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Application of Artificial Intelligence in MRI Image Analysis for Radiological Diagnosis: A Systematic Review

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Abstract

This systematic review critically evaluates recent advances in AI applied to MRI image analysis for radiological diagnosis, emphasizing improvements in diagnostic accuracy and clinical utility. A systematic literature review (SLR) was conducted using PRISMA guidelines, employing a PICOC framework. A comprehensive search of the Scopus database was performed, and studies were selected based on strict inclusion/exclusion criteria through screening and synthesis. The review found that AI techniques significantly enhance MRI diagnostic performance (e.g., better tumor detection) and streamline workflows by automating routine tasks. It also notes growing publication trends from 2020–2024 in this field, reflecting increasing global research interest. The review is limited by its reliance on a single database (Scopus) and a narrow publication window (2020–2024). Many included studies exhibit data biases and lack comprehensive external validation, which may affect generalizability. These results suggest that AI integration can improve clinical workflows. The authors emphasize the need for standardized protocols and multidisciplinary collaboration to ensure safe and effective implementation of AI in radiological practice. This study provides an original contribution by systematically synthesizing the latest literature on AI applications in MRI diagnostics, offering a comprehensive overview of current methods and trends. It fills a gap by critically evaluating recent studies and outlining future research directions.

Keywords: Artificial Intelligence; MRI; Radiological Diagnosis; Systematic Review; Diagnostic Accuracy; Clinical Efficiency.

Introduction

The integration of Artificial Intelligence (AI) into Magnetic Resonance Imaging (MRI) analysis for radiological diagnosis represents a significant advancement in medical imaging. As AI technologies rapidly evolve, conducting a Systematic Literature Review (SLR) in this domain becomes indispensable for synthesizing the expanding body of knowledge.

An SLR offers a comprehensive and methodical overview of current methodologies, technological progress, and emerging trends, thereby enabling researchers and clinicians to grasp the full scope of AI applications in MRI diagnostics. This approach facilitates the critical evaluation of diverse AI techniques, including machine learning algorithms, neural networks, and radiomics, assessing their effectiveness in

enhancing diagnostic accuracy and operational efficiency.

Moreover, an SLR identifies prevailing challenges such as data privacy concerns, ethical considerations, and the imperative for rigorous external validation prior to clinical implementation. By systematically collating and analyzing existing studies, the review not only highlights the strengths and limitations of current AI models but also informs the development of more reliable and clinically applicable solutions [1], [2], [3], [4], [5], [6], [7].

The primary objective of this research is to evaluate advancements in AI technologies for MRI image analysis, focusing on accuracy, clinical utility, and methodological rigor. This study aims to identify effective AI techniques and performance metrics, including sensitivity, specificity, and diagnostic accuracy. Additionally, it seeks to reveal limitations in current research, such as data biases and insufficient external validation, impacting AI model generalizability. Through this evaluation, the research intends to provide recommendations for enhancing AI integration into clinical practice. These recommendations highlight the need for standardized protocols and promote interdisciplinary collaboration to develop robust, transparent, and ethically sound AI applications in radiology. [1], [2], [3], [4], [5], [6], [7], [8].

This research elucidates the capacity of AI to enhance MRI diagnostic precision, notably in distinguishing tumor types and identifying subtle abnormalities missed by human radiologists. Additionally, AI streamlines radiology processes by automating routine tasks and expediting image assessment, thereby alleviating radiologists' workloads and enhancing patient care. Moreover, AI aids in clinical decision-making through quantitative analyses that provide critical

insights for treatment and prognosis.

Significantly, this study establishes a foundational framework for future inquiries, highlighting the necessity for advanced AI models, promoting interdisciplinary collaboration, and advocating for standardized methods to facilitate the secure and effective integration of AI technologies in radiology. (Gravante et al., 2025; Jahn et al., 2024; Codari et al., 2019; Kelly et al., 2022; Tian et al., 2025; Xu et al., 2024; Olthof et al., 2020; Bhasker et al., 2023).

