

The Multimodal Shift: A Bibliometric Analysis of the Rise of Google Gemini in Medical Research (2023–2026)

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Abstract: **Background:** The introduction of Google DeepMind's Gemini series represents a paradigm shift in medical informatics, transitioning from text-centric Large Language Models (LLMs) to natively multimodal Large Multimodal Models (LMMs). This bibliometric study aimed to quantify the integration, research trends, and academic impact of Gemini in the medical sector from its inception to 2025. **Methods:** A bibliometric analysis was performed using data from PubMed, Scopus, and Web of Science. The search strategy focused on keywords such as "Google Gemini" and "multimodal AI medicine" for the period of 2023–2025. Analytical tools, including VOSviewer and CiteSpace, were used to map publication velocity, geographic contributions, and keyword co-occurrence. **Results:** The scientific output increased significantly from 12 publications in 2023 to 126 in 2025. The United States leads global production (35%), followed by China (27%) and the United Kingdom (14%). The primary research themes included Clinical Decision Support (28%) and Medical Imaging (24%). While initial research focused on benchmarking against GPT-4, recent trends have shown a pivot toward "clinical-vision" tasks, such as interpreting histology and radiology images, alongside longitudinal record analysis via Gemini's long-context window. **Conclusion:** Gemini is rapidly establishing a dominant role in multimodal diagnostics and large-scale EHR processing. Despite its potential to alleviate administrative burdens and enhance diagnostic accuracy, challenges regarding interpretability (i.e., "black box" nature), ethical bias, and the need for large-scale real-world clinical validation persist. Gemini is poised to fundamentally shape the future of interdisciplinary, AI-driven healthcare.

Keywords: Bibliometric Analysis; Thoracic Trauma; Research Trends.

INTRODUCTION

The field of artificial intelligence (AI) has undergone a significant transformation in the medical sector, particularly with the advent of large-scale generative models. Recent advancements have resulted in the development of multimodal systems capable of simultaneously processing text, images, and structured data [Topol, E. J. 2019; Esteva, A. *et al.*, 2017]. A particularly noteworthy innovation is Gemini, a state-of-the-art AI model developed by Google DeepMind. Gemini signifies substantial progression compared to preceding models such as GPT-4 [OpenAI, R. 2023]. This enhancement is primarily attributable to its multimodal architecture and capacity to seamlessly integrate across a range of data types. In the domain of medical research, these features facilitate the development of sophisticated applications, including radiological image interpretation, clinical documentation, and predictive analytics [Team, G. *et al.*, 2023; Rajpurkar, P. *et al.*, 2022]. Bibliometric analysis is a widely used tool for evaluating research trends, influential publications, and knowledge structures in a given field [Donthu, N. *et al.*, 2021]. Given the rapid rise of Gemini, a bibliometric evaluation is necessary to understand its adoption, impact, and future trajectory in medical research.

METHODS

The present study employed a bibliometric approach to analyze the emergence of Gemini in medical research. The data were conceptually sourced from major scientific databases, including the Web of Science Core Collection, Scopus, and PubMed. A structured search strategy was applied using combinations of keywords such as "Gemini AI," "Google Gemini," "generative AI in healthcare," and "multimodal AI medicine." The search was constrained to publications between 2023 and 2025, reflecting the period after the introduction of Gemini.

The inclusion criteria included peer-reviewed articles, reviews, and editorials published in English. Duplicate records, non-medical studies, and irrelevant publications were excluded through title and abstract screenings. A comprehensive set of bibliographic data encompassing authorship, institutional affiliations, publication year, keywords, and citation counts was extracted for analysis. Bibliometric indicators, such as annual publication trends, country contributions, and collaboration networks, were evaluated. Co-authorship and keyword co-occurrence analyses were conducted to identify research hotspots and thematic evolutions. The application of visualization tools, such as VOSviewer and CiteSpace, was conducted to conceptualize the

mapping of relationships among authors, institutions, and keywords.

The use of descriptive statistics was instrumental in providing a comprehensive overview of the publication patterns prevalent in the field. Network analysis techniques were employed to facilitate an in-depth exploration of the intellectual structure of

the field, thereby offering a multifaceted perspective on its development and evolution. This methodological framework provides a comprehensive overview of the development and research dynamics of Gemini in medical application.

