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Original Article

Artificial Intelligence and Atrial Fibrillation: A Bibliometric Analysis

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Abstract

Background: Artificial Intelligence (AI) has emerged as a transformative tool in managing atrial fibrillation (AF); however, limited bibliometric studies have systematically analyzed its research trends and thematic evolution. This study addressed these gaps by examining the top 100 most-cited papers on AI and AF using comprehensive bibliometric indicators, including the h-index, g-index, and m-index, to evaluate author impact, citation trends, and productivity.

Methods: Bibliometric data were extracted from the Scopus database, given its extensive coverage of high-quality literature.

Results: A total of 258 papers were identified, with a notable increase in publications after 2020, reflecting heightened research interest. Among these, the United States led contributions with 89 publications, followed by significant input from institutions such as the Mayo Clinic (33 publications). The most prolific author was P.A. Noteworthy, with 24 publications. Journals like the *Journal of Cardiovascular Electrophysiology* prominently featured AI and AF research, publishing eight of the top 100 most cited articles. The top 100 most cited papers revealed critical themes, including predictive modeling, automated detection of AF episodes, and risk stratification using AI tools.

Conclusion: This bibliometric analysis provides valuable insights into the current state and global disparities of AI applications in AF research.

Keywords: Artificial intelligence, Atrial fibrillation, Bibliometric analysis, Regional disparities, Thematic clusters

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Introduction

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia and a major global health concern due to its association with stroke, heart failure, and increased mortality.[1] Numerous factors, including structural and electrical atrial remodeling, inflammation, autonomic imbalance, and genetic susceptibility, contribute to AF initiation and progression, but detailed pathophysiological mechanisms are beyond the scope of this bibliometric study.[2,3] Instead, this background is included only to contextualize the growing research interest surrounding AF.

In recent years, artificial intelligence (AI) has emerged as an important tool in cardiology, particularly in the detection, prediction, and management of AF through analysis of ECGs, imaging, and clinical data.[4] As AI-related AF research expands rapidly, bibliometric analysis provides a systematic way to evaluate publication trends, influential authors and institutions, and emerging thematic areas.[5]

Previous work, such as the study "Artificial Intelligence and Atrial Fibrillation: A Bibliometric Analysis from 2013 to 2023",[6] offered an initial overview of the field but relied primarily on publication and citation counts, limiting its ability to fully assess scientific influence. It also summarized only a small number of highly cited documents, providing limited insight into major research contributions. The present study aims to address these gaps by incorporating a broader set of performance indicators (e.g., h-index, g-index) and analyzing the top

100 most-cited papers in the field. This approach offers a more comprehensive evaluation of leading research, key contributors, and evolving trends in AI applications for atrial fibrillation

Methods

The Scopus database was used to collect bibliometric data for this analysis due to its extensive coverage of high-quality, peer-reviewed scientific literature. Data extraction was performed in December 2024. Scopus was selected because it provides comprehensive metadata and robust citation information, enabling accurate retrieval and analysis of publication records.

To ensure reproducibility, a clearly defined search strategy was applied. The search was performed using the Boolean string "artificial intelligence" AND ("Atrial Fibrillation*" OR "Auricular Fibrillation*") applied specifically to article abstracts. Only publications containing these terms in their abstracts were included, ensuring direct relevance to AI applications in atrial fibrillation. This approach enhanced precision, reduced irrelevant retrievals, and ensured that all included studies had a clear and explicit focus on the targeted research intersection.

This combination was designed to capture publications involving AI applications in atrial fibrillation while accounting for alternative terminology (e.g., "Auricular Fibrillation*"). No language or publication year restrictions were applied in order to capture the full historical trajectory of AI-related AF research. Only articles and review papers were included; editorials, conference papers, notes, and other non-primary document types were excluded. Self-citations were not removed, as the aim was to capture the complete citation landscape associated with the retrieved publications.

The extracted data included authors, affiliations, titles, abstracts, keywords, publication years, and citation counts. These metadata elements formed the basis for subsequent bibliometric and co-word analyses.

