

# Breast cancer detection and diagnosis using artificial intelligence<sup>1</sup>

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**Paper 1 / <sup>2</sup> Deep Learning for Breast Cancer Diagnosis: A Bibliometric Analysis and Future Prospects**

This paper performs a bibliometric analysis of deep learning applications in the diagnosis of breast cancer by analyzing 4797 publications indexed from 2019 to 2023 using the Scopus database. It highlights main trends, key publications, and contributing regions; the most extensive research outputs have been produced by China, the U.S., and India. Applications of DL in various medical image modalities were found, mainly in mammography, with research growing at about 35% every year.

Major contributors came from the Chinese Academy of Sciences and the University of Pittsburgh, while the funding also came largely from Chinese and U.S. institutions.

Notwithstanding these hopeful advances, the paper remarks that access to research is not equal for poor countries. The authors further indicate that research into DL ought to be extended globally, with a real clinical focus in an effort to make the diagnostics with DL fairer and more applicable in various healthcare settings.

**Paper 2 / Early Detection of Breast Cancer Using AI on MRI Scans**

The work described in this paper represents a deep-learning risk model leveraging CNNs to predict breast cancer up to a year in advance among high-risk patients. Trained on 3,029 MRI scans, the model outlines areas where early reevaluation is required. The AUC for the developed model was 0.72, using 10-fold cross-validation.

These findings indicate that the AI model detected 30% of cancers a year earlier with 90% specificity for the top 10% high-risk cases. Radiologists confirmed the model's prediction visually in 57% of cases where cancers were actually present on earlier MRIs. While the model seems promising clinically, the sensitivity is low and thus indicates refinement with larger datasets could be even more supportive for the radiologists in earlier detection.

**Paper 3 / <sup>4</sup> Detection and Diagnosis of Breast Cancer Using RetinaNet on DCE-MRI Images**

The present study investigates the diagnostic value of an AI system based on the RetinaNet model-the state-of-the-art object detection technique-for recognizing and diagnosing breast lesions using MIP images from DCE-MRI. This system was tested against the performance of four radiologists, each working independently, using a dataset with 30 normal cases, 49 benign cases, and 135 malignant cases; diagnostic accuracy, sensitivity, and specificity were measured.

This corresponds to an AUC of 0.925 by the AI model, compared with an AUC of 0.884 generated without any AI support by human readers. Radiologists' AUC was 0.899 with AI assistance, which also highlights the potential of AI for augmenting human diagnostic performance. This study has its limitation in single-center data and no cross-validation, hence it may affect the generalization aspect. The AI model is promising for assisting radiologists, though it needs wider validation to ensure clinical effectiveness.

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#### Paper 4 / Artificial intelligence-based diagnosis of breast cancer by mammography microcalcification

The objective of this study was to develop an AI system that detects and characterizes microcalcifications in mammography as potential early malignancy. For the record, the use of Faster R-CNN and FPNNet deep learning models studied 4,810 mammograms with the goal of distinguishing between benign and malignant calcification and characterizing additional features, including estrogen receptor status.

Our model attained the ability to reach an accuracy of 0.7237 in benign-malignant differentiation, where AUC was 0.8042, with a sensitivity of 0.7778 in malignancy detection. However, it has to be underlined that limited classification regarding pathological subtypes was achieved. That is probably due to the imbalance in sample numbers. Despite promising test performances, high false-positive rates hint toward the need for refinement in order not to cause unnecessary follow-ups and overdiagnosis.

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#### Paper 5 / Artificial Intelligence for Breast Cancer Detection: Technology, Challenges, and Opportunities

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The current review focuses on the role of AI in breast cancer detection with a focus on DM and DBT. Comparisons between the different advances in DL, in contrast to traditional computer-aided detection, are discussed together with barriers like data standardization, regulatory approval, and bias that exist in these data, which slow down clinical adoption.

While DL-based AI systems have demonstrated increasing value in improving diagnostic precision, relieving workload for radiologists, and reducing false negatives, two pivotal barriers to their wide applicability concern the lack of standard datasets and clinical validation. This paper calls for standardized guidelines and calls for collaboration among clinicians, researchers, and regulatory agencies if such challenges are to be overcome and AI implementation is to be advanced in breast cancer screening.

#### Paper 6/ Applying Artificial Intelligence in Breast Cancer Diagnosis and Prognosis Prediction

This review details recent uses of AI in diagnosis and prognosis, specifically in radiomics and deep learning applied to the area of breast cancer. It offers a focus on the prediction by AI in estimating cancer risk, diagnosing malignancy, and response to treatments by exploring correlations between imaging features and tumor biology. The synthesis herein involves different imaging modalities like mammography, ultrasound, and MRI.

They also showed promise for AI models in improving diagnostic accuracy and the prediction of treatment response, often outperforming traditional CAD models. However, formidable challenges remain in data standardization, model interpretability, and clinical validation. Large clinical trials that bridge research findings to real-world translation are thus called for in this review, hinting at the promise of AI in promoting personalized care for breast cancer.

