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Original Article

Global Mapping and Visualization of Artificial Intelligence Research in Breast Cancer: A Bibliometric Study

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Abstract

Introduction: Understanding the global landscape of artificial intelligence (AI) in breast cancer research is essential for guiding future studies. This bibliometric analysis offers a comprehensive overview of research published between January 2014 and November 1, 2024.

Methods: We systematically searched the Web of Science Core Collection (SCI-Expanded) for relevant publications within the specified timeframe. Bibliometric network analyses, including keyword and country co-occurrence, were conducted using VOSviewer, while quantitative analyses of trends, impact, and contributors were performed using R. The data encompassed publications, citations, authors, institutions, countries, journals, and keywords.

Results: The co-occurrence analysis of keywords identified six primary thematic clusters focused on "breast cancer," "deep learning," "machine learning," "artificial intelligence," "classification," and "transfer learning." China, India, and the USA were the most productive countries. Wang (China), Liu (China), and Zhang (USA) were the most prolific authors, while Helbich TH (Australia), Hipp JD (USA), and Khan S (India) were the most highly cited. Scientific Reports published the greatest number of articles, whereas PLOS ONE received the highest number of citations within this dataset.

Conclusion: This study provides an objective overview of the global landscape of AI in breast cancer research from 2014 to November 1, 2024. Our findings map publication trends, influential authors, countries, journals, and key research themes. These findings offer a valuable reference for researchers, institutions, and journals to understand the current landscape, identify collaboration opportunities, emerging trends, knowledge gaps, and highlight promising areas for future research in this dynamic field.

Introduction

Breast cancer is the most common malignancy and leading cause of cancer-related death among women worldwide, despite decades of research and advances in treatment strategies. [1–3] Early and accurate diagnosis is crucial for optimizing treatment outcomes and reducing mortality. According to World Health Organization statistics, one in every eight women will develop breast cancer. [4] Early and accurate diagnosis is the key to optimize treatment outcomes and lower mortality. Artificial intelligence (AI) applied to medical image analysis offers a promising approach to improving early detection and characterization of breast cancer. [5,6] AI plays a particularly important role in enabling earlier and more precise diagnoses. [7,8] Over the past twenty years, AI—especially through machine learning and deep learning algorithms—has significantly advanced computer-aided detection and diagnostic techniques. [9–11]

The past few years have witnessed a renewed interest in applying artificial intelligence (AI) to breast cancer research, primarily due to the remarkable performance of deep learning (DL) in detecting cancer and predicting five-year survival rates based on mammograms. [12–14]

Deep learning (DL) models have been shown to be comparable to, or even surpass, human experts in medical image analysis for breast cancer diagnosis and prognosis. [15] As the use of AI applications in breast cancer continues to grow, it is essential to gain a comprehensive understanding of the current research landscape, key contributors, and emerging trends to guide future efforts.

Although an increasing number of scientometric studies have examined the role of AI in medicine [16–17] and other cancer types, such as lung and skin cancer, [18–20] a

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comprehensive quantitative review that offers a holistic overview of the structure, trends, and key contributors in global AI research on breast cancer remains lacking. To address this gap, the present study conducts a bibliometric analysis of global research activities applying AI to breast cancer from 2014 through November 1, 2024. This study distinguishes itself from prior research in three main ways: (1) focusing on global mapping and visualization within an interdisciplinary field; (2) including a specific analysis of open-access publishing trends; and (3) providing an up-to-date and comprehensive overview of the entire research landscape in this field over the past decade.

The findings of this study will inform researchers by highlighting key journals, authors, and research topics; assist policymakers in strategic planning and budgetary decisions; and guide entrepreneurs by identifying active research institutions and potential areas for collaboration.

To our knowledge, this is one of the most comprehensive worldwide bibliometric examinations of AI in breast cancer research published over the past decade. Providing a quantitative snapshot of the research landscape has the potential to map the intellectual structure and evolution of the field through bibliometric indicators and network analysis.

Methods

Study Design

This study employs a bibliometric approach to evaluate global research trends, influential publications, and innovation patterns in the application of artificial intelligence (AI) to breast cancer research. By mapping and visualizing scientific publications, this methodology provides insights into the evolution, key contributors, and emerging themes within this interdisciplinary field. Bibliometric analysis is a descriptive-analytical or secondary quantitative research method because it does not directly collect primary data but instead analyzes existing data from scientific databases.