Method

The focus of this study is to examine the application of Artificial Intelligence (AI) in MRI image analysis for radiological diagnosis through a Systematic Literature Review (SLR) approach, utilizing the PRISMA methodology. A systematic literature review (SLR) is a rigorous and structured method used to map the current state of research, organize topics, and provide a foundation for future studies [9], [10]. This study aims to analyze the empirical evidence surrounding AI's role in MRI image analysis and its comparison to manual evaluations by radiologists. The objective is to enhance AI-based radiological methodologies through this comparative analysis.

The process begins with formulating a clear research question and developing a protocol to ensure transparency and validity [10], [11]. A comprehensive literature search and screening follow, applying strict inclusion and exclusion criteria to identify relevant studies, although this step can be time-consuming and prone to errors [12]. Subsequent stages include quality assessment, data extraction, and synthesis, often employing meta-evaluation techniques to provide a thorough understanding of key factors beyond mere frequency counts [13], [14].

Finally, findings are reported

systematically, guided by checklists to ensure clarity and accuracy [11]. The first stage utilizes the PICOC framework as shown in Table 1 to helps in defining clear

and focused research questions, ensuring that the systematic review is comprehensive and methodical [15].

Table 1. PICOC Framework

PICOC Component	Description
Population	Patients with MRI images
Intervention	Use of Artificial Intelligence for analysis and classification of MRI images
Comparison	Manual interpretation by radiologists
Outcome	Diagnostic accuracy, sensitivity, specificity, and time efficiency
Context	Clinical radiology settings (hospitals, diagnostic centers)

Source: Researcher, 2025

After identifying the appropriate PICOC, the next step is to formulate the research questions (RQ) based on the PICOC framework to guide the review

process [16]. In this study, the RQs are divided into four categories, as presented in Table 2.

Table 2. Request Question

ID	Research Question
RQ1	What are the main applications and effectiveness of Artificial Intelligence in radiology as reflected in current literature, particularly regarding diagnostic accuracy and clinical outcomes?
RQ2	How does the variation in research output on AI in radiology differ based on country, institution, and funding source, and what are the implications for global research priorities and collaboration patterns?
RQ3	Which sub-radiology fields and imaging modalities have received the most attention in AI research, and how do publication trends in major journals reflect the evolving focus in this field?
RQ4	How does the application of Artificial Intelligence in MRI image analysis influence the improvement of patient clinical outcomes?

Source: Researcher, 2025

The second stage involves conducting a comprehensive literature search and screening, which includes retrieving literature from databases using specific keywords combined with Boolean operators aligned with the PICOC Framework. The selected database is Scopus, chosen based on a comprehensive assessment to optimize the literature search process. The search string used for literature retrieval is: *(applicat OR implement*) AND (artificial) AND (intelligence) AND (radiolog*) AND (mri)**. Studies from the selected database are filtered based on titles, keywords, and abstracts.

Once the results are obtained, the next step is screening through a selection process using inclusion and exclusion criteria to identify literature relevant to the research objectives, such as country, source, language, and publication date [17], [18], [19]. The inclusion and exclusion criteria for this study are presented in Table 3. To ensure that the selected literature meets the criteria, several additional processes are conducted, including Title and Abstract Screening, where studies are filtered based on their titles and abstracts. This is followed by Full-Text Screening, in which qualifying studies undergo a thorough review through full-text reading, and

Quality Assessment. The extracted data are stored and managed using Zotero.

