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Research Article

Scientometric Analysis of Research on Artificial Intelligence Applications in Breast Cancer

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ABSTRACT

Breast cancer is a leading cause of global mortality, with outcomes significantly worsened by delayed diagnosis and healthcare disparities, particularly in regions like India. Artificial Intelligence (AI) has emerged as a transformative tool for improving diagnostic accuracy and early detection. This study aims to map the global research landscape of AI applications in breast cancer to identify trends, key contributors, and emerging thematic areas from 1991 to 2024. A scientometric analysis was conducted on 7,715 publications retrieved from the Web of Science database. The study evaluated annual growth rates, geographical and institutional contributions, prolific journals, influential authors, and keyword evolution using bibliometric mapping techniques. Research output has grown at an annual rate of 8.5%. The United States (with Harvard University contributing 5.15%) and China are the most productive countries. Leading journals include Cancers (2.76%) and Breast Cancer Research and Treatment (2.46%). Notable authors driving the field include Henry, N. Lynn and Stearns, Vered. Keyword analysis reveals a shift toward "deep learning," "convolutional neural networks," and "mammography." International collaboration accounts for 27.7% of the research. Thematic mapping identifies AI-driven classification as a primary "motor theme," while hormone therapy remains a niche area. While AI algorithms now rival radiologists in diagnostic precision, challenges regarding dataset standardization and regulatory frameworks persist. This study advocates for the integration of AI into clinical workflows to bridge healthcare gaps, enhance early detection, and ultimately reduce breast cancer mortality.

Keywords: Artificial Intelligence, Breast Cancer, Oncology, Scientometrics.

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INTRODUCTION

Breast cancer is the most prevalent malignancy among women worldwide, accounting for over 2.26 million new cases in 2020 (Sandbank *et al.*, 2022). In India, it represents 27.7% of female cancers, with survival rates plummeting from 93.3% in Stage I to 24.5% in Stage IV (Sathishkumar *et al.*, 2022). Socioeconomic disparities, limited healthcare access, and delayed diagnoses exacerbate mortality, necessitating urgent innovations in early detection and treatment (Mehrotra and Yadav, 2022). Artificial Intelligence (AI) has emerged as a pivotal tool in oncology, revolutionizing diagnostics through automated image analysis, risk prediction, and personalized treatment planning. AI-driven imaging modalities-such as mammography, ultrasound, and histopathological analysis-enhance diagnostic accuracy while reducing human error (Rodriguez-Ruiz *et al.*, 2019). For instance, Convolutional Neural Networks (CNNs) achieve 94.9% accuracy in detecting *cholangiocarcinoma*, demonstrating their clinical viability (Basile Njie *et al.*, 2023).

The present study conducts a scientometric analysis of 7,715 publications to evaluate trends, collaborations, and thematic shifts in AI applications for breast cancer. Objectives include assessing publication growth and global contributions, identifying key authors, institutions, and journals, mapping keyword evolution and research networks, and highlighting gaps and future directions. This analysis aims to guide policymakers, clinicians, and researchers in optimizing AI integration for equitable and efficient breast cancer management.

REVIEW OF LITERATURE

The integration of Artificial Intelligence (AI) into breast cancer research has revolutionized diagnostic accuracy, risk prediction, and therapeutic strategies. This section synthesizes advancements,

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challenges, and global trends in AI-driven breast cancer studies, drawing insights from seminal works and recent publications.

AI in Diagnostic Imaging

AI's transformative role in breast imaging is well-established. Deep learning models, particularly Convolutional Neural Networks (CNNs), dominate this domain due to their ability to classify tumors in mammograms, ultrasounds, and histopathological images with over 90% accuracy (Uzun *et al.*, 2023). For instance, di *et al.* (2017) demonstrated AI's non-inferiority to radiologists in mammography analysis, reducing false negatives by 22.83%. Ultrasound imaging has also benefited from AI innovations (McKinney *et al.*, 2020; Nafissi *et al.* (2024) highlighted AI's ability to predict interval cancers through breast density measurements, while Oliver *et al.* (2024) emphasized deep learning's superiority over traditional methods in digital breast tomosynthesis, detecting subtle abnormalities often missed by human observers. The study further added, despite these advancements, challenges persist, including the lack of standardized datasets and potential biases in training data.