Data Acquisition

Metadata of publications addressing AI applications in breast cancer research were downloaded from the Web of Science (WoS) Core Collection, specifically the Science Citation Index Expanded (SCI-Expanded) version (https://www.webofscience.com/), and the Journal Citation Reports (JCR) database (https://jcr.clarivate.com/jcr/home) on November 1, 2024.

The selection of the Web of Science (WoS) database is justified for the following reasons:

1. High Quality and Selectivity: Web of Science (WoS) employs a rigorous selection process, indexing high-quality journals with significant scientific impact. This is a key advantage for review studies aiming to map core and influential research.
2. Stability and Reliability of Citation Data: Citation data within the Web of Science (WoS) has historically demonstrated high stability and accuracy, making it a standard and reliable tool for citation-based analyses, such as identifying highly cited papers and influence networks.
3. Integration with Journal Citation Reports (JCR): Seamless access to Journal Impact Factor (JIF) metrics within this database enables the systematic, concurrent analysis of both publication quantity and quality.
4. Compatible Data Formats: The standardized and structured output formats of WoS, such as BibTeX or tab-delimited files, are ideal for input into bibliometric analysis software like VOSviewer and R.

However, we fully acknowledge that this choice—excluding other major databases such as Scopus and PubMed/Medline—introduces selection bias and may result in the omission of relevant publications, particularly from specific health science domains or geographic regions. This limitation is addressed in the limitations section of the manuscript.

Search Strategy

To retrieve related works, the search strategy was employed using keywords relevant to the study. The strategy applied using the keywords regarding the study topic. Limiting the search to title done to ensure achieve higher relevance and to include only those articles that directly address "artificial intelligence in cancer." Broader searches, such as those (e.g., the abstracts and keyword fields) may the papers only mention the incidentally, any substantive any relation to the topic. Limiting the search to titles reduces the sample while increases the accuracy of the results. This study, used this high-precision method to generate a focused and transparent topic mapping. The complete search strategy for database is provided in Supplementary file.

The present study aimed to comprehensively map the entire research landscape of artificial intelligence (AI) in breast cancer, encompassing all its potential complexities and subfields. To achieve this, a highly sensitive search strategy was designed to ensure that no relevant subfield—whether currently established or emerging in the future—was overlooked. This approach is common in comprehensive reviews and bibliometric studies focused on identifying emerging trends. Additionally, automatic filtering was performed by the analysis tools. The strength of bibliometric analysis and software such as VOSviewer lies in their ability to process large volumes of data and extract meaningful patterns. Although some peripheral terms may appear in the initial search results, keyword co-occurrence analysis automatically isolates or removes them, as these terms do not form significant connections with the main keywords in the network. Indeed, the final output of the analysis—the keyword networks and clusters presented in this paper—demonstrates that the meaningful core of the field has been effectively separated from potential noise.

The keywords were systematically extracted from MeSH (Medical Subject Headings) to ensure alignment with standardized biomedical terminology. We combined AI-related terms (e.g., "machine learning," "deep neural networks") with breast cancer terms (e.g., "breast neoplasms," "malignant breast tumors") using Boolean

operators (AND/OR). The "AND" operator linked AI and breast cancer concepts to retrieve targeted studies, while "OR" captured synonymous or variant terms (e.g., "breast carcinoma" OR "breast tumor") to maximize coverage. This approach balanced precision and recall, ensuring comprehensive yet relevant results.

Only peer-reviewed original articles were included in the analysis, while meeting abstracts, letters, editorials, and corrections were excluded. Furthermore, the study was limited to English-language publications published between 2014 and 2024. Bibliographic information—including publication year, citation counts, authors, journals, institutions, countries/regions, research areas, funding agencies, references, and keywords—was extracted and exported in BibTeX, CSV, plain text, and tab-delimited formats for subsequent analysis.

Data Analysis

Bibliometric analyses were conducted using VOSviewer version 1.6.20 software, employing the default settings, of VOSviewer including association strength normalization and the software's internal clustering algorithm. Additionally, the R package was utilized for quantitative analysis of the dataset, focusing on aspects such as publication years, publication frequencies, institutions, journals, cumulative citations, authors, keywords, and research fields. Co-occurrence analyses of author keywords and countries were performed using a binary counting method. Network maps were generated to visualize these co-occurrences. Keywords with general meanings unrelated to specific AI or breast cancer concepts were excluded from the analysis. In the network maps, node size corresponds to the frequency of the item, while link thickness indicates the strength of association.

Finally, to calculate the growth rate of publications based on the table, we used the percentage growth formula over the specified period, as shown below.

$$\text{Percentage growth over the period. (\%)} = \frac{\text{Publications in last Year} - \text{Publications in first Year}}{\text{Publications in first Year}} \times 100$$

This measures the total percentage increase in publications from an initial period to a final period.

