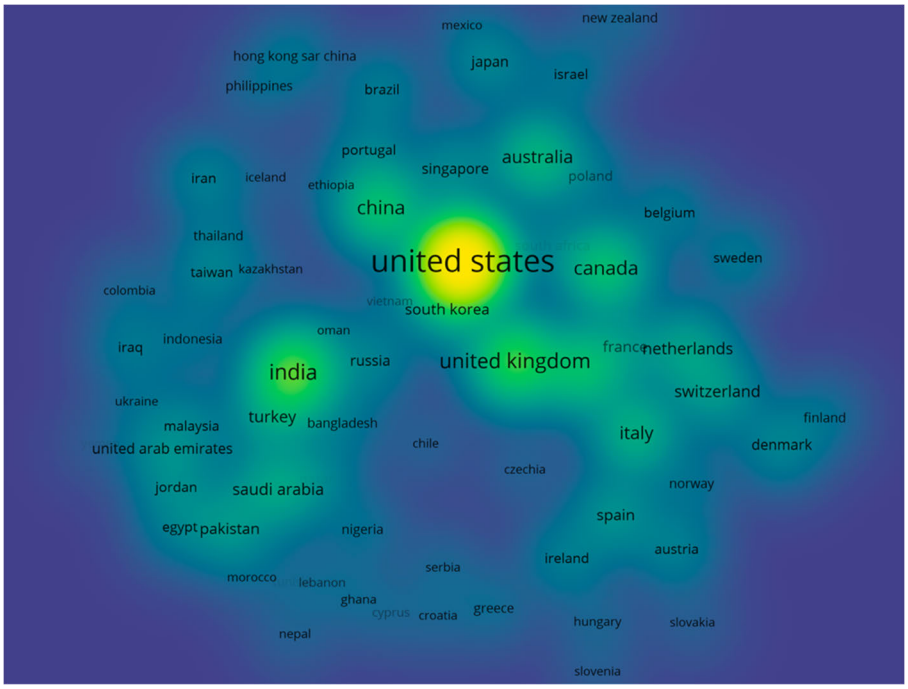

Figure 11: Geographic Heat-Map of Research Productivity and Author Density

London. These institutions are global centers of innovation and have been pivotal in the early adoption of AI-integrated educational curricula [25]. Recent policy initiatives including Saudi Vision 2030 have contributed to increased research output in the Gulf region however there are gaps in integration of digital health and AI to formal medical education This points to the need for more systematic curriculum development and institutional investment in emerging regions [26].

Interdisciplinary journals such as Cureus, BMC Medical Education and Digital Health help demonstrate the importance of sharing knowledge across domains. These platforms enable technologists, clinicians and educators to collaborate, helping accelerate the translation of research into practice. In addition, the correspondence of bibliometric trends to real-world applications (e.g., AI-assisted clinical documentation, predictive analytics and simulation-based training) suggests that research activity is closely correlated with practical implementation [21]. In educational interventions, AI-supported approaches have shown improvements in learner outcomes, while challenges regarding infrastructure and faculty preparedness are still an issue [27].

However, even with these advances, many barriers still exist for large-scale implementation. Data interoperability, privacy and algorithmic bias issues are still critical challenges that affect both scalability and trust in AI systems [24]. Overcoming these barriers will require concerted efforts that go beyond technology solutions to include regulatory frameworks, institutional policies and workforce development. Specifically, the integration of AI into health care education demands ongoing investment in faculty development and curriculum innovation to promote successful implementation [26].

These findings suggest the policy importance of targeted investment in artificial intelligence education especially in developing regions. To ensure the sustainable and equitable implementation of AI in healthcare and education systems, it is vital to enhance interdisciplinary collaboration, incorporate AI competencies into healthcare curricula and develop robust ethical and regulatory frameworks.