Predictive Analytics and Risk Assessment

Machine Learning (ML) algorithms excel in synthesizing genetic, clinical, and lifestyle data to predict breast cancer risk. The Breast Cancer Coimbra Dataset (BCCD) and Wisconsin Breast Cancer Dataset (WBCD) are pivotal in training ML models, with the U.S. leading in publication volume (Salod andSingh, 2020). AI tools like AICAD integrate genetic testing to identify high-risk individuals, enabling personalized screening protocols (Nafissi *et al.*, 2024). For example, AI-driven analysis of stromal tumor-infiltrating lymphocytes (sTILs) has improved prognostic accuracy in triple-negative breast cancer (Syed and Khan, 2022). However, ethical concerns, such as data privacy and algorithmic transparency, limit clinical adoption Alsharif (2023). Cautioned that biased training data could exacerbate healthcare disparities, particularly in low-resource settings.

Global Collaborations and Research Trends

Scientometric analyses reveal exponential growth in AI-cancer research, with a 12.7-fold increase in publications since 2013 (Zavereh *et al.*, 2024). The U.S., China, and Germany dominate contributions, driven by institutions like Harvard University (5.15% of publications) and the University of Toronto (4.80%) (Kocak *et al.*, 2024). Journals such as Cancers (2.76%) and IEEE Access (2.26%) serve as key dissemination platforms, reflecting the interdisciplinary nature of AI oncology research (Wu *et al.*, 2022). Correspondingly, Dastani *et al.* (2023) found that the USA, China, and Germany are the most active countries in AI-driven cancer research, focusing on pathology, diagnosis, cancer survival, and computer-aided detection, suggesting AI's potential for personalized therapies Xiao *et al.* (2024). Noted a shift toward digital health integration, advocating for AI's role in primary care and holistic cancer management.

Ethical and Technical Challenges

Despite AI's promise, technical barriers hinder scalability. For instance, Julian *et al.* (2024) found that artificial neural networks underperform in certain predictive tasks, underscoring the need for model optimization. Ethical dilemmas, including algorithmic bias and patient consent, further complicate implementation Freeman *et al.* (2021). Stressed that opaque "black-box" models erode clinician trust, advocating for interpretable AI frameworks.

Future Directions

The future of AI in breast cancer lies in multi-modal data fusion, standardized evaluation protocols, and clinician-AI collaboration Shen *et al.* (2022). Proposed integrating histopathological, genomic, and radiomic data to enhance predictive accuracy. Similarly Kocak *et al.* (2024), highlighted radiomics and clinicomics as emerging frontiers. Efforts to democratize AI access, particularly in low-income regions, are critical. Researchers emphasize the need for open-source platforms and equitable partnerships to bridge global healthcare disparities (Mehrotra and Yadav, 2022).

Objectives of the Study

- To analyze publication trends and growth patterns in AI-based breast cancer research.
- To evaluate citation metrics and impact assessment of AI studies in oncology.
- To examine keyword trends and thematic evolution in AI-driven breast cancer diagnostics.
- To assess authorship patterns and collaboration networks in AI oncology research.
- To visualize research networks and intellectual structures shaping AI applications in breast cancer.

METHODOLOGY

The research landscape from 1991 to 2024 is examined using bibliometric analysis and a dataset of 7,715 documents from 1,350 books, journals, and other academic publications. The analysis assesses theme advancements, authorship collaborations, citation patterns, and publishing trends. The dataset shows a steady increase in research production with an annual growth rate of 8.5%. A Web of Science database provided the data, ensuring a comprehensive and excellent data collection. The documents' average of 5.51 years shows how current and important the research contributions are. According to citation analysis, the influence and interconnectedness of research in this field are shown by the average of 25.33 citations per document, or 215,082

references. 11,796 Author Keywords (DE) and 7,594 Keywords Plus (ID) were analyzed for keyword analysis in order to identify emerging problems and core research areas. Two hundred thirty-eight contributing single-authored papers out of 38,022 writers were subjected to an authorship analysis. According to collaboration measures, a single author has 262 publications, and each document had an average of 6.78 co-authors, demonstrating strong collaborative efforts.

Additionally, international co-authorship was present in 27.7% of the research publications, demonstrating global scientific collaboration. Using programs like VOSViewer and Biblioshiny, the study applies bibliometric approaches such as co-word analysis, co-authorship networks, and citation mapping. These approaches make it easier to visualize conceptual frameworks, track research development, and identify ground breaking works. By identifying potential directions for further scholarly investigation, examining these indicators provides important insights into the evolution and impact of research in the field.

RESULTS

Data Analysis

This research covers from 1991 to 2024 as shown in Table 1. A yearly growth rate of 8.5% indicates a consistent rise in research output during this period. The data analysis ensures a wide variety of academic contributions, including research papers from 1,350 sources, including books and journals, etc., and an overall total of 7,715 research publications.

The data comprises recent research, crucial for current trends, as seen by the documents' average of 5.51 years. An average of 25.33 citations are given to each document, indicating a high degree of influence and effect throughout the academic community. The data includes 215082 references, demonstrating the background material's breadth and the investigation's depth.