Ethical considerations: This research was approved by the ethics committee of HUMS, and the assigned code was IR.HUMS.REC.1397.006

Results

Our systematic search in the Web of Science (WoS) database yielded 2945 published documents relevant to AI in breast cancer research. Co-occurrence analysis of author keywords (minimum of 10 occurrences) identified 322 distinct terms, which were subsequently grouped into six clusters, containing 124, 91, 60, 24, 12, and 10 terms, respectively. The most frequently occurring terms were "breast cancer" and "deep learning," highlighting the central focus of research in this area.

Evolution and Current Status of Scientific Research

The annual publication trends from 2014 to November 1, 2024 revealed a significant increase in research activity. The number of publications was lowest in 2014 (n = 21), followed by a gradual increase, with a notable surge in 2023 (n = 709). However, a slight downward trend was observed in 2024. The observed decrease in the number of publications in 2024 is most likely due to the incompleteness of the data for this year (up to the search date of November 1, 2024) and the inherent delay in article indexing within databases, rather than indicating an actual decline in scientific output (Figure 1). The growth rate from 2014 to 2023 was calculated at 96%, indicating a substantial increase in research output over the decade.

$$\text{Percentage growth over the period. (\%)} = \frac{709 - 21}{21} \times 100 = 3276\%$$

Top Cited Articles

Analysis of the top 10 most cited articles in the field (Table 1) showed a range of citations from 352 to 1930. The most highly cited article, "Diagnostic Assessment of Deep Learning Algorithms for Detection of Lymph Node Metastases in Women with Breast Cancer," published in *JAMA* in 2017, received 1930 citations, demonstrating its significant impact on the field.

Author's Analysis

Table 2 presents the top 10 most influential authors in the field, based on their publication count, citation metrics, and h-index. While most of the prolific authors are from China, Zhang J. from the USA has the highest h-index (14).

Table 3 lists the top 10 most highly cited authors in the field. Helbich T.H. from Austria, Hipp J.D. from the USA, and Khan S. from India are among the most cited, indicating their significant contributions.

Country Collaboration Analysis

Based on Table 4 and Figure 2, the leading countries in AI-driven breast cancer research are China, India, and the United States, collectively accounting for 62% of the total research output. Six of the top ten countries with international collaborations are from Asia, including China, India, Saudi Arabia, South Korea, Iran, and Pakistan. The most cited countries are the United States, China, India, the United Kingdom, Saudi Arabia, South Korea, Egypt, Iran, Pakistan, and Italy.

Distribution of Published Journals

Between 2014 and 2024, a total of 2945 articles were published across 196 publishers, Springer Nature (506 articles) and Elsevier (505 articles) contributing the most significantly. Detailed results are provided in Supplementary Table S1.

Also between 2014 and 2024 journals cover a range of disciplines, including multidisciplinary sciences, software engineering, computer science, and oncology, reflecting the

Table 1. Top 10 highly cited articles on AI in Breast Cancer-related publications, 2014–2024

Row	Title	Source	TC	TNC	PY
1	Diagnostic Assessment of Deep Learning Algorithms for Detection of Lymph Node Metastases in Women With Breast Cancer	JAMA	1777	1930	2017
2	Classification of breast cancer histology images using Convolutional Neural Networks	PLOS ONE	518	577	2017
3	Deep Learning to Improve Breast Cancer Detection on Screening Mammography	Scientific Reports	441	473	2019
4	A novel deep learning based framework for the detection and classification of breast cancer using transfer learning	Pattern Recognition Letters	425	445	2019
5	AggNet: Deep Learning From Crowds for Mitosis Detection in Breast Cancer Histology Images	IEEE (Transactions on Medical Imaging)	388	420	2016
6	A Deep Learning Mammography-based Model for Improved Breast Cancer Risk Prediction	Radiology	361	398	2019
7	Deep Neural Networks Improve Radiologists' Performance in Breast Cancer Screening	IEEE (Transactions on Medical Imaging)	354	373	2020
8	Breast Cancer Multi-classification from Histopathological Images with Structured Deep Learning Model	Scientific Reports	354	388	2017
9	Deep Learning Radiomics can Predict Axillary Lymph Node Status in Early-Stage Breast Cancer	Nature Communications	347	390	2020
10	Detection of Breast Cancer with Mammography: Effect of an Artificial Intelligence Support System	Radiology	328	352	2019

