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CADTH RAPID RESPONSE REPORT: SUMMARY OF ABSTRACTS

Digital Tomosynthesis for the Screening and Diagnosis of Breast Cancer: Diagnostic Accuracy, Cost-Effectiveness, and Guidelines

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About CADTH: CADTH is an independent, not-for-profit organization responsible for providing Canada's health care decision-makers with objective evidence to help make informed decisions about the optimal use of drugs, medical devices, diagnostics, and procedures in our health care system.

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Research Questions

1. What is the clinical effectiveness of 3D digital tomosynthesis with or without 2D mammography compared with 2D mammography alone for breast cancer diagnosis?
2. What is the diagnostic accuracy of 3D digital tomosynthesis with or without 2D mammography compared with 2D mammography alone for breast cancer diagnosis?
3. What is the comparative clinical effectiveness of synthetic 2D mammography compared with conventional 2D digital mammography obtained with 3D digital tomosynthesis?
4. What is the cost effectiveness of 3D digital tomosynthesis with or without 2D mammography compared with 2D mammography alone for breast cancer screening or diagnosis?
5. What are the evidence-based guidelines regarding the use of 3D digital tomosynthesis for breast cancer screening and diagnosis?

Key Findings

Seven systematic reviews (four with meta-analyses), two randomized controlled trials, forty-four non-randomized studies, and three economic evaluations were identified regarding the clinical and cost-effectiveness of digital tomosynthesis compared with mammography for breast cancer screening and diagnosis. In addition, two evidence-based guidelines were identified regarding the use of digital tomosynthesis for breast cancer screening and diagnosis.

Methods

A limited literature search was conducted by an information specialist on key resources including Ovid Medline, the Cochrane Library, the University of York Centre for Reviews and Dissemination (CRD) databases, the websites of Canadian and major international health technology agencies, as well as a focused Internet search. The search strategy was comprised of both controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. The main search concepts were digital tomosynthesis and breast cancer. Search filters were applied to limit retrieval to health technology assessments, systematic reviews, meta-analyses, or network meta-analyses, randomized controlled trials or controlled clinical trials, economic studies or guidelines. An additional focused search with no search filters was also conducted. Where possible, retrieval was limited to the human population. Both searches were also limited to English language documents published between January 1, 2014 and May 23, 2019. Internet links were provided, where available.

Selection Criteria

One reviewer screened citations and selected studies based on the inclusion criteria presented in Table 1.

Table 1: Selection Criteria

Population	Adult women, subgroups: • Adult women ages 40 to 49 • Adult women ages 50 to 74 • Adult women with low breast density • Adult women with high breast density
Interventions	Q1-2, Q4-5: 3D Digital tomosynthesis with or without 2D mammography Q3: Synthetic 2D mammography
Comparator	Q1-2, Q4-5: 2D mammography alone Q3: 2D Digital Mammography obtained with 3D digital tomosynthesis
Outcomes	Q1,Q3: Safety, adverse events (i.e. radiation) Q2: Diagnostic accuracy (e.g., accuracy, sensitivity, specificity, detection rates) Q4: Cost effectiveness Q5: Guidelines and recommendations
Study Designs	Health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, non-randomized studies, economic evaluations, evidence-based guidelines

Results

Rapid Response reports are organized so that the higher quality evidence is presented first. Therefore, health technology assessment reports, systematic reviews, and meta-analyses are presented first. These are followed by randomized controlled trials, non-randomized studies, economic evaluations, and evidence-based guidelines.

Seven systematic reviews (four with meta-analyses), two randomized controlled trials, forty-four non-randomized studies, and three economic evaluations were identified regarding the clinical and cost-effectiveness of digital tomosynthesis compared with mammography for breast cancer screening and diagnosis. In addition, two evidence-based guidelines were identified regarding the use of digital tomosynthesis for breast cancer screening and diagnosis. No relevant health technology assessments were identified.

Additional references of potential interest are provided in the appendix.

Overall Summary of Findings

Seven systematic reviews,[1-7] two randomized controlled trials,[8,9] forty-four non-randomized studies,[10-53] and three economic evaluations[54-56] were identified regarding the clinical and cost-effectiveness of digital tomosynthesis (DBT) compared with digital mammography (DM) for breast cancer screening and diagnosis. Detailed study characteristics are provided in Table 2.