Table 3. Inclusion and Exclusion Criteria

Topic	Inclusion	Exclusion
Database	Scopus	All other databases
Time frame	2020 - 2024	Article published before 2020 and after 2024
Document type	Article	All other document article (e.g. Review, Conference paper, Book chapter and Book)
Language	English	Other languages
Subject area	Medicine	Other subject area (e.g. Computer Science, Nursing, Health Profession)
Publication stage	Final	Article in press
Keyword	Artificial Intelligence	Another keyword (e.g. Human, Nuclear Magnetic, and etc)
Source type	Journal	Book, Conference proceeding and Book series)
Open Access	All open access	Green, Gold, Hybrid gold and Bronze

Source: Researcher, 2025

The final step in the second stage is to comprehensively describe all processes in detail using the PRISMA methodology [20], [21], [22] as illustrated in Figure 1. This methodology consists of three key phases: identification, screening, and inclusion. information flow using PRISMA

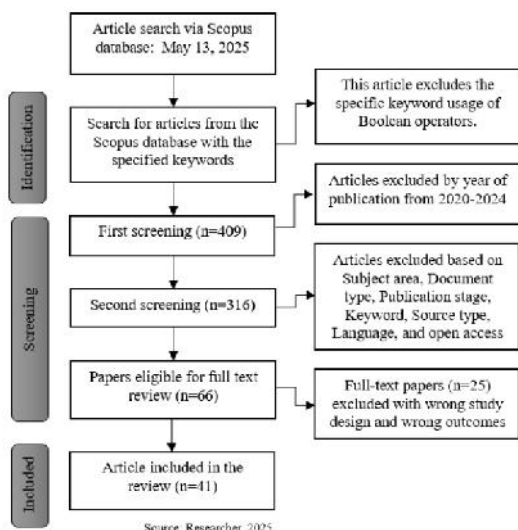
the publication year, reducing the dataset to 316 records. A second screening phase is then performed, further refining the selection to 66 records. Finally, a full-text review is conducted, yielding 41 articles, which are used to ensure the quality and credibility of the sources.

Results and Discussion

This study investigates four research questions based on 41 articles from the Scopus database regarding Artificial Intelligence's role in MRI image analysis for radiological diagnosis. The data is derived from the assessment of published articles, publication trends, and journal sources. Furthermore, the research will emphasize key factors in AI-assisted radiological diagnosis using MRI, such as authors, affiliations, countries involved, and AI's impact on MRI image analysis.

RQ1: What are the main applications and effectiveness of Artificial Intelligence in radiology as reflected in current literature, particularly regarding diagnostic accuracy and clinical outcomes?

According to the data retrieved from the Scopus database, it has been ascertained that over four years,

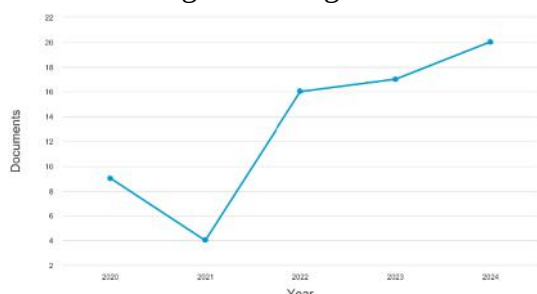


Source: Researcher, 2025

Figure 1. Systematic Literature Reviews

Based on Figure 1, the first stage involves identification using keywords, resulting in the retrieval of 409 records. Subsequently, an initial screening is conducted by excluding studies based on

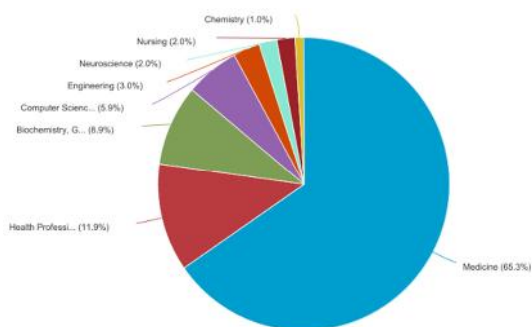
scholarly work about Application of Artificial Intelligence in MRI Image Analysis for Radiological Diagnosis comprises 41 articles; this suggests that investigations into Artificial Intelligence for Radiological Diagnosis remain



Source: Scopus database

Figure 2. Trend of Application Artificial Intelligence for Radiological Diagnosis Publication

Research on this topic experienced a decline in 2021, with only 4 documents, compared to 9 documents in 2020. However, the number of studies has consistently increased from 2022 to 2024, indicating growing research interest and the emergence of diverse subject areas, as illustrated in Figure 3.



