Analysis of the scientific literature on the applications of Artificial Intelligence in medicine[1]

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Abstract— **The rapid expansion of Artificial Intelligence (AI) research has led to an overwhelming number of scientific publications, especially in the healthcare sector. This abundance poses a challenge for researchers seeking to identify critical trends, research gaps, and future opportunities. This study systematically evaluates the effectiveness of VOSviewer, a widely-used bibliometric tool, in analyzing AI research in medicine. By focusing on AI-related health articles from the PubMed repository over the past four years, we aim to address two key questions: (1) Which sub-areas of healthcare are most frequently addressed by AI applications? (2) What untapped niches exist where future research could be particularly valuable? Our findings reveal significant trends in AI applications across various medical subfields, highlighting underexplored areas that warrant further investigation. The application of VOSviewer enabled the identification of clusters of research topics, providing a comprehensive overview of the current landscape and potential directions for future studies. This research contributes to the optimization of bibliometric analysis methodologies and offers insights to guide the development of AI in healthcare.**

Keywords— Artificial Intelligence, Bibliometric Analysis, VOSviewer, Healthcare, PubMed, Research Trends

I. INTRODUCTION

The integration of Artificial Intelligence (AI) across multiple sectors has significantly transformed traditional practices, with the healthcare domain emerging as one of the most profoundly impacted fields. Advances in machine learning, deep learning, and data-driven decision-support systems have enabled new approaches to diagnostics, treatment planning, and patient management, accelerating the adoption of AI-based solutions in clinical environments [1], [2], [3]. As a result, AI has become a central driver of innovation in modern medicine.

This rapid technological progress has been accompanied by an exponential growth in scientific publications addressing AI applications in healthcare. While this expanding body of literature reflects the maturity and relevance of the field, it also poses substantial challenges for researchers, funding bodies, and policymakers. Navigating an increasingly fragmented and heterogeneous research landscape makes it difficult to identify dominant research trends, assess the maturity of specific medical sub-domains, and detect underexplored areas with high potential impact [4], [5], [6].

Bibliometric analysis has emerged as a powerful and systematic approach for addressing these challenges. By quantitatively analysing large volumes of scientific publications, bibliometric methods enable the identification of research patterns, thematic structures, and knowledge gaps within a given domain [7], [6]. Tools such as VOSviewer have been widely adopted for constructing and visualising bibliometric networks, including co-occurrence, citation, and co-authorship maps, allowing researchers to explore the intellectual structure and evolution of scientific fields [8], [4], [9]. Despite their growing use, several studies have highlighted limitations in existing bibliometric analyses, particularly the prevalence of generic or technology-centred terminology that can obscure meaningful domain-specific insights [10], [3].

In the context of AI in medicine, prior bibliometric studies have primarily focused on citation metrics, geographic distribution of research output, or high-frequency keywords, often providing a broad but superficial overview of the field [1], [3], [11]. Although these studies consistently report strong research activity in areas such as oncology, cardiology, and medical imaging, they offer limited insight into how research attention is distributed across medical sub-areas over time or where significant gaps persist relative to global health priorities. Moreover, underexplored domains such as diabetes management, neurology, public health, and environmental health remain insufficiently discussed, despite their high disease burden and societal relevance [12], [13].

In response to these limitations, this study leverages bibliometric analysis to provide a refined and longitudinal examination of AI research in the healthcare sector. By analysing AI-related publications indexed in the PubMed repository over the past four years, this work aims to move beyond surface-level metrics and offer a clearer understanding of thematic concentration and research dispersion within the field. The use of VOSviewer, combined with an enhanced co-occurrence analysis and cluster elimination strategy, seeks to improve the interpretability of bibliometric maps and mitigate the noise introduced by generic technological terms [8], [10].

