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Sensitivity and specificity of ultrasound and mammography for detection of breast malignancy: A systematic review and meta-analysis

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ABSTRACT

Background and Aim: In recent years, breast cancer is the most common cancer among women, and the average age of its occurrence is decreasing. Due to dense breast tissue in younger women, which reduces the sensitivity of mammography in the diagnosis of carcinoma. The use of ultrasound as a supplement to mammography is very useful in its diagnosis. Thus, this systematic review and meta-analysis is aimed at pooling the sensitivity and specificity of mammography and ultrasonography in detection of breast malignancy.

Methods: We performed a systematic search of literature in PubMed, Web of Science, and Scopus with relevant keywords. Studies that did not perform ultrasound or mammography or did not perform any comparison were excluded. Data extraction was performed based on a standardized sheet. Pooling the sensitivities and specificities was performed with STATA, R, and RStudio.

Results: The initial search retrieved 19,022 articles from which 8753 duplicates were removed. Finally, 28 studies were included based on our eligibility criteria. The pooled sensitivity of mammography in detection of breast malignancy was 78% (95% CI: 72% - 83%, p-value < 0.001). The pooled specificity of mammography in detection of breast malignancy was 78% (95% CI: 66% - 86%, p-value < 0.001). The pooled sensitivity of ultrasonography in detection of breast malignancy was 87% (95% CI: 80% - 92%, p-value < 0.001). The pooled specificity of ultrasonography in detection of breast malignancy was 75% (95% CI: 61% - 84%, p-value < 0.001).

Conclusion: According to the findings of our study, ultrasonography had higher sensitivity for detection breast lesion malignancy compared to mammography, however, mammography showed higher specificity for detection of breast malignancy.

Key words: breast cancer, ultrasound, ultrasonography, mammography, breast malignancy

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INTRODUCTION

Today, breast cancer is one of the most common cancers and a common cause of death among women in the world. Breast tissue is dense in young people and gradually replaces dense breast tissue with age and fatty tissue. Despite the severe prognosis and high morbidity and mortality, the patient's prognosis will be better if diagnosed early. Early detection of breast cancer is the ultimate goal of radiology and the role of the radiologist is very crucial at this stage. Screening with mammography has caused a 22% decrease in the mortality of women over 50 years old and a 15% decrease in the mortality of women aged 40-49. Considering the incidence of breast cancer at younger ages in recent years and the presence of dense breast tissue in this group and the possibility of the lesion remaining hidden in this type of tissue, the existence of a complementary diagnostic method seems necessary to increase the sensitivity of diagnosis [1-4].

Primary randomized controlled trials have demonstrated the importance of mammography in early detection of breast cancer in asymptomatic women, with a 20-35% reduction in mortality, especially in women aged 50-69. It is shown. However, mammography-savvy women are still reluctant to undergo mammography because the cost is still prohibitive. In addition to economic problems, other difficulties also play a role. B. Fear of radiation, limited services available, anticipated pain, discomfort, fear of mammography for those in the know. Annual mammograms reportedly reduce breast cancer mortality in women over age 50 [5-9]. Hence, in this systematic review and meta-analysis study we aimed at pooling the sensitivity and specificity of mammography and ultrasonography in detection of breast malignancy.

METHODS AND MATERIALS

This systematic review and meta-analysis study was conducted based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guideline 2020 [1].

Search strategy

Two authors performed a systematic search of literature in the following electronic databases: PubMed, Web of Science, and Scopus. No time limitation was defined and all English studies from the beginning until June, 2023 were included. The relevant medical subject heading (MeSH) terms and related keywords were used in combination to build the search strategy; ("Ultrasound"

OR "Mammography" OR "Ultrasonography" OR "US") AND ("Breast Cancer" OR "Breast Neoplasm" OR "Breast Lesion"). More information regarding the search strategy is presented at Appendix 1.

Eligibility criteria

Our eligibility criteria were defined based on the PICO framework: (P) Population: women suspected for breast cancer. (I) Not Applicable. (C) Ultrasound/Mammography findings. (O) Not applicable. Those studies that did not perform ultrasound or mammography or did not perform any comparison were excluded. Studies that performed MRI, lacked individual data, or were not in English, were also excluded.