Analysis of Research Distribution

Figure 1 shows the links between nations, authors, and research keywords, with the United States having the largest share. The diagram also lists several authors connected to their respective nations and research areas, with few having multiple affiliations. Popular terms like "breast," "cancer," and "aromatase" emphasize biological and medical research, particularly in oncology and endocrinology. The complex network of relationships between authors and keywords demonstrates the multidisciplinary nature of research, highlighting how scholars contribute to various subjects. The diagram's layout demonstrates international research cooperation, important contributors, and the main ideas, highlighting the significant contributions made by particular nations and writers to advancing these subjects' research (Figure 1).

Distribution of Publications by Year

The number of articles published annually and their research contribution to the total (7,715 articles) are shown in Table 2. The number of publications produced annually increased gradually between 1991 and 2005. 2006 saw the start of a notable increase, which was followed by notable spikes in 2016 and 2017 and exponential growth starting in 2018. The most significant growth occurs between 2019 and 2024, when the number of articles increases significantly, reaching a peak of 1,552 in 2024 (20.12% of the total).

Sources of Publications

Table 3 lists the top 10 sources contributing to research publications, with "Cancers" having the most publications at 2.76%. Breast Cancer Research and Treatment is the most important, followed by "Cancers" at 2.46%. IEEE Access, with 2.26%, emphasizes computational and technical research, while "Scientific Reports" and "Frontiers in Oncology" have 2.09% and 2.07% respectively. Biomedical Signal Processing and Control, "Diagnostics," "Computers in Biology and Medicine," and "Journal of Clinical Oncology" highlight the importance of clinical trials and research focused on breast cancer.

Most Influential Authors

An overview of the most productive authors is given in Table 4, which is ranked by the percentage of papers they have contributed. The most publications (33, or 0.43%) belong to Henry, N. Lynn, who is closely followed by Stearns, Vered (29, or 0.38%) and

Table 1: Sample Size.

Description	Results
Main Information About Data	
Timespan	1991:2024
Sources (Journals, Books, etc)	1350
Documents	7715
Annual Growth Rate %	8.5
Document Average Age	5.51
Average citations per doc	25.33
References	215082
Document Contents	
Keywords Plus (ID)	7594
Author's Keywords (DE)	11796
Authors	
Authors	38022
Authors of single-authored docs	238
Authors Collaboration	
Single-authored docs	262
Co-Authors per Doc	6.78
International co-authorships %	27.7

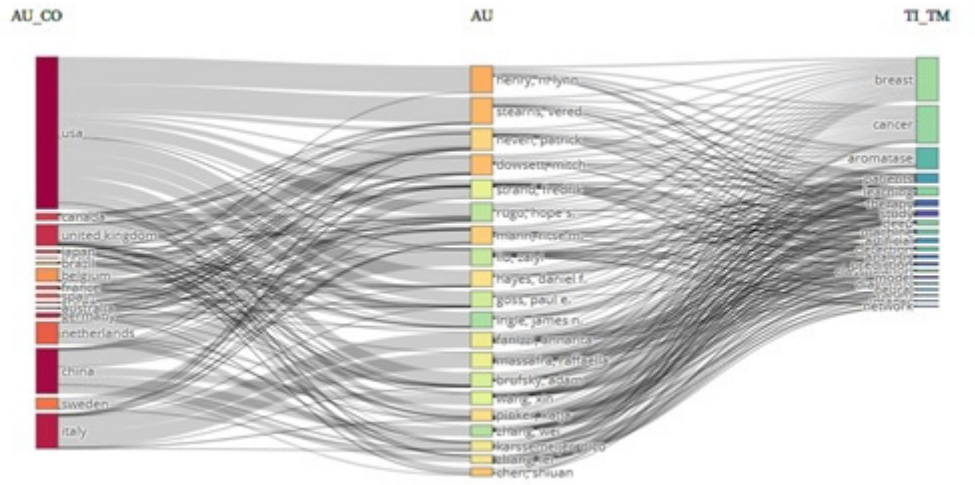

Figure 1: Diagram Representing Title, Author, and Country.

Dowsett, Mitch (27, or 0.35), all of whom have made important contributions to the field. These writers' existence suggests that they play a significant role in the field of study, especially in clinical and medical studies.

Major Contributing Institutions

The top affiliations that contribute to research publications are ranked in Table 5, with their respective article counts and percentages. Harvard University has the most publications (397, or 5.15% of the total), followed by the University of Toronto (370, or 4.80%) and the University of Texas System (352, or 4.56%), both of which exhibit high levels of research productivity. These universities are acknowledged for their superiority in scientific, technical, and medical research, strengthening their position as leaders in scholarly contributions.