Source: Scopus database

Figure 3. Subject Area of Application Artificial Intelligence for Radiological Diagnosis Publication

The most prominent subject area in this research is Medicine, accounting for 65.3% of the total retrieved database, while the least represented subject area is Chemistry, comprising only 1% with a single publication [23]. Several AI applications in this field, as identified in

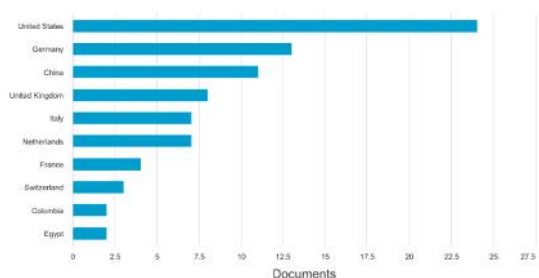
comparatively scarce, as illustrated in Figure 2. The exploration of Artificial Intelligence for Radiological Diagnosis commenced its progressive development during the last years, specifically from 2022.

the literature, include Medical Image Interpretation, Quality Evaluation and Reporting, and Prostate Cancer Diagnosis. Additionally, AI implementation has been shown to impact diagnostic accuracy and clinical outcomes [24], [25], [26].

RQ2: How does the variation in research output on AI in radiology differ based on country, institution, and funding source, and what are the implications for global research priorities and collaboration patterns?

The analysis of the distribution of variation Artificial Intelligence in radiology research in the 41 articles was executed by categorizing the articles according to classifications such as country, institution, and funding source with a constraint of solely the top 10 articles in each classification. Acumen regarding the allocation of scholarship pertinent to AI pada radiology will be advantageous for scholars and practitioners in elucidating the forthcoming research agenda, particularly in the sustainable advancement of the Artificial Intelligence in radiology.

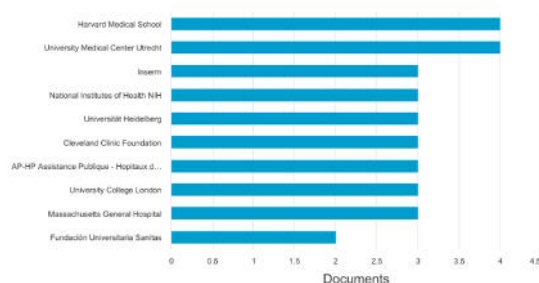
First, the allocation of scholarly inquiry pertinent to Artificial Intelligence in Radiology categorized by nation or geographical area is dominated by United States with 24 articles, Germany with 13 articles, China with 11 articles, United Kingdom with 8 articles, Italy and Netherlands with 7 articles, France with 4 articles, Switzerland with 3 articles, Colombia and Egypt with 2 articles (see Figure 4).



Source: Scopus database

Figure 4. Number of Articles by Top 10 Country

The data presented in Figure 4 indicates that the United States and other developed countries dominate publications on Artificial Intelligence in radiology, supported by renowned institutions that actively contribute to research in this field. Additionally, the top 10 institutions researching this topic, as shown in Figure 5, are predominantly affiliated with these countries. Harvard Medical School and University Medical Center Utrecht lead with four publications, while other universities have produced only two to three publications over the past four years.



Source: Scopus database

Figure 5. Number of Articles by Top 10 Affiliations

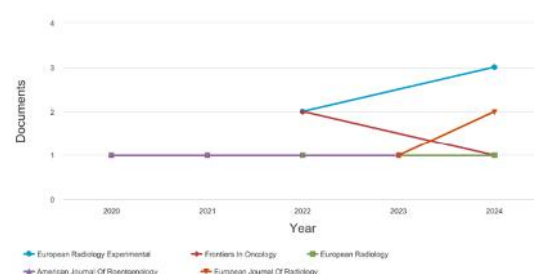
The implications of global research priorities and collaboration patterns are shaping the future of AI applications in medical imaging, particularly in key areas such as generalizability and data sharing, collaboration patterns, standardization and integration, and a focus on patient-centered care [27], [28].