Data extraction and outcome measures

A standardized Excel sheet was prepared for data extraction. Two independent authors performed the data extraction based on the aforementioned data extraction sheet. Disagreement between these two authors, regarding inclusion, exclusion or data extraction, was discussed and resolved by a third author. The data extraction sheet included the following study characteristics: first author's name, year of publication, study design, true positive ultrasonography cases, true negative ultrasonography cases, false positive ultrasonography cases, false negative ultrasonography cases, true positive mammography cases, true negative mammography cases, false positive mammography cases, false negative mammography cases, total number of mammography cases, and total number of ultrasonography cases.

Data synthesis and statistical analysis

We used R (R Foundation for Statistical Computing, Vienna, Austria), RStudio (RStudio, Inc., Boston, MA), and STATA 17.0 for the statistical analysis and creating the figures. The pooled sensitivity and specificity were calculated based on metadta package in STATA and mada package in R. The sensitivity and specificity were pooled using the hierarchical logistic regression. The 95% confidence interval was also estimated using the binomial distribution. The forest plots and receiver operating characteristic (SROC) plots were also created [10-12].

RESULTS

Our initial search retrieved 19,022 articles from PubMed, Scopus, and Web of Science, from which 8753 duplicates were removed. After screening the title and abstract of 10,449 records, 51 full texts were retrieved, among which 28 studies were included based on our eligibility criteria (Figure 1)[13-40].

More detail regarding the study characteristics of the included studies is summarised in Tables 1 and 2.

The pooled sensitivity of mammography in detection of breast malignancy was 78% (95% CI: 72% - 83%, p-value < 0.001). The pooled specificity of mammography in detection of breast malignancy was 78% (95% CI: 66% - 86%, p-value < 0.001). Further detail is available in Figures 2 and 3.

The pooled sensitivity of ultrasonography in detection of breast malignancy was 87% (95% CI: 80% - 92%, p-value < 0.001). The pooled specificity of ultrasonography in detection of breast malignancy was 75% (95% CI: 61% - 84%, p-value < 0.001). Further detail is available in Figures 4 and 5.

DISCUSSION

Based on the findings of our systematic review and meta-analysis

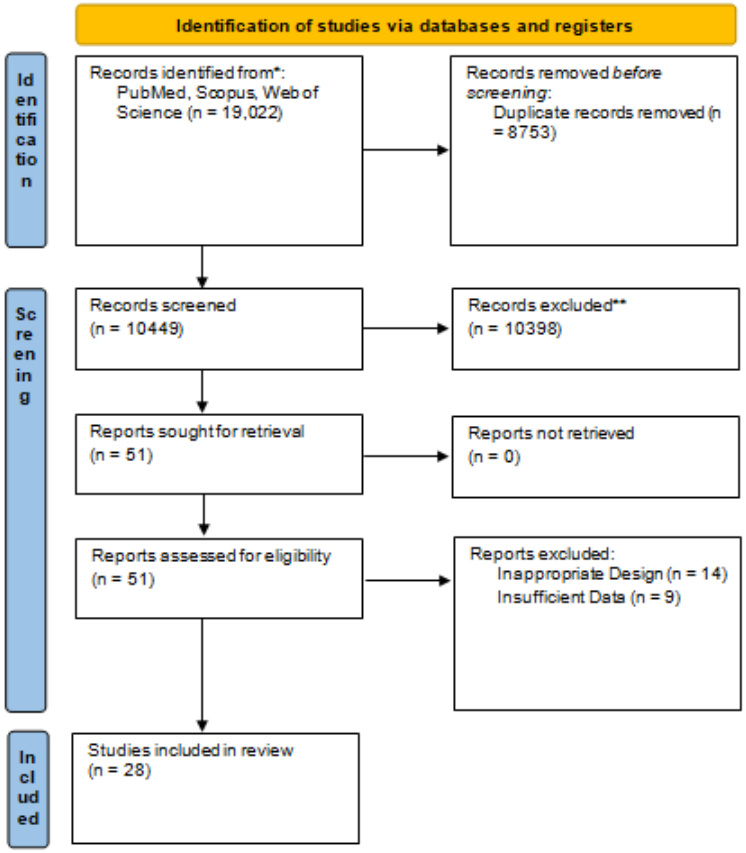

Fig.1. PRISMA flowchart of the included studies.