Bibliometric analyses were conducted using VOSviewer and R Studio (Bibliometrix package), both established tools for processing and visualizing bibliometric data. VOSviewer was used to generate co-authorship, co-citation, and co-word network visualizations, enabling the identification of collaborations, influential publications, and thematic clusters. The Bibliometrix package in R Studio was used to compute detailed performance indicators, including total citations, average citations per document, citation trends over time, and author-level metrics.[7,8]

In addition to traditional indicators, the study incorporated h-index, g-index, and m-index to provide a more comprehensive assessment of author impact and productivity, moving beyond simple publication or citation counts. To maintain analytical depth and focus, the study concentrated on the top 100 most cited articles. This approach allowed for the identification of major contributors, emerging themes, and structural patterns shaping the field of AI in atrial fibrillation research.

Results and Discussion

General Research Productivity

Research on AI and atrial fibrillation (AF) has expanded substantially in recent years (Figure 1), with a pronounced surge beginning in 2020. From 1994 to 2019, only 12 papers were published, but scholarly output increased sharply thereafter, reaching a peak of 73 publications by October 2024, followed by 48 in 2023 and 59 in 2022. This rapid rise reflects increasing interest and progress in applying AI to AF.

Most publications were original research articles (188), supplemented by 70 review articles. Key contributors included leading author Noseworthy, P.A., with 24 publications, and Attia, Z.I., and Friedman, P.A., each with 19 publications. Institutions with the highest contributions were the Mayo Clinic (33 publications), Harvard Medical School (10), and Massachusetts General Hospital (9), indicating their central roles in AI-driven cardiovascular research. Nationally, the United States led with 89 publications, followed by China with 42 and the United Kingdom with 33.

Funding support was dominated by major governmental agencies. The National Institutes of Health sponsored 22 studies, while the National Heart, Lung, and Blood Institute and the National Natural Science Foundation of China each funded 16. These funding patterns highlight the essential role of sustained governmental investment in advancing AI applications in cardiovascular health. The top contributors are presented in Table 1.

Regional Disparity in Research Output

The bibliometric analysis of AI and AF research shows clear global imbalances. The United States dominates with 89 publications, supported by strong funding, leading institutions, and early adoption of AI in healthcare. Asia also contributes substantially, driven mainly by China's 42 publications, though output drops sharply outside China, reflecting uneven regional support. Europe shows broader participation, led by the UK (33), France (18), Germany (16), and Spain (16), but Western Europe far outpaces Eastern Europe, where limited funding constrains research.

Research activity in the Middle East, Africa, and Latin America remains sparse. Countries like Israel, Turkey, South Africa, Nigeria, Uganda, and several

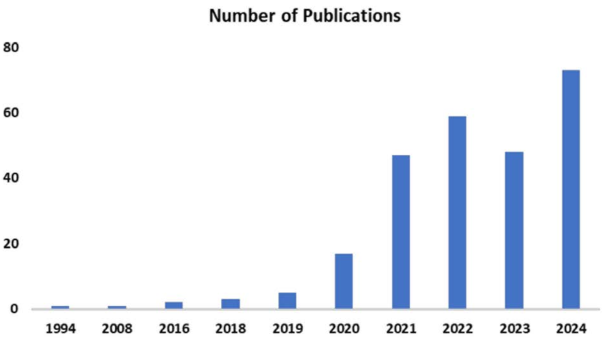

Figure 1. The per-year number of publications in the field of AI and AF

Table 1. Top contributors (authors, universities, countries, sponsors, and sources). The authors listed represent individual top contributors and are not directly affiliated with or linked to the universities or countries presented in the adjacent columns. Each column reflects its own independent ranking within the bibliometric analysis.

S#	Author Name	At least 5 Publications	Affiliation	With more than 5 Publications	Country	With or more than 10 Publications	Funding Sponsor	More than 5 Publications	Source Title	With or more than 5 Publications
1	Noseworthy, P.A.	24	Mayo Clinic	33	United States	89	National Institutes of Health	22	Journal Of Cardiovascular Electrophysiology	8
2	Attia, Z.I.	19	Harvard Medical School	10	China	42	National Heart, Lung, and Blood Institute	16	European Heart Journal Digital Health	7
3	Friedman, P.A.	19	Massachusetts General Hospital	9	United Kingdom	33	National Natural Science Foundation of China	16	Europace	6
4	Kapa, S.	8	Mayo Clinic in Jacksonville, Florida	6	France	18	U.S. Department of Health and Human Services	10	Frontiers In Cardiovascular Medicine	6
5	Yao, X.	8	Brigham and Women's Hospital	6	Canada	16	American Heart Association	9	Frontiers In Physiology	6
6	Lopez-Jimenez, F.	7	University of Oxford	6	Germany	16	Horizon 2020 Framework Programme	9	Journal Of Clinical Medicine	6
7	Gersh, B.J.	6	Beth Israel Deaconess Medical Center	6	Spain	16	Mayo Clinic	9	Herzschrittmachertherapie Und Elektrophysiologie	5
8	Druzhilov, M.A.	5	Centro de Investigación en Red en Enfermedades Cardiovasculares	6	Australia	15	British Heart Foundation	7	Sensors	5
9	Rabinstein, A.A.	5			Italy	15	European Commission	7		
10	Siontis, K.C.	5			South Korea	15	Ministry of Health and Welfare	7		
					Taiwan	13	Ministry of Science and Technology of the People's Republic of China	7		
					Belgium	11	National Research Foundation of Korea	6		
					Japan	10				
					Russian Federation	10				

