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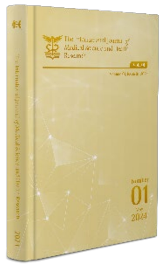

The Analysis Study of Diagnostic Performance and Accuracy of Mammography as Screening and Diagnostic of Breast Cancer: A Comprehensive Systematic Review

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ABSTRACT

Background: Breast cancer is the most commonly diagnosed cancer in women, excluding skin cancer, and the second leading cause of cancer death after lung cancer. Screening mammography, introduced in the mid-1970s, aimed to diagnose breast cancer at earlier stages and reduce disease-specific mortality. This systematic review aims to evaluate the diagnostic performance and accuracy of mammography as screening and diagnostic of breast cancer by analyzing available studies on literatures of the last 10 years. **Methods:** The study adhered to PRISMA 2020 standards, examining English literature from 2014 to 2024. It excluded editorials, reviews from the same journal, and submissions without a DOI. PubMed, SagePub, SpringerLink, and Google Scholar were utilized as literature sources. **Result:** Initially retrieving 360 articles from online databases (PubMed, SagePub, SpringerLink and Google Scholar) eight relevant papers were selected after three rounds of screening for full-text analysis. **Conclusion:** Mammography remains a cornerstone in breast cancer screening due to its high specificity and moderate sensitivity. However, the combination of mammography with other modalities such as MRI and ultrasound can enhance diagnostic performance.

Keywords: diagnostic mammography, breast cancer, diagnostic

INTRODUCTION

Breast cancer is the most commonly diagnosed cancer in women, excluding skin cancer, and the second leading cause of cancer death after lung cancer, with about 40,000 deaths annually. By 2012, breast cancer had affected nearly 2.7 million women, with an additional 234,190 diagnoses projected for 2015. The average woman's lifetime risk of developing breast cancer is 12.3%, but it can be as high as 85% for those with hereditary breast and ovarian cancer syndrome, though hereditary cases represent only 5-10% of patients.[1,2]

Screening mammography, introduced in the mid-1970s, aimed to diagnose breast cancer at earlier stages and reduce disease-specific mortality. Since 1990, breast cancer mortality has declined by nearly 40%, from 33.2 per 100,000 in 1988-1989 to 21.3 per 100,000 in 2012.[3] Five-year survival rates have improved from 75.2% in 1975 to 89.4% in 2007, attributed to better treatments and routine mammography screening. Mammography, with a sensitivity of 69-90% and a specificity of 94-97%, remains the most common and effective screening method, aiding in early diagnosis and mortality reduction.[4,5]

The American Cancer Society's recent review recommended annual screening mammography starting at age 40-44 (qualified recommendation), annually for ages 45-54 (strong recommendation), and transitioning to biennial or maintaining annual screening at age 55 and above (qualified recommendation). Screening should continue in older women with good overall health and a life expectancy of at least 10 years.[6,7]

Contrast-enhanced breast magnetic resonance imaging (breast MRI) is considered the best imaging modality for breast cancer detection and assessment, but it has high costs, long acquisition and reading times, and limited availability. Additionally, it is contraindicated for patients with claustrophobia, certain metal implants, or hypersensitivity to Gadolinium-based contrast agents.

Therefore, breast MRI is not the primary imaging modality and is reserved for specific patient populations.[8,9]

This systematic review aims to evaluate the diagnostic performance and accuracy of mammography as screening and diagnostic of breast cancer by analyzing available studies on literatures of the last 10 years.

METHODS

Protocol

The author carefully followed the rules laid out in the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020. This was done to make sure the study met all its standards. The selection of this methodological approach was specifically aimed at ensuring the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic to evaluate the diagnostic performance and accuracy of mammography as screening and diagnostic of breast cancer based on literatures of the last 10 years. This study meticulously analyzed data on literatures to provide insights and enhance patient treatment strategies. The primary objective of this paper is to highlight the collective significance of the identified key points.

Inclusion criteria for this study entail: 1) Papers must be in English, and 2) Papers must have been published between 2014 and 2024. Exclusion criteria comprise: 1) Editorials; 2) Submissions without a DOI; 3) Previously published review articles; and 4) Duplicate entries in journals.

