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Application of AI in detection of breast cancer with laboratory results monitoring

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Abstract

Breast cancer is one of the most common types of cancer among women worldwide, therefore an early and precise process of diagnostics plays an important role in improving the prognosis and outcome of treatment. The application of artificial intelligence (AI) allows faster and more precise analysis of medical imaging, which contributes to the early detection of tumors and lowers the number of false-negative results. This review article analyzed 60 scientific papers and using the most recent findings about this topic, searched for AI implementation in breast cancer research and how AI may improve overall survival outcomes for breast cancer patients.

Keywords: Breast cancer; Artificial intelligence; Oncology; Diagnostics; Early detection

1. Introduction

Breast cancer is a significant health concern that affects many people globally, especially women. It is a complex process that can have profound physical, emotional, and social impacts on patients and their families. Understanding the various facets of breast cancer including risk factors and treatment options, is crucial in promoting early detection and improving outcomes of women diagnosed with breast cancer [1, 2].

The prevalence of breast cancer underscores the importance of awareness and education about this disease. According to the World Health Organization (WHO), breast cancer is the most common cancer among women worldwide, with an estimated 2.3 million new cases diagnosed and 670.000 deaths in 2022 alone. These statistics highlight the urgency of addressing breast cancer as a public health priority so strategies to reduce its burden on individuals and healthcare systems can be developed [3].

1.1. Breast cancer risk factors and symptoms

Risk factors for breast cancer can be divided in three groups including: genetic predisposition, hormonal influences and lifestyle choices with age being a primary factor as the risk increases with advancing age. Some of other factors are: family history, obesity, alcohol consumption, smoking etc. Understanding these risk factors can help individuals make informed decisions about their health and potentially reduce their risk of developing the disease [4]. In the terms of symptoms, breast cancer can start as a lump or mass in the breast, but also include changes in the size or shape of the breast, nipple discharge, or skin changes such as redness or dimpling [5]. It is very important for individuals to be aware of signs and symptoms and promptly seek medical help if they notice any unusual changes in their breasts [6, 7].

1.2. Breast cancer diagnosis and treatment

By increasing awareness and understanding of breast cancer, as well as embracing technological advancements such as application of AI in detection and diagnosis, we can empower individuals to take proactive steps towards prevention, early detection, and effective management of this complex disease [7, 8]. Diagnosis of breast cancer usually involves a combination of screening tests, such as mammograms and biopsies, which are used to confirm the presence of cancerous cells. Early detection through regular screenings can significantly improve treatment outcomes and prognosis for individuals diagnosed with breast cancer [9].
Treatment options for breast cancer vary depending on the type and stage of cancer but it often includes surgery, chemotherapy, radiation therapy, and hormone therapy. Multidisciplinary approaches involving healthcare professionals from various specialties are commonly used to provide comprehensive care for patients with breast cancer [10-12].

1.3. AI in detection of breast cancer

In recent years, the application of AI in detection of breast cancer has shown promising results. AI algorithms can analyze mammograms and other imaging studies with high degree of accuracy, with big potential aiding in the early detection of breast cancer and decision making. One of the primary applications of AI in breast cancer detection is in the analysis of mammography images, although it can also be used for other techniques like MRI or PET-CT [13].

1.3.1. Use of AI for breast cancer detection in imaging techniques

Artificial intelligence (AI) has emerged as a game-changer in the field of healthcare, particularly in the detection and diagnosis of breast cancer. By integrating AI into imaging techniques, medical professionals have gained a powerful tool that enhances the accuracy, efficiency, and effectiveness of detecting breast cancer at various stages. AI algorithms are trained on large datasets to recognize subtle patterns and abnormalities that may indicate the presence of cancerous lesions [14, 15].

1.3.2. AI in detecting breast cancer biomarkers

Artificial intelligence (AI) is playing a critical role in advancing the identification and analysis of biomarkers and tumor markers in the laboratory setting for breast cancer research including biochemical and molecular biomarkers [16, 17]. Biomarkers are biological indicators that can be measured to assess the presence or progression of a disease, while tumor markers are specific proteins or other substances produced by tumor cells that can be detected in blood or tissue samples [18, 19]. AI algorithms are being employed to analyze vast amounts of data from genomic sequencing, proteomic profiling, and other high-throughput technologies to identify novel biomarkers and tumor markers associated with breast cancer [20, 21].