Latin American nations contribute only a handful of publications; Brazil leads regionally but without widespread regional engagement. Overall, the data reveal significant disparities, with the U.S. and select Asian and European countries driving progress, underscoring the need for global collaboration and more equitable research resources.

The Top 100 Most Cited Documents

Main Information

The bibliometric analysis of AI and AF research (1994–2024) highlights a rapidly growing and highly influential field. The top 100 most cited papers, drawn from 77 journals, consisted mainly of original articles (71) and reviews (29), with an average age of just 3.16 years—reflecting the field's recency and fast-paced evolution. Each paper received an average of about 51 citations, underscoring strong scholarly interest.

Early influential studies from 2019 had exceptionally high citation averages (225 per article), likely providing foundational insights. As publication volume increased in subsequent years—12 articles in 2020, 36 in 2021, 30 in 2022, and 12 in 2023—average citations per article declined. This trend reflects both the recency of newer papers, which have had less time to accumulate citations, and the diversification of research topics as the field has expanded. By 2024, one highly cited publication (40 citations) demonstrated immediate relevance.

Overall, despite decreasing mean citations per article over time, the growing number of publications indicates a broadening research landscape and sustained momentum in advancing AI applications in atrial fibrillation.

The Top Authors, Universities, and Countries

A total of 776 authors contributed, demonstrating strong collaboration in this multidisciplinary field. With only two single-authored papers and an average of 9.19 co-authors per study, teamwork and shared expertise were essential. International collaboration was also high at 37%. Author impact varied across metrics: while Noseworthy, PA ranked highest by h-index and Hg score, Attia, ZI and Friedman, PA led in total citations, and Gersh, BJ showed notable impact despite fewer publications. These differences highlight that no single metric fully captures author influence.[9, 10]. The shuffled author rankings show that evaluating research impact requires multiple metrics to capture diverse contributions. Institutionally, output was highly concentrated: Mayo Clinic led with 83 publications, followed by the Guangdong Cardiovascular Institute (17) and the Medical University of South Carolina (15), reflecting strong U.S. leadership and growing activity in Asia. Country-level data revealed similar disparities. The United States dominated with 3,078 citations, far surpassing Belgium (387) and China (276). While Belgium achieved strong influence despite fewer papers, China's rising output reflects its expanding focus on AI in healthcare. Overall, the uneven distribution of publications and citations highlights significant regional and institutional gaps, even as global interest in AI for atrial fibrillation continues to grow. Data for all authors, universities, countries, and sources involved in the top 100 most cited papers on AI and AF research can be provided on demand Supplementary Tables 1-3. Additionally, collaboration networks are provided in Figures 2-4, respectively. The dynamics among authors, universities,