Accordingly, the objectives of this study are twofold: (i) to identify the healthcare sub-areas most frequently addressed by

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AI applications in recent scientific literature, and (ii) to uncover underexplored niches that represent opportunities for future research and innovation. By addressing these objectives, this work contributes both empirical insights into the current state of AI in medicine and a methodological framework that can support more informed and targeted research efforts in this rapidly evolving field.

II. Methodology

A. Data Extraction

To systematically analyze the landscape of AI research in medicine, we utilized the PubMed repository, a comprehensive database for biomedical literature. The data extraction process was facilitated by the OpenAlex API, which allows for efficient retrieval of large datasets. Our search criteria focused on AI-related articles published between 2020 and 2024. The following query was employed to extract relevant articles:

Fulltext: ("AI" OR "Artificial Intelligence") AND Language: "English" AND Year: [2020 TO 2024] AND Repository: "PubMed"

This query was designed to capture a broad range of AI applications within the medical field, ensuring a comprehensive dataset for analysis.

B. Data Processing and Analysis

- VOSviewer Tool: VOSviewer, a software tool for constructing and visualizing bibliometric networks, was employed to analyze the extracted data. VOSviewer is particularly suited for handling large datasets and provides multiple visualization options, including network, overlay, and density visualizations. The tool's capabilities in text mining and term co-occurrence mapping make it ideal for identifying trends and research gaps in scientific literature.
- Concept Co-occurrence: The initial step involved creating a map based on text data from article titles and abstracts. We utilized VOSviewer's binary counting method, where each term's occurrence was counted once per document. The parameters were set to a minimum of 10 occurrences for inclusion and 60% of the most relevant terms. However, due to the high volume of terms and the presence of non-relevant terms, further refinement was necessary.
- Cluster Elimination Technique: To enhance the relevance of our findings, we applied a cluster elimination technique. This involved identifying and removing clusters of terms that were either too generic or irrelevant to the specific focus of AI in medicine. For example, clusters dominated by terms like "AI" and "technology" were excluded. The methodological process began with an initial visualisation, in which a co-occurrence map was created to identify the dominant clusters within the analysed literature. This was followed by cluster identification, using VOSviewer's item functionality to detect clusters containing generic or non-relevant terms. Based on this identification, a cluster removal algorithm was developed to exclude the identified clusters and terms from the dataset. Finally, a re-visualisation step was carried out, generating a refined co-occurrence map composed only of the remaining terms, thereby allowing relevant trends and key research areas to be highlighted more clearly (Figure 1).
- Optimizing Parameters: Through iterative testing, we determined optimal parameters for term inclusion and relevance. For the final analysis, a minimum occurrence threshold (MOT) of 10 and a percentage of terms most relevant (PTMR) set at 10% were used. This ensured a balanced representation of significant terms without overwhelming the visualization with irrelevant data.
- Result Visualization: The final maps generated by VOSviewer provided clear visualizations of key research areas and trends in AI applications within the medical field. These visualizations facilitated the identification of underexplored niches and emerging trends, guiding future research directions.