TNC: Total Number of Cited (TNC Citations aggregated from multiple sources that were used to provide a more comprehensive citation count.), "multiple sources" referred to the different indices within WoS (such as Science Citation Index, Social Science Citation Index). TC: Time Cited (TC Likely refers to the total citations received by the paper *as recorded in the specific database* used for the study (e.g., Web of Science or Scopus), PY: publication Year

Table 2. Top 10 most influential authors on AI in Breast Cancer-related publications, 2015–2024

Authors' names	Institutions (Country)	NP	TC (AI & B)	H-index (2)	Country
Li J	Xi An Jiaotong University	35	611	13	China
Zhang J	Duke University	31	881	14	USA
Wang Y	Beihang University	29	901	13	China
Zhang Y	University of California, Irvine	29	444	10	USA
Liu Y	Southern Medical University, China	26	896	10	China
Wang J	Sun Yat Sen University	25	364	9	China
Li H	University of Chicago	20	264	7	China
Zhang L	Sichuan University	19	244	8	China
Wang S	Peking University	18	463	9	China
Wang YY	Fudan University	16	830	12	China

NP: Number of Publications by the query of the research, TC: Time Cited
Note: Authors listed in this table represent bibliometric entities identified from the Web of Science dataset and are not cited references.

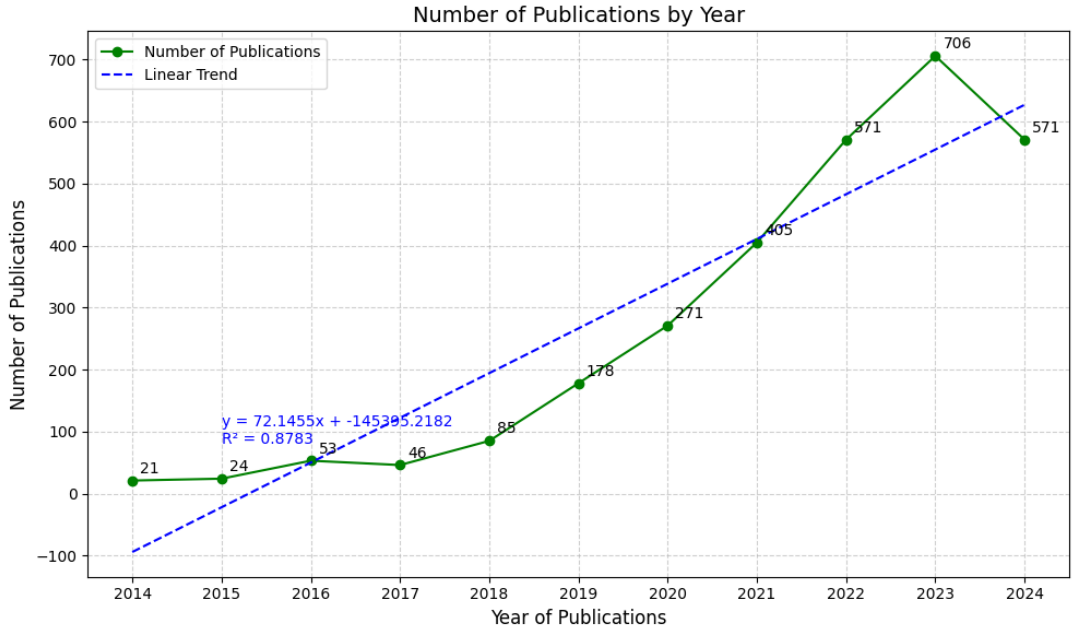


Figure 1. Annual Trends of AI in Breast Cancer-related Publications

Table 3. Top 10 most influential highly cited authors on AI in Breast Cancer-related publications, 2014–2024

Authors' names	Institutions (Country)	NP	TC (AI & B)	H-index (2)	Country
Jabeen K	Hitec University	3	153	3	Pakistan
Khan MA	Hitec University	3	153	3	Pakistan
Alhaisoni M	University Hail	2	143	2	Saudi Arabia
Cui XW	Huazhong University Science & Technology	2	316	2	China
Dietrich CF	Huazhong University of Science and Technology	2	258	2	China
Helbich TH	Med University Vienna	2	519	2	Austria
Hipp JD	Google AI Healthcare	2	474	2	USA
Huang Z	New York Univ.	2	383	2	USA
Khan S	Chandigarh Univ.	2	438	2	India
Li X	South Cent Univ. Nationalities	2	217	2	China

NP: Number of Publications based on the query of the research; TC: Time Cited
Note: Authors listed in this table represent bibliometric entities identified from the Web of Science dataset and are not cited references.