Geographical Distribution of Authors

The Figure 2 shows documents published by researchers from different nations, with China having the most documents, indicating a preference for indigenous research. The USA follows, showing greater global cooperation. India, the UK, and Korea also contribute significantly, with SCPs outnumbering MCPs. European nations like Germany, France, and the Netherlands have a stronger propensity for international cooperation. Emerging research countries with a preponderance of single-country publications show lower overall publication counts.

Highly Cited Articles

Table 6 lists the most cited research papers according to both their average number of citations annually and their overall number of citations. The highest citation occurred in 1845. The most influential paper was written by Babak Ehteshami (2017) and published in JAMA. Kourou K's (2015) study in Computational and Structural Biotechnology came in second place with 1678 citations, highlighting its long-term impact on computational and biomedical research.

Emerging Research Trends

Figure 3 shows a trend analysis of research topics from 1992-2024, showing an upward trend in terms of artificial intelligence, neural networks, breast cancer, tumor angiogenesis, and genomic hybridization. This indicates a growing interest in scientific study in various fields, with publications on topics like artificial intelligence and healthcare demonstrating the convergence of technology and healthcare.

Collaborative Authorship Network

A co-authorship network visualisation is shown in Figure 4. The connections between the nodes indicate co-authorship links, each representing an author. Each node's size reflects the author's research contribution, publications, and various research communities or collaborative organisations.

This network shows Chen, Shiua, and Henry, N. Lynn as key players in a big red cluster, indicating that they have worked with several co-authors regularly. Li, Hui, Liu, Zaiyi, Li, Jing, Zheng, Yuanjie, and Wang, Tao are also included in this cluster, demonstrating a robust research network.

Co-Citation Network

Figure 5 shows the density of co-citations in scholarly literature, with bright yellow regions indicating high citation frequencies, green sections indicating moderate levels, and blue or dark purple areas indicating lesser densities. The most frequently co-cited reference is a bright yellow zone, indicating its central role in the study. Green-yellow regions contribute significantly to the network, despite having a lower frequency. The graphic also shows an organized clustering pattern, with high-impact

biomedical and cancer research journals in a sizable cluster, and a smaller cluster on the right, indicating distinct study areas.

Keyword Clustering Analysis

The research trends on breast cancer are analyzed using a term co-occurrence network visualization as mentioned in Figure 6. The core cluster focuses on breast cancer, involving machine learning, computer-aided diagnosis, and segmentation in medical image analysis. Treatment methods cluster includes tamoxifen, letrozole, and adjuvant endocrine therapy, with research on hormone therapy and drug resistance. The biological and molecular mechanisms cluster focuses on immunotherapy, genomics, and personalized medicine strategies for treating breast cancer. The network also emphasizes risk factors and patient treatment, focusing on patient outcomes, public health issues, and inequities in the diagnosis and treatment of breast cancer. The network highlights the importance of understanding and addressing these issues to improve patient outcomes and improve public health outcomes.

Co-Occurrence Analysis

Figure 7 displays a visualization of study terms, highlighting various themes. The green cluster highlights the role of hormone therapy in breast cancer treatment, focusing on aromatase inhibitors and their effects. The blue cluster explores molecular biology, genetics, and processes contributing to breast cancer development, using terms like gene expression, cellular reactions, and molecular interactions. The red cluster highlights the importance of artificial intelligence and computational techniques in cancer detection and treatment, with keywords like learning, computer, and histopathological image. The yellow cluster highlights research on data integration and cancer diagnostics, connecting AI-based studies with practical applications. The real-world use of AI in healthcare contexts is highlighted by keywords like reader, data system, and interval cancer. The use of NAC (neoadjuvant chemotherapy) suggests that artificial intelligence is applied to therapy personalization and treatment response prediction. Bibliometric analysis suggests that academics also assess the effects of artificial intelligence and other developments in the field.

Thematic Analysis

The strategic diagram in Figure 8 categorizes research themes based on their centrality and density. Motor themes, such as mammography, deep learning, and classification, focus on AI-powered diagnostic methods for breast cancer identification. Core themes, such as breast cancer, *breast neoplasms*, and chemotherapy, are central to oncological research and are essential for understanding disease progression and treatment. Niche themes, like tamoxifen and aromatase inhibitors, are advanced but less relevant to the field. These treatments are essential for certain patient subgroups, particularly those with hormone receptor-positive breast cancer. The lower left quadrant represents developing or decreasing themes, with apoptosis indicating a shift in research focus towards more sophisticated therapeutic approaches. The diagram's four quadrants reflect the field's maturity and research priorities.

Table 2: Yearly Publications.