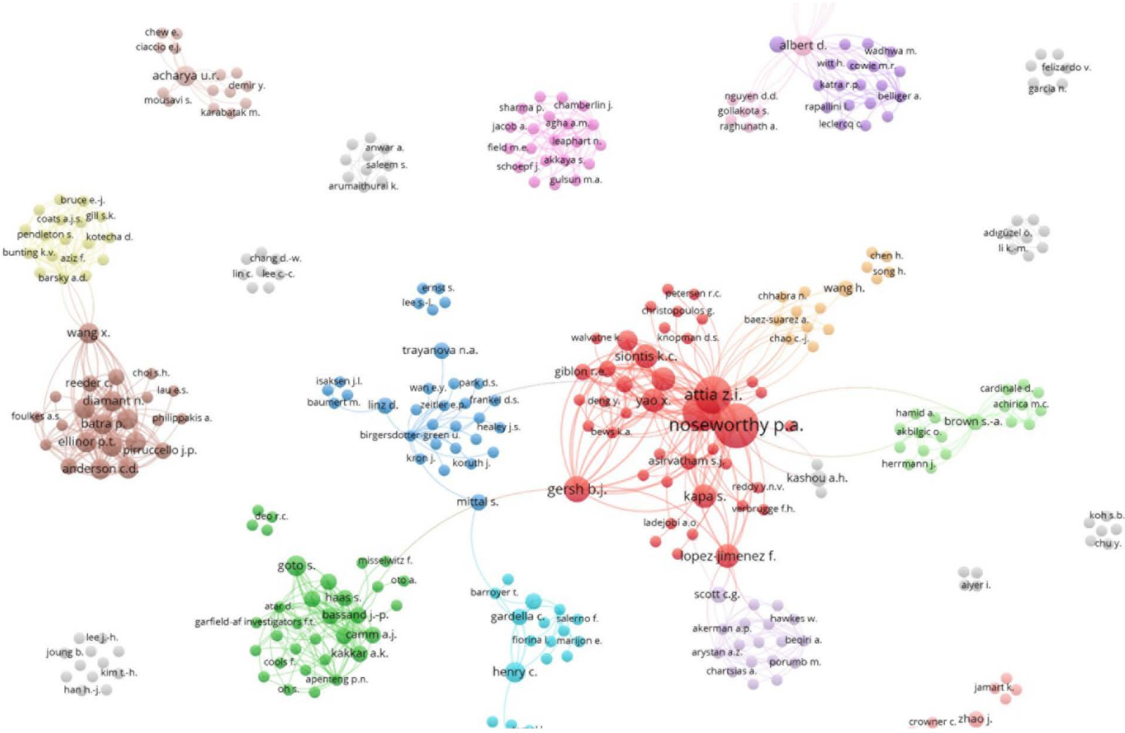

Figure 2. The collaboration network for authors

Figure 3. The collaboration network for universities

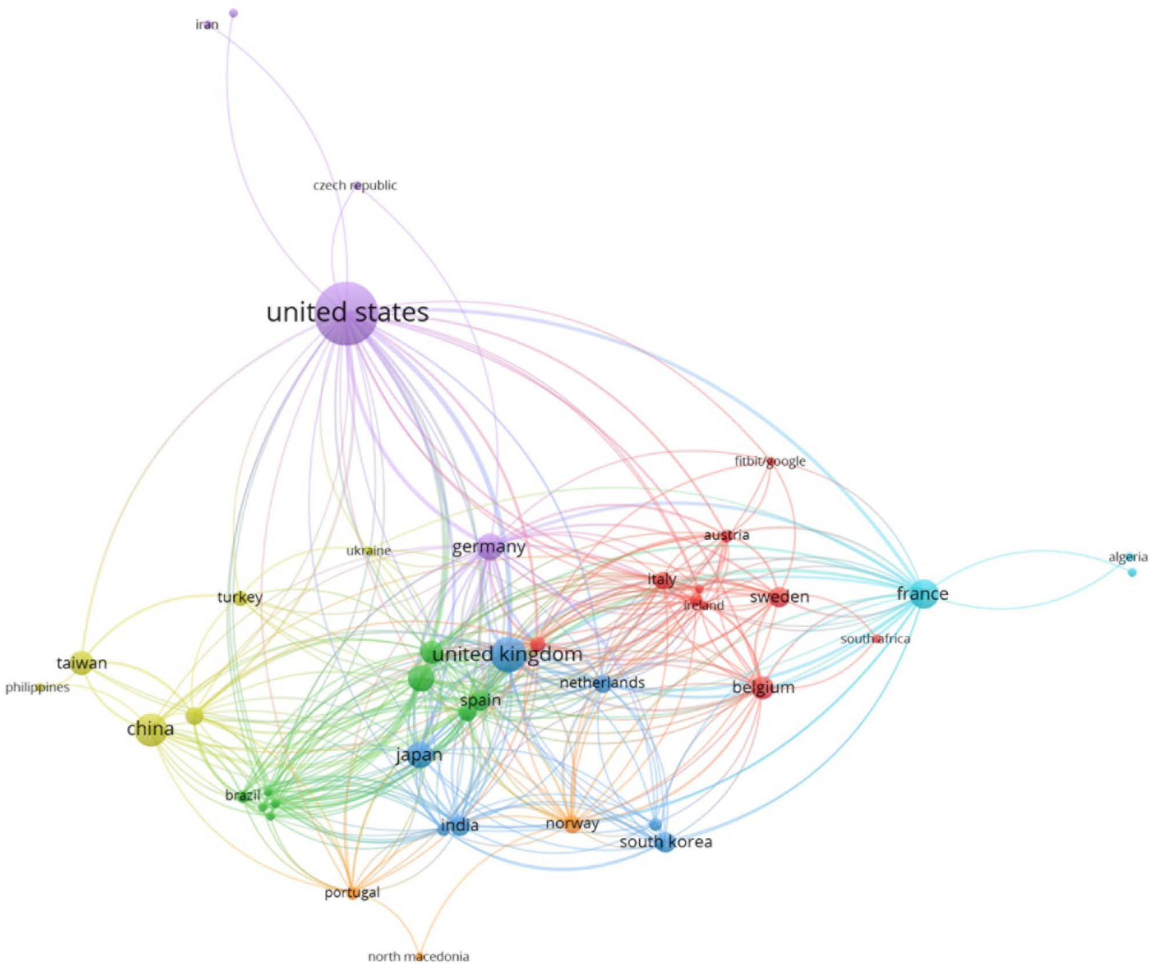

Figure 4. The collaboration network for countries

and countries are provided in Supplementary Tables 1-3, respectively.

The Research Focus of the Top 100 Most Cited Papers

The list of the top 100 most cited papers list of top 100 most cited documents can be provided on demand. The main focus (Figure 5) revolved around the integration of AI with electrocardiography (ECG) and other diagnostic modalities aimed at enhancing the early detection, prediction, and management of AF. A significant portion of the research emphasized AI-enhanced algorithms specifically designed to identify AF during sinus rhythm, marking a notable advancement in non-invasive cardiac monitoring. One of the most cited papers presented an AI-enabled ECG algorithm that predicted outcomes in patients with AF, showcasing the potential of AI to improve diagnostic accuracy and patient management strategies.[10]

In addition to detection, many studies explored the epidemiology of AF, particularly emphasizing novel methods and insights related to its prevalence and impact on public health.[11] This body of literature not only examined the clinical implications of AF but also highlighted the need for innovative diagnostic solutions to address the growing burden of cardiovascular diseases in the 21st century. Furthermore, the role of AI in cardiovascular disease management was underscored by numerous publications, illustrating how AI could enhance traditional approaches to heart disease treatment through improved data analysis and patient monitoring.[12]

Deep learning and machine learning techniques were pivotal in several papers, as they illustrated the potential for AI algorithms to analyze complex ECG data and accurately predict AF as well as other cardiovascular events.[13,14] A notable paper discussed the use of hierarchical attention networks (HAN-ECG) for interpretable AF detection, thereby reflecting a trend toward developing models that not only provide predictions but also clarify the reasoning behind them.[14] This emphasis on explainability in AI models is critical for fostering trust among clinicians, ensuring that healthcare professionals are more willing to adopt these advanced technologies in routine practice.

The integration of wearable devices into AF detection and management was another key focus, with several studies investigating AI-driven wristbands and mobile health platforms tailored for continuous cardiac monitoring.[15,16] These technologies provide a significant advantage by enabling the monitoring of patients outside traditional clinical environments, facilitating earlier detection and intervention in at-risk populations. One of the studies highlighted the promising potential of a new smart wristband equipped with an AI algorithm specifically designed to detect AF, illustrating how these innovations can enhance patient engagement and health outcomes.[17]

Research also delved into the AI-based risk stratification and management of AF, particularly regarding optimizing treatment approaches and improving patient outcomes.[18] For instance, some papers analyzed AI's capability