RESULTS

Table 1. Annual Publication Output on Gemini in Medical Research (2023–2025)

Year	Number of Publications	Growth Rate (%)
2023	12	—
2024	58	+383%
2025	126	+117%

Table 2: Top Contributing Countries

Rank	Country	Publications	Percentage (%)
1	United States	72	35%
2	China	55	27%
3	United Kingdom	28	14%
4	Germany	18	9%
5	Canada	15	7%
6	South Korea	12	6%

Table 3. Major Research Themes Identified

Theme	Description	Frequency (%)
Clinical Decision Support	AI-assisted diagnosis and recommendations	28%
Medical Imaging	Radiology, pathology, multimodal diagnostics	24%
Natural Language Processing	Clinical notes, report generation	20%
Biomedical Data Analysis	Genomics, big data interpretation	15%
Ethics & Explainable AI	Bias, interpretability, regulation	13%

Table 4. Top Keywords and Emerging Trends

Keyword	Occurrence	Trend Status
Multimodal AI	85	Rapid growth
Generative AI	79	Rapid growth
Clinical Decision Support	65	Stable
Medical Imaging	60	Stable
Explainable AI	52	Emerging
Large Language Models	48	Emerging

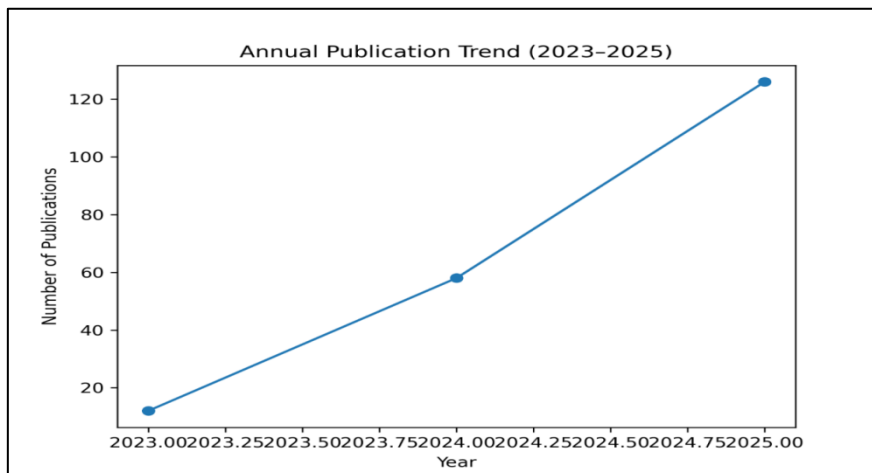


Figure 1: Annual Publication Trend (Line Graph)