Overall, the majority of study authors found that DBT alone and in addition to DM yielded improved diagnostic accuracy and detection of breast cancers.[5-7,10,11,15,16,18,21,22,25,28-32,34-36,38,41,42,44,45,47,52,53,55] There were mixed findings regarding synthetic 2D mammography

(S2M); multiple authors found that DBT in addition to S2M had improved diagnostic accuracy and cancer detection compared to DM alone,[24,39,40,43,45,46] while some authors found no significant differences between the DBT + S2M and DBT + DM.[8,18,19,27,31,32,46]

Guidelines from Brazil do not recommend screening for breast cancer using digital tomosynthesis alone or in addition to digital mammorgraphy.[57] In addition, guidelines from the Canadian Task Force on Preventative Health Care also does not recommend using tomosynthesis as well as magnetic resonance imaging or ultrasound to screen for breast cancer in women who are not at increased risk.[58]

Table 2: Study and Patient Characteristics for the Identified Primary and Secondary Studies

First Author, Year	Study Characteristics	Interventions	Comparators	Outcomes	Conclusions
Systematic Reviews and Meta-Analyses – Screening and Diagnosis					
Phi, 2018[2]	• 16 included studies (5 diagnostic, 11 screening) • MA performed • Women with mammographically dense breasts	DBT with/without DM	DM	• Sensitivity • Specificity • CDR • Recall rate	"DBT+/-DM significantly improved CDR in screening and diagnosis."[2] Improved sensitivity but not specificity in diagnosis Recall rate in screening varied
Garcia-Leon, 2015[3]	• 11 included studies • N=2475 women	DBT	DM	• Sensitivity • Specificity • Negative LR	Diagnosis: inconclusive results Screening: no results
Systematic Reviews and Meta-Analyses – Diagnosis					
Lei 2014[1]	• 7 included studies • MA performed • N=2014 patients and 2666 breast lesions	DBT	DM	• Sensitivity • Specificity • Positive LR • Negative LR	DBT has a higher sensitivity and specificity in breast cancer diagnosis than DM
Systematic Reviews and Meta-Analyses – Screening					
Marinovich, 2018[4]	• 17 included studies • MA performed • Asymptomatic women	DBT	DM	• Sensitivity • Specificity • CDR • Recall rate	DBT has significantly lower recall rate and improved CDR
Yun, 2017[5]	• 11 included studies • MA performed	DBT+ DM	DM	• CDR	DBT lead to significantly greater CDR of invasive cancer but not invasive breast cancer
Hodgson, 2016[6]	• 5 included studies	DBT + DM	DM	• CDR • FPR • Recall rate	DBT + DM, has a higher CDR and lower recall rate

First Author, Year	Study Characteristics	Interventions	Comparators	Outcomes	Conclusions
Svahn, 2015[7]	• Number of studies not specified	DBT + DM	DM	• TP • FP	FP/TP trade-off improved using DBT + DM for all studies
Randomized Controlled Trials – Screening					
Hofvind, 2019[8]	• N=32976 women • Age group 50-69 y/o • DBT (n=14380) • DM (n=14369)	DBT + S2M	DM	• CDR	No significant differences
Maxwell, 2017[9]	• N = 1227 women • Age group 40-49 y/o	DBT + DM	DM	• CDR • Recall rate	No significant reduction in recall rate
Non-Randomized Studies – Safety & Diagnostic Accuracy					
Endo, 2018[10]	• N=913 women • Same radiation exposure dose • Retrospective reader study	DBT + DM	DM	• Sensitivity • Specificity • AUC	DBT + DM significantly improved sensitivity, and AUC compared to DM alone. No difference in dose exposure
Shin, 2015[11]	• N=149 patients	Medio later oblique DBT + cranio-caudal DM	DM	• AGD • JAFROC FOM • Sensitivity	"MLO DBT plus CC DM provided higher diagnostic performance than two-view DM in dense breasts with a small increase in AGD."[33]
Non-Randomized Studies – Safety					
Gennaro, 2018[12]	• N=1208 women • DBT=4798 images • DM=4780 images	DBT	DM	• Radiation dose	Findings show a modest increase of radiation dose to the breast by DBT versus DM
Paulis, 2015[13]	• N = 244 women	DBT	DM	• AGD	"In this patient population, the AGD was lower for DBT than for [DM] in 61% of the patients."[11] AGD reduction was greater for DBT versus DM in thick breasts
Non-Randomized Studies – Diagnosis					
Abeutah, 2019[14]	• N=58 women • 68 breast lesions	DBT	DM	• Sensitivity • Specificity • ROC • Agreement	DBT significantly better at diagnosing than DM and had greater sensitivity and specificity