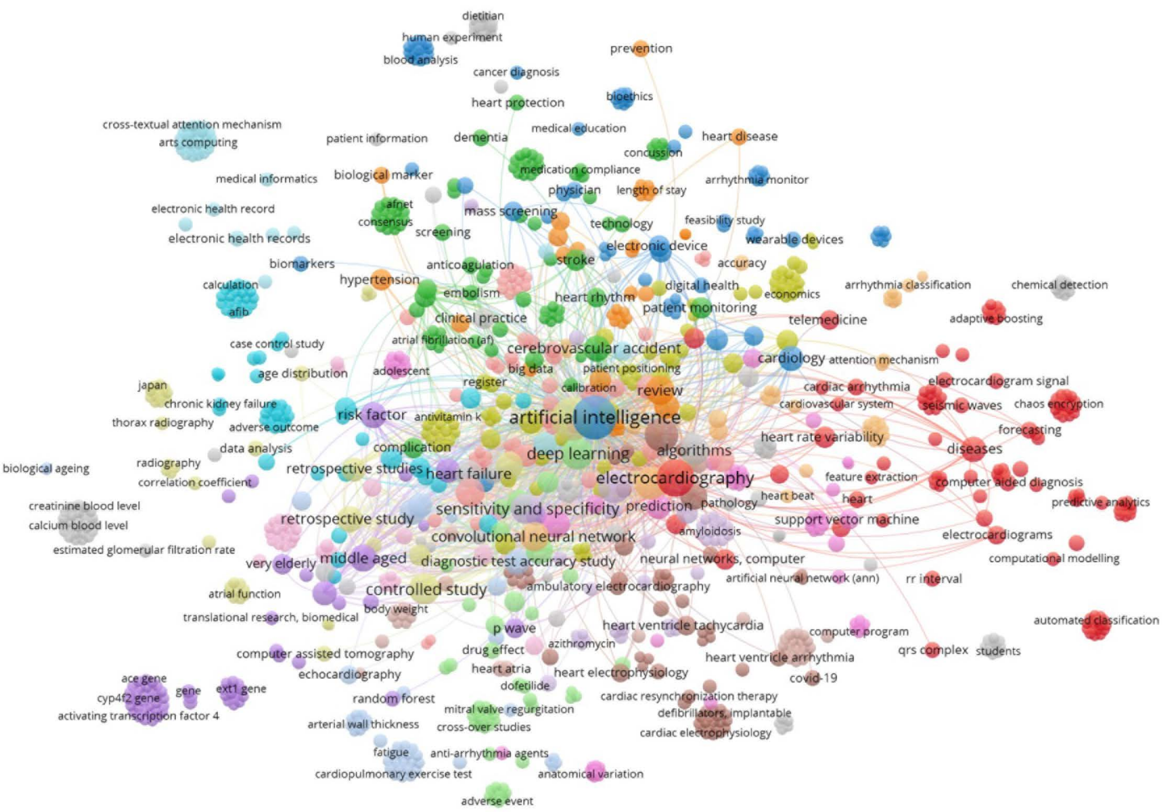

Figure 5. The co-words analysis of top 100 most cited papers

to redefine beta-blocker response in heart failure patients with AF, demonstrating how AI could lead to more personalized therapeutic strategies that cater to individual patient needs.[19,20] Moreover, discussions on AI's role in advancing precision medicine indicated a broader movement towards individualized patient care in cardiology, where treatment plans are adapted based on AI-driven insights.

Additionally, several articles contributed to the literature by offering comprehensive reviews and meta-analyses that encapsulated the current advancements in AI-driven AF diagnosis and management.[21,22] These reviews served to synthesize existing research findings and provide a cohesive overview of the transformative impact of AI in the field of cardiology. The overall trajectory of the research suggests a robust and growing interest in leveraging AI to tackle the challenges associated with AF and improve cardiovascular health outcomes.

A comprehensive review highlights the use of machine learning for predicting atrial fibrillation. The findings demonstrate that these algorithms can analyze vast datasets to identify patterns associated with AF, ultimately improving diagnostic accuracy and facilitating timely interventions.[23] By harnessing historical data and patient characteristics, machine learning models can predict AF occurrences with high sensitivity, potentially transforming clinical practice in managing this prevalent arrhythmia.

One notable advancement is the development of an AI prediction model that utilizes serial prothrombin time international normalized ratio (INR) measurements for patients on Vitamin K antagonists. This model, part of the GARFIELD-AF initiative, aims to enhance anticoagulation management in AF patients by providing personalized treatment recommendations based on INR data.[24] The implications of this research underscore the importance of individualized care in reducing thromboembolic events among patients with AF.