Search Strategy

The keywords used for this research are diagnostic mammography, breast cancer, diagnostic. The Boolean MeSH keywords inputted on databases for this research are: *((("mammography"[MeSH Terms] OR "mammography"[All Fields] OR "mammographies"[All Fields] OR "mammography s"[All Fields]) AND ("breast neoplasms"[MeSH Terms]*

OR ("breast"[All Fields] AND "neoplasms"[All Fields]) OR "breast neoplasms"[All Fields] OR ("breast"[All Fields] AND "cancer"[All Fields]) OR "breast cancer"[All Fields]) AND ("diagnosis"[MeSH Terms] OR "diagnosis"[All Fields] OR "diagnostic"[All Fields] OR "diagnostical"[All Fields] OR "diagnostically"[All Fields] OR "diagnostics"[All Fields])) OR ("diagnosis"[MeSH Subheading] OR "diagnosis"[All Fields] OR "screening"[All Fields] OR "mass screening"[MeSH Terms] OR ("mass"[All Fields] AND "screening"[All Fields]) OR "mass screening"[All Fields] OR "early detection of cancer"[MeSH Terms] OR ("early"[All Fields] AND "detection"[All Fields] AND "cancer"[All Fields]) OR "early detection of cancer"[All Fields] OR "screen"[All Fields] OR "screenings"[All Fields] OR "screened"[All Fields] OR "screens"[All Fields])) AND ((y_10[Filter]) AND (clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter]) AND (fft[Filter]))

Data retrieval

The authors assessed the studies by reviewing their abstracts and titles to determine their eligibility, selecting relevant ones based on their adherence to the inclusion criteria, which aligned with the article's objectives. A consistent trend observed across multiple studies led to a conclusive result. The chosen submissions had to meet the eligibility criteria of being in English and a full-text.

This systematic review exclusively incorporated literature that met all predefined inclusion criteria and directly pertained to the investigated topic. Studies failing to meet these criteria were systematically excluded, and their findings were not considered. Subsequent analysis examined various details uncovered during the research process, including titles, authors, publication dates, locations, study methodologies, and parameters.

Quality Assessment and Data Synthesis

Each author independently evaluated the research presented in the title and abstract of the publication to determine which ones merited further exploration. The subsequent stage involved assessing all articles that met the predefined criteria for inclusion in the review. Decisions on including articles in the review were based on the findings uncovered during this evaluation process.

Table 1. Article Search Strategy

Database	**Strategi Pencarian**	***Hits***
Pubmed	*((("mammography"[MeSH Terms] OR "mammography"[All Fields] OR "mammographies"[All Fields] OR "mammography s"[All Fields]) AND ("breast neoplasms"[MeSH Terms] OR ("breast"[All Fields] AND "neoplasms"[All Fields]) OR "breast neoplasms"[All Fields] OR ("breast"[All Fields] AND "cancer"[All Fields]) OR "breast cancer"[All Fields]) AND ("diagnosis"[MeSH Terms] OR "diagnosis"[All Fields] OR "diagnostic"[All Fields] OR "diagnostical"[All Fields] OR "diagnostically"[All Fields] OR "diagnostics"[All Fields])) OR ("diagnosis"[MeSH Subheading] OR "diagnosis"[All Fields] OR "screening"[All Fields] OR "mass screening"[MeSH Terms] OR ("mass"[All Fields] AND "screening"[All Fields]) OR "mass screening"[All Fields] OR "early detection of cancer"[MeSH Terms] OR ("early"[All Fields] AND "detection"[All Fields] AND "cancer"[All Fields]) OR "early detection of cancer"[All Fields] OR "screen"[All Fields] OR "screenings"[All Fields] OR "screened"[All Fields] OR "screens"[All Fields])) AND ((y_10[Filter]) AND (clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter]) AND (fft[Filter]))*	100
Science Direct	*(((mammography) AND (breast cancer)) AND (diagnostic)) OR (screening)*	150
Sagepub	*(((mammography) AND (breast cancer)) AND (diagnostic)) OR (screening)*	50
Google Scholar	*(((mammography) AND (breast cancer)) AND (diagnostic)) OR (screening)*	160