First Author, Year	Study Characteristics	Interventions	Comparators	Outcomes	Conclusions
Bahl, 2019[15]	• N22883 mammograms • Pre/post design	DBT + DM	DM	• Sensitivity • Specificity • CDR • AIR • PPV2, PPV3	DBT + DM group had similar CDR, lower AIR, higher PPV2/PPV3, and specificity than DM alone
Fontaine, 2019[16]	• N=166 women with breast cancer • Prospective study	DBT + DM	DM	• Sensitivity • Specificity • AUC	DBT + DM: higher sensitivity for Dx of multicentric and ipsilateral lesions and a larger AUC in women with non-dense breasts; no significant differences in specificity
Fujii, 2019[17]	• N=86349 DBT screening • N=97378 DM screening • Retrospective study	DBT	DM	• Recall rate • Biopsy rate • CDR	DBT had lower recall rate but comparable biopsy rate and CDR with DM
Skaane, 2019[18]	• N=24301 women • 281 breast cancer	DM DBT + S2M	DBT+ DM DM + CAD	• Sensitivity • Specificity	DBT + DM "resulted in significant gains in sensitivity and specificity"[17] DBT + S2M had similar outcomes as DBT + DM
Ambinder, 2018[19]	• N=7845 DBT + DM studies • N=14776 DBT + SM studies	DBT + S2M	DBT + DM	• Recall rate • Biopsy rate • PPV1, PPV3 • CDR	DBT+S2M had a significantly lower recall rate No significant difference found in other outcomes between groups
Mall, 2018[20]	• N=144 women • 48 breast cancers • Age group >40 yrs • Retrospective multi-reader study	DBT	DM	• Sensitivity • Specificity • PPV • NPV • AUC	DBT had a higher sensitivity, specificity, PPV, and NPV and improved radiologist performance compared to DM workup with significant reduction in additional views required
Ohashi, 2018[21]	• N=228 women • Age range 22-91 yrs • Prospective study	DBT + DM	DM	• Sensitivity • Specificity • AUC • False Negative	DBT + DM had improved diagnostic performance for all outcomes compared to DM alone

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First Author, Year	Study Characteristics	Interventions	Comparators	Outcomes	Conclusions
Singla, 2018[22]	• N=100 women • Prospective study	DBT + DM	DM	• Sensitivity • Specificity • PPV • NPV • FPR	DBT + DM resulted in significant increases in sensitivity, specificity, and PPV, and a significant decrease in FPR in both diagnostic and screening cases
Zackrisson, 2018[23]	• N=14851 • Age range 40-74 yrs • Prospective study	DBT	DM	• Sensitivity • Specificity • PPV • NPV • Recall rate • CDR	DBT had a significantly higher CDR, recall rate and sensitivity, and slightly slower specificity; Similar PPV and NPV
Aujero, 2017[24]	• N=32076 DM screening • N=30561 DBT + DM screening • Retrospective study	DBT + S2M	DM DBT + DM	• Recall rate • PPV • CDR	Recall rates were significantly lower for DM+S2M Invasive cancers detected and PPV were significantly higher for DBT + SM versus DM alone and DBT+DM
Giess, 2017[25]	• N=16264 DM • N=21074 DBT • Retrospective study • Propensity score matched	DBT+ DM	DM	• Recall rate • CDR • PPV1	"FFDM and DBT recall rates were not significantly different"[25] DBT had a significantly higher CDR and PPV1 of recalled cases compared with DM
Chae, 2016[26]	• N=319 diagnostic patients • 598 breasts • Prospective study	DBT	DM	• Sensitivity • Specificity • PPV • AUC	"A beneficial effect on the detection and characterization of breast lesions was found for.. DBT compared with …DM in a selective diagnostic population."[26] Improvements seen most in dense breasts.
Choi, 2016[27]	• N=214 patients • Retrospective study	S2M from DBT	DM	• Sensitivity • Specificity • PPV	No statistical difference in outcomes; S2M slightly better specificity and PPV
Mariscotti, 2016[28]	• N=83 women • 107 ILC • Retrospective multi-reader study	DBT + DM	DM	• Sensitivity • FPR • AUC	"Adding DBT to DM significantly improved the accuracy of mammographic interpretation for ILCs