In a similar vein, AI has been utilized to combine structured and unstructured data from electronic health records (EHRs) through natural language processing techniques. This approach enables the identification of non-valvular atrial fibrillation, potentially decreasing the incidence of strokes and mortality rates associated with the condition.[25] The ability to integrate various data types illustrates AI's versatility in extracting clinically relevant information from comprehensive patient records, supporting proactive management strategies.

Research has also explored the intersection of AI and deep learning within biomedical image analysis. An extensive review discusses the progress made in this field, emphasizing its applications in electrocardiogram (ECG) interpretation and AF detection .[25] The advancement of deep learning algorithms enhances the accuracy of ECG readings, allowing for more effective identification of arrhythmias and improving overall diagnostic capabilities.

Moreover, the Edge2Analysis platform represents a novel application of AI in AF recognition and detection. This AIoT (AI of Things) platform aims to provide real-time monitoring and analysis of patients, enhancing clinical responsiveness and patient engagement.[26] By leveraging AI technology in wearable devices, the platform facilitates continuous tracking of heart rhythms, thereby enabling early detection of AF episodes.

Detection of left atrial myopathy through AI-enabled electrocardiography signifies another innovative use of AI in cardiac care. This technique allows for the identification of structural heart changes associated with AF, which can inform treatment decisions and improve patient outcomes.[27] The integration of AI in electrocardiography exemplifies its role in enhancing diagnostic precision in the evaluation of arrhythmias.

Investigations into genetic factors contributing to AF are gaining traction, with machine learning techniques applied to identify associated genes. This research not only enhances understanding of AF's etiology but also supports translational efforts in precision medicine by predicting disease risk based on genetic profiles.[28] Such findings underscore the potential for AI to facilitate more tailored approaches to managing cardiovascular diseases.

In the context of cardiovascular health, AI has proven beneficial in identifying various arrhythmia patterns through convolutional neural networks (CNNs). These networks analyze ECG data to classify arrhythmias with improved accuracy, thereby assisting healthcare providers in making informed clinical decisions.[29] The application of CNNs highlights the capacity of AI to enhance the diagnostic workflow and optimize patient care.

Furthermore, a hybrid attention-based deep learning network has been developed for automated arrhythmia classification, showcasing the potential of combining various AI techniques to improve diagnostic performance.[30] This network aims to address challenges in traditional arrhythmia classification by utilizing advanced machine-learning methods that can process complex ECG signals effectively.

AI in cardiovascular diseases encompasses both detection and therapy. Systematic reviews highlight its potential and challenges for diagnosing arrhythmias, emphasizing the need for rigorous validation—especially across diverse populations—to ensure reliability, clinical applicability, and trust in improving patient outcomes.[31]

AI has improved the detection accuracy of cardiac insertable monitors. A pilot study showed that AI algorithms enhance AF episode identification, enabling continuous monitoring, timely interventions, and potentially reducing stroke and other AF-related complications.[32]

Automated signal quality assessments of single-lead ECGs enable real-time monitoring and early detection of silent AF, ensuring accurate data interpretation and helping reduce risks from undiagnosed arrhythmias.[33]

The phenomenon of subclinical AF presents another layer of complexity, often described as a silent threat with uncertain implications. This type of AF can occur without overt symptoms, leading to potential delays in diagnosis and treatment.[34] Understanding the nuances of subclinical AF and its detection through AI technologies is vital for managing the associated risks effectively.

Digital cardiology is opening new frontiers for disease prevention, providing opportunities to leverage technology for early intervention in cardiovascular diseases.[35] AI-driven tools are being developed to analyze large datasets from various sources, enabling healthcare professionals to identify patients at risk of developing AF and other cardiovascular conditions.

Wearable ECG devices, such as those studied in the HUAMI heart study, enable continuous AF monitoring and outperform traditional methods. Integrating AI enhances real-time analysis and alerts, while AI applications extend to other modalities, including chest radiographs, improving AF detection and management.[36] By analyzing imaging data, AI algorithms can identify patterns indicative of AF, showcasing the versatility of AI in integrating various diagnostic tools for comprehensive patient evaluation.

Moreover, research exploring the role of AI in autonomic nervous system assessment using heart rate variability highlights its potential in understanding the physiological mechanisms underlying AF.[37] This assessment could provide insights into individual patient profiles, aiding in personalized management strategies.

Recent advancements have also focused on the development of AI-driven algorithms for predicting drug effects on AF.[38] These in silico population models facilitate the exploration of pharmacological interventions and their potential impact on AF management, contributing to personalized treatment approaches.