## **Critical Analysis**

What is being realized from these six studies is the trend toward the development of diagnosing breast cancer with artificial intelligence; most of these studies used either deep learning-based or radiomics-based AI methodologies applied to mammography, MRI, or other imaging modalities. The breakdown of methodological approaches and strengths and weaknesses found across these studies follows in the next lines of this article.

Overall, these six articles have contributed together to emphasize the transformational role of AI in both detecting and prognosticating breast cancer, with significant contributions from the two most visible approaches in DL and radiomics. However, they also highlighted several critical challenges regarding methodologies and applications. The important strengths involve the potential ability of AI to enhance diagnosis accuracy, particularly for complex imaging modalities, whereas the weaknesses include issues concerning data standardization, generalizability, and real-world validation. The interdisciplinary collaboration and the use of multi-modal approaches are convergent themes, whereas sensitivity and specificity, radiomics and DL, and fair access to validated AI models create discord. Such issues will have to be discussed if AI is to find a successful place within clinical care for breast cancer.

## **Connections:**

**AI's Potential in Early Detection:** All the studies strongly put forward that AI, more so the deep learning models, have a role in early detection through the identification of subtle imaging features that may not be visible by radiologists easily. This potential to enhance early detection corresponds with the objectives of better prognosis and reduction of mortality rates due to breast cancer.

**Interdisciplinary and Multi-Modal Approaches:** Each paper highly stresses the benefits of merging radiomics with DL and more traditional CAD systems. Multi-modality imaging (a combination of mammography with MRI or DBT) indeed is likely to show enhanced diagnostic performance, which may indicate that multimodal models can result in more complete and accurate diagnostic SATANISM: Although there are methodological differences, all studies find the same message about the real need of robust clinical trials and validation with a view to taking AI models from research into clinical practice, pointing to one common awareness of the gap between the efficacy, as studied in the laboratory, and real-world applicability.

## **Conflicts:**

**Sensitivity vs. Specificity:** One major conflict in results is always between high sensitivity-that means, detection of all possible cancers-and holding specificity high, meaning low false positives. For example, AI models using CNNs show high sensitivity but often offer too many false positives, which could result in overtreatment and anxiety for the patient. On the contrary, those models inclined toward specificity may miss early or minimal cancer signs, thus delaying diagnosis.

**Radiomics vs. Deep Learning:** Results with respect to the performance of radiomics in contrast to DL are very disparate. While radiomics-based models guarantee interpretability and robustness of the identified image-based features regarding tumor biology, DL models represent the group of "black-box" approaches characterized by higher accuracy and low interpretability. This opens a very critical debate concerning this issue of interpretability versus accuracy, especially in clinical applications where comprehension of AI decisions is particularly important.

**Equity in Model Training and Generalizability:** A common tension throughout these studies is that there is a fine balance between the promise of AI in diagnostics for breast cancer with the limitation brought about by single-institution, homogenous datasets. There is a difference between model performance that can be observed in highly controlled research settings and what is expected in diverse clinical settings-particularly for underrepresented populations. There is, therefore, a need for broader datasets and validation efforts so these AI tools will be equitable in their performance across varied patient demographics.

| 2 | Study                                                                                             | Year | RDK  | Key Findings/Results                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Methodology                                                                                                                                                                                                                                                                                                                                   | Limitations                                                                                                                                                                                                                                                                                                                                                                                     |
|---|---------------------------------------------------------------------------------------------------|------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|   | Deep learning for breast cancer diagnosis: A bibliometric analysis and future research directions | 2024 | Book | The research on DL in the diagnosis of breast cancer is growing at an annual growth rate of 35%. In current research, the common technique used is imaging, and the modality most in use is mammography.                                                                                                                                                                                                                                                                                                                                 | through a bibliometric analysis that investigates 4,797 articles taken from the Scopus database for data between 2019 and 2023. The paper maps out the trends, major journals, and contributors to the DL research field in the diagnosis of breast cancer with regard to funding sources, institutional collaboration, and regional outputs. | These include the database bias of relying solely on Scopus for data, while relevant research indexed in either PubMed or Web of Science could have been excluded. The nature of the study, being descriptive, does not allow for in-depth analysis into specific deep learning models or applications; hence, it cannot address practical clinical challenges.                                 |
| 9 | Early Detection of Breast Cancer in MRI Using AI                                                  | 2024 | Book | A review of the top 10% high-risk cases for the AI model showed that the model found 30% of cancers a year in advance with 90% specificity. For a subset of cancers, radiologists confirmed that 83 of 115 cancers could be visibly seen on prior-year MRIs and location predictions from the model matched 57% of cancer cases. Although sensitivity for the AI system was limited, it did indicate possible areas for early re-evaluation, hence providing some potential clinical benefits if optimized further with larger datasets. | For this, a CNN-based AI model was developed and trained using a retrospective dataset of 3,029 MRI scans, including high-risk and cancer-positive cases. Later, this model was validated using 10-fold cross-validation to measure AUC and identify regions that needed early reevaluation for cancer risk.                                  | Poor model sensitivity may be due to the overall smaller size of the dataset and also single-source in origin. Besides, using retrospective data which is not generalizable to real-world patients may fail to capture the real-world variability. This high specificity but mediocre sensitivity renders its application not fully useful in widespread screening without tuning of the model. |