RQ3: Which sub-radiology fields and imaging modalities have received the most

attention in AI research, and how do publication trends in major journals reflect the evolving focus in this field?

The analysis of sub-radiology fields and imaging modalities has received the most attention in AI research, and publication trends in major journals reflect the evolving focus in this field, as evidenced by 41 articles. The subsequent analysis of articles output from various sources between 2020 and 2024 reveals specific trends as illustrated in Figure 6. European Radiology Experimental demonstrates the most significant upward trend in the number of articles throughout the period of 2020 – 2024.

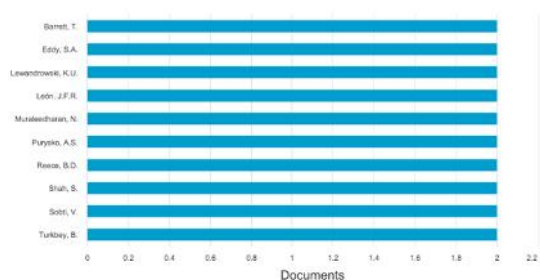
Frontiers In Oncology exhibits a fluctuating number of articles. European Radiology experienced a transient increase followed by a subsequent decline. The American Journal Of Roentgenology maintained a consistent number of articles until 2023, with no data recorded for 2024. The European Journal Of Radiology indicates an increase in the number of documents between 2023 and 2024.



Source: Scopus database

Figure 6. Number of Articles per Year by Sources

The distribution of research related to AI in Radiology based on authors reveals no clear dominance. Among top 10 authors have each written 2 articles (see figure 7).

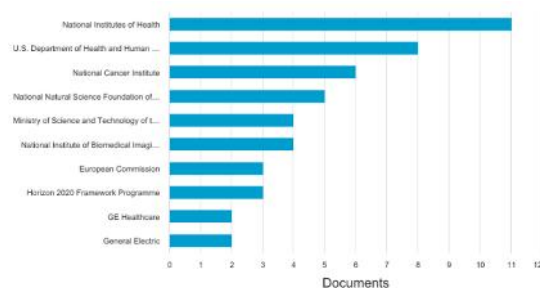


Source: Scopus database

Figure 7. Number of Articles by Top 10 Author

RQ4: How does the application of Artificial Intelligence in MRI image analysis influence the improvement of patient clinical outcomes?

The analysis of Artificial Intelligence in MRI affecting the improvement of patient clinical outcomes based on 41 articles shows that the sponsorship as a research funder is very influential for research on this topic (see figure 8). The largest funding sponsor is dominated by the National Institute of Health, then the U.S. Department of Health with 11 articles and the U.S. Department of Health and Human Services with 8 articles, the National Cancer Institute 7 articles. all three funding sponsors are from the United States, thus placing it in the first position of the most articles from the country review.



Source: Scopus database

Figure 8. Number of Articles by Top 10 Funding Sponsor

1. Interpretation of AI Performance in MRI Analysis

The AI-based automatic diagnosis system for preoperative MRI of uterine

sarcoma exhibited an accuracy of 89.32% to 92.44%. It utilizes deep neural networks to analyze various MRI sequences for tumor feature extraction. Nonetheless, issues like limited sample size and unbalanced MRI sequences may hinder the model's generalizability. Therefore, further validation and dataset augmentation are essential to improve clinical relevance [29].

The implementation of AI via CAD in prostate MRI enhanced lesion detection but did not markedly decrease radiologists' workflow time. Notably, radiologists allocated more time to high-suspicion scans with AI support, suggesting that AI may not necessarily streamline clinical processes. This underscores the necessity to balance clinical demands and examine the tangible effects of AI integration in radiological practice [24].