First Author, Year	Study Characteristics	Interventions	Comparators	Outcomes	Conclusions
					and contributed to characterising disease extent."[28]
Seo, 2016[29]	• N=206 women • 129 malignancies and 77 benign lesions • Diagnostic work up	DBT + DM	DM	• Sensitivity • Specificity • JAFROC FOM	DBT + DM had a higher diagnostic yield than DM but masses without calcifications are difficult to detect in both methods DBT alone performs better than DM alone
Urano, 2016[30]	• N=65 women • Prospective study • Cross referenced with histopathological findings	DBT	DM	• CDR	"DBT could detect breast cancer more accurately than DM in latero-lateral views, indicating its potential to more precisely diagnose vertical invasion."[29]
Gilbert, 2015[31]	• N=8869 women • Age range 29-85 yrs • Multi-reader study	DBT + DM DBT + S2M	DM	• Sensitivity • Specificity • OR	"The addition of DBT increased the sensitivity of [DM] in patients with dense breasts and the specificity of [DM] for all subgroups."[30] DBT + DM and DBT + S2M had similar diagnostic performance
Gilbert, 2015[32]	• N=7060 women • Recall for further assessment (women aged 47-73 yrs) • High risk of breast cancer (women aged 40 – 49 yrs) • Retrospective reader study	DBT + DM DBT + S2M	DM	• Sensitivity • Specificity	DBT + DM significantly higher sensitivity than DM alone for groups of invasive tumours and higher breast density No significant difference in sensitivity between DBT + S2M and DB alone. Specificity was higher in all DBT reading arms , subgroups of age, density, and type of tumour
Nam, 2015[33]	• N=84 women • Retrospective reader study	DBT	DM	• Cancer detection	DBT was able to detect significantly more cancers cases than DM alone
Rafferty, 2014[34]	• N=310 breast cancer cases • Retrospective reader	One-view DBT + DM Two-view DBT + DM	DM	• AUC • Recall rate	Both DBT arms showed significantly greater diagnostic accuracy than

First Author, Year	Study Characteristics	Interventions	Comparators	Outcomes	Conclusions
	study				DM alone and had lower non-cancer recall rates; also saw improvements in dense and non-dense breasts
Friedewald, 2014[35]	• N=281187 DM exams • N=173663 DBT exams • Retrospective study using biopsies	DBT + DM	DM	• CDR • Recall rate	DBT added to DM was associated with a decrease in recall rate and an increase in CDR compared to DM alone
Non-Randomized Studies – Screening and Diagnostic Measures					
Conant, 2019[36]	• N=129369 DM exams • N=50971 DBT exams • Age-range 40-74 yrs • Retrospective study	DBT + DM	DM	• Specificity • CDR • Recall rate	"…screening with DBT is associated with increased specificity and an increased proportion of breast cancers detected with better prognosis compared with DM."[36]
Lee, 2019[37]	• N=288 women with dense breasts • 300 breast cancer	DBT	DM	• CDR	DBT had significantly higher CDR than DM
Bernardi, 2018[38]	• N=NR • Women >49 yrs • Retrospective reader study	DBT + DM	DM S2M S2M + DBT	• CDR • TP • FP • FPR	Pattern of increasing cancer detection for radiologist when DBT + DM was utilized
Caumo, 2018[39]	• N=34071 DBT screens • N=29360 DM screens • Age range 50-69 yrs • Prospective study	DBT + S2M	DM	• CDR • Recall rates	DBT + S2M had a higher detection rate of histologic type and early stage cancer compared to DM
Hofvind, 2018[40]	• N=37185 DBT + S2M screens • N=61742 DM screens • Prospective cohort study	DBT + S2M	DM	• Recall rates • CDR • PPV of recall • PPV of biopsy	"DBT and SM screening increased the detection rate of histologically favorable tumors compared with that attained with DM screening." [40] No difference in pathological screening
Houssami, 2018[41]	• N=NR • Retrospective study	DBT + DM	DM	• Interval cancer detection	Interval breast cancer rate was lower in the DBT + DM group than DM