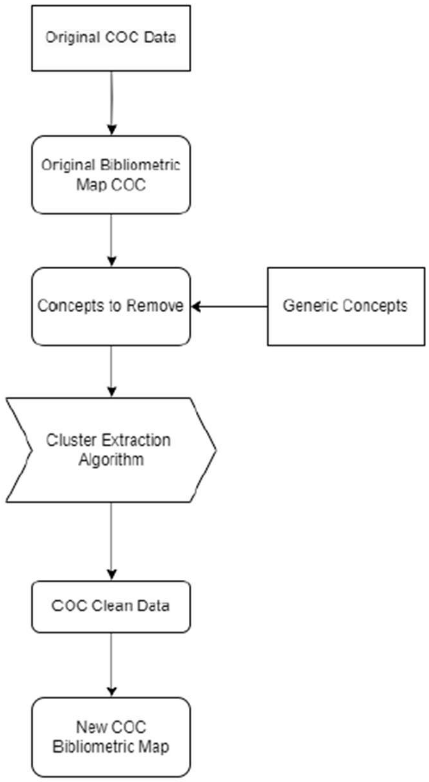

Figure 1. Diagram of the Clustering Technique

III. Results

A. Overview of Data

The bibliometric analysis comprised AI-related scientific articles retrieved from the PubMed repository, covering the period from 2020 to 2024. In total, approximately 131,000 articles were analysed, reflecting the rapid expansion of research on AI applications in the medical domain. The year-by-year extraction strategy enabled the identification of thematic trends and variations over time, while ensuring compliance with data retrieval constraints imposed by the API. The resulting dataset provides a robust basis for assessing both dominant research areas and underexplored topics within AI-driven medical research.

B. *Key Research Areas*

The analysis revealed a strong concentration of AI research across a limited number of medical sub-areas. Internal medicine emerged as the most prominent domain, encompassing a wide range of applications related to diagnostics, treatment optimisation, and patient management. The frequent co-occurrence of terms associated with disease diagnosis and clinical decision support highlights AI's transversal role in supporting general medical practice, a trend also noted in prior bibliometric studies [1], [3].

Cardiology constituted another major research focus, with strong associations between AI and concepts such as cardiovascular disease, cardiac imaging, and predictive modelling. These results indicate sustained interest in applying AI techniques to early detection, risk assessment, and long-term management of heart-related conditions, consistent with the literature on AI-driven cardiovascular analytics [14].

Oncology represented a further highly investigated area, with recurrent terms related to cancer detection, tumour classification, and treatment planning. The prominence of these concepts reflects the growing reliance on AI-based methods to support personalised oncology and improve diagnostic accuracy, reinforcing observations reported in previous reviews and bibliometric analyses [15].

The impact of AI on radiology and medical imaging was particularly evident. Frequent references to image analysis, magnetic resonance imaging (MRI), and computed tomography (CT) scans confirm the central role of AI in automating image interpretation and enhancing diagnostic workflows. This finding aligns with existing systematic reviews highlighting medical imaging as one of the most mature application domains for AI in healthcare [16], [17].

Finally, virology and infectious diseases constituted a significant research cluster, especially during the early years of the analysed period. The prevalence of terms related to COVID-19, pandemics, and viral detection underscores the rapid adoption of AI-based solutions in response to global health emergencies, a trend widely reported in recent literature [18], [19].

These thematic concentrations and their interrelationships are visually synthesised in Figure 2, which presents the refined co-occurrence map after the application of the cluster elimination technique.

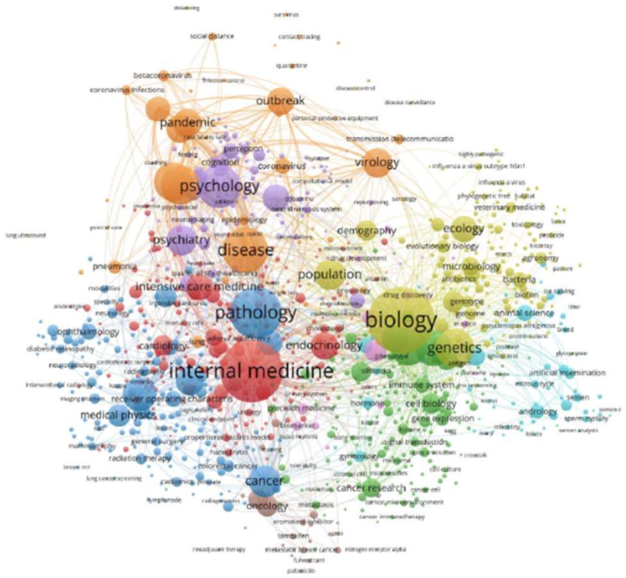

Figure 2. Data PubMed 2020 COC CE

C. *Trends Over Time*

A temporal analysis of the bibliometric maps revealed notable shifts in research focus over the analysed period. Between 2020 and 2021, AI research in medicine was strongly influenced by the COVID-19 pandemic, with a surge in studies addressing viral detection, epidemiological modelling, and public health response mechanisms.

