Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Siegel RL, Miller KD, Jemal A. Cancer Statistics, 2017. CA Cancer J Clin. 2017;67(1):7-30.	Review/Other-Dx	N/A	To estimate the numbers of new cancer cases and deaths that will occur in the United States in the current year and compile the most recent data on cancer incidence, mortality, and survival.	Mortality data were collected by the National Center for Health Statistics. In 2017, 1,688,780 new cancer cases and 600,920 cancer deaths are projected to occur in the United States. For all sites combined, the cancer incidence rate is 20% higher in men than in women, while the cancer death rate is 40% higher. However, sex disparities vary by cancer type. For example, thyroid cancer incidence rates are 3-fold higher in women than in men (21 vs 7 per 100,000 population), despite equivalent death rates (0.5 per 100,000 population), largely reflecting sex differences in the "epidemic of diagnosis." Over the past decade of available data, the overall cancer incidence rate (2004-2013) was stable in women and declined by approximately 2% annually in men, while the cancer death rate (2005-2014) declined by about 1.5% annually in both men and women. From 1991 to 2014, the overall cancer death rate dropped 25%, translating to approximately 2,143,200 fewer cancer deaths than would have been expected if death rates had remained at their peak. Although the cancer death rate was 15% higher in blacks than in whites in 2014, increasing access to care as a result of the Patient Protection and Affordable Care Act may expedite the narrowing racial gap; from 2010 to 2015, the proportion of blacks who were uninsured halved, from 21% to 11%, as it did for Hispanics (31% to 16%). Gains in coverage for traditionally underserved Americans will facilitate the broader application of existing cancer control knowledge across every segment of the population.	4

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2. Reduction in breast cancer mortality from organized service screening with mammography: 1. Further confirmation with extended data. Cancer Epidemiol Biomarkers Prev. 2006;15(1):45-51.	Observational-Dx	542,187 women in prescreening and 566,423 women in screening epochs. 6,231 deaths due to breast cancer.	To evaluate data from breast cancer screening programs in 13 large areas within nine counties; examine a period of follow-up (20-44 years); apply new analytic methods for the evaluation of incidence-based breast cancer mortality; and estimate the number needed to screen to save one life.	There was a significant 45% reduction in incidence-based breast cancer mortality among screened women in the screening epoch relative to incidence-based breast cancer mortality in the prescreening epoch (relative risk, 0.55; 95% confidence intervals, 0.51-0.59). After adjusting for self-selection bias, there still was a significant 43% reduction in incidence-based breast cancer mortality associated with screening (relative risk, 0.57; 95% confidence intervals, 0.53-0.62). Results indicate a reduction in breast cancer mortality of between 40% and 45% in association with screening, after adjustment for self-selection bias. These results were obtained with modest human costs: the number needed to screen to save one life was estimated as 472.	3
3. D'Orsi CJ, Sickles EA, Mendelson EB, et al. ACR BI-RADS® Atlas, Breast Imaging Reporting and Data System. Reston, VA, American College of Radiology; 2013.	Review/Other-Dx	N/A	N/A	N/A	4
4. Tabar L, Vitak B, Chen TH, et al. Swedish two-county trial: impact of mammographic screening on breast cancer mortality during 3 decades. Radiology. 2011;260(3):658-663.	Observational-Dx	133,065 women	To estimate the long-term (29-year) effect of mammographic screening on breast cancer mortality in terms of both relative and absolute effects.	There was a highly significant reduction in breast cancer mortality in women invited to screening according to both local end point committee data (relative risk [RR] = 0.69; 95% confidence interval: 0.56, 0.84; P < .0001) and consensus data (RR = 0.73; 95% confidence interval: 0.59, 0.89; P = .002). At 29 years of follow-up, the number of women needed to undergo screening for 7 years to prevent one breast cancer death was 414 according to local data and 519 according to consensus data. Most prevented breast cancer deaths would have occurred (in the absence of screening) after the first 10 years of follow-up.	3

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5. Hendrick RE, Helvie MA. Mammography screening: a new estimate of number needed to screen to prevent one breast cancer death. AJR Am J Roentgenol. 2012;198(3):723-728.	Review/Other-Dx	N/A	To estimate the number of women needed to screen (NNS) to prevent one breast cancer death and the number needed to screen per life-year gained (NNS/LYG) with annual or biennial screening mammography and to compare NNS to the number needed to invite (NNI) to a screening trial to prevent one breast cancer death.	For women between the ages of 40 and 49 years undergoing annual screening mammography, CISNET modeling results estimate an NNS of 746, 39% of the NNI of 1904 estimated by USPSTF on the basis of randomized controlled trial (RCT) data. The NNS based on CISNET results for women between 50 and 59 years is 351 (26% of the NNI of 1339 estimated by USPSTF from RCT data), for women between 60 and 69 years is 233 (62% of the NNI of 377 estimated by USPSTF from RCT data), and for women between 70 and 79 years is 377. Annual screening of women between 40 and 84 years yields an NNS of 84 and an NNS/LYG of 5.3. Biennial screening of women ages 50-74 yields an NNS of 144 and an NNS/LYG of 9.1.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
6. Siu AL. Screening for Breast Cancer: U.S. Preventive Services Task Force Recommendation Statement. Ann Intern Med. 2016;164(4):279-296.	Review/Other-Dx	N/A	To update the 2009 U.S. Preventive Services Task Force (USPSTF) recommendation on screening for breast cancer.	The USPSTF recommends biennial screening mammography for women aged 50 to 74 years. (B recommendation) The decision to start screening mammography in women prior to age 50 years should be an individual one. Women who place a higher value on the potential benefit than the potential harms may choose to begin biennial screening between the ages of 40 and 49 years. (C recommendation) The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of screening mammography in women aged 75 years or older. (I statement) The USPSTF concludes that the current evidence is insufficient to assess the benefits and harms of digital breast tomosynthesis (DBT) as a primary screening method for breast cancer. (I statement) The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of adjunctive screening for breast cancer using breast ultrasonography, magnetic resonance imaging (MRI), DBT, or other methods in women identified to have dense breasts on an otherwise negative screening mammogram. (I statement).	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
7. Schousboe JT, Kerlikowske K, Loh A, Cummings SR. Personalizing mammography by breast density and other risk factors for breast cancer: analysis of health benefits and cost-effectiveness. Ann Intern Med. 2011;155(1):10-20.	Review/Other-Dx	N/A	To estimate the cost-effectiveness of mammography by age, breast density, history of breast biopsy, family history of breast cancer, and screening interval.	RESULTS OF BASE-CASE ANALYSIS: Biennial mammography cost less than $100,000 per QALY gained for women aged 40 to 79 years with BI-RADS category 3 or 4 breast density or aged 50 to 69 years with category 2 density; women aged 60 to 79 years with category 1 density and either a family history of breast cancer or a previous breast biopsy; and all women aged 40 to 79 years with both a family history of breast cancer and a previous breast biopsy, regardless of breast density. Biennial mammography cost less than $50,000 per QALY gained for women aged 40 to 49 years with category 3 or 4 breast density and either a previous breast biopsy or a family history of breast cancer. Annual mammography was not cost-effective for any group, regardless of age or breast density. RESULTS OF SENSITIVITY ANALYSIS: Mammography is expensive if the disutility of false-positive mammography results and the costs of detecting nonprogressive and nonlethal invasive cancer are considered. LIMITATION: Results are not applicable to carriers of BRCA1 or BRCA2 mutations.	4
8. Destounis SV, Arieno AL, Morgan RC, et al. Comparison of breast cancers diagnosed in screening patients in their 40s with and without family history of breast cancer in a community outpatient facility. AJR Am J Roentgenol. 2014;202(4):928-932.	Observational-Dx	388 patients	To compare invasive breast cancer in patients in their 40s with and without a family history of breast cancer as well as the lymph node meta-static rate and mastectomy rate.	The difference in lesions detected by imaging was not statistically significant ($p = 0.17$); 65% (154/238) had invasive and 35% (84/238) noninvasive disease in the no family history of breast cancer group and 65% (98/150) and 35% (52/150), respectively, in the family history of breast cancer group ($p = 0.90$). The mastectomy rate was not statistically significantly different ($p = 0.14$). Fifteen percent (35/238) of the no family history of breast cancer patients and 12% (18/150) of the family history of breast cancer patients had positive lymph nodes ($p = 0.45$).	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
9. Price ER, Keedy AW, Gidwaney R, Sickles EA, Joe BN. The Potential Impact of Risk-Based Screening Mammography in Women 40-49 Years Old. AJR Am J Roentgenol. 2015;205(6):1360-1364.	Review/Other-Dx	136 cases	To determine the prevalence of very strong family history and extremely dense tissue in women 40-49 years old with breast cancer detected on screening mammography.	One hundred thirty-six cases of breast cancer were identified on screening mammography in 40- to 49-year-old women; 50% were invasive cancers, and 50%, ductal carcinoma in situ. Very strong family history was absent in 88%, and extremely dense breast tissue was absent in 86%. Seventy-six percent of patients had neither very strong family history nor extremely dense breasts, including 79% of the cases of invasive cancers, of which 25% had axillary nodal involvement and 89% were estrogen receptor positive.	4
10. Lee CH, Dershaw DD, Kopans D, et al. Breast cancer screening with imaging: recommendations from the Society of Breast Imaging and the ACR on the use of mammography, breast MRI, breast ultrasound, and other technologies for the detection of clinically occult breast cancer. J Am Coll Radiol. 2010;7(1):18-27.	Review/Other-Dx	N/A	Recommendations from the Society of Breast Imaging and the ACR on the use of mammography, breast MRI, breast US, and other technologies for the detection of clinically occult breast cancer.	N/A	4
11. Monticciolo DL, Newell MS, Hendrick RE, et al. Breast Cancer Screening for Average-Risk Women: Recommendations From the ACR Commission on Breast Imaging. J Am Coll Radiol. 2017:[E-pub ahead of print].	Review/Other-Dx	N/A	To provide recommendations from the ACR Commission on Breast Imaging on breast cancer screening for average-risk women.	The ACR recommends annual mammography screening starting at age 40 for women of average risk of developing breast cancer.	4