1.3.3. Correlation between Vitamin D and breast cancer

Studies have explored the potential correlation between vitamin D levels and breast cancer risk. Vitamin D is believed to have anti-cancer properties and play a role in regulating cell growth, which may impact the development and progression of breast cancer [22, 23].
Some research suggests that higher levels of vitamin D could be associated with a lower risk of developing breast cancer. Findings have been mixed, with some studies showing no significant link between vitamin D levels and breast cancer risk [24-26]. It's important to note that while the relationship vitamin D and breast cancer is an area of ongoing research, maintaining adequate vitamin D levels through sunlight exposure, diet, and supplementation is still considered beneficial for overall health [27, 28].

It's always advisable to consult with a healthcare provider for personalized advice on optimizing your vitamin D intake and to discuss your individual risk factors for breast cancer [29, 30].

1.3.4. Correlation between calcium, phosphorus and osteoporosis with breast cancer

The intricate relationship between essential minerals like phosphorus and calcium and their impact on health conditions such as osteoporosis and breast cancer present a complex interplay that continues to be a subject of scientific investigation and clinical interest [31, 32].

Phosphorus, a vital component in various cellular functions and signaling pathways, has been implicated in promoting cell proliferation, a hallmark of cancer development. Elevated phosphorus levels in the body may contribute to cellular changes that could potentially influence breast cancer risk [33, 34].

2. Research method

This research has been conducted as a review article using the data from 60 scientific papers in June 2024. Inclusion criteria were papers which were up to 8 years old and published mainly few years ago in English with one paper from 2009 which was included because of its significance. Papers were usually published in database PubMed and in many recognized and global journals which are found in this database in June 2024. Studies which were included had the newest data related to the novel technologies and innovations in the field of early detection of breast cancer with artificial intelligence. This research utilized randomized samples, and the studies themselves were selected randomly after excluding some based-on inclusion and exclusion criteria. This approach minimized the possibility of bias and enhanced representativeness during data synthesis.

3. Results

AI is very useful in medical applications including detecting tumors with using convolution neural networks (CNN) which can sometimes detect the importance in decision making much faster than human eye. CNN, or Convolutional Neural Networks, have shown promising results in detecting breast cancer through the analysis of medical images such as mammograms [35]. CNNs are a type of deep learning algorithm that is particularly well-suited for image recognition tasks. When applied to medical imaging, CNNs can analyze large sets of mammograms and identify patterns indicative of breast cancer, such as tumors or suspicious masses. This can help radiologists and healthcare professionals in detecting breast cancer at an early stage and making life-changing decisions when treatment is most effective [9].

Advancements in artificial intelligence (AI) techniques have revolutionized the field of imaging technologies, particularly in the detection and diagnosis of breast cancer. From traditional methods like mammography to more recent innovations such as computer-aided detection (CAD) systems AI is playing a crucial role in improving the accuracy and efficiency of breast cancer screening. One of the AI techniques used in imaging technologies for detecting breast cancer is deep learning. Deep learning algorithms are capable of analyzing large amounts of medical imaging data, such as mammograms, MRIs, and ultrasounds, to identify patterns and anomalies that may indicate the presence of cancerous tumors. These algorithms can learn from vast datasets and continually improve their performance over time, making them valuable tools for radiologists in interpreting complex imaging studies [35].

Another important application of AI in breast cancer detection is the development of CAD systems. CAD systems are designed to assist radiologists in interpreting medical images by highlighting suspicious areas that may require further attention. By leveraging AI algorithms, CAD systems can help radiologists to detect subtle abnormalities in breast tissue that may be indicative of early-stage breast cancer [36].

By assisting radiologists in interpreting mammograms, AI can improve the detection of early-stage tumors and reduce the occurrence of false positives and false negatives, ultimately leading to earlier interventions and improved patient outcomes. Furthermore, AI is revolutionizing the interpretation of breast MRI and ultrasound images [13]. In addition to enhancing diagnostic capabilities, AI also plays a crucial role in assessing a patient's risk of developing breast cancer. AI models can predict the likelihood of malignancy and help healthcare professionals tailor screening and prevention strategies based on individual risk profiles. This personalized approach to risk assessment enables more targeted interventions and improved patient care. Moreover, AI-powered imaging techniques facilitate image-guided biopsies with higher precision and accuracy. By analyzing imaging data in real-time, AI systems assist clinicians in identifying suspicious areas for biopsy, optimizing the biopsy process and minimizing unnecessary procedures. This not only enhances diagnostic confidence but also reduces patient discomfort and anxiety associated with invasive procedures. Furthermore, AI contributes to personalized treatment planning by analyzing imaging data and other patient-specific information. By considering individual characteristics and treatment responses, AI algorithms help healthcare providers tailor treatment plans to the unique needs of each patient, optimizing therapeutic outcomes and minimizing potential side effects [9].