Year	Articles	%
1991	3	0.04
1992	5	0.06
1993	3	0.04
1994	10	0.13
1995	13	0.17
1996	15	0.19
1997	27	0.35
1998	23	0.30
1999	25	0.32
2000	26	0.34
2001	22	0.29
2002	35	0.45
2003	35	0.45
2004	38	0.49
2005	49	0.64
2006	83	1.08
2007	65	0.84
2008	86	1.11
2009	73	0.95
2010	92	1.19
2011	101	1.31
2012	104	1.35
2013	135	1.75
2014	124	1.61
2015	125	1.62
2016	152	1.97
2017	190	2.46
2018	257	3.33
2019	404	5.24
2020	592	7.67
2021	788	10.21
2022	1130	14.65
2023	1285	16.66
2024	1600	20.74
Total	7715	100.00

Table 3: **Distribution of Publications by Source.**

Sl. No.	Sources	Articles	%
1.	Cancers	213	2.76
2.	Breast Cancer Research and Treatment	190	2.46
3.	IEEE Access	174	2.26
4.	Scientific Reports	161	2.09
5.	Frontiers in Oncology	160	2.07
6.	Diagnostics	138	1.79
7.	Biomedical Signal Processing and Control	105	1.36
8.	Computers in Biology and Medicine	105	1.36
9.	Journal of Clinical Oncology	95	1.23
10.	Breast	84	1.09

Table 4: **Leading Authors with Highest Publications.**

Sl. No.	Authors	Articles	%
1.	Henry, N. Lynn	33	0.43
2.	Stearns, Vered	29	0.38
3.	Dowsett, Mitch	27	0.35
4.	Chen, Shiuan	25	0.32
5.	Mann, Ritse M.	24	0.31
6.	Neven, Patrick	23	0.30
7.	Pinker, Katja	22	0.29
8.	Hayes, Daniel F.	21	0.27
9.	Zhang, Lei	21	0.27
10.	Karssemeijer, Nico	20	0.26

Table 5: **Institutions with Highest Research Contributions.**

Sl. No.	Institutions	Articles	%
1.	Harvard University	397	5.15
2.	University of Toronto	370	4.80
3.	University of Texas System	352	4.5.6
4.	Unicancer	332	4.30
5.	University of California System	280	3.63
6.	Pennsylvania Commonwealth System of Higher Education (PCSHE)	233	3.02
7.	Egyptian Knowledge Bank (EKB)	228	2.96
8.	University of London	212	2.75
9.	Chinese academy of sciences	210	2.72
10.	University of Pittsburgh	195	2.53

LIMITATIONS

This study has several limitations that should be considered when interpreting the findings. First, the analysis is based solely on data retrieved from the Web of Science database, which may not comprehensively cover all relevant publications, particularly those indexed in other databases such as Scopus, PubMed, or Google Scholar. As a result, some relevant studies may have been excluded.

Second, the dataset is limited to 7,715 publications published between 1991 and 2024. Although this represents a substantial body of literature, it may not fully capture the most recent developments or emerging research trends, especially for the latest year where indexing may still be incomplete.

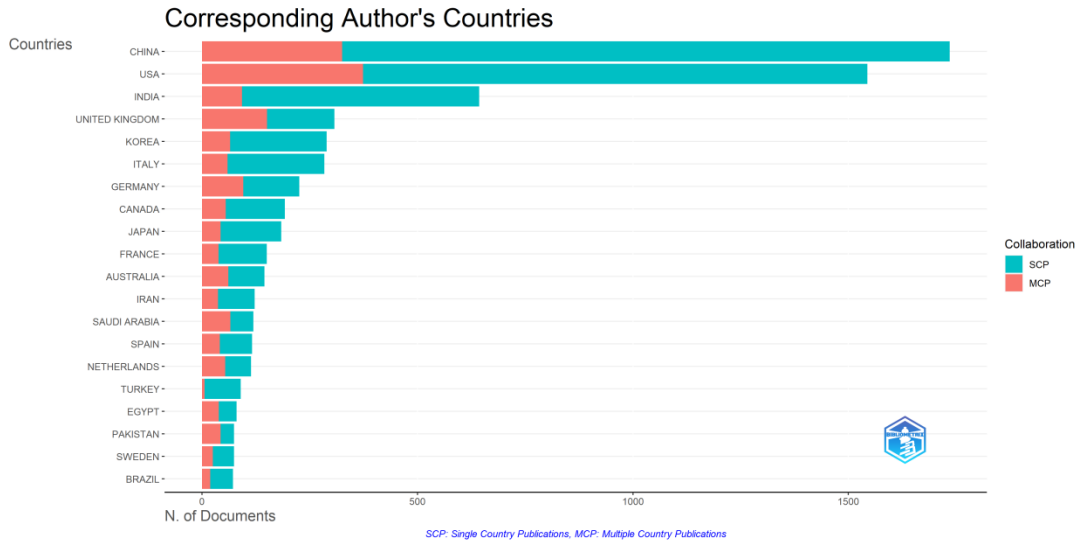

Figure 2: Countries Represented by Authors.