Table 2. JBI *Critical appraisal of Study*

Parameters	Zeeshan (2018)	Sprague (2017)	Moon (2014)	Aristokli (2022)	Sumkin (2019)	Lehman (2015)	Lee (2016)	Badu-Peprah (2018)
1. Bias related to temporal precedence Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which variable comes first)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Bias related to selection and allocation Was there a control group?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Bias related to confounding factors Were participants included in any comparisons similar?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Bias related to administration of intervention/exposure Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	No.	No.	No.	No.	No.	No.	No.	No.
5. Bias related to assessment, detection, and measurement of the outcome Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were the outcomes of participants included in any comparisons measured in the same way?	No.	No.	No.	No.	No.	No.	No.	No.
Were outcomes measured in a reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

6. Bias related to participant retention Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Statistical conclusion validity Was appropriate statistical analysis used?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

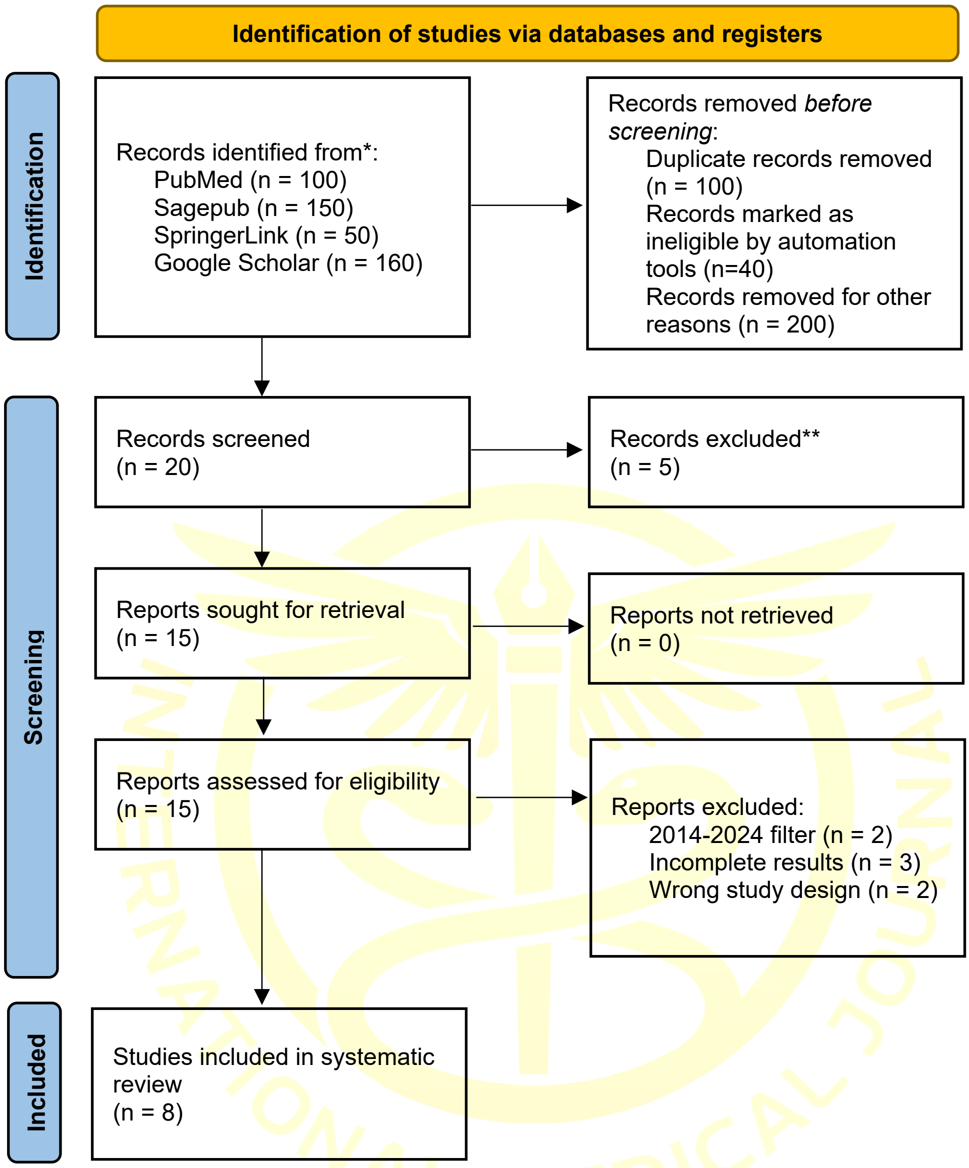

Figure 1. Article search flowchart

RESULT

The initial number of articles retrieved from online databases (PubMed, SagePub, SpringerLink, and Google Scholar) is 360 articles. After conducting three levels of screening, eight articles that directly relate to the current systematic review have been chosen for further assessment through full-text reading and analysis. Table 3 presents the selected literature included in this analysis.

Table 3. The literature included in this study

No.	Author	Origin	Method	Sample	Result
1.	Zeeshan, et al.[10] (2018)	Pakistan	Cross-sectional study	122 patients	The results of the study demonstrated that digital mammography is a highly accurate tool for breast cancer detection. The sensitivity of digital mammography was found to be 97%, and the specificity was 64.5%. Additionally, the positive predictive value was 89%, and the negative predictive value was 90.9%. The overall diagnostic accuracy of digital mammography was determined to be 89.3%.
2.	Sprague, et al.[11] (2017)	USA	Retrospective cohort study	265360 patients	The study evaluated the diagnostic performance of mammography and reported several key findings. The cancer detection rate was 34.7 per 1000 (95% CI: 34.1, 35.2), and the abnormal interpretation rate was 12.6% (95% CI: 12.5%, 12.7%). The positive predictive value (PPV) of a biopsy recommendation (PPV2) was found to be 27.5% (95% CI: 27.1%,