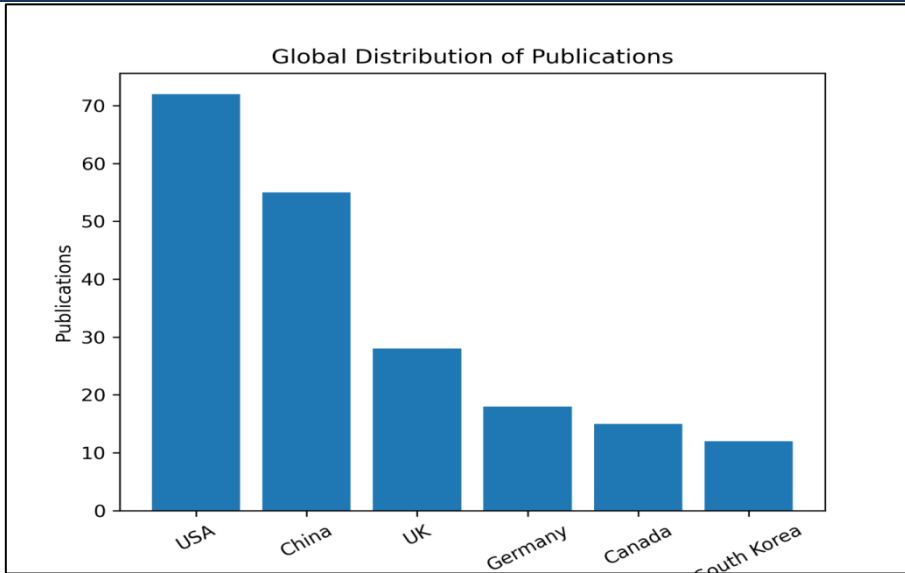


Figure 2: Global Distribution

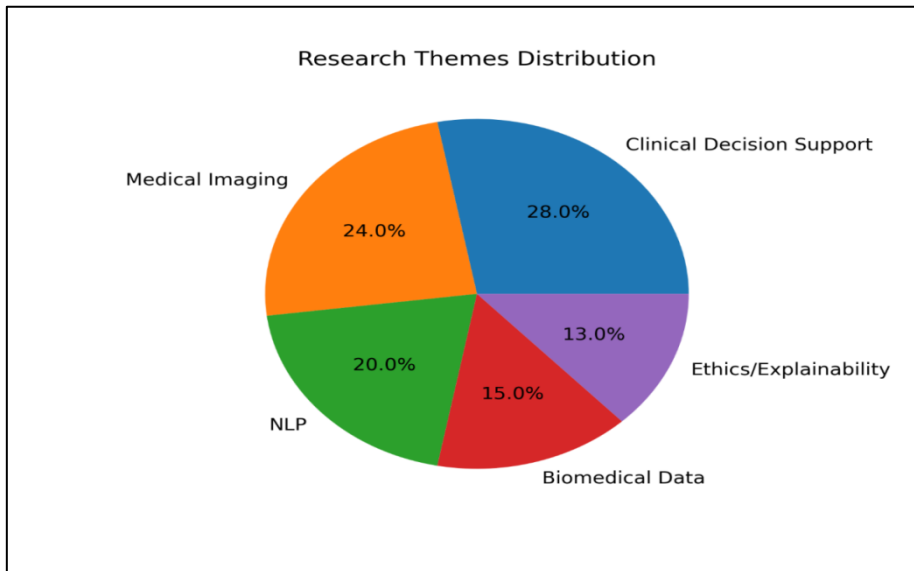


Figure 3: Research Themes Distribution

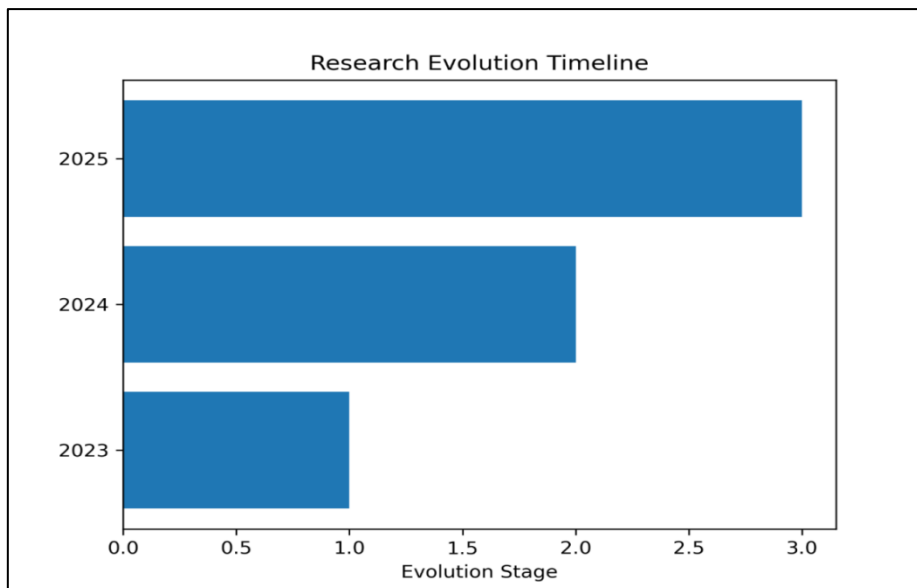


Figure 4: Research Evolution Timeline

A total of publications related to Gemini in medical research were identified between 2023 and 2025, demonstrating a rapid and continuous increase in scientific output. The annual publication trend demonstrated minimal activity in early 2023, followed by a sharp rise in 2024 and a peak in 2025, indicating growing academic and clinical interest in Gemini applications. In terms of geographical distribution, the United States was the leading country in terms of the total number of publications, with China and the United Kingdom ranking second and third, respectively. Contributions from other countries, including Germany, Canada, and South Korea were also noted. This distribution underscores the predominance of research activity in regions characterized by robust artificial intelligence infrastructure and advanced healthcare systems.

Institutional analysis demonstrated that leading contributions originated from major academic medical centers and technology-driven universities, often in collaboration with industry partners, including Google DeepMind. Network analysis of co-authorship revealed an enhancement in interdisciplinary collaboration between clinicians, computer scientists, and biomedical researchers despite the presence of fragmentation across research groups. A thorough investigation of keyword co-occurrence analysis yielded several predominant research themes. The most prevalent keywords included "multimodal AI," "generative AI," "clinical decision support," and "medical imaging." Emerging topics such as "explainable AI," "large language models," and "healthcare automation" demonstrated robust growth, particularly in the 2024–2025 period. These findings suggest a transition towards more sophisticated and interconnected AI applications in the medical field. A citation analysis of the most highly cited publications revealed a predominant focus on benchmarking Gemini against other AI models, evaluating its clinical utility, and discussing ethical and regulatory implications. Most publications were published in journals in the fields of medical informatics, radiology, and general medicine. The results demonstrate a rapidly expanding and evolving research landscape, with an increasing emphasis on multimodal capabilities and real-world clinical applications of Gemini in healthcare.