Additionally, deep learning algorithms are being used in laboratory monitoring to analyze complex imaging and pathology data associated with breast cancer. AI can be used to analyze laboratory data and biomarkers and improve their use in early diagnostics and prediction of treatment and prognosis of women who have breast cancer. The use of artificial intelligence (AI) and biomarkers in breast cancer research and diagnosis represents a significant advancement in the field of oncology [37].

By training deep learning models on high-resolution images of breast tissue samples, radiologists and pathologists can gain more accurate and detailed insights into the presence of cancerous lesions, tumor characteristics, and disease progression (38-40). This advanced imaging analysis can help guide treatment decisions and monitor response to therapy in real-time [18].

AI techniques, such as machine learning and deep learning, combined with the identification of specific biomarkers, are revolutionizing the way breast cancer is detected, diagnosed, and treated [13].

Machine learning is a key AI technique used in monitoring breast cancer. By training algorithms on large datasets of laboratory test results, genetic profiles, and other biomarkers, machine-learning models can predict a patient's risk of developing breast cancer and identify specific subtypes of the disease. These predictive models can help clinicians tailor treatment plans based on individual patient characteristics, leading to more targeted and personalized care [10].

Another important AI technique in laboratory monitoring of breast cancer is natural language processing (NLP). NLP algorithms can extract and analyze text-based data from medical reports, research papers, and other sources to uncover valuable insights related to breast cancer diagnosis, progression, and treatment outcomes. NLP can help researchers and healthcare providers stay up-to-date on the latest advancements in breast cancer research and ensure that patients receive the most current and effective treatments [38].

Biomarkers play a crucial role in breast cancer diagnosis and management by providing information about the presence, severity, and progression of the disease. Biomarkers can be genetic, molecular, or biochemical characteristics that are associated with breast cancer development or progression. When AI is combined with biomarker analysis, researchers can leverage the power of machine learning to identify novel biomarkers that were previously unknown or underutilized [39, 40].

These can detect subtle patterns and correlations within complex datasets that may not be immediately apparent to human researchers, leading to the discovery of new molecular signatures for early detection, prognosis, and treatment response prediction [41].

By integrating multiple types of data, such as genomic, transcriptomic, and proteomic profiles, AI systems can identify potential biomarkers that signal the presence of breast cancer and indicate the aggressiveness of the disease. AI can also play a significant role in interpreting the clinical significance of biomarkers and tumor markers by analyzing their associations with patient outcomes and treatment responses. This information can help healthcare providers in predicting disease progression, monitoring treatment efficacy, and adjusting therapeutic strategies over time [42, 43].

AI has shown promising potential in the detection of human epidermal growth factor receptor 2 (HER2), a protein overexpressed in some breast cancers. By utilizing machine learning algorithms, AI technologies can analyze histopathological images and genetic data to assist in the identification and characterization of HER2-positive tumors through the analysis of immunohistochemical (IHC) staining patterns in tissue samples [44].

Machine learning algorithms can be trained on large datasets of annotated images to accurately classify HER2 staining intensity levels, helping pathologists determine the HER2 status of a tumor. This automated approach not only speeds up the diagnostic process but also reduces the potential for human error and variability in interpretation [45].

Ki-67 is a protein marker that is commonly used in assessing the proliferation of cancer cells, including in breast cancer. expression level of Ki-67 is a significant prognostic indicator in determining the aggressiveness of tumors and guiding treatment decisions [46].

One common approach to train AI models on large datasets of histopathological images that have been annotated with Ki-67 expression levels. These models can learn to recognize and quantify the percentage of Ki-67-positive cells in tumor samples, providing valuable information about the tumor's proliferative activity. AI can also be used to identify spatial patterns of Ki-67 expression within the tumor, which may offer insights into tumor heterogeneity and help stratify patients for tailored treatment strategies [47].

Machine learning-based assessment of tumor-infiltrating lymphocytes (TILs in breast cancer is a promising approach to characterizing the immune response within the tumor microenvironment. TILs play a crucial role in the body's immune defense against cancer and their presence has been linked to better outcomes in certain types of breast cancer. AI algorithms can be trained on histopathological images of breast cancer tissue samples to automatically quantify and classify TILs. By analyzing the spatial distribution and density of TILs within the tumor, machine-learning models can provide valuable insights into the immune profile of the tumor and its potential impact on disease progression and response to treatment [48].