In 2022 and 2023, the relative prominence of pandemic-related research declined, while traditional medical domains such as cardiology and oncology regained centrality. This shift reflects a gradual reorientation of AI research towards chronic disease management and long-term clinical applications, following the stabilisation of the global health crisis.

By 2024, emerging trends pointed towards increased interest in precision medicine and genomics, with growing attention to AI-supported genetic analysis and personalised treatment strategies. These developments indicate a gradual transition towards more individualised and data-intensive healthcare paradigms, consistent with broader trends in AI-enabled precision medicine [15].

D. *Identified Research Gaps*

Despite the breadth of AI applications identified, the analysis revealed several notable research gaps. Neurology appeared comparatively underrepresented, with fewer occurrences of terms related to neurological disorders and brain imaging. This finding suggests unrealised potential for AI applications in neurodegenerative disease diagnosis and clinical decision support.

Similarly, diabetes management emerged as a significantly underexplored area. Given the global prevalence and long-term societal impact of diabetes, the limited visibility of AI-related research in blood glucose monitoring, insulin regulation, and personalised diabetes care highlights a critical gap in the literature [12], [13].

The analysis also identified limited research activity in public health and preventive medicine, with low representation of concepts related to population health, prevention strategies, and health promotion. This underrepresentation suggests that AI research remains predominantly focused on individual-level clinical care, rather than broader public health applications.

Finally, environmental health was among the least explored domains. Terms associated with environmental monitoring, pollution, and climate-related health impacts were scarce, indicating that the intersection between AI, environmental factors, and health outcomes remains largely neglected in current medical AI research.

E. Cluster Analysis

The cluster analysis further highlighted specific themes within the broader research areas:

Cluster 1: Focused on AI in diagnostic imaging, including advancements in MRI and CT scan technologies.

Cluster 2: Centered around AI in oncology, particularly in cancer detection and treatment planning.

Cluster 3: Related to AI applications in cardiology, emphasizing predictive modeling and patient management.

Cluster 4: Addressed the use of AI in managing infectious diseases, with a significant focus on COVID-19.

F. Visualizations

The visualizations generated by VOSviewer provided a comprehensive overview of the relationships and trends within the AI in medicine literature. The co-occurrence maps illustrated the interconnectedness of various research themes and helped identify central and peripheral topics within the field.

IV. DISCUSSION

A. Interpretation of Findings

The bibliometric analysis presented in this study offers a comprehensive and longitudinal overview of the scientific landscape concerning AI applications in medicine. The results reveal a clear concentration of research efforts in areas such as internal medicine, cardiology, oncology, radiology, and virology, reflecting the domains where AI technologies have demonstrated immediate clinical applicability and measurable impact. This distribution is consistent with the growing global emphasis on data-driven diagnostics, personalised medicine, and clinical decision-support systems in healthcare [1], [2], [20].

The prominence of internal medicine highlights the transversal role of AI across multiple clinical workflows, supporting activities ranging from diagnostic assistance to patient monitoring. The strong presence of cardiology and oncology aligns with the global burden of chronic and life-threatening diseases, where AI-driven models have been widely applied for early detection, prognostic assessment, and treatment personalisation [15], [14]. Similarly, the dominance of radiology and medical imaging confirms AI's central role in automating image interpretation and improving diagnostic accuracy, a trend consistently reported in systematic reviews and bibliometric studies on AI in medical imaging [16], [17].

B. Comparison with Existing Literature

The findings of this study are largely aligned with existing bibliometric and review-based literature, which consistently identifies oncology, cardiology, and radiology as the most mature and research-intensive domains for AI adoption in medicine [1], [2], [3]. Prior studies have documented the transformative impact of AI in cancer diagnosis and cardiovascular disease management, reinforcing the robustness of the thematic patterns identified in this analysis [15], [14].