CONCLUSIONS

The bibliometric analysis shows that the current state of AI research in healthcare and education is dynamic and growing rapidly. As the field grows, there is a definite shift from tech-centric approaches to more human-centric designs that respect ethics and interdisciplinary collaboration. Such a move is increasingly needed to ensure that AI development aligns with human values and society's needs. North America and Western Europe still dominate the research output, though other regions contribute more, indicating a gradual globalisation of AI research in these fields. There has been a lot of progress but the analysis also shows that there are still challenges ahead in translating research into practice. Data interoperability across different systems, privacy concerns in an increasingly data-driven world and algorithmic bias to avoid the reinforcement of existing inequalities are important issues.

Addressing these challenges and harnessing the full transformative potential of AI in healthcare and education requires future research to develop sustainable integration strategies that balance technological innovation with ethical considerations. This entails raising AI literacy among healthcare providers and educators, matching the development of AI with the changing regulatory landscape

and continuing to advance explainable AI to foster trust and equitable deployment across different populations and settings.

Limitations

This study has a number of limitations. First, the dependency on the OpenAlex database may restrict coverage compared to other databases like EMBASE and Web of Science, which may impact the completeness of the dataset. Second, the limitation to English language publications may result in language bias, possibly missing relevant studies from non-English speaking nations. Third, author disambiguation was performed using ORCID identifiers and similarity-based algorithms but some inaccuracies could arise from homonym and synonym variations. These limitations should be taken into consideration when interpreting the results, especially in terms of the global representation and completeness of the analysed literature.

REFERENCES

[1] Alhur, A. *et al.* "Evaluating the Trustworthiness of ChatGPT-Generated Health Information among Future Health Care Professionals." *Georgian Medical News*, nos. 364-365, July 2025, pp. 101-106.

[2] Jiang, F. *et al.* "Artificial Intelligence in Healthcare: Past, Present and Future." *Stroke and Vascular Neurology*, vol. 2, no. 4, 2017, pp. 230-243. https://doi.org/10.1136/svn-2017-000101.

[3] Liu, Y. *et al.* "Factors Influencing Artificial Intelligence (AI) Literacy in the Age of Generative AI Chatbots for Health Information Seeking." *Information Development*, June 2025.

[4] Rajkomar, A. *et al.* "Ensuring Fairness in Machine Learning to Advance Health Equity." *Annals of Internal Medicine*, vol. 169, no. 12, 2018, pp. 866-872. https://doi.org/10.7326/M18-1990.

[5] Alhur, A. *et al.* "Incorporating Technology in Pharmacy Education: Outcomes of an AI-Supported Learning Intervention." *Journal of Pharmacy Education*, vol. 57, no. 4, 2023, pp. 233-241.

[6] Rajkomar, A. *et al.* "Machine Learning in Medicine." *New England Journal of Medicine*, vol. 380, no. 14, 2019, pp. 1347-1358. https://doi.org/10.1056/NEJMra1814259.

[7] Rudin, C. "Stop Explaining Black-Box Machine-Learning Models for High-Stakes Decisions and Use Interpretable Models Instead." *Nature Machine Intelligence*, vol. 1, 2019, pp. 206-215. https://doi.org/10.1038/s42256-019-0048-x.

[8] Shortliffe, E.H. "Biomedical Informatics Education: Balancing Technology and Patient Care." *Academic Medicine*, vol. 87, no. 1, 2012, pp. 21-24. https://doi.org/10.1097/ACM.0b013e31823f11ba.

[9] Topol, E.J. "High-Performance Medicine: The Convergence of Human and Artificial Intelligence." *Nature Medicine*, vol. 25, no. 1, 2019, pp. 44-56. https://doi.org/10.1038/s41591-018-0300-7.

[10] Topol, E.J. *Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again.* Basic Books, 2019.

[11] Alhur, A.A. *et al.* "Paradox of AI in Higher Education: Qualitative Inquiry into AI Dependency among Educators in Palestine." *JMIR Medical Education*, vol. 11, September 2025.