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EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
12. Ciatto S, Houssami N, Bernardi D, et al. Integration of 3D digital mammography with tomosynthesis for population breast-cancer screening (STORM): a prospective comparison study. Lancet Oncol. 2013;14(7):583-589.	Experimental-Dx	7292 women	To investigate the effect of integrated 2D and 3D mammography in population breast-cancer screening.	7292 women were screened (median age 58 years [IQR 54-63]). We detected 59 breast cancers (including 52 invasive cancers) in 57 women. Both 2D and integrated 2D and 3D screening detected 39 cancers. We detected 20 cancers with integrated 2D and 3D only versus none with 2D screening only ($p<0.0001$). Cancer detection rates were 5.3 cancers per 1000 screens (95% CI 3.8-7.3) for 2D only, and 8.1 cancers per 1000 screens (6.2-10.4) for integrated 2D and 3D screening. The incremental cancer detection rate attributable to integrated 2D and 3D mammography was 2.7 cancers per 1000 screens (1.7-4.2). 395 screens (5.5%; 95% CI 5.0-6.0) resulted in false positive recalls: 181 at both screen reads, and 141 with 2D only versus 73 with integrated 2D and 3D screening ($p<0.0001$). We estimated that conditional recall (positive integrated 2D and 3D mammography as a condition to recall) could have reduced false positive recalls by 17.2% (95% CI 13.6-21.3) without missing any of the cancers detected in the study population.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
13. Bernardi D, Caumo F, Macaskill P, et al. Effect of integrating 3D-mammography (digital breast tomosynthesis) with 2D-mammography on radiologists' true-positive and false-positive detection in a population breast screening trial. Eur J Cancer. 2014;50(7):1232-1238.	Experimental-Dx	7,292 participants	To report an evaluation of the effect of integrating 3D-mammography with 2D-mammography for breast screening on individual radiologists' true-positive (TP) and FP detection, based on radiologists who participated in the STORM trial.	There were 59 cancers and 395 false recalls amongst 7292 screening participants. At 2D-mammography screening, radiologist-specific TP detection ranged between 38% and 83% (median 63%; mean 60% and sd 15.4%); at integrated 2D/3D-mammography, TP detection ranged between 78% and 93% (median 87%; mean 87% and sd 5.2%). For all but one radiologist, 2D/3D-mammography improved breast cancer detection (relative to 2D-mammography) ranging between 0% and 54% (median 29%; mean 27% and sd 16.2%) increase in the proportion of detected cancers. Incremental CDR attributable to integrating 3D-mammography in screening varied between 0/1000 and 5.3/1000 screens (median 1.8/1000; mean 2.3/1000 and sd 1.6/1000). Radiologist-specific FPR for 2D-mammography ranged between 1.5% and 4.2% (median 3.1%; mean 2.9% and sd 0.87%), and FPR based on the integrated 2D/3D-mammography read ranged between 1.0% and 3.3% (median 2.4%; mean 2.2% and sd 0.72%). Integrated 2D/3D-mammography screening, relative to 2D-mammography, had the effect of reducing FP and increasing TP detection for most radiologists	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
14. Bernardi D, Ciatto S, Pellegrini M, et al. Application of breast tomosynthesis in screening: incremental effect on mammography acquisition and reading time. Br J Radiol. 2012;85(1020):e1174-1178.	Observational-Dx	10 cancers and 90 negative controls	To supplement the paucity of information available on logistical aspects of the application of three-dimensional (3D) mammography in breast screening.	Average acquisition time (measured from start of first-view breast positioning to compression release at completion of last view) for seven radiographers, based on 20 screening examinations, was longer for 2D+3D (4 min 3 s; range 3 min 53 s-4 min 18 s) than 2D mammography (3 min 13 s; range 3 min 0 s-3 min 26 s; $p<0.01$). Average radiologists' reading time per screening examination (three radiologists reading case-mix of 100 screens: 10 cancers, 90 controls) was longer for 2D+3D (77 s; range 60-90 s) than for 2D mammography (33 s; range 25-46 s; $p<0.01$). 2D+3D screen-reading was associated with detection of more cancers and with substantially fewer recalls than 2D mammography alone.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
15. Caumo F, Bernardi D, Ciatto S, et al. Incremental effect from integrating 3D-mammography (tomosynthesis) with 2D-mammography: Increased breast cancer detection evident for screening centres in a population-based trial. Breast. 2014;23(1):76-80.	Observational-Dx	57 subjects, 59 breast cancers	To examine centre-specific effect of integrated 2D/3D mammography based on the STORM (screening with tomosynthesis or standard mammography) trial.	Of 33 cancers detected in Trento, 21 were detected at both 2D and 2D/3D screening, 12 cancers were detected only with integrated 2D/3D screening compared with none detected at 2D-only screening ($P < 0.001$). Of the 26 cancers detected in Verona, 18 were detected at both 2D and 2D/3D screening, 8 cancers were detected only with integrated 2D/3D screening compared with none detected at 2D-only screening ($P = 0.008$). There were no differences between centres in baseline CDR, and incremental CDR attributable to 3D-mammography was similar for Trento (2.8/1000 screens) and for Verona (2.6/1000 screens). Trento had 239 FPR (5.7% of screens): 103 FPR at both screen-readings, 93 FPR only at 2D-mammography compared with 43 FPR only at 2D/3D-mammography ($p < 0.001$). Verona had 156 FPR (5.2% of screens): 78 FPR at both screen-readings, 48 FPR only at 2D-mammography compared with 30 FPR only at 2D/3D-mammography ($p = 0.054$). Estimated reduction in FPR proportion had recall been conditional to 2D/3D-mammography-positivity differed between centres (21.0% versus 11.5%; $P = 0.02$).	1

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16. Friedewald SM, Rafferty EA, Rose SL, et al. Breast cancer screening using tomosynthesis in combination with digital mammography. JAMA. 2014;311(24):2499-2507.	Observational-Dx	454,850 examinations	To determine if mammography combined with tomosynthesis is associated with better performance of breast screening programs in the United States.	A total of 454,850 examinations (n=281,187 digital mammography; n=173,663 digital mammography + tomosynthesis) were evaluated. With digital mammography, 29,726 patients were recalled and 5056 biopsies resulted in cancer diagnosis in 1207 patients (n=815 invasive; n=392 in situ). With digital mammography + tomosynthesis, 15,541 patients were recalled and 3285 biopsies resulted in cancer diagnosis in 950 patients (n=707 invasive; n=243 in situ). Model-adjusted rates per 1000 screens were as follows: for recall rate, 107 (95% CI, 89-124) with digital mammography vs 91 (95% CI, 73-108) with digital mammography + tomosynthesis; difference, -16 (95% CI, -18 to -14; P < .001); for biopsies, 18.1 (95% CI, 15.4-20.8) with digital mammography vs 19.3 (95% CI, 16.6-22.1) with digital mammography + tomosynthesis; difference, 1.3 (95% CI, 0.4-2.1; P = .004); for cancer detection, 4.2 (95% CI, 3.8-4.7) with digital mammography vs 5.4 (95% CI, 4.9-6.0) with digital mammography + tomosynthesis; difference, 1.2 (95% CI, 0.8-1.6; P < .001); and for invasive cancer detection, 2.9 (95% CI, 2.5-3.2) with digital mammography vs 4.1 (95% CI, 3.7-4.5) with digital mammography + tomosynthesis; difference, 1.2 (95% CI, 0.8-1.6; P < .001). The in situ cancer detection rate was 1.4 (95% CI, 1.2-1.6) per 1000 screens with both methods. Adding tomosynthesis was associated with an increase in the positive predictive value for recall from 4.3% to 6.4% (difference, 2.1%; 95% CI, 1.7%-2.5%; P < .001) and for biopsy from 24.2% to 29.2% (difference, 5.0%; 95% CI, 3.0%-7.0%; P < .001).	3

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17. Greenberg JS, Javitt MC, Katzen J, Michael S, Holland AE. Clinical performance metrics of 3D digital breast tomosynthesis compared with 2D digital mammography for breast cancer screening in community practice. AJR Am J Roentgenol. 2014;203(3):687-693.	Observational-Dx	59,617 women	To assess the clinical performance of combined 2D-3D digital breast tomosynthesis (DBT), referred to as "3D DBT," compared with 2D digital mammography (DM) alone for screening mammography in a community-based radiology practice.	For patients screened with 3D DBT, the relative change in recall rate was 16.1% lower than for patients screened with 2D DM ($p > 0.0001$). The overall cancer detection rate (CDR), expressed as number of cancers per 1000 patients screened, was 28.6% greater ($p = 0.035$) for 3D DBT (6.3/1000) compared with 2D DM (4.9/1000). The CDR for invasive cancers with 3D DBT (4.6/1000) was 43.8% higher ($p = 0.0056$) than with 2D DM (3.2/1000). The positive predictive value for recalls from screening (PPV1) was 53.3% greater ($p = 0.0003$) for 3D DBT (4.6%) compared with 2D DM (3.0%). No significant difference in the positive predictive value for biopsy (PPV3) was found for 3D DBT versus 2D DM (22.8% and 23.8%, respectively) ($p = 0.696$).	3