					27.9%), while the PPV of biopsies performed (PPV3) was 30.4% (95% CI: 29.9%, 30.9%). The false-negative rate was 4.8 per 1000 (95% CI: 4.6, 5.0). Sensitivity was calculated at 87.8% (95% CI: 87.3%, 88.4%), and specificity at 90.5% (95% CI: 90.4%, 90.6%).
3.	Moon, et al.[12] (2014)	South Korea	Retrospective cohort study	2005 patients	Mammography demonstrated superior performance in several key metrics compared to ultrasound. The specificity of mammography was 88.90% (95% CI: 87.93, 89.81), the accuracy was 88.85% (95% CI: 87.88, 89.76), and the positive predictive value (PPV) was 2.61% (95% CI: 1.39, 4.41). These values were significantly higher than the corresponding US values of 69.07% (95% CI: 66.99, 71.09) for specificity, 69.13% (95% CI: 67.05, 71.15) for accuracy, and 0.64% (95% CI: 0.18, 1.64) for PPV.
4.	Aristokli, et al.[13] (2022)	USA	Retrospective cohort study	2000 patients	The study evaluated the diagnostic performance of various imaging modalities for breast cancer detection. Mammography showed an overall sensitivity of 54.5% (range 27%–86.8%) and a specificity of 85.5% (range 62.9%–98.8%). In comparison, MRI demonstrated higher overall sensitivity at 94.6%

					(range 85.7%–100%) but lower specificity at 74.2% (range 25%–100%). Ultrasound had an overall sensitivity of 67.2% (range 26.9%–87.5%) and a specificity of 76.8% (range 18.8%–96.9%).
5.	Sumkin, et al.[14] (2019)	USA	Retrospective cohort study	102 patients	In a study involving 102 women (mean age 51 years, range 32–77 years), 99 participants completed the protocol. Of these, 71 women (79 index malignancies) underwent lumpectomy or mastectomy without neoadjuvant chemotherapy, while 28 women (31 index malignancies) had the procedures with neoadjuvant chemotherapy. Among the 110 index malignancies, MRI depicted 102 (93%; 95% CI: 86%, 97%), contrast-enhanced mammography (CEM) depicted 100 (91%; 95% CI: 84%, 96%), and molecular breast imaging (MBI) depicted 101 (92%; 95% CI: 85%, 96%).
6.	Lehman, et al.[15] (2015)	USA	Retrospective cohort study	323 973 patients	The study assessed the impact of computer-aided detection (CAD) on mammography screening performance. It found that the use of CAD did not improve any screening metrics. The sensitivity of mammography was 85.3% (95% CI: 83.6%-86.9%) with CAD and 87.3% (95% CI: 84.5%-89.7%) without