Tab.1. Detailed characteristics of the included studies for mammography.

Author	Year	Design	Age	TP	FP	FN	TN	Total
Ying et al.	2012	Retrospective Cohort Study	46	201	61	45	358	665
Wu et al.	2016	Prospective Cohort Study	49	77	9	41	185	312
Shao et al.	2013	Prospective Cohort Study	53	40	13	15	22	90
Mello et al.	2017	Retrospective Cohort Study	NA	83	44	9	528	664
Berg et al.	2012	Retrospective Cohort Study	NA	57	414	18	4325	4814
Habib et al.	2009	Retrospective Cohort Study	36.5	11	4	1	4	20
Lehman et al.	2012	Retrospective Cohort Study	35	14	66	9	1119	1208
Zahid et al.	2009	Retrospective Cohort Study	35	40	6	12	152	210
Yu et al.	2016	Retrospective Cohort Study	48.2	127	40	41	79	287
Ozulker et al.	2010	Prospective Cohort Study	NA	13	5	3	8	29
Omranipour et al.	2016	Prospective Cohort Study	49.5	70	12	17	33	132
Meissnitzer et al.	2015	Prospective Cohort Study	50	57	18	10	7	92
Tan et al.	2014	Retrospective Cohort Study	40	36	28	38	224	326
Cho et al.	2016	Retrospective Cohort Study	NA	49	42	17	54	162
Lee et al.	2012	Retrospective Cohort Study	49.63	103	34	7	330	474
Zhao et al.	2015	Retrospective Cohort Study	NA	117	37	15	105	274
Park et al.	2014	Retrospective Cohort Study	49.6	24	14	18	62	118
Yao et al.	2014	Retrospective Cohort Study	35	374	27	104	1529	2034
Novikov et al.	2017	Prospective Cohort Study	NA	346	19	21	51	437
Wang et al.	2022	Prospective Cohort Study	35-70	1527	343	408	566	2844
Mubuuke et al.	2023	Cross-sectional Study	46.9	77	60	29	46	212
Disha et al.	2009	Retrospective Cohort Study	30-79	135	212	124	75	546
Shafiq et al.	2022	Cross-sectional Study	58.91	34	31	12	13	100

Tab.2. Detailed characteristics of the included studies for ultrasonography.

Author	Year	Design	Age	TP	FP	FN	TN	Total
Barco et al.	2016	Retrospective Cohort Study	58.5	162	76	180	1115	1533
Habib et al.	2009	Retrospective Cohort Study	36.5	12	3	2	5	22
Lehman et al.	2012	Prospective Cohort Study	35	22	128	1	1057	1208
Sarica et al.	2014	Retrospective Cohort Study	48	130	61	8	78	277
Shao et al.	2013	Prospective Cohort Study	53.2	44	14	11	21	90
Ying et al.	2012	Retrospective Cohort Study	50	235	82	11	337	665
Wu et al.	2016	Retrospective Cohort Study	49	32	3	86	191	312
Zahid et al.	2009	Retrospective Cohort Study	35	40	9	12	148	209
Yu et al.	2016	Retrospective Cohort Study	48.2	138	27	30	92	287
Ozulker et al.	2010	Prospective Cohort Study	NA	11	1	5	10	27
Meissnitzer et al.	2015	Prospective Cohort Study	50	66	20	1	5	92
Vassiou et al.	2009	Prospective Cohort Study	39	44	6	6	21	77
Wang et al.	2015	Retrospective Cohort Study	44	32	16	7	41	96
Tan et al.	2014	Retrospective Cohort Study	40	58	38	13	202	311
Zhao et al.	2015	Retrospective Cohort Study	NA	127	47	5	95	274
Zhi et al	2012	Retrospective Cohort Study	43	52	6	2	52	112
Cho et al.	2016	Retrospective Cohort Study	NA	58	19	8	77	162
Lee et al.	2012	Retrospective Cohort Study	49.63	108	47	2	317	474
Park et al.	2014	Retrospective Cohort Study	49.6	41	29	1	47	118
Yao et al.	2014	Retrospective Cohort Study	35	399	108	81	1148	1736
Wang et al.	2022	Prospective Cohort Study	35-70	1851	519	84	390	2844
Mubuuke et al.	2023	Cross-sectional Study	46.9	73	55	33	51	212
Disha et al.	2009	Retrospective Cohort Study	30-79	188	254	71	33	546
Shafiq et al.	2022	Cross-sectional Study	58.91	39	37	17	7	100

study, ultrasonography had higher sensitivity for detection breast lesion malignancy compared to mammography, however, mammography showed higher specificity for detection of breast malignancy.