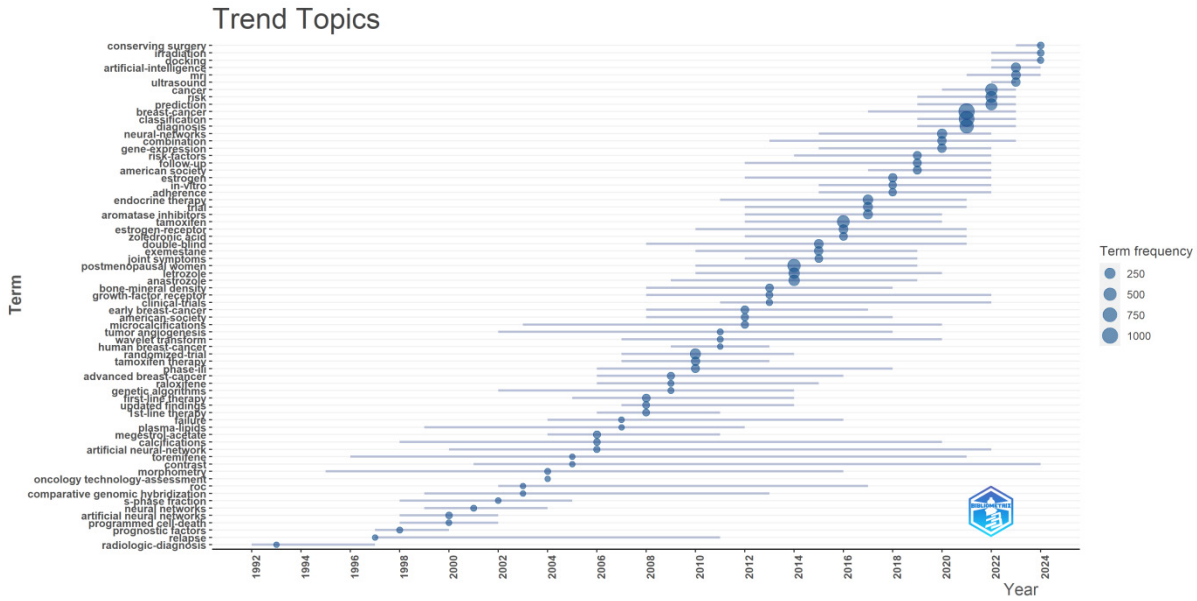

Figure 3: Trending Research Areas.

Table 6: **Most Referenced Articles.**

Sl. No.	Paper	DOI	Total Citations	TC per Year
1.	di BE, 2017, JAMA -J Am Med Assoc	10.1001/jama.2017.14585	1845	205.00
2.	Kourou K, 2015, Comput Struct Biotec	10.1016/j.csbj.2014.11.005	1678	152.55
3.	Mckinney SM, 2020, Nature	10.1038/s41586-019-1799-6	1337	222.83
4.	Desantis CE, 2017, CA-Cancer J Clin	10.3322/caac.21412	1225	136.11
5.	Katzman JL, 2018, BMC Med Res Methodol	10.1186/s12874-018-0482-1	892	111.50
6.	Spanhol FA, 2016, IEEE Bio-Med Eng	10.1109/TBME.2015.2496264	853	85.30
7.	Bera K, 2019, Nat Rev Clin Oncol	10.1038/s41571-019-0252-y	755	107.86
8.	Litjens G, 2016, Sci Rep-UK	10.1038/srep26286	680	68.00
9.	Delen D, 2005, Artif Intell Med	10.1016/j.artmed.2004.07.002	659	31.38
10.	Kooi T, 2017, Med Image Anal	10.1016/j.media.2016.07.007	655	72.78