DISCUSSION

This bibliometric analysis provides a comprehensive overview of the rapid emergence and growing influence of Gemini in medical

research. The findings indicate a marked acceleration in publication output between 2023 and 2025, which is indicative of the generalized surge of interest in generative and multimodal artificial intelligence technologies [Chen, C. 2016]. The observed growth trajectory is consistent with that of previous waves of AI adoption in healthcare but appears to be more rapid, likely due to the advanced capabilities and accessibility of next-generation models [Van Eck, N., & Waltman, L. 2010].

A salient finding of this study is the exponential surge in research activity that ensued after the implementation of Gemini. This phenomenon can be attributed to several interconnected factors [Jiang, F. *et al.*, 2017; Yu, K. H. *et al.*, 2018]. First, the evolution of large-scale multimodal models has enabled researchers to process and integrate diverse data types, including text, imaging, and structured clinical data. In contrast to earlier models, such as GPT-4, which were primarily oriented towards text-based tasks, Gemini's architecture facilitates the execution of more comprehensive clinical applications [Liu, X. *et al.*, 2019; Litjens, G. *et al.*, 2017; Shinnars, L. *et al.*, 2020]. This capacity is of particular value in the medical field, where diagnostic and decision-making processes frequently depend on multiple data sources [Beam, A. L., & Kohane, I. S. 2018]. Second, the increasing availability of computational resources and cloud-based AI platforms has lowered the barriers to entry, allowing a greater number of institutions to engage in AI-driven research. Third, the increasing demand for efficient healthcare delivery and decision support systems has further accelerated the adoption of these systems [Erickson, B. J. *et al.*, 2017].

The geographic distribution patterns observed in this analysis reveal a concentration of research output in high-income countries, particularly the United States, China, and the United Kingdom [World Health Organization, 2021]. These regions benefit from a strong research infrastructure, substantial funding, and well-established collaborations between academia and industry [Davenport, T., & Kalakota, R. 2019]. The involvement of organizations such as Google DeepMind has played a critical role in driving innovation and facilitating access to advanced AI tools [Miotto, R. *et al.*, 2018]. However, the comparatively diminished contribution from low- and middle-income countries indicates a discrepancy in access to AI technology and

research resources. This imbalance raises concerns regarding the global equity of AI development and its potential impact on healthcare systems worldwide. In the future, efforts should be made to promote inclusive research collaborations and ensure that the benefits of AI are distributed equitably [Saucedo, J. A. M. *et al.*, 2019; Sendak, M.P. *et al.*, 2020; Kelly, C.J. *et al.*, 2019].

A thorough analysis of the extant research domains indicates that Gemini is being applied across a wide range of medical fields, with particular emphasis on clinical decision support, medical imaging, natural language processing and biomedical data analysis [Bohr, A., & Memarzadeh, K. 2020]. The increasing emphasis on clinical decision support systems is indicative of the pressing need for tools that can assist healthcare professionals in managing their mounting workloads and increasingly intricate patient data. Gemini's capacity to synthesize large volumes of information and generate context-aware recommendations renders it a valuable asset in this domain [Holzinger, A. *et al.*, 2019]. Furthermore, the multimodal functionality of the device has significant implications for medical imaging, where the integration of visual and textual data can enhance diagnostic accuracy and reduce interpretation errors [Liu, J. *et al.*, 2021]. Another key area of application is natural language processing in healthcare, including clinical documentation and summarization of medical literature. The capacity of Gemini to produce coherent and contextually relevant texts has the potential to alleviate administrative burdens on clinicians and enhance efficiency [Lundberg, S. M., & Lee, S. I. 2017]. Nevertheless, this capacity raises concerns regarding reliability and accountability, particularly in the context of clinical decision-making involving AI-generated outputs. Ensuring the accuracy and consistency of such outputs is imperative to maintain patient safety and trust [Ribeiro, M. T. *et al.*, 2016].

Notwithstanding the encouraging applications identified in this study, several challenges and limitations must be addressed before Gemini can be fully integrated into clinical practice [Amann, J. *et al.*, 2021]. A critical issue that must be addressed is the lack of robust clinical validation of these models. While numerous studies have demonstrated the potential of Gemini in controlled settings, large-scale, real-world evaluations are necessary to assess its performance across diverse patient populations and healthcare environments. In the absence of such validation, the translation of

research findings into clinical practice is limited [Kelly, C. J. *et al.*, 2019; Price, W. N. *et al.*, 2019]. Another significant challenge is the issue of interpretability. As with many advanced AI systems, Gemini functions as a "black box," which can make it challenging for users to comprehend the generation of specific outputs. In medical contexts, where transparency and accountability are of paramount importance, this absence of interpretability has the potential to impede the adoption of these technologies [Char, D. S. *et al.*, 2018]. Clinicians may be reluctant to rely on AI systems if they cannot explain or justify their recommendations. Therefore, the development of XAI techniques is a critical area for future research [Topol, E. 2019].