One common method used in machine learning-based assessment of TILs is image segmentation, where AI algorithms delineate regions of interest corresponding to TILs in tissue slides. By distinguishing TILs from other cell types and structures, machine learning models can quantify the percentage of TILs present in the tumor, as well as assess their spatial organization and relationship to other tumor features [49].

Artificial Intelligence-based mitosis scoring in breast cancer is a cutting-edge approach that utilizes advanced algorithms to automate the assessment of mitotic activity in tumor samples. Mitosis scoring plays a crucial role in determining the aggressiveness of breast cancer, as it reflects the rate of cell division and proliferation within the tumor. By leveraging machine learning and deep learning techniques, AI models can be trained on large datasets of histopathological images to accurately identify and count mitotic figures in breast cancer tissue samples. These algorithms can learn to distinguish mitotic cells from non-mitotic cells based on morphological features, allowing for a more precise and objective evaluation of mitotic activity. One of the key advantages of AI-based mitosis scoring is its ability to analyze a large number of tumor cells rapidly and consistently, making it a valuable tool for pathologists in assessing the grade and prognosis of breast cancer. Automated mitosis scoring using AI can reduce inter-observer variability and improve the reproducibility of results, ultimately leading to more reliable diagnostic and treatment decisions [50].

Research has brought attention to a potential relationship between vitamin D levels and breast cancer risk, sparking interest in the role of this essential nutrient in cancer prevention and management [25].

Vitamin D is known for its diverse functions in the body, including its involvement in cell growth regulation and immune system modulation. It has been suggested that adequate levels of vitamin D may exert protective effects against breast cancer by influencing various biological pathways involved in cancer development. Multiple studies have investigated the association between vitamin D status and breast cancer risk, with some findings that higher levels of vitamin D could be linked to a reduced risk of developing breast [28].

The mechanisms behind potential protective effect are complex, as vitamin D is believed to play a role in inhibiting tumor growth, promoting healthy cell differentiation, and modulating inflammatory responses that could contribute to carcinogenesis. However, the relationship between vitamin D and breast cancer risk is not yet fully understood, and research outcomes have been inconsistent. Some studies have reported no significant correlation between vitamin D levels and breast cancer risk, highlighting the need for further investigation and exploration of potential confounding factors that may influence these outcomes [30].

The intricate relationship between essential minerals like phosphorus and calcium and their impact on health conditions such as osteoporosis and breast cancer presents a complex interplay that continues to be a subject of scientific investigation and clinical interest [51].

Osteoporosis, characterized by reduced bone density and increased fracture risk, is closely linked to the balance of phosphorus and calcium in the body [52, 53].

Calcium is a fundamental mineral vital for bone strength and integrity. When calcium levels are inadequate, the body may leach calcium from the bones, leading to bone deterioration and the onset of osteoporosis. Phosphorus, working synergistically with calcium, plays a key role in the formation of hydroxyapatite crystals essential for bone structure. Imbalances in phosphorus levels can disrupt bone mineralization processes, contributing to bone loss and osteoporosis development. Thus, maintaining a harmonious equilibrium of phosphorus and calcium is crucial for preserving optimal bone health and preventing osteoporosis [54].

The relationship between phosphorus, calcium, and breast cancer risk is an area of ongoing research and scientific inquiry. Phosphorus, a vital component in various cellular functions and signaling pathways has been implicated in promoting cell proliferation, a hallmark of cancer development. Elevated phosphorus levels in the body may contribute to cellular changes that could potentially influence breast cancer risk. On the other hand, calcium has been investigated for its potential anti-cancer properties, with studies suggesting that adequate calcium intake may help regulate cell growth, differentiation, and programmed cell death, all of which are significant factors in cancer prevention. Understanding the complex interplay between phosphorus, calcium, and health conditions like osteoporosis and breast cancer underscores the importance of maintaining balanced and nutritious diet rich in essential minerals. Dietary choices that support optimal phosphorus and calcium levels can have profound implications for bone health and potentially influence the risk of developing certain health conditions. Collaboration with healthcare professionals, including nutrition experts, can offer tailored guidance on how to optimize nutrient intake to support bone health, overall wellness, and potentially mitigate the risk of osteoporosis and breast cancer. As research continues to expand our comprehension of the intricate connections between these essential minerals and health outcomes, emphasizing the significance of a well-rounded diet and lifestyle that prioritizes phosphorus and calcium balance emerges as a pivotal strategy for promoting long-term health and vitality [55].