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18. Houssami N, Macaskill P, Bernardi D, et al. Breast screening using 2D-mammography or integrating digital breast tomosynthesis (3D-mammography) for single-reading or double-reading--evidence to guide future screening strategies. Eur J Cancer. 2014;50(10):1799-1807.	Experimental-Dx	7,292 participants	To compare detection measures for breast screening strategies comprising single-reading or double-reading using standard 2D-mammography or 2D/3D-mammography, based on the 'screening with tomosynthesis or standard mammography' (STORM) trial.	Amongst 7292 screening participants, there were 65 (including six interval) breast cancers; estimated first-year interval cancer rate was 0.82/1000 screens (95% confidence interval (CI): 0.30-1.79/1000). For single-reading, 35 cancers were detected at both 2D and 2D/3D-mammography, 20 cancers were detected only with 2D/3D-mammography compared with none at 2D-mammography alone ($p<0.001$) and 10 cancers were not detected. For double-reading, 39 cancers were detected at 2D-mammography and 2D/3D-mammography, 20 were detected only with 2D/3D-mammography compared with none detected at 2D-mammography alone ($p<0.001$) and six cancers were not detected. The incremental CDR attributable to 2D/3D-mammography (versus 2D-mammography) of 2.7/1000 screens (95% CI: 1.6-4.2) was evident for single and for double-reading. Incremental CDR attributable to double-reading (versus single-reading) of 0.55/1000 screens (95% CI: -0.02-1.4) was evident for 2D-mammography and for 2D/3D-mammography. Estimated FP:TP ratios showed that 2D/3D-mammography screening strategies had more favourable FP to TP trade-off and higher sensitivity, applying single-reading or double-reading, relative to 2D-mammography screening	1
19. Lei J, Yang P, Zhang L, Wang Y, Yang K. Diagnostic accuracy of digital breast tomosynthesis versus digital mammography for benign and malignant lesions in breasts: a meta-analysis. Eur Radiol. 2014;24(3):595-602.	Meta-analysis	7 studies involving 2,014 patients and 2,666 breast lesions	To evaluate the diagnostic performance of digital breast tomosynthesis (DBT) and digital mammography (DM) for benign and malignant lesions in breasts.	A total of seven studies involving 2,014 patients and 2,666 breast lesions were included. Compared with the gold standard (histological results), the pooled sensitivity and specificity of DBT were 90.0% and 79.0%, and for DM they were 89.0% and 72.0%, respectively. The pooled positive likelihood ratio of DBT and DM was 3.50 and 2.83; the pooled negative likelihood ratio of DBT and DM was 15% and 18%; the pooled DOR for DBT and DM was 26.04 and 16.24, respectively.	M

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20. McCarthy AM, Kontos D, Synnestvedt M, et al. Screening outcomes following implementation of digital breast tomosynthesis in a general-population screening program. J Natl Cancer Inst. 2014;106(11).	Observational-Dx	15,571 women screened with DBT and 10,728 screened with DM alone	To report the impact on screening outcomes for DBT screening implemented in an entire clinic population.	DBT screening showed a statistically significant reduction in recalls compared to DM alone. For the entire population, there were 16 fewer recalls (8.8% vs 10.4%, P <.001, adjusted OR = 0.80, 95% confidence interval [CI] = 0.74 to 0.88, P < .001) and 0.9 additional cancers detected per 1000 screened with DBT compared to DM alone. There was a statistically significant increase in PPV1 (6.2% vs 4.4%, P = .047). In women younger than age 50 years screened with DBT, there were 17 fewer recalls (12.3% vs 14.0%, P = .02) and 3.6 additional cancer detected per 1000 screened (5.7 vs 2.2 per 1000, P = .02).	3
21. Rafferty EA, Park JM, Philpotts LE, et al. Assessing radiologist performance using combined digital mammography and breast tomosynthesis compared with digital mammography alone: results of a multicenter, multireader trial. Radiology. 2013;266(1):104-113.	Experimental-Dx	997 subjects	To compare radiologists' diagnostic accuracy and recall rates for breast tomosynthesis combined with digital mammography versus digital mammography alone.	Diagnostic accuracy for combined tomosynthesis and digital mammography was superior to that of digital mammography alone. Average difference in area under the curve in study 1 was 7.2% (95% confidence interval [CI]: 3.7%, 10.8%; P < .001) and in study 2 was 6.8% (95% CI: 4.1%, 9.5%; P < .001). All 27 radiologists increased diagnostic accuracy with addition of tomosynthesis. Recall rates for noncancer cases for all readers significantly decreased with addition of tomosynthesis (range, 6%-67%; P < .001 for 25 readers, P < .03 for all readers). Increased sensitivity was largest for invasive cancers: 15% and 22% in studies 1 and 2 versus 3% for in situ cancers in both studies.	1

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22. Rafferty EA, Park JM, Philpotts LE, et al. Diagnostic accuracy and recall rates for digital mammography and digital mammography combined with one-view and two-view tomosynthesis: results of an enriched reader study. AJR Am J Roentgenol. 2014;202(2):273-281.	Observational-Dx	310 cases	To compare two methods of combining tomosynthesis with digital mammography by assessing diagnostic accuracy and recall rates for digital mammography alone and digital mammography combined with one-view tomosynthesis and two-view tomosynthesis.	The area under the ROC curve (AUC) for digital mammography (DM), DM plus one-view tomosynthesis, and DM plus two-view tomosynthesis was 0.828, 0.864, and 0.895, respectively. Both one-view and two-view tomosynthesis plus DM were significantly better than DM alone (Delta AUCs 0.036 [$p = 0.009$] and 0.068 [$p < 0.001$]). Average noncancer recall rates for digital mammography, DM plus one-view tomosynthesis, and DM plus two-view tomosynthesis were 44.2%, 27.2%, and 24.0%, respectively. Combined with DM, one-view and two-view tomosynthesis both showed significantly lower noncancer recall rates than digital mammography alone ($p < 0.001$). Digital mammography with two-view tomosynthesis showed a significantly lower recall rate than digital mammography with one-view tomosynthesis ($p < 0.001$). Diagnostic accuracy for dense (Delta AUC, 0.091%; $p < 0.001$) and nondense (Delta AUC, 0.035%; $p = 0.001$) breasts improved with DM plus two-view tomosynthesis compared with digital mammography alone. Compared with digital mammography, diagnostic sensitivity for invasive cancers increased with the addition of both one-view (Delta12.0%, $p < 0.001$) and two-view (Delta21.7%, $p < 0.001$) tomosynthesis	3
23. Rose SL, Tidwell AL, Ice MF, Nordmann AS, Sexton R, Jr., Song R. A reader study comparing prospective tomosynthesis interpretations with retrospective readings of the corresponding FFDM examinations. Acad Radiol. 2014;21(9):1204-1210.	Observational-Dx	10,878 DBT plus FFDM screening mammograms, and 10,878 corresponding FFDM examinations alone	To compare performance of prospective interpretations of clinical tomosynthesis (digital breast tomosynthesis [DBT]) plus full-field digital mammography (FFDM) examinations with retrospective readings of the corresponding FFDM examinations alone.	During the prospective clinical interpretations of DBT plus FFDM, 588 cases were recalled (588 of 10,878, 5.41%) compared to 888 cases recalled (888 of 10,878, 8.16%) during the FFDM-alone retrospective interpretations (absolute difference, 35%; P<.0001). There were 59 and 38 suspicious abnormalities later verified as cancers detected during the DBT plus FFDM and the FFDM-alone interpretations, respectively (absolute increase, 55%; P<.0001). Invasive cancer detections were 48 and 29, respectively (absolute increase, 66%; P<.0001).	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
24. Skaane P, Bandos AI, Gullien R, et al. Prospective trial comparing full-field digital mammography (FFDM) versus combined FFDM and tomosynthesis in a population-based screening programme using independent double reading with arbitration. Eur Radiol. 2013;23(8):2061-2071.	Experimental-Dx	12,621 women	To compare double readings when interpreting full field digital mammography (2D) and tomosynthesis (3D) during mammographic screening.	Pre-arbitration false-positive scores were 10.3 % (1,286/12,501) and 8.5 % (1,057/12,501) for 2D and 2D + 3D, respectively (P < 0.001). Recall rates were 2.9 % (365/12,621) and 3.7 % (463/12,621), respectively (P = 0.005). Cancer detection was 7.1 (90/12,621) and 9.4 (119/12,621) per 1,000 examinations, respectively (30 % increase, P < 0.001); positive predictive values (detected cancer patients per 100 recalls) were 24.7 % and 25.5 %, respectively (P = 0.97). Using 2D + 3D, double-reading radiologists detected 27 additional invasive cancers (P < 0.001).	1
25. Skaane P, Bandos AI, Gullien R, et al. Comparison of digital mammography alone and digital mammography plus tomosynthesis in a population-based screening program. Radiology. 2013;267(1):47-56.	Experimental-Dx	12,621 cases	To assess cancer detection rates, false-positive rates before arbitration, positive predictive values for women recalled after arbitration, and the type of cancers detected with use of digital mammography alone and combined with tomosynthesis in a large prospective screening trial.	Detection rates, including those for invasive and in situ cancers, were 6.1 per 1000 examinations for mammography alone and 8.0 per 1000 examinations for mammography plus tomosynthesis (27% increase, adjusted for reader; P = .001). False-positive rates before arbitration were 61.1 per 1000 examinations with mammography alone and 53.1 per 1000 examinations with mammography plus tomosynthesis (15% decrease, adjusted for reader; P < .001). After arbitration, positive predictive values for recalled patients with cancers verified later were comparable (29.1% and 28.5%, respectively, with mammography alone and mammography plus tomosynthesis; P = .72). Twenty-five additional invasive cancers were detected with mammography plus tomosynthesis (40% increase, adjusted for reader; P < .001). The mean interpretation time was 45 seconds for mammography alone and 91 seconds for mammography plus tomosynthesis (P < .001).	1