Table 4. Top 10 countries contributed to AI in Breast Cancer-related publications, 2014–2024

Row	county	NP	% of Pub	Citation
1	People's Republic of China	827	28	13756
2	India	524	18	6653
3	USA	481	16	14907
4	Saudi Arabia	199	7	3416
5	South Korea	145	5	2816
6	Iran	136	5	2538
7	England	123	4	3775
8	Pakistan	109	4	2398
9	Egypt	100	3	2607
10	Italy	87	3	1432

NP: Number of Publication; Pub: Publication

interdisciplinary nature of AI in breast cancer research.The primary metrics for journal comparison in this study are the Number of Publications (TNP) and the Journal Impact Factor (JIF). The complete list of studies is presented in Supplementary Table S2.

The result showed a significant trend toward open access publishing in AI and breast cancer research. Out of 2,935 articles, 1,827 (62.24%) were published as all open access. Gold open access, where the final version is immediately available, accounts for 46.33% (1,360 articles). An additional 7.42% (218 articles) were published as gold-hybrid open access. Green open access, involving self-archiving, includes 37.68% (1,106 articles) for published versions and 3.23% (95 articles) for accepted versions. These numbers highlight the accessibility of AI-related breast cancer research. Additional information is available in Supplementary Table S3.

Top Institutes and Web of Science Categories

The results showed that between 2014 and 2024, The Egyptian Knowledge Bank (EKB) ranked first among institutions contributing to AI in breast cancer with 93 articles (3.16%). It was followed by the Chinese Academy of Sciences (62 articles, 2.11%) and the National Institute of Technology (NIT) System (58 articles, 1.97%). The most common Web of Science categories for these publications were Oncology (507 articles, 17.27%) and Radiology, Nuclear Medicine & Medical Imaging (386 articles, 13.15%). Detailed results are provided in Supplementary Table S4.

Keywords Analysis and Research Hotspots

Keywords in the publications reflect the primary research areas. Co-occurrence analysis revealed research foci in AI applied to breast cancer. Figure 3 illustrates thematic clusters based on keyword co-occurrence, which might be a profound reference for further research (Figure 3 (A)). Moreover, the most prominent keywords include "breast cancer," "deep learning," "machine learning," "artificial intelligence," "classification," and "transfer learning." (Figure 3 (B))

Co-authorship Analysis

Co-authorship analysis of 29 authors (minimum of 5 documents per author) revealed three clusters with a Total Link Strength (TLS) of 116. Liu (TLS = 17), Li (TLS = 15), Zhang (TLS = 15), and Wu (TLS = 15) were the most strongly connected authors.

Analysis of co-authorship between countries (minimum of 10 documents per country) identified three clusters with a TLS of 1018. The United States ranked first (TLS = 298), followed by China (TLS = 235), Saudi Arabia (TLS = 225), the United Kingdom (TLS = 225), and Pakistan (TLS = 160).

Discussion

To our knowledge, this study provides the first comprehensive bibliometric analysis of artificial intelligence (AI) in breast cancer research indexed in the Web of Science Core Collection (WoSCC) database. Our research aims to offer a general overview of the knowledge framework and research trends related to AI applications in breast cancer. We retrieved 2,945 articles published between November 1, 2014, and 2024, reflecting a growing interest in this field. Trend analysis indicates that deep learning, machine learning, and transfer learning are emerging as significant AI technologies in breast cancer research, particularly in enabling earlier and more accurate diagnoses. [17,18] The increasing adoption of AI-based methods also creates