The challenge is determining which method is suitable for screening. Current imaging guidelines recommend mammography as the gold standard for imaging, especially for women over the age of 40. However, mammography has some limitations. For example, sensitivity is significantly lower in women with dense breasts, but such women have an increased risk of developing breast cancer. This is despite having automated systems to support diagnostics. B. A computerized system that allows superior performance compared to human readers, even in dense breasts during mammography. Based on the results of this study, it can be argued that the addition of ultrasound to breast cancer screening procedures is more likely to result in better detection and early patient treatment. Previous literature supports this observation [41-46].

The use of breast ultrasound becomes even more important in low-income areas where mammography machines are not available or where formal national mammography screening procedures are not available to all women. One reason for this is the enormous costs associated with establishing routine mammography screening procedures. Therefore, breast ultrasound may be promoted as an evaluation tool because it is relatively accessible and more affordable in low-income settings. The use of ultrasound as an

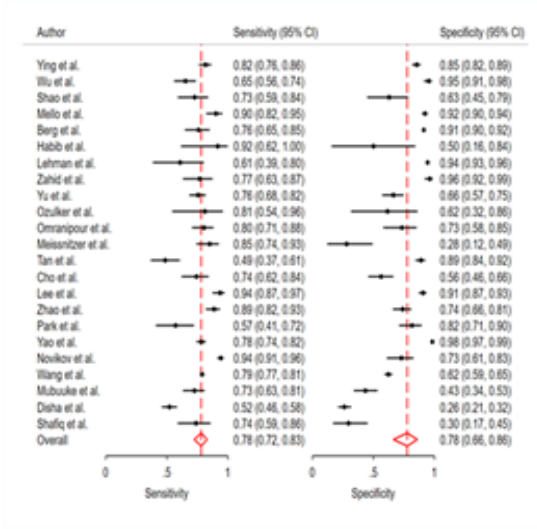

Fig. 2. Pooled sensitivity and specificity of mammography.

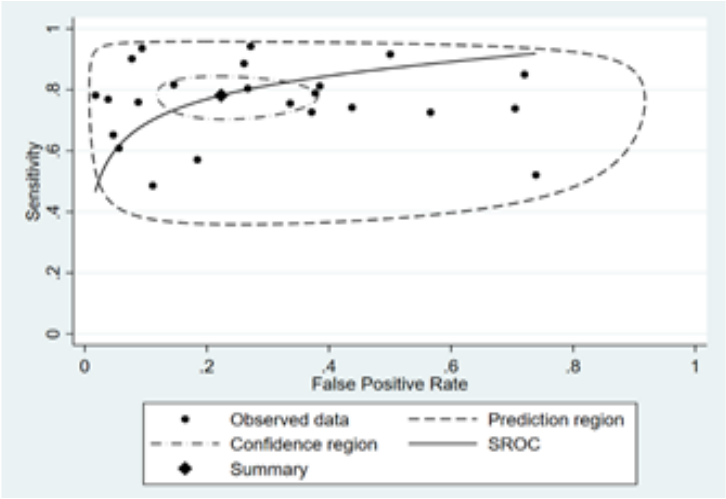

Fig.3. The receiver operating characteristic plot of mammography.