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
26. Svahn TM, Chakraborty DP, Ikeda D, et al. Breast tomosynthesis and digital mammography: a comparison of diagnostic accuracy. Br J Radiol. 2012;85(1019):e1074-1082.	Observational-Dx	185 patients (1 breast per patient included in study).	To compare the ability of radiologists to detect breast cancers using one-view breast tomosynthesis (BT) and two-view digital mammography (DM) in an enriched population of diseased patients and benign and/or healthy patients.	The diagnostic accuracy of BT was significantly better than that of DM (JAFROC: p=0.0031, ROC: p=0.0415). The average sensitivity of BT was higher than that of DM (approximately 90% vs approximately 79%; 95% confidence interval of difference: 0.036, 0.108) while the average false-positive fraction was not significantly different (95% confidence interval of difference: -0.117, 0.010).	2
27. Takamoto Y, Tsunoda H, Kikuchi M, et al. Role of breast tomosynthesis in diagnosis of breast cancer for Japanese women. Asian Pac J Cancer Prev. 2013;14(5):3037-3040.	Observational-Dx	195 breasts of 99 patients	To assess the detectability of lesions by conventional 2DMMG and 3DBT in diagnosis of breast cancer for Japanese women.	Of the affected breasts, 77 (75.5%) had lesions assigned to the same categories by 2DMMG and 3DBT. For 24 (23.5%) lesions, the category increased in 3DBT indicating improvement in diagnostic performance compared to 2DMMG. 3DBT improved diagnostic sensitivity for patients with mass, focal asymmetric density (FAD), and architectural distortion. However, 3DBT was not statistically superior in diagnosis of the presence or absence of calcification	3

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
28. Durand MA, Haas BM, Yao X, et al. Early clinical experience with digital breast tomosynthesis for screening mammography. Radiology. 2015;274(1):85-92.	Observational-Dx	17,955 screening mammograms	To examine recall rates from screening mammography and the mammographic findings that caused recall in women who underwent digital breast tomosynthesis with conventional mammography (referred to as two-dimensional [2D two-dimensional] with three-dimensional [3D three-dimensional] imaging [2D two-dimensional + 3D three-dimensional]) and in women who underwent conventional mammography alone (referred to as 2D two-dimensional).	This study included 17 955 screening mammograms; of the total, there were 8591 (47.8%) 2D two-dimensional + 3D three-dimensional screening examinations and 9364 (52.2%) 2D two-dimensional examinations. The recall rate was 7.8% (671 of 8592) for 2D two-dimensional + 3D three-dimensional and 12.3% (1154 of 9364) for 2D two-dimensional ($P < .0001$); the rate of recall was 36.6% lower in the 2D two-dimensional + 3D three-dimensional group than in the 2D two-dimensional group. Recall rates for the 2D two-dimensional + 3D three-dimensional group were significantly lower for patients with asymmetries, (2D two-dimensional + 3D three-dimensional vs 2D two-dimensional , 3.1% [267 of 8591] vs 7.4% [689 of 9364], respectively; $P < .0001$) and calcifications (2D two-dimensional + 3D three-dimensional vs 2D two-dimensional , 2.4% [205 of 8591] vs 3.2% [297 of 9364], respectively; $P = .0014$). For patients with masses and architectural distortion, the difference in recall rates was not significant (masses: 2D two-dimensional + 3D three-dimensional vs 2D two-dimensional , 2.5% [215 of 8591] vs 2.5% [237 of 9364], respectively; $P = .90$; architectural distortion: 2D two-dimensional + 3D three-dimensional vs 2D two-dimensional , 0.68% [58 of 8591] vs 0.69% [65 of 9364]; $P = .88$). Cancer detection was highest in the 2D two-dimensional + 3D three-dimensional group at 5.9 cancers per 1000 examinations, with 5.7 cancers per 1000 examinations in the concurrent 2D two-dimensional group, and 4.4 cancers per 1000 examinations in the historic control.	3

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
29. Lourenco AP, Barry-Brooks M, Baird GL, Tuttle A, Mainiero MB. Changes in recall type and patient treatment following implementation of screening digital breast tomosynthesis. Radiology. 2015;274(2):337-342.	Observational-Dx	12,577 digital mammography exams and 12,921 digital breast tomosynthesis exams.	To compare recall rate, types of abnormalities recalled, additional imaging required, biopsy positive predictive value (PPV), and cancer detection rate before and after implementation of screening digital breast tomosynthesis (DBT).	The recall rate was 9.3% (1175 of 12 577 examinations; 95% confidence interval [CI]: 8.8%, 9.9%) for DM and 6.4% (827 of 12 921 examinations; 95% CI: 6.0%, 6.8%) for DBT, an overall reduction of 31% (P < .00001). The recall rate was lower with DM than with DBT for masses (8.9% vs 26.8%, respectively), distortions (0.6% vs 5.3%), and calcifications (13.4% vs 20.3%) (P < .0001 for all). The recall rate was lower with DBT than with DM for asymmetries (13.3% vs 32.2%, respectively) and focal asymmetries (18.2% vs 32.2%) (P < .0001 for both). Diagnostic evaluation with ultrasonography (US) increased with DBT at the time of additional imaging (2.6% for DM vs 28.3% for DBT, P < .0001). There was no significant difference between DM and DBT with regard to biopsy PPV (30.2% vs 23.8%, P = .21) or cancer detection rate per 1000 patients (5.4 vs 4.6, P = .44).	3
30. Rose SL, Tidwell AL, Bujnoch LJ, Kushwaha AC, Nordmann AS, Sexton R, Jr. Implementation of breast tomosynthesis in a routine screening practice: an observational study. AJR Am J Roentgenol. 2013;200(6):1401-1408.	Observational-Dx	13,856 screening mammography alone and 9,499 screening mammography with tomosynthesis.	To assess the changes in performance measures, if any, after the introduction of tomosynthesis systems into our clinical practice.	For the group as a whole, the introduction and routine use of tomosynthesis resulted in significant observed changes in recall rates from 8.7% to 5.5% (p < 0.001), nonsignificant changes in biopsy rates from 15.2 to 13.5 per 1000 screenings (p = 0.59), and cancer detection rates from 4.0 to 5.4 per 1000 screenings (p = 0.18). The invasive cancer detection rate increased from 2.8 to 4.3 per 1000 screening examinations (p = 0.07). The positive predictive value for recalls increased from 4.7% to 10.1% (p < 0.001).	3

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
31. Haas BM, Kalra V, Geisel J, Raghu M, Durand M, Philpotts LE. Comparison of tomosynthesis plus digital mammography and digital mammography alone for breast cancer screening. Radiology. 2013;269(3):694-700.	Observational-Dx	13,158 patients	To compare screening recall rates and cancer detection rates of tomosynthesis plus conventional digital mammography to those of conventional digital mammography alone.	A total of 13 158 patients presented for screening mammography; 6100 received tomosynthesis. The overall recall rate was 8.4% for patients in the tomosynthesis group and 12.0% for those in the conventional mammography group (P < .01). The addition of tomosynthesis reduced recall rates for all breast density and patient age groups, with significant differences (P < .05) found for scattered fibroglandular, heterogeneously dense, and extremely dense breasts and for patients younger than 40 years, those aged 40-49 years, those aged 50-59 years, and those aged 60-69 years. These findings persisted when multivariate logistic regression was used to control for differences in age, breast density, and elevated risk of breast cancer. The cancer detection rate was 5.7 per 1000 in patients receiving tomosynthesis versus 5.2 per 1000 in patients receiving conventional mammography alone (P = .70).	3
32. Mun HS, Kim HH, Shin HJ, et al. Assessment of extent of breast cancer: comparison between digital breast tomosynthesis and full-field digital mammography. Clin Radiol. 2013;68(12):1254-1259.	Observational-Dx	173 lesions in 169 patients	To compare the accuracy of digital breast tomosynthesis (DBT) and full-field digital mammography (FFDM) in preoperative assessment of local extent of breast cancer.	The dataset included 173 malignant breast lesions (mean size 23.8 mm, 43% of lesions were </=2 cm in size) in 169 patients, two-thirds of which had heterogeneously or extremely dense breasts. Overall, the percentage of lesions mis-sized at DBT was significantly lower than at FFDM (19% versus 29%, p = 0.003). There was significantly less mis-sizing at DBT in both heterogeneously dense breasts (11.1% difference between DBT and FFDM, p = 0.016) and extremely dense breasts (15.8% difference, p = 0.024). DBT also had significantly less mis-sizing than FFDM in the subgroup of lesions that were </=2 cm in size (14.7% difference, p = 0.005)	2