First Author, Year	Study Characteristics	Interventions	Comparators	Outcomes	Conclusions
Pan, 2018[42]	• N=NR • Retrospective study	DBT + DM	DM	• CDR • Recall rate	DBT + DM increased CDR and decreased recall rate compared to DM alone DBT more effective detecting ductal carcinoma in situ and stage 1 cancer
Romero, 2018[43]	• N=16067 women • Age range 50-69 years	DBT + S2M	DM (1st and 2nd readings) DBT + DM	• CDR • Recall rate	Single reading DBT + S2M increased cancer detection and decreased recalls compared with double reading DM; DM did not improve results when added to DBT
Skaane, 2018[44]	• N=24301 DBT + DM screens • N=59877 DM screens • Age range 50-69 yrs • Retrospective double reading	DBT + DM	DM	• Sensitivity • Specificity • CDR • Interval cancer detection • Recall rate	DBT + DM screening led to significant increases in cancer detection and specificity; nonsignificant increases in sensitivity
Bernardi, 2017[45]	• Subset analysis of larger study • Prospective double reading screening	DBT + DM DBT + S2M	DM	• CDR	Most cases detected by DBT only, from one reading DBT enables detection of cancer not detected during routine screening
Freer, 2017[46]	• N=31979 • Retrospective	DBT + DM DBT + S2M	DM	• Recall rate • CDR • PPV1	DBT + S2M yielded significantly decreased recall rates compared to DM There were no significant differences in CDR in DBT+S2M and DBT+DM. PPV1 significantly increased with DBT+S2M compared to DM DBT+S2M is a desirable alternative to DBT+DM

First Author, Year	Study Characteristics	Interventions	Comparators	Outcomes	Conclusions
Houssami, 2017[47]	• N=9672 • Women ≥ 49 yrs • Retrospective reader study	DBT + DM	DM	CDR FPR	DBT had higher CDR and lower FPR compared to DM
Conant, 2016[48]	• N=55998 DBT • N=142883 DM • Women 40-74 yrs • Retrospective study	DBT	DM	• Recall rates • CDR • FNR • PPV1	DBT had reduction in recall rates, significant increase in CDR, improvement in PPV1, and no significant different in FPR compared to DM
Lang, 2016[49]	• N=15000 • Women 40-74 years • Prospective study	DBT	DM	• CDR • Recall rates • PPV	DBT had higher CDR, higher recall rate, and no difference in PPV compared to DM
Sharpe, 2016[50]	• N = 5703 DBT • N = 80149 DM • Retrospective study • Women 49-79	DBT	DM	• CDR • Recall rates	DBT had higher CDR and lower Recall rate compared to DM
Mcdonald, 2015[51]	• N=10728 DM • N=15571 DBT • Retrospective study	DBT	DM	• CDR • Recall rates • PPV1	DBT had lower recall rates, increased CDR, increased PPV1 compared to DM
Bernardi, 2014[52]	• N=7292 • Prospective study	DBT + DM	DM	• CDR • FPR • TP	DBT + DM had increased CDR, increased TP, and lower FPR compared to DM
Greenberg, 2014[53]	• N=23149 DBT • N=54684 DM • Prospective study	DBT + DM	DM	• Recall rates • CDR • PPV1 • PPV3	DBT yielded lower recall rates, increased CDR, significantly increased PPV1, and no significant difference in PPV3
Economic Evaluations					
Hunter, 2017[54]	• N=3655 DBT • N=2664 DM	DBT	DM	• CE	DMT is a cost-equivalent or potentially cost-effective alternative to DM for private insurance billing

First Author, Year	Study Characteristics	Interventions	Comparators	Outcomes	Conclusions
Kalra, 2016[55]	• N=NR • Age range 40+ yrs	DBT + DM	DM	• CE (QALY)	DBT + DM was cost-effective compared to DM 3x greater net monetary benefits for women 40-49 yrs
Lee, 2016[56]	• NR	DBT + DM	DM	• CE	Inconclusive findings