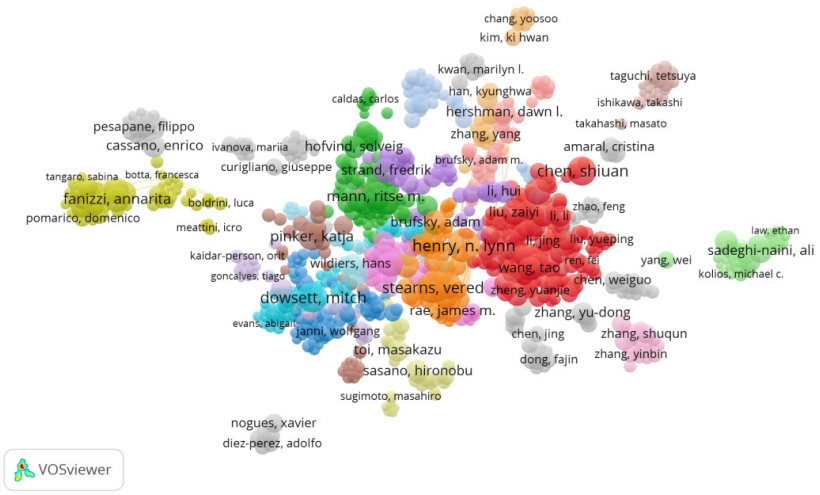

Figure 4: Co-Authorship Analysis.

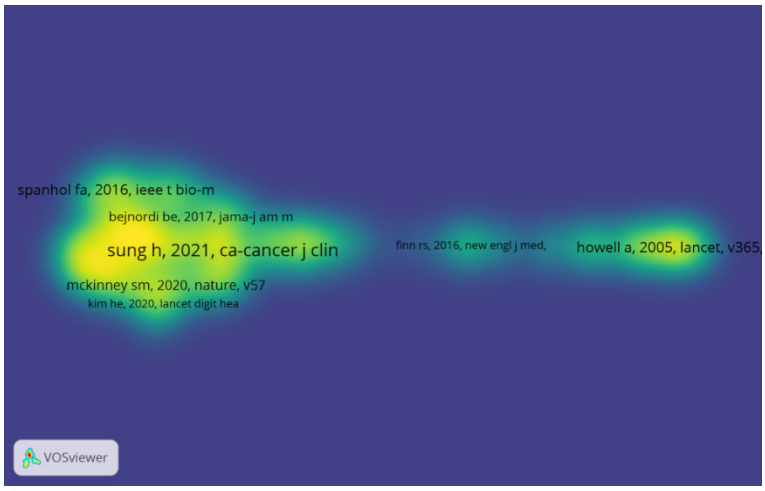

Figure 5: Visualization of Co-Citation.

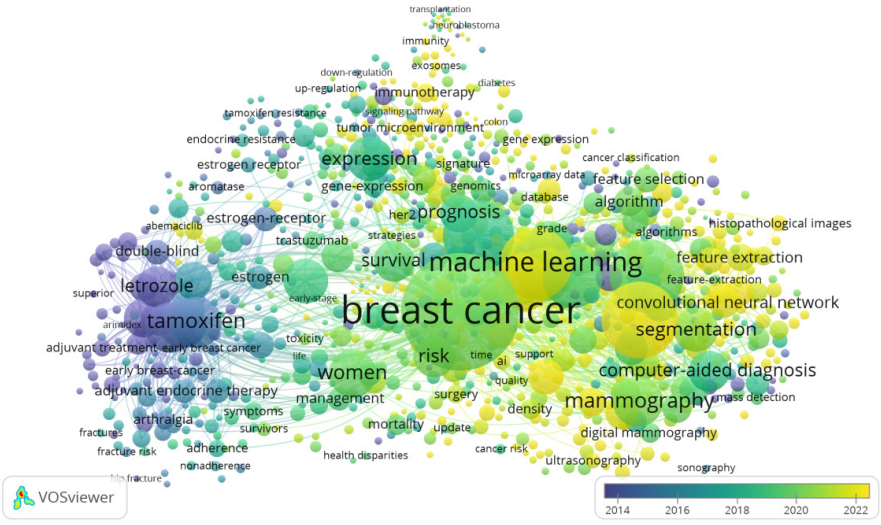

Figure 6: Keyword Cluster Visualization.

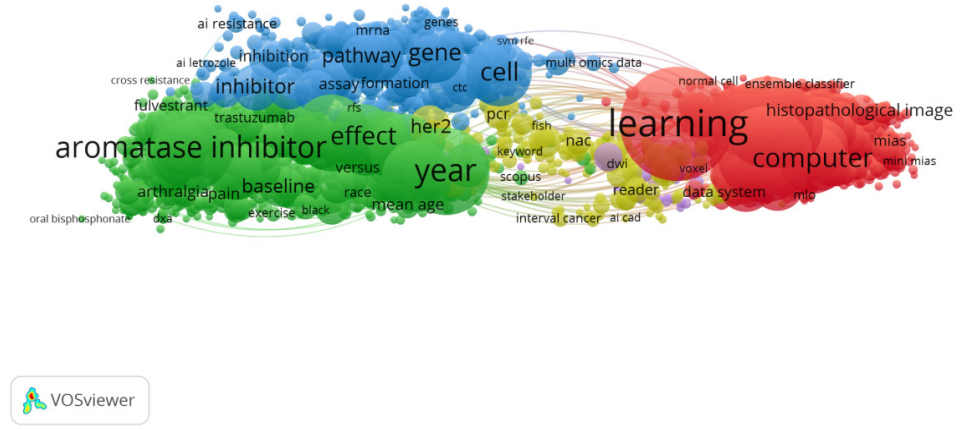

Figure 7: Visualization of Co-Occurrence.