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
33. Lang K, Andersson I, Zackrisson S. Breast cancer detection in digital breast tomosynthesis and digital mammography-a side-by-side review of discrepant cases. Br J Radiol. 2014;87(1040):20140080.	Observational-Dx	26 discrepant cases resulting from 24 females with 25 cancer lesions in 24 breasts.	To analyse discrepant breast cancer detection in digital breast tomosynthesis (DBT) and digital mammography (DM).	The proportion of lesion periphery in fatty tissue was statistically significantly larger, and there were significantly more spiculated masses in DBT compared with DM in the DBT only group ($p = 0.018$; $p = 0.015$). The main reasons for missing a lesion were poor lesion visibility when using DM and interpretative error when using DBT.	3
34. Dang PA, Freer PE, Humphrey KL, Halpern EF, Rafferty EA. Addition of tomosynthesis to conventional digital mammography: effect on image interpretation time of screening examinations. Radiology. 2014;270(1):49-56.	Observational-Dx	3665 examinations (1502 combined and 2163 digital mammography)	To determine the effect of implementing a screening tomosynthesis program on real-world clinical performance by quantifying differences between interpretation times for conventional screening mammography and combined tomosynthesis and mammography for multiple participating radiologists with a wide range of experience in a large academic center.	The mean number of studies interpreted in hour was 23.8 +/- 0.55 (standard deviation) (range, 14.4-40.4) for combined tomosynthesis and mammography and 34.0 +/- 0.55 (range, 20.4-54.3) for digital mammography alone. A mean of 10.2 fewer studies were interpreted per hour during combined tomosynthesis and mammography compared with digital mammography sessions ($P < .0001$). The mean interpretation time was 2.8 minutes +/- 0.9 (range, 1.5-4.2 minutes) for combined tomosynthesis and mammography and 1.9 minutes +/- 0.6 (range, 1.1-3.0) for digital mammography; interpretation time with combined tomosynthesis and mammography was 0.9 minute longer (47% longer) compared with digital mammography alone ($P < .0001$). With the increase in years of breast imaging experience, the overall additional time required to read images from combined tomosynthesis and mammography examinations decreased ($R(2) = 0.52$, $P = .03$).	2

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
35. Skaane P, Bandos AI, Eben EB, et al. Two-view digital breast tomosynthesis screening with synthetically reconstructed projection images: comparison with digital breast tomosynthesis with full-field digital mammographic images. Radiology. 2014;271(3):655-663.	Experimental-Dx	24,901 examinations	To compare the performance of two versions of reconstructed two-dimensional (2D) images in combination with digital breast tomosynthesis (DBT) versus the performance of standard full-field digital mammography (FFDM) plus DBT.	Cancer detection rates were 8.0, 7.4, 7.8, and 7.7 per 1000 screening examinations for FFDM plus DBT in period 1, initial reconstructed 2D images plus DBT in period 1, FFDM plus DBT in period 2, and current reconstructed 2D images plus DBT in period 2, respectively. False-positive scores were 5.3%, 4.6%, 4.6%, and 4.5%, respectively. Corresponding reader-adjusted paired comparisons of false-positive scores revealed significant differences for period 1 (P = .012) but not for period 2 (ratio = 0.99; 95% confidence interval: 0.88, 1.11; P = .85)	1
36. Zuley ML, Guo B, Catullo VJ, et al. Comparison of two-dimensional synthesized mammograms versus original digital mammograms alone and in combination with tomosynthesis images. Radiology. 2014;271(3):664-671.	Observational-Dx	123 patients	To assess interpretation performance and radiation dose when two-dimensional synthesized mammography (SM) images versus standard full-field digital mammography (FFDM) images are used alone or in combination with digital breast tomosynthesis images.	Probability of malignancy-based mean AUCs for SM and FFDM images alone was 0.894 and 0.889, respectively (difference, -0.005; 95% confidence interval [CI]: -0.062, 0.054; P = .85). Mean AUC for SM with tomosynthesis and FFDM with tomosynthesis was 0.916 and 0.939, respectively (difference, 0.023; 95% CI: -0.011, 0.057; P = .19). In terms of the reader-specific AUCs, five readers performed better with SM alone versus FFDM alone, and all eight readers performed better with combined FFDM and tomosynthesis (absolute differences from 0.003 to 0.052). Similar results were obtained by using a nonparametric analysis of forced BI-RADS ratings	3
37. Winkler NS, Raza S, Mackesy M, Birdwell RL. Breast density: clinical implications and assessment methods. Radiographics. 2015;35(2):316-324.	Review/Other-Dx	N/A	To discuss the clinical implications and assessment methods for breast density	No results stated in abstract	4

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
38. Brem RF, Tabar L, Duffy SW, et al. Assessing improvement in detection of breast cancer with three-dimensional automated breast US in women with dense breast tissue: the SomoInsight Study. Radiology. 2015;274(3):663-673.	Observational-Dx	112 women	To determine improvement in breast cancer detection by using supplemental three-dimensional (3D) automated breast (AB) ultrasonography (US) with screening mammography versus screening mammography alone in asymptomatic women with dense breasts.	Breast cancer was diagnosed at screening in 112 women: 82 with screening mammography and an additional 30 with AB US. Addition of AB US to screening mammography yielded an additional 1.9 detected cancers per 1000 women screened (95% confidence interval [CI]: 1.2, 2.7; P < .001). Of cancers detected with screening mammography, 62.2% (51 of 82) were invasive versus 93.3% (28 of 30) of additional cancers detected with AB US (P = .001). Of the 82 cancers detected with either screening mammography alone or the combined read, 17 were detected with screening mammography alone. Of these, 64.7% (11 of 17) were ductal carcinoma in situ versus 6.7% (two of 30) of cancers detected with AB US alone. Sensitivity for the combined read increased by 26.7% (95% CI: 18.3%, 35.1%); the increase in the recall rate per 1000 women screened was 284.9 (95% CI: 278.0, 292.2; P < .001).	3
39. Chae EY, Kim HH, Cha JH, Shin HJ, Kim H. Evaluation of screening whole-breast sonography as a supplemental tool in conjunction with mammography in women with dense breasts. J Ultrasound Med. 2013;32(9):1573-1578.	Observational-Dx	20,864 women	To evaluate the use and performance of supplemental screening whole-breast sonography in conjunction with mammography in asymptomatic women with dense breast tissue.	Among the 20,864 women with dense breasts, 35 cancers were diagnosed, with a mean size of 13 mm. The cancer detection yield was 0.480 per 1000 women in the mammography-only group and increased to 2.871 in the mammography-plus-sonography group. Of 24 cancers detected in the mammography-plus-sonography group, the mean size was 11 mm, and the axillary lymph nodes were negative in 19 of 20. The sensitivity was significantly higher in the mammography-plus-sonography group than the mammography-only group (100% versus 54.55%; P = .002). The positive predictive values of sonographically prompted biopsy were 11.1% for the mammography-plus-sonography group and 50% for the mammography-only group.	3

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
40. Giuliano V, Giuliano C. Improved breast cancer detection in asymptomatic women using 3D-automated breast ultrasound in mammographically dense breasts. Clin Imaging. 2013;37(3):480-486.	Observational-Dx	3418 women	to demonstrate that ABUS increases the detection of non-palpable breast cancers in mammographically dense breasts when used as an adjunct diagnostic modality in asymptomatic women	Automated breast ultrasound (ABUS)was performed in 3418 asymptomatic women with mammographically dense breasts. The addition of ABUS to mammography in women with greater than 50% breast density resulted in the detection of 12.3 per 1,000 breast cancers, compared to 4.6 per 1,000 by mammography alone. The mean tumor size was 14.3 mm and overall attributable risk of breast cancer was 19.92 (95% confidence level, 16.75 - 23.61) in our screened population. These preliminary results may justify the cost-benefit of implementing the judicious us of ABUS in conjunction with mammography in the dense breast screening population.	2

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
41. Hooley RJ, Greenberg KL, Stackhouse RM, Geisel JL, Butler RS, Philpotts LE. Screening US in patients with mammographically dense breasts: initial experience with Connecticut Public Act 09-41. Radiology. 2012;265(1):59-69.	Observational-Dx	935 women	To determine performance and utilization of screening breast ultrasonography (US) in women with dense breast tissue who underwent additional screening breast US in the 1st year since implementation of Connecticut Public Act 09-41 requiring radiologists to inform patients with heterogeneous or extremely dense breasts at mammography that they may benefit from such examination.	Of 935 women, 614 (65.7%) were at low risk, 149 (15.9%) were at intermediate risk, and 87 (9.3%) were at high risk for breast cancer. Of the screening breast US examinations, in 701 (75.0%), results were classified as Breast Imaging Reporting and Data System (BI-RADS) category 1 or 2; in 187 (20.0%), results were classified as BI-RADS category 3; and in 47 (5.0%), results were classified as BI-RADS category 4. Of 63 aspirations or biopsies recommended and performed in 53 patients, in nine, lesions were BI-RADS category 3, and in 54, lesions were BI-RADS category 4. Among 63 biopsies and aspirations, three lesions were malignant (all BI-RADS category 4, diagnosed with biopsy). All three cancers were smaller than 1 cm, were found in postmenopausal patients, and were solid masses. One cancer was found in each risk group. In 44 of 935 (4.7%) patients, examination results were false-positive. Overall positive predictive value (PPV) for biopsy or aspirations performed in patients with BI-RADS category 4 masses was 6.5% (three of 46; 95% confidence interval [CI]: 1.7%, 19%). Overall cancer detection rate was 3.2 cancers per 1000 women screened (three of 935; 95% CI: 0.8 cancers per 1000 women screened, 10 cancers per 1000 women screened).	2