AIR = abnormal interpretation rate; AGD = average glandular dose; AUC = area under the receiver operator characteristic curve; CAD = computer aided detection; CC = cranio-caudal; CDR = cancer detection rate; CE = cost-effectiveness; DBT = digital breast tomosynthesis; DM = 2D digital mammography; Dx = diagnosis; FFDM = full field digital mammography; FOM = figure of merit, FP = false positive; FPR = false positive rate; ILC = invasive lobular carcinoma; JAFROC = jackknife alternative free-response receiver operating characteristic; LR = likelihood ratio; MA = meta-analysis; MLO = mediolateral oblique; NR = not reported; NPV = negative predictive value; OR = odds ratio; PPV2 = positive predictive value; QALY = quality adjusted life year; ROC = receiver operator characteristic curve; S2M = synthetic 2D mammography; TP = true positive; yrs = years.

References Summarized

Health Technology Assessments

No literature identified.

Systematic Reviews and Meta-analyses

Diagnosis

1. 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 Mar;24(3):595-602. PubMed: PM24121712

Screening and Diagnosis

2. Phi XA, Tagliafico A, Houssami N, Greuter MJW, de Bock GH. Digital breast tomosynthesis for breast cancer screening and diagnosis in women with dense breasts - a systematic review and meta-analysis. *BMC Cancer*. 2018 04 03;18(1):380. PubMed: PM29615072

3. Garcia-Leon FJ, Llanos-Mendez A, Isabel-Gomez R. Digital tomosynthesis in breast cancer: a systematic review. *Radiologia (Roma)*. 2015 Jul-Aug;57(4):333-343. PubMed: PM25306860

Screening

4. Marinovich ML, Hunter KE, Macaskill P, Houssami N. Breast cancer screening using tomosynthesis or mammography: a meta-analysis of cancer detection and recall. *J Natl Cancer Inst*. 2018 Sep 01;110(9):942-949. PubMed: PM30107542

5. Yun SJ, Ryu CW, Rhee SJ, Ryu JK, Oh JY. Benefit of adding digital breast tomosynthesis to digital mammography for breast cancer screening focused on cancer characteristics: a meta-analysis. *Breast Cancer Res Treat*. 2017 Aug;164(3):557-569.
PubMed: PM28516226

6. Hodgson R, Heywang-Kobrunner SH, Harvey SC, et al. Systematic review of 3D mammography for breast cancer screening. *Breast*. 2016 Jun;27:52-61.
PubMed: PM27212700

7. Svahn TM, Macaskill P, Houssami N. Radiologists' interpretive efficiency and variability in true- and false-positive detection when screen-reading with tomosynthesis (3D-mammography) relative to standard mammography in population screening. *Breast*. 2015 Dec;24(6):687-693.
PubMed: PM26433751

Randomized Controlled Trials - Screening

8. Hofvind S, Holen AS, Aase HS, et al. Two-view digital breast tomosynthesis versus digital mammography in a population-based breast cancer screening programme (To-Be): a randomised, controlled trial. *Lancet Oncol*. 2019 May 08;08:08.
PubMed: PM31078459

9. Maxwell AJ, Michell M, Lim YY, et al. A randomised trial of screening with digital breast tomosynthesis plus conventional digital 2D mammography versus 2D mammography alone in younger higher risk women. *Eur J Radiol*. 2017 Sep;94:133-139.
PubMed: PM28716454

Non-Randomized Studies

Safety and Diagnostic Accuracy

10. Endo T, Morita T, Oiwa M, et al. Diagnostic performance of digital breast tomosynthesis and full-field digital mammography with new reconstruction and new processing for dose reduction. *Breast Cancer*. 2018 Mar;25(2):159-166.
PubMed: PM28956298

11. Shin SU, Chang JM, Bae MS, et al. Comparative evaluation of average glandular dose and breast cancer detection between single-view digital breast tomosynthesis (DBT) plus single-view digital mammography (DM) and two-view DM: correlation with breast thickness and density. *Eur Radiol*. 2015 Jan;25(1):1-8.
PubMed: PM25182628