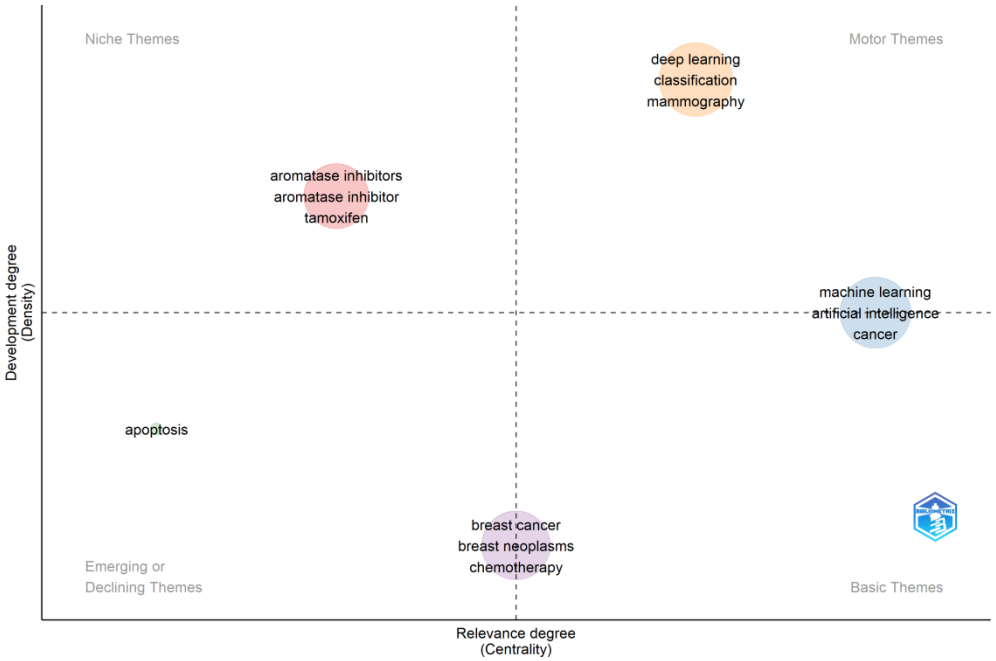

Figure 8: Evaluation of Research Themes.

Third, the study relies on bibliometric and scientometric indicators, which primarily measure publication and citation patterns rather than the qualitative impact or clinical effectiveness of artificial intelligence applications in breast cancer.

Fourth, the analysis depends on the accuracy of metadata (e.g., author names, affiliations, keywords) provided in the database, which may contain inconsistencies or errors that could influence the results.

Finally, no external validation or experimental verification of findings was conducted, as the study is based on secondary data analysis. Therefore, the conclusions should be interpreted as indicative of research trends rather than definitive evidence of clinical outcomes.

CONCLUSION

The integration of AI in breast cancer research has significantly transformed diagnostic and therapeutic approaches, offering improved accuracy, efficiency, and personalized treatment

options. AI-driven technologies, particularly deep learning and machine learning models, have enhanced cancer detection through advanced imaging and histopathological analysis. Scientometric analysis reveals a growing trend in AI research, with increasing global collaborations and contributions from leading institutions. Despite challenges such as data privacy, algorithmic biases, and standardization issues, AI continues to show promise in revolutionizing breast cancer care. Future research must focus on developing equitable AI frameworks, enhancing interdisciplinary collaborations, and addressing ethical concerns to optimize AI's impact in oncology. By leveraging AI's potential, the medical community can improve breast cancer prognosis, reduce mortality rates, and enhance patient outcomes.

ABBREVIATIONS

AI: Artificial Intelligence; **WoS:** Web of Science; **CNN:** Convolutional Neural Networks; **ML:** Machine Learning; **BCCD:** Breast Cancer Coimbra Dataset; **WBCD:** Wisconsin Breast Cancer Dataset; **sTILs:** Stromal Tumor-Infiltrating Lymphocytes; **SCP:** Single Country Publication; **MCP:** Multiple Country Publication; **DOI:** Digital Object Identifier; **TC:** Total Citations; **JAMA:** Journal of the American Medical Association; **NAC:** Neoadjuvant Chemotherapy.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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