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
42. Parris T, Wakefield D, Frimmer H. Real world performance of screening breast ultrasound following enactment of Connecticut Bill 458. Breast J. 2013;19(1):64-70.	Observational-Dx	5519 women	To retrospectively evaluate the benefits of screening breast ultrasound in women with dense breast tissue following enactment of Connecticut Bill 458 in October 2009.	We focused on the women who had negative mammograms and biopsy recommendations based on ultrasound findings (BIRADS 4 and 5). The data were compared with those from a group of 1319 women who were screened with breast ultrasound before the law went into effect between October 2008 and September 2009 (pre-law group). Prior to the law, ultrasound studies were performed only at the referring clinician's request. Of the 5,519 women in the post law group, 10 malignant lesions were found, with a cancer detection rate of 0.18%, biopsy rate of 3.3%, and a positive predictive value of 5.5%. The tumor size on ultrasound ranged from 4 to 15 mm; mean 9.7 mm. Sentinel lymph node biopsy was negative in 7 of 10 patients. Of the 1,319 women in the pre-law group, 20 biopsies were recommended, all of which were benign. No malignancies were detected in the pre-law group.	2
43. Gartlehner G, Thaler KJ, Chapman A, et al. Adjunct ultrasonography for breast cancer screening in women at average risk: a systematic review. Int J Evid Based Healthc. 2013;11(2):87-93.	Review/Other-Dx	N/A	To systematically assess the comparative benefits and harms of mammography with adjunct breast ultrasonography and mammography only in breast cancer screening.	We did not detect any controlled studies that provide evidence for (or against) the use of adjunct ultrasonography for screening in women at average risk for breast cancer. Extrapolations of results from women at elevated risk for breast cancer indicate that the false-positive rates in women at average risk who were recalled because of positive ultrasonographies will exceed 98%. In women with dense or very dense breast tissue, the evidence regarding the use of adjunct ultrasonography is not conclusive.	4

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
44. Rhodes DJ, Hruska CB, Conners AL, et al. Journal club: molecular breast imaging at reduced radiation dose for supplemental screening in mammographically dense breasts. AJR Am J Roentgenol. 2015;204(2):241-251.	Observational-Dx	1585 patients	To assess the diagnostic performance of supplemental screening molecular breast imaging (MBI) in women with mammographically dense breasts after system modifications to permit radiation dose reduction.	In 1585 participants with a complete reference standard, 21 were diagnosed with cancer: two detected by mammography only, 14 by MBI only, three by both modalities, and two by neither. Of 14 participants with cancers detected only by MBI, 11 had invasive disease (median size, 0.9 cm; range, 0.5-4.1 cm). Nine of 11 (82%) were node negative, and two had bilateral cancers. With the addition of MBI to mammography, the overall cancer detection rate (per 1000 screened) increased from 3.2 to 12.0 ($p < 0.001$) (supplemental yield 8.8). The invasive cancer detection rate increased from 1.9 to 8.8 ($p < 0.001$) (supplemental yield 6.9), a relative increase of 363%, while the change in DCIS detection was not statistically significant (from 1.3 to 3.2, $p = 0.250$). For mammography alone, sensitivity was 24%; specificity, 89%; and PPV3, 25%. For the combination, sensitivity was 91% ($p < 0.001$); specificity, 83% ($p < 0.001$); and PPV3, 28% ($p = 0.70$). The recall rate increased from 11.0% with mammography alone to 17.6% ($p < 0.001$) for the combination; the biopsy rate increased from 1.3% for mammography alone to 4.2% ($p < 0.001$).	1

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
45. Rhodes DJ, Hruska CB, Phillips SW, Whaley DH, O'Connor MK. Dedicated dual-head gamma imaging for breast cancer screening in women with mammographically dense breasts. Radiology. 2011;258(1):106-118.	Observational-Dx	936 patients	To compare performance characteristics of dedicated dual-head gamma imaging and mammography in screening women with mammographically dense breasts.	Of 936 participants, 11 had cancer (one with mammography only, seven with gamma imaging only, two with both combined, and one with neither). Diagnostic yield was 3.2 per 1000 (95% confidence interval [CI]: 1.1, 9.3) for mammography, 9.6 per 1000 (95% CI: 5.1, 18.2) for gamma imaging, and 10.7 per 1000 (95% CI: 5.8, 19.6) for both (P = .016 vs mammography alone). One participant had a second ipsilateral cancer detected with gamma imaging only. Prevalent screening gamma imaging demonstrated equivalent specificity relative to incident screening mammography (93% [861 of 925] vs 91% [840 of 925], P = .069). Of eight cancers detected with gamma imaging only, six (75%) were invasive (median size, 1.1 cm; range, 0.4-5.1 cm); all were node negative. The ratio of the number of patients with breast cancer per number of screening examinations with abnormal findings was 3% (three of 88) for mammography and 12% (nine of 73) for gamma imaging (P = .01). The number of breast cancers diagnosed per number of biopsies performed was 18% (three of 17) for mammography and 28% (10 of 36) for gamma imaging (P = .36)	2
46. Holbrook A, Newel MS. Alternative screening for women with dense breasts: breast-specific gamma imaging (molecular breast imaging). AJR Am J Roentgenol. 2015;204(2):252-256.	Review/Other-Dx	N/A	To review the literature pertinent to the performance of breast-specific gamma imaging (BSGI) in patients with dense breasts.	Many studies have reported the sensitivity of BSGI in finding cancers even in dense breasts. However, BSGI has not yet been validated as an effective screening tool in large prospective studies. In addition, whole-body dose remains a significant concern.	4

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
47. Saslow D, Boetes C, Burke W, et al. American Cancer Society guidelines for breast screening with MRI as an adjunct to mammography. CA Cancer J Clin. 2007;57(2):75-89.	Review/Other-Dx	N/A	To provide new evidence on breast MRI screening guidelines for the early detection of breast cancer in women.	A guideline panel has reviewed this evidence and developed new recommendations for women at different defined levels of risk. Screening MRI is recommended for women with an approximately 20%–25% or greater lifetime risk of breast cancer, including women with a strong family history of breast or ovarian cancer and women who were treated for Hodgkin disease. There are several risk subgroups for which the available data are insufficient to recommend for or against screening, including women with a personal history of breast cancer, carcinoma in situ, atypical hyperplasia, and extremely dense breasts on mammography.	4

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
48. Berg WA, Blume JD, Cormack JB, et al. Combined screening with ultrasound and mammography vs mammography alone in women at elevated risk of breast cancer. JAMA. 2008;299(18):2151-2163.	Experimental-Dx	2725 women	Prospective, multicenter trial to compare the diagnostic yield, defined as the proportion of women with positive screen test results and positive reference standard, and performance of screening with US plus mammography vs mammography alone in women at elevated risk of breast cancer.	40 participants (41 breasts) were diagnosed with cancer: 8 suspicious on both US and mammography, 12 on US alone, 12 on mammography alone, and 8 participants (9 breasts) on neither. The diagnostic yield for mammography was 7.6 per 1000 women screened (20 of 2637) and increased to 11.8 per 1000 (31 of 2637) for combined mammography plus US; the supplemental yield was 4.2 per 1000 women screened (95% CI, 1.1-7.2 per 1000; P = .003 that supplemental yield is 0). The diagnostic accuracy for mammography was 0.78 (95% CI, 0.67-0.87) and increased to 0.91 (95% CI, 0.84-0.96) for mammography plus ultrasound (P = .003 that difference is 0). Of 12 supplemental cancers detected by ultrasound alone, 11 (92%) were invasive with a median size of 10 mm (range, 5-40 mm; mean [SE], 12.6 [3.0] mm) and 8 of the 9 lesions (89%) reported had negative nodes. The positive predictive value of biopsy recommendation after full diagnostic workup was 19 of 84 for mammography (22.6%; 95% CI, 14.2%-33%), 21 of 235 for ultrasound (8.9%, 95% CI, 5.6%-13.3%), and 31 of 276 for combined mammography plus ultrasound (11.2%; 95% CI. 7.8%-15.6%). Adding a single screening US to mammography will yield an additional 1.1 to 7.2 cancers per 1000 high-risk women, but it will also substantially increase the number of false positives.	1

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
49. Berg WA, Zhang Z, Lehrer D, Jong RA, Pisano ED, Barr RG, Böhm-Vélez M, Mahoney MC, Evans WP 3rd, Larsen LH, Morton MJ, Mendelson EB, Farria DM, Cormack JB, Marques HS, Adams A, Yeh NM, Gabrielli G; ACRIN 6666 Investigators.. Detection of breast cancer with addition of annual screening ultrasound or a single screening MRI to mammography in women with elevated breast cancer risk. JAMA. 2012 Apr 4;307(13):1394-404.	Observational-Dx	2662 women	To determine supplemental cancer detection yield of ultrasound and MRI in women at elevated risk for breast cancer.	The 2662 patients underwent 7473 mammograms and US, with 110 women having 111 breast cancers detected, of which 33 were detected on mammography only, 32 on US only, 26 on both mammography and US, and 9 on MRI after mammography and US. Eleven were not detected by any imaging modality. Supplemental incidence-screening US identified 3.7 cancers per 1000 women-screens (95% CI 2.1 to 5.8, p<.001). Sensitivity, specificity, and PPV3 for M +US were 57/75 (0.76, 95% CI 0.65 to 0.85), 3987/4739 (0.84, 95% CI 0.83 to 0.85), and 55/339 (0.16, 95% CI 0.12 to 0.21); and for mammography alone 39/75 (0.52, 95% CI 0.40 to 0.64), 4325/4739 (0.91,95% 0.90 to 0.92), and 37/97 (0.38, 95% CI 0.28 to 0.49) (p<.001 all comparisons). Of 612 analyzable MRI participants, 16 (2.6%) had breast cancer diagnosed. Supplemental yield of MRI was 14.7 per 1000 (95% CI 3.5 to 25.9, p=.004). Sensitivity, specificity, and PPV3 for MRI+M+US were 16/16 (1.00, 95% CI 0.79 to 1.00), 390/596 (0.65, 95% CI 0.61 to 0.69), and 15/81 (0.19, 95% CI 0.11 to 0.29); and for M+US 7/16 (0.44, 95% CI 0.20 to 0.70, p=.004), 503/596 (0.84, 95% CI 0.81 to 0.87, p <.001), and 7/38 (0.18, 95% CI 0.08 to 0.34, p= .98) for M+US. Number of screens needed to detect one cancer was 127(95%CI 99 to 167) for mammography; 234(95%CI 173 to 345) for supplemental ultrasound, and 68 (95%CI 39 to 286) for MRI after negative M+US.	2