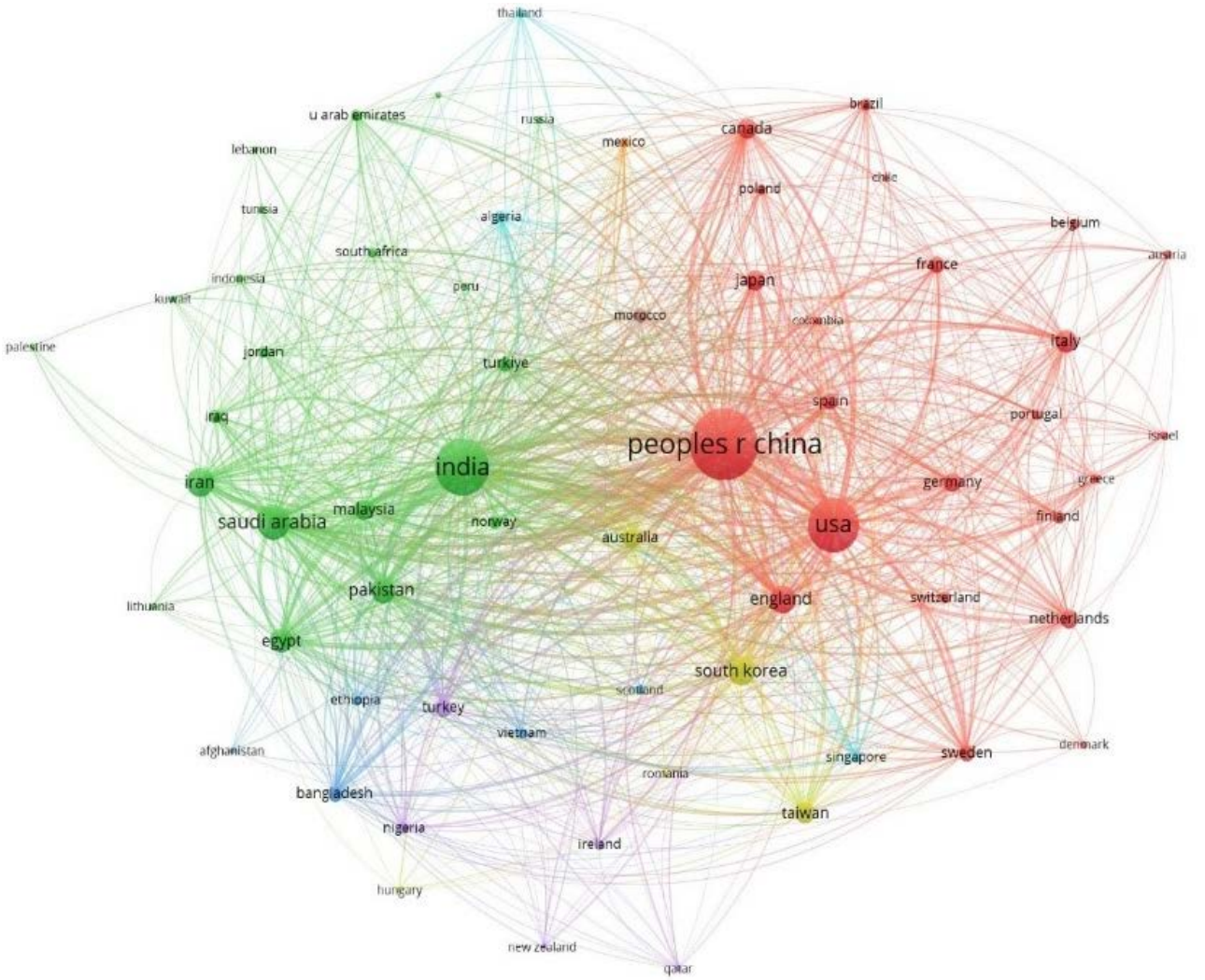


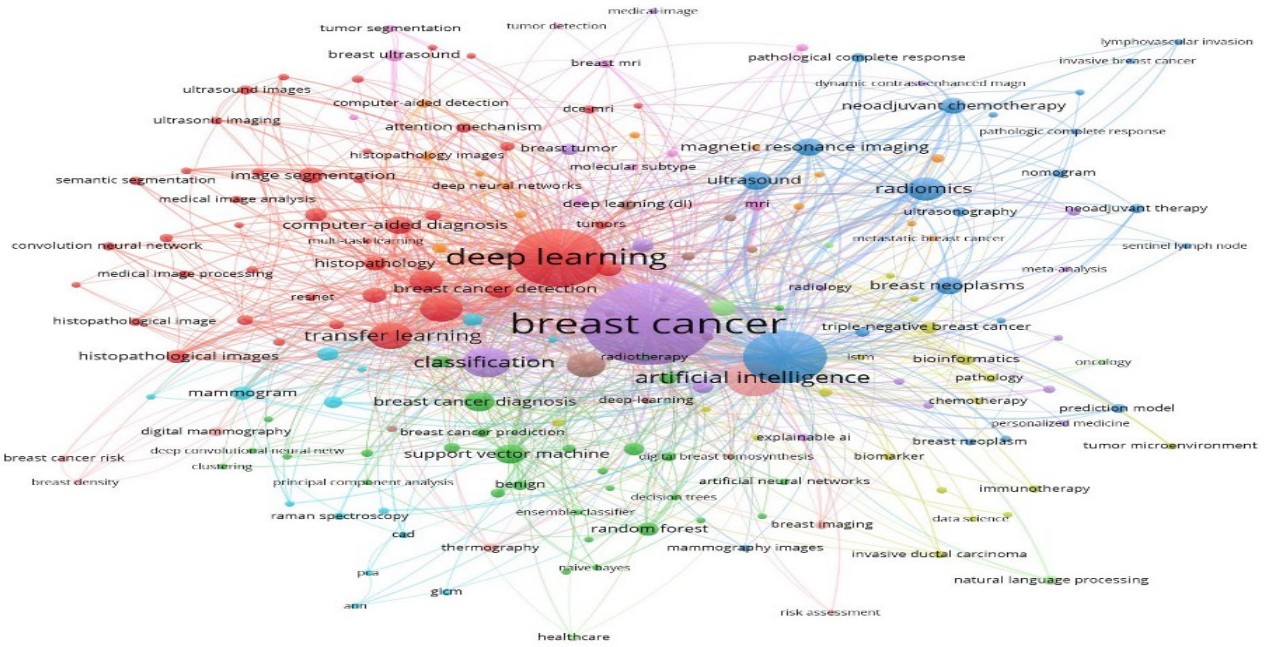
Figure 2. Top productive countries in the field of AI in Breast Cancer -analyzed by citation, related publications, 2014- 2024 (Country's collaboration based on citations)