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| <p>3</p> <p>Detection and Diagnosis of Breast Cancer Using Artificial Intelligence Based Assessment of Maximum Intensity Projection Dynamic Contrast-Enhanced Magnetic Resonance Images</p> | 2020 | Article | <p>8</p> <p>The AI system attained an AUC of 0.925, outperforming human readers without AI support at 0.884 and with AI support at 0.899. Sensitivity and specificity were also higher for the AI system than for human readers. AI enhanced the performance of human readers, emphasizing the clinical utility that could be derived from AI in the diagnosis of breast lesions on DCE-MRI. Critical Analysis</p> | <p>It is a deep learning model, RetinaNet, whose main aim is to elucidate MIP images obtained from DCE-MRI in terms of malignancy classification. The performance comparisons are based on those of human radiologists regarding sensitivity, specificity, and AUC metrics in a dataset involving benign and malignant cases.</p>                                                                  | <p>These include a single-center dataset without cross-validation, which may limit the generalisability. A simplified MIP DCE-MRI approach instead of full DCE-MRI could reduce the diagnostic comprehensiveness of this model. Apart from this, real-world validation will become necessary to understand how well the model performs outside controlled study conditions.</p>                                                                                  |
| <p>10</p> <p>Artificial intelligence-based diagnosis of breast cancer by mammography microcalcification</p>                                                                                 | 2023 | Article | <p>For the classification in the test set for benign and malignant cases, an overall accuracy of 0.7237 with an AUC of 0.8042 was achieved, with its sensitivity as high as 0.7778 in the detection of malignancies. However, the pathological type and ER status classification, due to inherent sample imbalance and molecular-level problems, resulted in lower accuracy. Critical Analysis.</p>                | <p>Faster R-CNN and FPNNet constitute the frameworks used in this paper for mammography image analysis, focusing on the detection and classification of microcalcifications into malignancy. After aggregating data from a multi-center dataset, the model was trained to classify calcifications into benign or malignant and further predict other pathological variables such as ER status.</p> | <p>Although the model was highly sensitive, it also showed a high false positive rate that could lead to overdiagnosis. For some subtypes, such as ER status, their classification tasks were a little unsatisfactory due to the limited number of positive samples. Although this research adopted multi-center data, there could still be some problems concerning the generalization of this model due to the large difference in quality among different</p> |

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|                                                                                                 |      |      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                          | mammography devices and institutions.                                                                                                                                                                                                                                  |
| 1<br>Artificial Intelligence for breast cancer detection: Technology, challenges, and prospects | 2024 | Book | DL-based AI systems significantly enhanced their detection performance, hence enabling them to take part of the workload from radiologists by outlining subtle abnormalities while at the same time reducing false-negative rates. However, challenges such as non-standardized datasets and a lack of sufficient clinical validation have created difficulties that must be overcome before more general acceptance of the technology can be achieved. This review then points out that there is an urgent need for guidelines with which AI systems will be fair, traceable, and robust. | A critical review of various research on different deep learning models juxtaposed against traditional CAD systems focuses on their application in DM and DBT, identifying major trends-data standardization-and challenges-like regulatory concerns-that have impacts on the translation of AI into a clinical setting. | the review is based on retrospective data, thus limiting insights into real-world application. Whereas challenges are discussed in general, without providing solutions for particular models or practices; this reduces the immediate clinical relevance of the work. |

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|------------------------------------------------------------------------------------------------------------------|------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5<br>Applying artificial intelligence technology to assist with breast cancer diagnosis and prognosis prediction | 2022 | Book | breast cancer, machine<br>The AI models have shown very promising results regarding improvement in diagnostic accuracy and prediction of treatment response. Most of the DL models outperform conventional CAD systems. Radiomic features provided important information regarding tumor physiology, such as vascular characteristics, which improved the risk profile assessment and diagnostic precision. However, data heterogeneity and inter-institutional inconsistencies are some critical challenges that certainly hamper the use of these models in routine clinical practice. | This review intends to discuss recent advances in AI applied to the risk prediction of breast cancer, classification of malignancy, and response to treatment based on radiomics and deep learning. It discusses interrelationships of image-based features versus tumor microenvironment for predicting clinical outcomes by gathering data from mammography, ultrasound, and MRI studies. | Most of the data reviewed herein is retrospective in nature; thus, generalizing into clinical use is limited. While the paper points to some of the challenges facing the studies, such as standardization of data and model interpretability, it does not recount strategies to deal with them. The findings also remain theoretical, without prospective validation for real-world practical implementation in the real world. |
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