4. Discussion

One of the key advantages of using CNNs in breast cancer detection is their ability to learn and adapt from large datasets. By training the CNN on a diverse set of mammogram images with known diagnoses, the network can learn to recognize subtle patterns and features that may not be easily detectable by human observers. This can potentially lead to more accurate and reliable detection of breast cancer. However, it's important to note that while CNNs show promise in breast cancer detection, they are not meant to replace human radiologists or healthcare providers. These AI algorithms should be used as a tool to assist medical professionals in interpreting images and making diagnoses, rather than making autonomous decisions. Additionally, further research and validation studies are needed to ensure the reliability and generalizability of CNNs in the context of breast cancer detection [9].

By integrating AI algorithms with biomarker data, scientists can develop more accurate diagnostic tools, prognostic models, and treatment strategies for breast cancer patients. Furthermore, the integration of AI and biomarkers in breast cancer research can lead to the development of personalized medicine approaches. By identifying specific biomarkers that are unique to individual patients, healthcare providers can tailor treatments to target the molecular characteristics of each patient's tumor, leading to more effective and targeted therapies. Overall, the use of AI in conjunction with biomarker analysis is transforming the way breast cancer is understood and managed. By leveraging these advanced technologies, researchers and healthcare providers can improve early detection and decision making, develop more precise diagnostic tools, and personalize treatment strategies for patients with breast cancer. This innovative approach has the potential to significantly impact patient outcomes and contribute to the advancement of breast cancer research and care [10-12].

Artificial intelligence (AI) techniques have significantly advanced laboratory monitoring for cancer, and healthcare professionals with powerful tools to aid in early detection, diagnosis, and treatment. Various AI techniques are being used in laboratory settings to analyze and help interpretation of molecular, genetic, and pathological data related to cancer, allowing for personalized and effective patient care [35, 36].

Convolutional Neural Networks (CNNs) undergo a rigorous training process involving intricate technical procedures to facilitate feature extraction and model optimization. This process commences with data preprocessing to standardize and enrich the dataset for improved learning capabilities. Key components, such as convolutional layers for feature extraction and pooling layers for data reduction, are pivotal in extracting salient features. Activation functions, particularly Rectified Linear Units (ReLU), introduce necessary non-linearity to enable the model to grasp intricate patterns effectively. Backpropagation emerges as a fundamental technique for computing gradients and adjusting model weights iteratively, thus enhancing model performance through optimization. Selecting an apt loss function to evaluate model predictions against actual labels is paramount to monitore training progress. Epoch after epoch, the model refines its weights based on calculated gradients, with optimization algorithms like Stochastic Gradient Descent fine-tuning this process. These deliberate steps in model training, executed with precision and expertise, empower machine learning professionals to craft robust CNNs tailored for tasks ranging from image recognition to natural language processing [56].