new opportunities for research, which can be translated into improved prediction and treatment strategies for the disease.

The rapid development of this field is evidenced by the increasing participation of mainstream universities and research institutes worldwide. Our results highlight the contributions of over 12,357 authors from more than 102 countries, publishing in over 802 scientific journals from 196 international publishers, and supported by 3,246 research grants. Additionally, more than 62% of the published papers were indexed in open-access journals, underscoring the importance of knowledge sharing within the discipline. The emphasis on open access suggests that eliminating cost barriers can significantly promote scientific and technological progress in AI and breast cancer research.

Geographical analysis revealed that China, India, and the United States are the top three countries in AI-based breast cancer research, collectively accounting for 62% of the total research output. The prominent roles of the United States and China are largely driven by substantial and sustained investments in artificial intelligence, biomedical research funding, advanced research infrastructure, and strong collaborations among academia, healthcare institutions, and the technology sector. In contrast, India's growing contribution appears to be influenced by a combination of a high breast cancer burden, a rapidly expanding pool of engineers and computer scientists, and increasing national initiatives in digital health and AI-driven healthcare solutions. [18,19] Publications from the United States and China received the highest citation counts, reflecting the quality and influence of their research. Within the institutional context, the Chinese Academy of Sciences and the Egyptian Knowledge Bank are leaders in scientific production in this domain, demonstrating significant investment in AI-based breast cancer research. Expanding international cooperation and broadening scientific networks based on these findings could further advance the field.

Common term analysis identified "breast cancer," "deep learning," "machine learning," "artificial intelligence," "classification," and "transfer learning" as the most frequent keywords. The cluster dominated by keywords such as "breast cancer," "deep learning," "machine learning," "artificial intelligence," and "convolutional neural network" reflects the methodological core of this



(A)



(B)

Figure 3. Principal 100 Frequency Occurrences of the Author's Keywords in AI in Breast Cancer: (A) Network of Keyword Co-occurrences, (B) Word Cloud of Annual Trends in AI in Breast Cancer

research field, highlighting data-driven and algorithmic approaches in breast cancer–related studies. This cluster also encompasses research focused on medical image analysis, particularly mammography, histopathological images, and radiological imaging.

Another prominent cluster, centered around the keywords "classification" and "diagnosis," encompasses studies focused on developing predictive and categorization models for breast cancer–related data. This cluster reflects clinically oriented research aimed at supporting early

detection and medical decision-making. Additionally, the presence of a distinct cluster dedicated to "transfer learning" underscores researchers' efforts to enhance model performance when faced with limited domain-specific data. Notably, the most cited paper, "Diagnostic Assessment of Deep Learning Algorithms for Detection of Lymph Node Metastases in Women with Breast Cancer" (2017), demonstrates the effectiveness of deep learning algorithms in early detection, with the potential to reduce human error. Recent advances in medical and image data processing have further improved the accuracy of deep learning models, potentially lowering diagnostic costs and increasing survival rates. [21,22]