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
50. Friedlander LC, Roth SO, Gavenonis SC. Results of MR imaging screening for breast cancer in high-risk patients with lobular carcinoma in situ. Radiology. 2011;261(2):421-427.	Observational-Dx	198 patients	To determine the outcome of screening breast magnetic resonance (MR) imaging examinations performed in patients with lobular carcinoma in situ (LCIS) at the authors' institution.	A total of 445 breast MR examinations in 198 patients with LCIS were identified. Of these, 308 were screening examinations in 134 patients. One patient was a BRCA mutation carrier and was excluded. Of the remaining 307 screening examinations, 254 (82.7%) had BI-RADS category 1 or 2 findings; 27 (8.8%) had BI-RADS category 3 findings; and 27 (8.8%) had B-IRADS category 4 or 5 findings. Of the 27 studies that led to a biopsy recommendation, 10 (37%) yielded benign pathologic findings, five (18.5%) yielded malignant pathologic findings, and seven (25.9%) yielded high-risk lesions. Of the 27 studies with BI-RADS 3 findings, two (7.4%) resulted in biopsy, findings of both were benign. Overall, malignancy was detected in five of 307 screening studies (1.6%) and in five of 133 screened patients (3.8%). The positive predictive value (PPV) of these screening studies for which biopsy was recommended was 18.5%. The PPV 3 (studies for which biopsy was recommended and actually performed, as described in the BI-RADS guidelines) was 23.8%.	3

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
51. Sung JS, Malak SF, Bajaj P, Alis R, Dershaw DD, Morris EA. Screening breast MR imaging in women with a history of lobular carcinoma in situ. Radiology. 2011;261(2):414-420.	Observational-Dx	220 women	To assess the utility of screening MR imaging in the detection of otherwise occult breast cancers in women with a history of lobular carcinoma in situ (LCIS).	Biopsy was recommended in 63 lesions seen in 58 (9%) of 670 screening MR studies. Eight additional lesions were identified at short-term follow-up MR imaging for a total of 71 lesions in 59 patients. Twelve cancers (20%) were identified in 60 lesions sampled. Biopsy was recommended in 26 additional lesions identified at mammography; biopsy was performed in 25 of these lesions and revealed malignancy in five (20%). Overall, 17 cancers were detected in 14 patients during the study period. Of these, 12 were detected with MR imaging alone, and five were detected with mammography alone. Of the 12 cancers detected at MR imaging, there were nine invasive cancers and three cases of ductal carcinoma in situ (DCIS). Of the five cancers detected at mammography, two were invasive and three were DCIS. MR imaging is a useful adjunct modality with which to screen women with a history of LCIS at high-risk of developing breast cancer, resulting in a 4.5% incremental cancer detection rate. Sensitivity in the detection of breast cancers with a combination of MR imaging and mammography was higher than sensitivity of either modality alone.	4
52. Lehman CD, Lee JM, DeMartini WB, et al. Screening MRI in Women With a Personal History of Breast Cancer. J Natl Cancer Inst. 2016;108(3).	Observational-Dx	1521 women	To compare screening MRI performance in women with personal history versus genetic risk or family history of breast cancer.	Of 1521 women who underwent screening MRI from July 2004 to November 2011, 915 had PH and 606 had GFH of breast cancer. Overall, MRI sensitivity was 79.4% for all cancers and 88.5% for invasive cancers. False-positive exams were lower in the PH vs GFH groups (12.3% vs 21.6%, $P < .001$), specificity was higher (94.0% vs 86.0%, $P < .001$), and sensitivity and cancer detection rate were not statistically different ($P > .99$). Age ($P < .001$), prior MRI ($P < .001$), and clinical indication ($P < .001$) were individually associated with initial false-positive rate; age and prior MRI remained statistically significant in multivariable modeling ($P = .001$ and $P < .001$, respectively).	3

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
53. Brennan S, Liberman L, Dershaw DD, Morris E. Breast MRI screening of women with a personal history of breast cancer. AJR Am J Roentgenol. 2010;195(2):510-516.	Observational-Dx	144 women	To determine the cancer detection and biopsy rate among women who have breast MRI screening solely on the basis of a personal history of breast cancer.	Of 144 women, 44 (31% [95% CI, 15%–29%]) underwent biopsies prompted by MRI examination. Biopsies revealed malignancies in 17 women (12% [95% CI, 7%–18%]) and benign findings only in 27 women (19% [95% CI, 13%–26%]). Of the 17 women in whom cancer was detected, 7 also had benign biopsy results. In total, 18 malignancies were found. One woman had 2 metachronous cancers. MRI screening resulted in a total of 61 biopsies, with a positive predictive value of 39% (95% CI, 27%–53%). The malignancies found included 17 carcinomas and 1 myxoid liposarcoma. Of the 17 cancers, 12 (71%) were invasive, 5 (29%) were DCIS, and 10 (59%) were minimal breast cancers. Of 17 cancers, 10 were detected by MRI only. The 10 cancers detected by MRI only, vs 7 cancers later found by other means, were more likely to be DCIS (4/10 [40%] vs 1/7 [14%]; P=0.25) or minimal breast cancers (7/10 [70%] vs 3/7 [43%]; P=0.26).	3
54. Hagen AI, Kvistad KA, Maehle L, et al. Sensitivity of MRI versus conventional screening in the diagnosis of BRCA-associated breast cancer in a national prospective series. Breast. 2007;16(4):367-374.	Observational-Dx	867 MRI in 445 BRCA1 and 46 BRCA2 mutation carriers	To compare the sensitivities of breast MRI and the conventional screening programme consisting of mammography (XRM) +/- US for early diagnosis of breast cancer in BRCA1/2 mutation carriers in a national prospective series.	25 cancers were observed, five (20%) as interval cancers. At the time of diagnosis, sensitivity to detect cancer was 19/22=86% for MRI and 12/24=50% for XRM. Twenty-one were examined by both methods at the time of diagnosis. In the19 BRCA1 mutation carriers among them, MRI had a sensitivity of 1/3(33%) to diagnose DCIS and 15/16 (94%) among the invasive cancers. For XRM the sensitivities were 1/3(33%) for DCIS, 3/7(42%) for pT1b, 3/6(50%) for pT1c, and 3/3/100%) for pT2. In the two BRCA2 mutation carriers, both were demonstrated by breast MRI, neither was detected by XRM. Breast MRI had increased sensitivity compared to XRM to diagnose all cancers staged less than pT2.	3

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
55. Kriege M, Brekelmans CT, Boetes C, et al. Differences between first and subsequent rounds of the MRISC breast cancer screening program for women with a familial or genetic predisposition. Cancer. 2006;106(11):2318-2326.	Observational-Dx	1909 eligible women	To determine whether previously reported increased diagnostic accuracy of MRI compared with mammography would be maintained during subsequent screening rounds.	The difference in sensitivity for invasive cancers between mammography and MRI was largest in the first round of women previously screened with mammography (20.0 vs. 93.3%; P = .003), but also in subsequent rounds, there was a significant difference in favor of MRI (29.4 vs. 76.5%; P = .02). The difference in false-positive rate between mammography and MRI was also largest in the first round of women previously screened with mammography (5.5 vs. 14.0%; P<.001), and it remained significant in subsequent rounds (4.6 vs. 8.2%; P<.001). Screen-detected tumors were smaller and more often lymph node negative than symptomatic tumors in age-matched control patients, but no major differences in tumor stage were found between tumors detected at subsequent rounds compared with those in the first round. In subsequent rounds, a significantly higher sensitivity and better discriminating capacity of MRI compared with mammography was maintained, and a favorable tumor stage compared with age-matched symptomatic controls.	4

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
56. Kuhl CK, Schrading S, Leutner CC, et al. Mammography, breast ultrasound, and magnetic resonance imaging for surveillance of women at high familial risk for breast cancer. J Clin Oncol. 2005;23(33):8469-8476.	Observational-Dx	529 asymptomatic women	To compare the effectiveness of mammography, breast US, and MRI for surveillance of women at increased familial risk for breast cancer (lifetime risk of 20% or more).	43 breast cancers were identified in the total cohort (34 invasive, nine ductal carcinoma-in-situ). Overall sensitivity of diagnostic imaging was 93% (40 of 43 breast cancers); overall node-positive rate was 16%, and one interval cancer occurred (one of 43 cancers, or 2%). In the analysis by modality, sensitivity was low for mammography (33%) and US(40%) or the combination of both (49%). MRI offered a significantly higher sensitivity (91%). The sensitivity of mammography in the higher risk groups was 25%, compared with 100% for MRI. Specificity of MRI (97.2%) was equivalent to that of mammography (96.8%). Mammography alone, and also mammography combined with breast US, seems insufficient for early diagnosis of breast cancer in women who are at increased familial risk with or without documented BRCA mutation. If MRI is used for surveillance, diagnosis of intraductal and invasive familial or hereditary cancer is achieved with a significantly higher sensitivity and at a more favorable stage.	2