Successful clinical implementations of CNN in breast medical image classification can be identified by evaluating the performance metrics achieved. In the following sentences, we will note a few successful implementations based on the performance metrics. Jiao et al. from China achieved a high accuracy of 96.7% and utilized CNN architecture along with preprocessing techniques like normalization and data augmentation. Arevalo et al. from Columbia demonstrated an AUC of 82.2% by using CNN along with specific preprocessing strategies like cropping and contrast normalization. Sun et al. from Texas, USA achieved an accuracy of 82.43% and an AUC of 88.18% through CNN models integrated with feature extraction, data weighing, and labeling techniques. These examples showcase successful clinical implementations of CNN in breast medical image classification, as they have shown high accuracy rates and strong performance metrics in terms of AUC values. These results indicate the potential effectiveness of CNN models in assisting with breast cancer diagnosis and classification in clinical settings [56]. There should be more studies that emphasize the valuable role of AI in healthcare and outline the challenges involved in its integration. In a study conducted by Mennella et al. it is proven that AI shows promising results in improving medical care, but addressing issues such as regulatory approval, standardization, training, and ethical considerations are crucial for successful implementation. The study highlights the need for collaboration in overcoming obstacles and recognizing the potential of AI in enhancing medical diagnosis, patient care, and administrative efficiency. Despite advancements, challenges related to data security, privacy, and understanding human emotions remain important considerations in the journey toward widespread AI adoption in healthcare [57]. In another study conducted by Harishbhai Tilala et al. it is concluded that by addressing issues such as data privacy and security, algorithmic bias, transparency, clinical validation, and professional responsibility, healthcare stakeholders can navigate the ethical complexities surrounding AI and ML integration in health care while safeguarding patient welfare and upholding the principles of beneficence, non-maleficence, autonomy, and justice. By embracing ethical best practices and fostering collaboration across interdisciplinary teams, the healthcare community can harness the full potential of AI and ML technologies to usher in a new era of personalized data-driven healthcare that prioritizes patient well-being and equity [58]. There are other challenges and limitations in implementing AI in the current healthcare system. Some of them are that if the dataset used in the research paper is very large, a sea of computation and time is needed to complete the training. On the other hand, if the dataset used in the research paper is very small, it could cause an overfitting problem. Most of the breast cancer diagnosis models are based on CNN. Therefore, we need to be sure which layer has the best feature or which layer of features we should extract, which creates new challenges and problems. For the segmentation of breast cancer based on CNN, there are some limitations. These methods selected public datasets for experiments. However, these public datasets need many expert doctors to label these images. Moreover, the application of unsupervised learning technology in the segmentation of breast cancer ibreast cancer diagnosis models based on CNN is not very good [59]. Convolutional Neural Networks (CNNs) are powerful tools used in various applications, but they come with biases and limitations that can impact their effectiveness. These factors include biases in training data, overfitting, limited interpretability, computational complexity, data efficiency challenges, susceptibility to adversarial attacks, limited robustness to variability, and dependency on architecture and hyperparameters. Addressing these issues requires careful consideration of data quality, interpretability, robustness testing, and ongoing research efforts to enhance CNN models' reliability and mitigate potential shortcomings in their deployment. To overcome the limitations and biases of Convolutional Neural Networks (CNNs a strategic approach encompassing various best practices can be employed. Ensuring training data is diverse and representative, utilizing techniques like data augmentation and regularization, implementing fairness-aware training methods, embracing interpretability and explainability, conducting robustness testing, prioritizing ethical considerations, establishing monitoring feedback loops, and encouraging collaboration and diversity in AI development teams are essential steps. By integrating these strategies, practitioners can work towards building more robust, fair, and reliable CNN algorithms that mitigate biases and limitations, ultimately leading to the development of ethical and impactful AI systems [60].

5. Conclusions

The use of AI algorithms, particularly CNNs, enables the processing of complex medical data, including genetic information and imaging studies, to sometimes identify patterns and correlations that may not be easily discernible by human observers and make decision making easier. The integration of AI in imaging techniques for breast cancer detection represents a significant leap forward in healthcare. Continued research and development in this field will further drive innovation and progress in the fight against breast cancer. The integration of AI with biomarker analysis allows for the discovery of novel biomarkers that can provide valuable insights into the development and progression of breast cancer. By identifying specific biomarkers that are unique to each patient, healthcare providers can deliver more targeted and effective treatments, ultimately improving patient outcomes and quality of care. The application of AI in the study of biomarkers and tumor markers in breast cancer research is driving innovation and accelerating discoveries in the field.

In the future, researchers can try more unlabeled data sets for breast cancer detection as goals for the advancement of AI research for medical applications. Compared with labeled datasets, unlabeled datasets are less expensive and more numerous. What’s more, researchers can try more new methods for image feature extraction, such as EL, TL, xDNNs, U-Net, transformer, and so on. Although breast cancer diagnosis technology based on CNN has achieved great success and can be used as an auxiliary means to help doctors diagnose breast cancer, there is still much to be improved such as cost-effectiveness, sensitivity and specificity, reliability and making people trust in this new technology etc. By harnessing the power of deep learning, CAD systems, machine learning, and other AI tools, healthcare providers can improve the accuracy, efficiency, and effectiveness of breast cancer screening programs, ultimately leading to better outcomes for patients.

The connection between vitamin D and breast cancer risk continues to be an area of scientific interest, embracing a holistic approach to health that includes adequate vitamin D intake, along with other lifestyle factors like a balanced diet, regular exercise, and proactive health monitoring, can contribute to a comprehensive strategy for promoting breast health and potentially reducing cancer risk. The same scientific interest is about other minerals connected with this disease like phosphorus and calcium. In conclusion, breast cancer remains a pressing health issue that requires continuous research, advocacy, and support to improve outcomes for individuals affected by the disease.

Declaration of competing interest

The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.

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Author contribution

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