A novel crowdsourcing approach has been applied to AF detection in outpatient ECG monitoring, enabling the aggregation of multiple algorithms and expert opinions to enhance diagnostic accuracy.[39] This collaborative model leverages diverse data sources to optimize AF detection, illustrating the potential for innovative methodologies in the field.

The use of mobile electrocardiograms enabled by AI presents another exciting frontier for event prediction in paroxysmal AF.[40]

Portable devices enable continuous monitoring and real-time analysis, promoting proactive patient engagement. Machine learning in cardiac electrophysiology improves diagnostic and therapeutic outcomes, while deep-learning analysis of 12-lead ECGs helps assess genetic susceptibility to AF, enhancing precision in management.[41] By identifying genetic markers associated with AF, these algorithms provide insights into the hereditary aspects of the condition, potentially guiding preventive strategies in at-risk populations.

Overall, the literature shows a clear trend toward integrating AI in AF management, improving diagnosis and enabling personalized treatment. As AI advances, it is poised to play a pivotal role in enhancing patient outcomes and optimizing cardiology care.

Conclusion

AI research in atrial fibrillation (AF) has grown rapidly since 2020, driven by advances in cardiovascular technology. Productivity is concentrated in the U.S., parts of Europe, and China, while Africa, Latin America, and much of Asia remain underrepresented, and highlighting global disparities. The field is highly collaborative, integrating cardiologists, data scientists, and engineers. Top studies focus on combining AI with ECGs, wearable devices, EHRs, and imaging for early detection, risk stratification, and personalized AF management. Innovations like wearable monitors, mobile health platforms, and AIoT solutions, along with machine and deep learning applied to diverse data sources, are advancing precision medicine. Explainable AI, interpretability, and external validation are essential for clinical adoption and regulatory trust.

Recommendations

Future research should prioritize translational studies that bridge computational advances with real-world clinical utility, ensuring AI tools are accurate, interpretable, and actionable. Multidisciplinary and internationally collaborative frameworks should be encouraged to address regional disparities and enhance global knowledge sharing. Explainable AI models, validated across diverse populations, should be emphasized to facilitate clinical integration and regulatory approval. Additionally, continued development of AI-driven pharmacological, genetic, and individualized therapy approaches can advance precision medicine in AF care.

Healthcare institutions and policymakers should support the integration of AI-powered wearables, predictive analytics, and EHR-based tools, accompanied by adequate infrastructure, clinician training, and ethical oversight. Systematic reviews, meta-analyses, and bibliometric studies should continue to guide strategic investment, research prioritization, and policy decisions.

Implications

The findings of this study suggest that AI has the potential to substantially improve AF detection, prediction, and personalized therapy, leading to earlier interventions, reduced complications, and better patient outcomes. Funding agencies should promote collaborative, translational, and globally inclusive research programs, particularly in underrepresented regions, to ensure equitable progress. In healthcare systems, AI-driven solutions can transform AF management, but successful implementation depends on proper infrastructure, trained personnel, and ethical governance.

Future research should focus on explainable AI, real-world validation, and the integration of genetic and pharmacological data to enable personalized treatment strategies. Ensuring accessibility and applicability of AI innovations across diverse populations is critical to maximize their impact and ensure that the benefits of AI in AF care are realized broadly and equitably.

Limitations

This study has several limitations that should be acknowledged. First, the analysis relied exclusively on the Scopus database, which may have resulted in the omission of relevant publications indexed elsewhere. Second, errors in author names, affiliations, or institutional details were not manually verified, potentially affecting the accuracy of collaboration and productivity metrics. Third, the study is primarily descriptive, focusing on bibliometric trends, publication patterns, and citation analyses, without incorporating qualitative assessments of research content, methodology, or clinical impact.

Future studies are encouraged to address these limitations by integrating multiple databases, performing manual verification of author and affiliation information, and combining quantitative bibliometric analysis with qualitative approaches to provide deeper insights into research quality, methodological rigor, and clinical relevance.

Ethics statement
Not applicable.

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Conflict of interests declaration
All authors of this study declared that there is no conflict of interest.

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Data availability statement
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Writing–review & editing: Aysa Rezabakhsh, Waseem Hassan.

Supplementary File
Supplementary File contains Table S1.

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