[12] Vayena, E. *et al.* "Machine Learning in Medicine: Addressing Ethical Challenges." *PLoS Medicine*, vol. 15, no. 11, 2018. https://doi.org/10.1371/journal.pmed.1002689.

[13] World Health Organization. *Ethics and Governance of Artificial Intelligence for Health: WHO Guidance.* WHO, 2021. https://www.who.int/publications/i/item/9789240029200.

[14] Yang, K. *et al.* "Digital Health Literacy: Bibliometric Analysis." *Journal of Medical Internet Research*, vol. 24, no. 7, 2022. https://doi.org/10.2196/35816.

[15] Jiang, F. *et al.* "Artificial Intelligence in Healthcare: Past, Present and Future." *Stroke and Vascular Neurology*, vol. 2, no. 4, 2017, pp. 230-243. https://doi.org/10.1136/svn-2017-000101.

[16] Rajkomar, A. *et al.* "Ensuring Fairness in Machine Learning to Advance Health Equity." *Annals of Internal Medicine*, vol. 169, no. 12, 2018, pp. 866-872. https://doi.org/10.7326/M18-1990.

[17] Vayena, E. *et al.* "Machine Learning in Medicine: Addressing Ethical Challenges." *PLoS Medicine*, vol. 15, no. 11, 2018. https://doi.org/10.1371/journal.pmed.1002689.

[18] Jin, L. *et al.* "Exploring the Determinants and Effects of Artificial Intelligence (AI) Hallucination Exposure on Generative AI Adoption in Healthcare." *Information Development*, June 2025.

[19] Kelly, C.J. *et al.* "Key Challenges for Delivering Clinical Impact with Artificial Intelligence." *BMC Medicine*, vol. 17, 2019. https://doi.org/10.1186/s12916-019-1426-2.

[20] Rudin, C. "Stop Explaining Black-Box Machine-Learning Models for High-Stakes Decisions and Use Interpretable Models Instead." *Nature Machine Intelligence*, vol. 1, 2019, pp. 206-215. https://doi.org/10.1038/s42256-019-0048-x.

[21] Assefa, Y. *et al.* "From Learning to Leading: Modelling the Predictive Impacts of Lifelong Learning on Adaptive Expertise and Sustainable Leadership Competencies Development." *Studies in the Education of Adults*, November 2025, pp. 1-20.

[22] Rajkomar, A. *et al.* "Machine Learning in Medicine." *New England Journal of Medicine*, vol. 380, no. 14, 2019, pp. 1347-1358. https://doi.org/10.1056/NEJMra1814259.

[23] Shortliffe, E.H. "Biomedical Informatics Education: Balancing Technology and Patient Care." *Academic Medicine*, vol. 87, no. 1, 2012, pp. 21-24. https://doi.org/10.1097/ACM.0b013e31823f11ba.

[24] Alhur, A.A. and N.K. Al-Kahtani. "Generative Artificial Intelligence in Health Informatics Education: A Comprehensive Bibliometric Assessment of Cognitive Outcome Research (2019-2025)." *International Journal of Advances in Signal and Image Sciences*, January 2026, pp. 895-915.

[25] Alhur, A.A. *et al.* "Attitudes Towards AI in Healthcare Among University of Hail Health Sciences Students: A Qualitative Exploration." *Journal of Pioneering Medical Sciences*, vol. 14, 2025, pp. 1-6.

[26] Jin, Y.S. *et al.* "Leveraging the Environmental Health Literacy Framework for Effective Assessment and Practice in the Era of Climate Change Crisis." *Health Information & Libraries Journal*, vol. 42, no. 1, March 2025, pp. 123-128.

[27] Sani, J. *et al.* "Machine Learning-Based Prediction of Institutional Delivery Dropout (IDD) Among Nigerian Women: An Exploratory Study Using SHAP Interpretability." *Journal of Epidemiology and Global Health*, February 2026.