AI has significant potential to improve MRI diagnostic accuracy. However, its implementation requires ongoing assessment. Future studies must aim to broaden training datasets for better AI generalizability and investigate the impact of AI on radiologists' efficiency and patient outcomes.[29]

2. Challenges and Limitations of AI in MRI Applications

The limitation of extensive, varied datasets hinders AI model applicability, with many dependent on restricted samples susceptible to overfitting [30]. Furthermore, unequal representation of MRI sequences and tumor categories diminishes model efficacy [29].

Tumor appearance variability and scanner inconsistencies hinder AI training and detection precision. The substantial computational requirements of deep neural networks restrict feasible application.

Integration of AI in clinical settings encounters opposition owing to concerns

about heightened workload and disruption of existing protocols [31]. Moreover, imaging protocol standardization variability affects diagnostic consistency, emphasizing the necessity for uniform guidelines [32].

3. Potential Clinical Integration and Workflow Improvements

The incorporation of AI in radiology significantly improves efficiency and patient outcomes. Involving radiologists early in AI development is essential for aligning tools with clinical requirements [31]. While AI can simplify radiology reports for patients, improving comprehension and satisfaction [33], the implications of AI on radiologist workload require in-depth analysis. Preliminary research indicates that AI may not alleviate workload and could extend reading durations for intricate cases.

Future research must assess AI's actual effects on workflow and patient outcomes, emphasizing liability, transparency, and explainability. Synthetic data can improve AI models, mitigate data limitations, and aid decision support system development [33]. In conclusion, the integration of AI in radiology requires meticulous evaluation and sustained inquiry to actualize its advantages for radiologists and patients.

4. Future Research Directions

Research should investigate the moderation of work outcomes by EPM characteristics, including purpose, invasiveness, synchronicity, and transparency [34]. Further research is required on the psychological effects of monitoring. The effects of technology that tracks internal states are particularly understudied.

Future research should examine qualitative challenge demands as factors influencing the impact of time pressure on

engagement and self-esteem, distinguishing between challenge and hindrance perceptions [35]. Investigating longitudinal cross-lagged effects may elucidate the relationship between role strain and perceived demands.

Emerging technologies like augmented reality and artificial intelligence require in-depth study to assess their impact on improving tourism experiences during itinerary development and on-site engagement [36]. Research must emphasize sustainability and cultural awareness to promote inclusive tourism innovations.

Research into customer acceptance of circular business models is crucial, particularly how digital tools can enable behavioural shifts [37]. Examining interrelations among factors can inform effective circular economy strategies.

Conclusion

This study analyzes 41 academic publications from the Scopus repository between 2020 and 2024, leading to five key findings. Research on AI in radiology declined in 2021 but increased in 2022, demonstrating the expansion of research focus areas such as Medical Image Interpretation, Quality Evaluation and Reporting, and Prostate Cancer Diagnosis, which have positively influenced diagnostic accuracy and clinical outcomes. AI research in radiology is predominantly conducted in developed countries, including the United States, Germany, and China, supported by leading institutions such as Harvard Medical School and University Medical Center Utrecht. No single researcher has dominated this field, while the largest financial support for research on this topic originates from the United States. Lastly, a conceptual framework has been proposed linking AI capabilities to clinical outcomes, underscoring AI's role in enhancing

diagnostic precision and improving patient care.

The review identifies specific limitations, particularly the reliance on a single database, which may constrain the scope and generalizability of the findings. Additionally, numerous artificial intelligence models lack extensive external validation, raising concerns about their reliability across diverse clinical contexts. Future research should aim to integrate data from multiple databases to strengthen the evidentiary foundation and develop more robust, externally validated AI models. Emphasizing interdisciplinary collaboration, standardized methodologies, and regulatory frameworks will be crucial to ensuring the safe, effective, and ethical integration of AI technologies into clinical radiology.

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