					CAD. Specificity was 91.6% (95% CI: 91.0%-92.2%) with CAD and 91.4% (95% CI: 90.6%-92.0%) without CAD. The cancer detection rate remained the same at 4.1 per 1000 women screened, regardless of CAD use. Additionally, CAD did not enhance intraradiologist performance. Sensitivity was significantly lower for mammograms interpreted with CAD compared to those interpreted without CAD by radiologists who used both methods (odds ratio, 0.53; 95% CI: 0.29-0.97).
7.	Lee, et al.[16] (2016)	South Korea	Retrospective cohort study	128,756 patients	In this study, 128,756 cases from 10 hospitals were analyzed from 2005 to 2010 to evaluate mammography screening performance. The recall rate was 19.1%, showing a significant downward trend of 12.1% per year (95% CI: -15.9 to -8.2). The cancer detection rate (CDR) was 2.69 per 1000 examinations, with no significant trend over time. The positive predictive value (PPV) was 1.4%, demonstrating a significant upward trend of 20.8% per year (95% CI: 15.2 to 26.7). The sensitivity of mammography was 86.5%, with no significant trend observed, while specificity was 81.1%, showing a

					significant upward trend of 3.3% per year (95% CI: 2.1 to 4.5).
8.	Badu-Peprah, et al.[17] (2018)	Ghana	Retrospective cohort study	103 patients	In this study, participants had a mean age of 55 years (±15 years). Among them, 52 individuals (50.5%) were found to have malignant lesions. The overall sensitivity of clinical diagnosis was 50.5%. In comparison, mammography showed an overall sensitivity of 73.0% and specificity of 80.0%. Ultrasound had an overall sensitivity of 100% and a specificity of 80.4%.

Zeeshan, et al.[10] (2018) showed that mammography is effective in detecting breast cancer. This study suggested replacing screen-film mammography with digital mammography for both screening and diagnostic purposes due to its high accuracy in breast cancer detection.

Sprague, et al.[11] (2017) showed that erformance metrics varied significantly across different diagnostic indications, with the highest cancer detection rate (64.5 per 1000) and abnormal interpretation rate (18.7%) observed in diagnostic mammograms obtained to evaluate breast problems with a lump. When compared to the screen-film mammography era, digital mammography showed increased abnormal interpretation and cancer detection rates, but decreased PPVs.

Moon, et al.[12] (2014 showed that while supplemental screening with ultrasound in mammographically negative breasts can detect additional carcinomas in women at average risk, it is not as effective as screening mammography. This is due to the lower cancer yield, invasive cancer yield, specificity, accuracy, and PPV, along with a higher short-term follow-up rate observed with ultrasound compared to mammography.

Aristokli, et al.[13] (2022) showed that as standalone modalities, MRI exhibited the highest sensitivity, while mammography had the lowest sensitivity regardless of breast type, density, and history. Combining different modalities, such as ultrasound with MRI or mammography with MRI, further increased sensitivity. Specificity varied based on the size and type of the tumor as well as the patient's history, with ultrasound alone showing the highest specificity when considering breast density.

Sumkin, et al.[14] (2019) showed that contrast-enhanced mammography (CEM), molecular breast imaging (MBI), and MRI all demonstrated similar detection rates for malignancies. However, MRI identified more nonindex suspicious benign lesions than CEM or MBI, leading to a lower positive predictive value for additional biopsies. All three modalities tended to overestimate the size of index tumors, with MRI showing the greatest degree of overestimation.