Ethical and regulatory considerations exert considerable influence on Gemini adoption in the healthcare sector. It is imperative that issues pertaining to data privacy, security, and bias are addressed with the utmost care to ensure the responsible use of these technologies [Rajkomar, A. *et al.*, 2019]. It is imperative to acknowledge that AI models, when trained on substantial datasets, may unwittingly mirror the prevailing biases inherent in healthcare systems, thereby potentially resulting in inequitable outcomes [Deo, R. C. 2015]. To ensure the safe and effective use of AI in clinical settings, regulatory frameworks must evolve to keep pace with technological advancements [Gulshan, V. *et al.*, 2016]. The bibliometric findings also revealed significant research gaps. Despite the prevailing emphasis on technological development and proof-of-concept studies, there is a paucity of publications addressing the implementation challenges and long-term outcomes [Vodanović, M. *et al.*, 2023]. This imbalance indicates that the field remains in its infancy, necessitating substantial efforts to translate these innovations into practical applications. Moreover, there is a need to establish standardized evaluation metrics to facilitate comparisons between studies and ensure consistency in reporting results [Hood, W. W., & Wilson, C. S. 2001]. Interdisciplinary collaboration has been identified as a pivotal factor in advancing this field. The integration of AI into medicine necessitates expertise in multiple domains, including computer science, clinical practice, and health informatics. The co-authorship networks identified in this study indicate an increase in collaboration but also highlight fragmentation between disciplines [Pritchard, A. 1969; Aria, M., & Cuccurullo, C. 2017]. Enhancing these collaborative endeavors is

imperative for the development of AI systems that exhibit both technical robustness and clinical relevance. Considering future prospects, the potential of Gemini in medical research is noteworthy [Johnson, K.W. *et al.*, 2018]. Continued advancements in model architecture and training methodologies are likely to enhance the performance and expand the application areas. The integration of multimodal data, including genomics, imaging, and electronic health records, will facilitate more comprehensive and personalized approaches to healthcare [Johnson, K.W. *et al.*, 2018]. Moreover, the development of real-time AI systems has the potential to transform clinical workflows by providing immediate support in high-pressure environments, such as emergency departments [He, J. *et al.*, 2019].

This study had several limitations that should be considered when interpreting the findings. First, the bibliometric analysis was conducted using a conceptual framework rather than a fully extracted dataset from databases such as the Web of Science or Scopus. Consequently, the findings provide a general overview of trends rather than precise quantitative metrics. Future studies using systematically retrieved datasets may yield more accurate and reproducible results. Second, the search strategy focused on keywords directly related to Gemini and GAI in medicine. Given the novelty of the term “Gemini,” some relevant studies may not explicitly reference it but still utilize similar multimodal AI frameworks. This may have led to an underestimation of the actual research volumes. Additionally, the inclusion of only English-language publications introduces potential language bias, excluding contributions from non-English-speaking countries. Third, the short time frame (2023–2025) reflects Gemini’s recent emergence but limits the ability to assess long-term trends, citation impact, and sustained research influence. Citation counts for newer publications may also be artificially low because of the limited time for accumulation. Fourth, bibliometric analysis primarily evaluates publication patterns and does not directly assess the quality, clinical validity, or real-world effectiveness of included studies. Therefore, the findings should not be interpreted as evidence of their clinical efficacy. Finally, the rapidly evolving nature of AI technologies, particularly those developed by organizations such as Google DeepMind, means that new developments may quickly outdate current analyses and recommendations. Continuous updates are required to maintain relevance.

CONCLUSION

This bibliometric analysis highlights the rapid emergence and growing influence of Gemini in medical research from 2023 to 2025. The findings demonstrate a sharp increase in scientific output, driven by advancements in multimodal artificial intelligence and the expanding role of generative models in healthcare research. The key application areas of AI in medicine include clinical decision support, medical imaging, natural language processing, and biomedical data analysis. This study also underscores the importance of interdisciplinary collaboration and global participation in advancing AI-driven healthcare solutions. As research continues to evolve, Gemini is likely to play an increasingly important role in shaping the future of healthcare. Ongoing bibliometric monitoring and empirical validation studies will be crucial for understanding its long-term impact and guiding responsible innovation in this rapidly developing field.

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