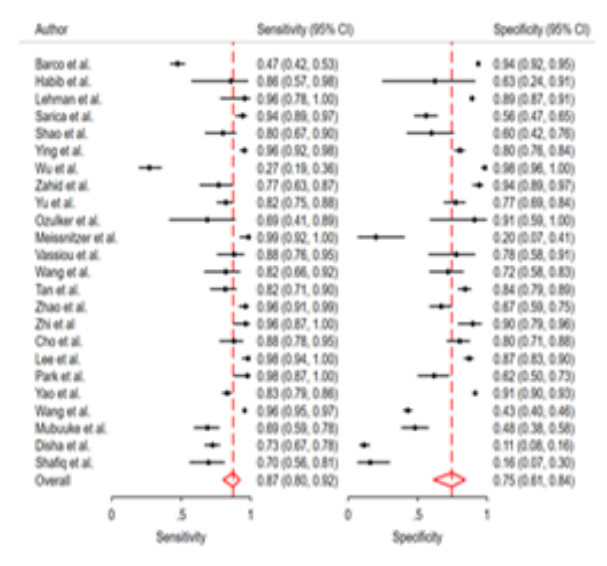

Fig. 4. Pooled sensitivity and specificity of ultrasonography.

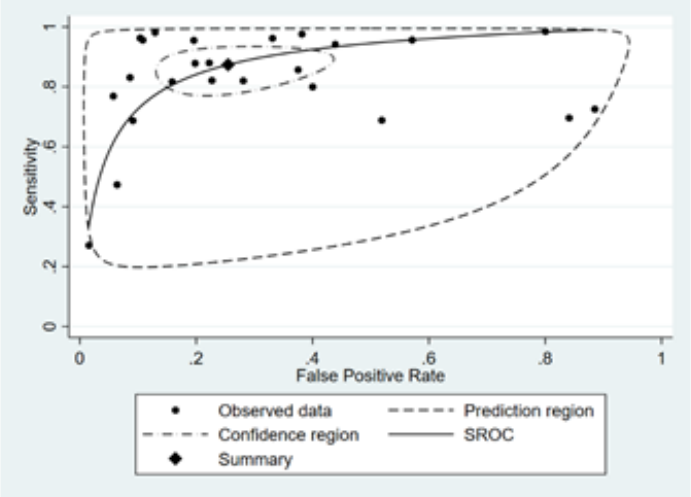

Fig.5. The receiver operating characteristic plot of ultrasonography.

adjunct to mammography in breast cancer screening continues to provoke controversy, mainly due to its low PPV and likely high NPV. Therefore, further studies in different contexts are needed to contribute to these discussions [47-49].

The use of BI-RADS systems to characterize breast tumors is recommended in many settings, and such reporting systems may help distinguish between benign and malignant breast tumors. The accuracy of BI-RADS systems remains controversial, and further research is needed in many areas to provide evidence on how accurate BI-RADS is in practice. The results of this study indicate that his PPV rate of BI-RADS 3–5 is high. This could bring light to the end of the tunnel. The use of BI-RADS has the potential to distinguish between benign and malignant masses, reducing unnecessary biopsies as well as unnecessary surgeries. This observation has already been pointed out in previous literature. The risk of BI-RADS 3 malignancies is less than 2% and most physicians recommend observation only for this category of patients. Although BI-RADS 4 breast tumors are classically non-malignant, there is sufficient suspicion for core biopsy, whereas BI-RADS 5 masses are at high risk of malignancy and warrant biopsy. there is [50-52].

When imaging suspicious breast lesions, there are other factors that affect imaging accuracy. For example, patient age, surgical history, characteristics of the lesion itself, menstrual and menopausal status, imaging techniques and protocols, use of newer technologies such as vacuum-assisted breast biopsy techniques, and imaging equipment used. All of these must be considered when using image accuracy results. A major limitation of this study is that breast density was not considered in the analysis and may play an important role. It is therefore recommended that future studies addressing breast density consider breast density. We also did not perform age-related sub-analyses to compare results for women under 40 years of age and those over 40 years of age. Therefore, we recommend future studies to investigate this aspect. Furthermore, further studies on the accuracy of breast ultrasound and her BI-RADS in other settings are encouraged to further improve the evidence for considering these aspects in breast cancer screening [1, 53-55].

CONCLUSION

In conclusion, our systematic review and meta-analysis aimed to consolidate data on the sensitivity and specificity of both mammography and ultrasonography in the detection of breast malignancies. Our study findings reveal that ultrasonography demonstrated higher sensitivity in detecting breast lesion malignancies when compared to mammography. However, it's noteworthy that mammography exhibited greater specificity in the detection of breast malignancies.

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