Our results demonstrate that artificial neural networks, specifically deep learning algorithms, outperform conventional techniques such as Decision Trees, Random Forests, and Support Vector Machines. The accuracy (up to 100% in certain studies) of deep learning in the detection of breast cancer detection—reaching up to 100% in certain studies—highlights the critical role this technology plays in enhancing medical diagnoses. This underscores the necessity of developing deep learning-based systems to achieve optimal diagnostic precision, independent of traditional methods. [23] These findings align with other bibliometric analyses of AI and cancer research. For example, Gencer et al. identified deep learning, machine learning, and AI as the most frequently occurring terms in AI and lung cancer research, with China and the United States leading in scientific article publications, consistent with our findings in breast cancer. They reported that the Chinese Academy of Sciences and Harvard University had the highest number of publications. The Chinese Academy of Sciences also ranked among the top institutions in our analysis. [18]Wang et al. ranked the United States and China as the top nations in AI-based cancer research; however, we observed that China surpassed the United States in publication volume. Their most common terms included "machine learning," "traditional neural network," and "natural language processing," whereas our study emphasized "deep learning." These differences may result from variations in search terms, databases, and search dates. [19]Liu et al. reported that the USA had the highest number of publications on AI in skin cancer, with China second, while we found a greater number of publications and contributing authors from China in breast cancer research. Liu et al. identified Harvard University as the leading institution in publication count, whereas our findings highlighted the Egyptian Knowledge Bank (EKB) and the Chinese Academy of Sciences as the top contributors. Despite these differences, terms such as "artificial intelligence," "deep learning," "classification," and "detection" were common to both studies. [20] Analysis of scientific journals revealed that the most prominent publications featuring AI-related breast cancer research predominantly belong to interdisciplinary categories, including software engineering, computer science, and oncology. This highlights the interdisciplinary nature of AI research and its close connection to medicine and oncology. [24,25] *Scientific Reports* has been a leader in this field, publishing 103 articles. Furthermore, the high citation rates of articles in the open-access journal *PLOS ONE* attest to the validity of the research published there. Interdisciplinary AI journals in medicine feature leading articles that explore both theoretical and practical aspects of AI in medicine and healthcare. [26–28] Open-access gold journals enhance the visibility and accessibility of research, thereby increasing citations and scientific impact [29–31], while also promoting collaborative and interdisciplinary research. [32-34]

Strengths and Limitations

This research examines the empirical literature landscape by identifying key trends, influential authors, prominent journals, and collaboration networks, while addressing methodological considerations. The analysis provides valuable insights for both academic research and policy formulation; however, its findings should be interpreted in light of four limitations: (1) potential selection bias resulting from reliance solely on the Web of Science, which excludes relevant studies indexed in Scopus and other major databases; (2) limited analytical depth due to dependence on metadata rather than full-text content; (3) potential inconsistencies arising from evolving indexing practices and domain-specific terminology over time; and (4) incomplete data for 2024, which affects trend analysis.

Conclusion

In this study, we evaluated articles related to artificial intelligence in breast cancer research indexed in the Web of Science database, published between 2014 and 2024, to provide accurate information for scientists and researchers worldwide. Developed countries such as China, India, and the United States played a significant role in these publications. Among the top ten countries with international collaborations, six Asian countries were represented, including China, India, Saudi Arabia, South Korea, Iran, and Pakistan. Therefore, strengthening international academic collaboration in AI and breast cancer research across both developing and developed countries is essential.

Our findings indicate that most publications on AI in breast cancer research focus on breast cancer, deep learning, machine learning, artificial intelligence, classification, and transfer learning. Among these topics, deep learning, machine learning, and breast cancer had the highest average number of publications. Given the rapid growth in the number of publications in AI and breast cancer, this study provides researchers with a comprehensive understanding of the current status and trends in the field, as well as insights for future research.

Suggestions for Future Research

To advance this field, future studies should: (1) expand searches to include diverse databases (e.g., Scopus, PubMed) to minimize bias; (2) incorporate non-English publications through comparative analyses; (3) investigate

contextual drivers of publication trends (e.g., the impacts of COVID-19, technological breakthroughs); (4) develop hybrid researcher evaluation metrics that combine quantitative and qualitative indicators; and (5) conduct longitudinal analyses to identify sustained patterns. These recommendations aim to enhance the rigor, inclusivity, and translational relevance of future research.

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Conceptualization: Masoomeh Latifi, Nader Afsharzad (Alishan Karami)
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Methodology: Masoomeh Latifi, Nader Afsharzad (Alishan Karami)
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Writing–review & editing: Masoomeh Latifi, Farzaneh Fazli, Nader Afsharzad (Alishan Karami)[5]

Competing Interests
The authors declare no conflict of interest.

Ethical Approval
Not applicable.

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Supplementary files
Supplementary file 1 contains Table S1-S4.

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