The surge in publications related to COVID-19 and virology between 2020 and 2022 is also well documented in the literature, reflecting the rapid mobilisation of AI-based solutions to support pandemic response, diagnostic processes, and epidemiological modelling [18], [19]. Unlike several previous bibliometric studies that focus primarily on citation counts, country productivity, or keyword frequency [3], this work advances the state of the art by combining co-occurrence analysis with a cluster elimination technique. This approach enables clearer identification of meaningful research themes, reducing noise caused by generic technological terminology, as previously highlighted as a limitation in bibliometric mapping studies [4], [10].

Despite these convergences, the analysis reveals notable discrepancies between disease burden and research intensity. Areas such as neurology, diabetes management, public health, and environmental health remain comparatively underrepresented in the AI literature. This imbalance is particularly evident in diabetes research, despite its high global prevalence and societal impact, suggesting missed opportunities for AI-driven innovation in chronic disease management [12], [13].

C. Implications for Future Research

The research gaps identified in this study highlight several promising directions for future investigation. Neurology represents a critical area where AI could significantly contribute to early diagnosis, disease progression modelling, and clinical decision support for neurodegenerative disorders such as Alzheimer's and Parkinson's diseases, as suggested by emerging AI-healthcare research trends [1], [3].

Similarly, the limited presence of AI applications in diabetes management points to opportunities for developing predictive models, continuous monitoring systems, and personalised treatment strategies, building on early conceptual solutions already proposed in the literature [12]. Beyond individual clinical domains, the relatively low visibility of AI research in public health and preventive medicine indicates a need to extend AI applications from patient-centred care to population-level health management, including surveillance, prevention, and emergency preparedness [19].

Moreover, the weak representation of environmental health-related research highlights an emerging but underexplored field. As environmental factors increasingly influence health outcomes, AI could play a strategic role in monitoring environmental risks and supporting evidence-based public health policies, an aspect that has received limited attention in current bibliometric studies [1], [11].

D. Strengths and Limitations

One of the main strengths of this study lies in its systematic and scalable methodological approach, combining a large dataset from PubMed with advanced bibliometric techniques supported by VOSviewer [8], [9]. In addition to empirical findings, this work provides a methodological contribution by demonstrating how cluster elimination can enhance the interpretability of bibliometric maps, addressing limitations previously reported in studies dominated by generic or technology-focused terminology [4], [10].

Nevertheless, some limitations must be acknowledged. The analysis was restricted to English-language publications indexed in PubMed, which may exclude relevant studies published in other languages or indexed in alternative databases [20]. Furthermore, the rapid evolution of AI technologies means that very recent advances may not yet be fully reflected in the analysed literature. Future studies could mitigate these limitations by incorporating multiple databases, multilingual datasets, and complementary bibliometric techniques [5].

V. CONCLUSIONS

This study provides a systematic and methodologically robust overview of the current state of AI applications in medicine. The results indicate that, despite a substantial increase in publication volume, research efforts remain concentrated in a limited number of medical domains, particularly internal medicine, oncology, cardiology, radiology, and virology, a pattern consistent with previous bibliometric analyses [1], [2], [3].

At the same time, significant research gaps persist in areas such as neurology, diabetes management, public health, and environmental health, despite their high relevance to global health challenges. By applying an enhanced bibliometric methodology based on co-occurrence analysis and cluster elimination, this work contributes not only empirical insights but also a reusable analytical framework for future bibliometric studies [4], [10].

Addressing the identified gaps may enable a more balanced and impactful integration of AI across medical disciplines, supporting improved healthcare delivery, chronic disease management, and population health outcomes. As AI technologies continue to evolve, expanding their application to underexplored domains represents a critical opportunity for both scientific advancement and societal benefit.

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