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
57. Leach MO, Boggis CR, Dixon AK, et al. Screening with magnetic resonance imaging and mammography of a UK population at high familial risk of breast cancer: a prospective multicentre cohort study (MARIBS). Lancet. 2005;365(9473):1769-1778.	Observational-Dx	649 women	Prospective multicentre cohort study was performed to compare contrast enhanced MRI (CE MRI) with mammography for screening.	35 cancers were diagnosed in 649 women screened with both mammography and CE MRI (1881 screens): 19 by CE MRI only, six by mammography only, and eight by both, with two interval cases. Sensitivity was significantly higher for CE MRI (77%, 95% CI 60-90) than for mammography (40%, 24-58; p=0.01), and was 94% (81-99) when both methods were used. Specificity was 93% (92-95) for mammography, 81% (80-83) for CE MRI (p<0.0001), and 77% (75-79) with both methods. The difference between CE MRI and mammography sensitivities was particularly pronounced in BRCA1 carriers (13 cancers; 92%vs 23%, p=0.004). Findings indicate that CE MRI is more sensitive than mammography for cancer detection. Specificity for both procedures was acceptable. Despite a high proportion of grade 3 cancers, tumours were small and few women were node positive. Annual screening, combining CE MRI and mammography, would detect most tumours in this risk group.	2
58. Saadatmand S, Vos JR, Hooning MJ, et al. Relevance and efficacy of breast cancer screening in BRCA1 and BRCA2 mutation carriers above 60 years: a national cohort study. Int J Cancer. 2014;135(12):2940-2949.	Observational-Dx	548 patients	To address the clinical relevance and extent of this issue, we first assess the proportion of BRCA1/2 mutation carriers with remaining breast tissue at risk at age 60, in an on-going nationwide cohort study and a family cancer clinic cohort. Secondly, to determine the optimal breast cancer screening strategy for BRCA1/2 mutation carriers 60, we compared tumour stage at detection per screening strategy.	Of 548 BRCA1/2 mutation carriers >/=60 years in 2012, 395 (72%) did not have bilateral mastectomy before the age of 60. Of these 395, 224 (57%) had a history of breast or other invasive carcinoma. In 136 BRCA1/2 mutation carriers, we compared 148 breast cancers (including interval cancers) detected >/=60, of which 84 (57%) were first breast cancers. With biennial mammography 53% (30/57) of carcinomas were detected in unfavourable stage, compared to 21% (12/56) with annual mammography (adjusted odds ratio: 4.07, 95% confidence interval [1.79-9.28], p = 0.001). With biennial screening 40% of breast cancers were interval cancers, compared to 20% with annual screening (p = 0.016).	3

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
59. Sardanelli F, Podo F, D'Agnolo G, et al. Multicenter comparative multimodality surveillance of women at genetic-familial high risk for breast cancer (HIBCRIT study): interim results. Radiology. 2007;242(3):698-715.	Observational-Dx	278 women	Prospective, multicenter trial to compare clinical breast examination (CBE), mammography, US, and contrast material-enhanced MR imaging for screening women at genetic-familial high risk for breast cancer and report interim results, with pathologic findings as standard.	Breast cancer was found in 11 of 278 women at first round and seven of 99 at second round (14 invasive, four intraductal; eight were	2
60. Kuhl C, Weigel S, Schrading S, Arand B, Bieling H, König R, Tombach B, Leutner C, Rieber-Brambs A, Nordhoff D, Heindel W, Reiser M, Schild HH. Prospective multicenter cohort study to refine management recommendations for women at elevated familial risk of breast cancer: the EVA trial. J Clin Oncol. 2010 Mar 20;28(9):1450-7.	Observational-Dx	687 women	To investigate the respective contribution (in terms of cancer yield and stage at diagnosis) of clinical breast examination (CBE), mammography, ultrasound, and quality-assured breast magnetic resonance imaging (MRI), used alone or in different combination, for screening women at elevated risk for breast cancer.	Twenty-seven women were diagnosed with breast cancer: 11 ductal carcinoma in situ (41%) and 16 invasive cancers (59%). Three (11%) of 27 were node positive. All cancers were detected during annual screening; no interval cancer occurred; no cancer was identified during half-yearly ultrasound. The cancer yield of ultrasound (6.0 of 1,000) and mammography (5.4 of 1,000) was equivalent; it increased nonsignificantly (7.7 of 1,000) if both methods were combined. Cancer yield achieved by MRI alone (14.9 of 1,000) was significantly higher; it was not significantly improved by adding mammography (MRI plus mammography: 16.0 of 1,000) and did not change by adding ultrasound (MRI plus ultrasound: 14.9 of 1,000). Positive predictive value was 39% for mammography, 36% for ultrasound, and 48% for MRI.	1
61. Weinstein SP, Localio AR, Conant EF, Rosen M, Thomas KM, Schnall MD. Multimodality screening of high-risk women: a prospective cohort study. J Clin Oncol. 2009 Dec 20;27(36):6124-8.	Observational-Dx	609 women	To prospectively compare cancer detection of digital mammography (DM), whole-breast ultrasound (WBUS), and contrast-enhanced MRI in a high-risk screening population previously screened negative by film screen mammogram (FSM).	Twenty cancers were diagnosed in 18 patients (nine ductal carcinomas in situ and 11 invasive breast cancers). The overall cancer yield on a per-patient basis was 3.0% (18 of 609 patients). The cancer yield by modality was 1.0% for FSM (six of 597 women), 1.2% for DM (seven of 569 women), 0.53% for WBUS (three of 567 women), and 2.1% for MRI (12 of 571 women). Of the 20 cancers detected, some were only detected on one imaging modality (FSM, n = 1; DM, n = 3; WBUS, n = 1; and MRI, n = 8).	1

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
62. Berg WA. Tailored supplemental screening for breast cancer: what now and what next? AJR. 2009;192(2):390-399.	Review/Other-Dx	N/A	To review breast cancer risk assessment and the rationale for current screening guidelines, including when to consider using supplemental screening with MRI or sonography in addition to mammography. Other emerging technologies is discussed.	Mammography remains the mainstay of breast cancer screening. Mammography should be performed as digital imaging when possible in women with dense breasts. In women at high risk, particularly if they also have dense breasts, annual MRI is recommended, although further validation of outcomes is needed. In intermediate-risk women with dense breasts, especially those with other risk factors, and in high-risk women with dense breasts who are unable to tolerate MRI, supplemental sonography screening is an option at facilities with availability of qualified personnel. Developing technologies are not appropriate for screening at this time, although further study is encouraged.	4
63. Plevritis SK, Kurian AW, Sigal BM, et al. Cost-effectiveness of screening BRCA1/2 mutation carriers with breast magnetic resonance imaging. JAMA. 2006;295(20):2374-2384.	Review/Other-Dx	N/A	To evaluate the cost-effectiveness of screening BRCA1/2 mutation carriers with mammography plus breast MRI compared with mammography alone.	Screening strategies that incorporate annual MRI as well as annual mammography have a cost per QALY gained ranging from less than $45,000 to more than $700,000, depending on the ages selected for MRI screening and the specific BRCA mutation. Relative to screening with mammography alone, the cost per QALY gained by adding MRI from ages 35 to 54 years is $55,420 for BRCA1 mutation carriers, $130,695 for BRCA2 mutation carriers, and $98,454 for BRCA2 mutation carriers who have mammographically dense breasts.	4

Breast Cancer Screening
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
64. Taneja C, Edelsberg J, Weycker D, Guo A, Oster G, Weinreb J. Cost effectiveness of breast cancer screening with contrast-enhanced MRI in high-risk women. J Am Coll Radiol. 2009;6(3):171-179.	Review/Other-Dx	Cohorts of 10,000 women	To estimate the cost effectiveness of breast cancer screening with contrast-enhanced MRI, with and without adjunctive x-ray mammography (XM), compared with XM alone in high-risk women.	Among the 400 women (of 10,000) with BRCA1/2 mutations and undiagnosed breast cancer, 361 cases would be detected with MRI and XM, 290 with MRI, and 160 with XM. False-positive results would total 1,526, 1,190, and 528, respectively. Cost per QALY gained with MRI and XM compared with XM alone for women with BRCA1/2 mutations was $25,277. Among other high-risk women, cost per QALY gained with MRI and XM compared with XM alone varied depending on the prevalence of breast cancer, ranging from $45,566 (300 cases) to $310,616 (50 cases). The cost effectiveness of MRI alone compared with XM alone was similar. Screening with MRI, alone or in combination with XM, in women with BRCA1/2 mutations is cost effective by current standards compared with XM alone. In women with other high-risk characteristics, MRI screening may also be cost effective, depending on the expected prevalence of undiagnosed breast cancer at the time of screening.	4
65. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: http://www.acr.org/~/media/ACR/Documents/AppCriteria/RadiationDoseAssessmentIntro.pdf.	Review/Other-Dx	N/A	Guidance document on exposure of patients to ionizing radiation.	N/A	4

Evidence Table Key

Study Quality Category Definitions

- *Category 1*: The study is well-designed and accounts for common biases.
- *Category 2*: The study is moderately well-designed and accounts for most common biases.
- *Category 3*: There are important study design limitations.
- *Category 4*: The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
  a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
  b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
  c) the study is an expert opinion or consensus document.
- M = Meta-analysis

Dx = Diagnostic

Tx = Treatment