Lehman, et al.[15] (2015) showed that computer-aided detection does not improve the diagnostic accuracy of mammography. These findings suggest that the additional costs incurred by insurers for CAD do not provide a proven benefit to women undergoing mammography screening.

Lee, et al.[16] (2016) showed that the sensitivity and cancer detection rate (CDR) of screening mammography from 2005 to 2010 were similar to those reported for Western women. However, the recall rate, positive predictive value (PPV), and specificity were initially suboptimal but showed significant improvements over the study period. Further analysis is needed to explain the institutional variations in diagnostic accuracy.

Badu-Peprah, et al.[17] (2018) demonstrated that clinical diagnosis, ultrasound, and mammography each have potential in predicting breast cancer with significant sensitivity and specificity. Mammography and ultrasound, in particular, showed higher sensitivity and specificity compared to clinical diagnosis, highlighting their effectiveness in breast cancer detection.

DISCUSSION

This systematic review evaluates the diagnostic performance and accuracy of mammography as a tool for breast cancer screening and diagnosis, integrating findings from multiple studies conducted across various regions and years.

The study by Zeeshan et al. (2018) highlighted the high accuracy of digital mammography, with a sensitivity of 97% and specificity of 64.5%. This suggests that digital mammography is highly effective for breast cancer detection, particularly given its high sensitivity. The recommendation to replace screen-film mammography with digital mammography is supported by these findings due to the improved diagnostic accuracy and predictive values of digital mammography.[10]

In contrast, Sprague et al. (2017) provided a broader perspective on mammography performance in a large cohort. Their findings revealed a sensitivity of 87.8% and a specificity of 90.5%. While the cancer detection rate and abnormal interpretation rate were notable, the study highlighted that digital mammography showed increased detection rates but also decreased positive predictive values (PPVs) compared to the screen-film era. This underscores the importance of considering both the benefits and limitations of technological advancements in mammography.[11]

Moon et al. (2014) compared mammography with ultrasound, finding that while ultrasound could detect additional carcinomas in mammographically negative cases, mammography remained superior in terms of specificity and positive predictive value. This reinforces the value of mammography in screening, despite ultrasound's complementary role in certain diagnostic scenarios.[12]

Aristokli et al. (2022) evaluated mammography in conjunction with other imaging modalities and found that MRI had the highest sensitivity, whereas mammography alone had lower sensitivity but higher specificity. This highlights the role of mammography as a standard screening tool, while also emphasizing the benefits of combining it with MRI or ultrasound to improve overall diagnostic performance.[13]

Sumkin et al. (2019) reported similar detection rates for malignancies with contrast-enhanced mammography (CEM), molecular breast imaging (MBI), and MRI. However, MRI's tendency to overestimate tumor size and identify more nonindex lesions suggests that while it provides high sensitivity, it also requires careful interpretation to avoid unnecessary biopsies.[14]

Lehman et al. (2015) assessed the impact of computer-aided detection (CAD) on mammography performance and found that CAD did not enhance diagnostic accuracy. This finding is crucial for guiding future investments in screening technology, suggesting that additional costs associated with CAD may not be justified given its lack of improvement in mammography performance.[15]

Lee et al. (2016) demonstrated that while the sensitivity and cancer detection rates of mammography were comparable to those reported for Western women, there were significant improvements in recall rates, PPVs, and specificity over time. This indicates that although mammography performance has improved, there remains variability that warrants further investigation.[16]

Finally, Badu-Peprah et al. (2018) confirmed the effectiveness of mammography and ultrasound in detecting breast cancer, with mammography showing substantial sensitivity and specificity compared to clinical diagnosis. This study reinforces the importance of mammography as a reliable screening tool and highlights its effectiveness compared to other diagnostic methods. Advancements in technology and improvements over time are promising, but continuous evaluation and optimization are necessary to address existing limitations and enhance the overall efficacy of breast cancer screening programs.[17]

CONSCLUSION

Mammography remains a cornerstone in breast cancer screening due to its high specificity and moderate sensitivity. However, the combination of mammography with other modalities such as MRI and ultrasound can enhance diagnostic performance.

DISCLOSURE STATEMENT

Disclosure Statement : The authors have no conflicts of Interest to declare.

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