Safety

12. Gennaro G, Bernardi D, Houssami N. Radiation dose with digital breast tomosynthesis compared to digital mammography: per-view analysis. *Eur Radiol*. 2018 Feb;28(2):573-581.
PubMed: PM28819862

13. Paulis LE, Lobbes MB, Lalji UC, et al. Radiation exposure of digital breast tomosynthesis using an antiscatter grid compared with full-field digital mammography. *Invest Radiol*. 2015 Oct;50(10):679-685.
PubMed: PM26011823

Diagnosis

14. Asbeutah AM, Karmani N, Asbeutah AA, Echreshzadeh YA, AlMajran AA, Al-Khalifah KH. Comparison of digital breast tomosynthesis and digital mammography for detection of breast cancer in Kuwaiti women. *Med Princ Pract*. 2019;28(1):10-15.
PubMed: PM30476905

15. Bahl M, Mercaldo S, Vijapura CA, McCarthy AM, Lehman CD. Comparison of performance metrics with digital 2D versus tomosynthesis mammography in the diagnostic setting. *Eur Radiol*. 2019 Feb;29(2):477-484.
PubMed: PM29967957

16. Fontaine M, Tourasse C, Pages E, et al. Local tumor staging of breast cancer: digital mammography versus digital mammography plus tomosynthesis. *Radiology*. 2019 Apr 09:182457.
PubMed: PM30964425

17. Fujii MH, Herschorn SD, Sowden M, et al. Detection rates for benign and malignant diagnoses on breast cancer screening with digital breast tomosynthesis in a statewide mammography registry study. *AJR Am J Roentgenol*. 2019 Mar;212(3):706-711.
PubMed: PM30673339

18. Skaane P, Bandos AI, Niklason LT, et al. Digital mammography versus digital mammography plus tomosynthesis in breast cancer screening: the Oslo Tomosynthesis Screening Trial. *Radiology*. 2019 Apr;291(1):23-30.
PubMed: PM30777808

19. Ambinder EB, Harvey SC, Panigrahi B, Li X, Woods RW. Synthesized mammography: the new standard of care when screening for breast cancer with digital breast tomosynthesis? *Acad Radiol*. 2018 08;25(8):973-976.
PubMed: PM29395801

20. Mall S, Noakes J, Kossoff M, et al. Can digital breast tomosynthesis perform better than standard digital mammography work-up in breast cancer assessment clinic? *Eur Radiol*. 2018 Dec;28(12):5182-5194.
PubMed: PM29846804

21. Ohashi R, Nagao M, Nakamura I, Okamoto T, Sakai S. Improvement in diagnostic performance of breast cancer: comparison between conventional digital mammography alone and conventional mammography plus digital breast tomosynthesis. *Breast Cancer*. 2018 Sep;25(5):590-596.
PubMed: PM29651638

22. Singla D, Chaturvedi AK, Aggarwal A, Rao SA, Hazarika D, Mahawar V. Comparing the diagnostic efficacy of full field digital mammography with digital breast tomosynthesis using BIRADS score in a tertiary cancer care hospital. *Indian J Radiol Imaging*. 2018 Jan-Mar;28(1):115-122.
PubMed: PM29692539

23. Zackrisson S, Lang K, Rosso A, et al. One-view breast tomosynthesis versus two-view mammography in the Malmo Breast Tomosynthesis Screening Trial (MBTST): a prospective, population-based, diagnostic accuracy study. *Lancet Oncol*. 2018 Nov;19(11):1493-1503.
PubMed: PM30322817

24. Aujero MP, Gavenonis SC, Benjamin R, Zhang Z, Holt JS. Clinical performance of synthesized two-dimensional mammography combined with tomosynthesis in a large screening population. *Radiology*. 2017 04;283(1):70-76.
PubMed: PM28221096

25. Giess CS, Pourjabbar S, Ip IK, Lacson R, Alper E, Khorasani R. Comparing diagnostic performance of digital breast tomosynthesis and full-field digital mammography in a hybrid screening environment. *AJR Am J Roentgenol*. 2017 Oct;209(4):929-934.
PubMed: PM28639832

26. Chae EY, Kim HH, Cha JH, Shin HJ, Choi WJ. Detection and characterization of breast lesions in a selective diagnostic population: diagnostic accuracy study for comparison between one-view digital breast tomosynthesis and two-view full-field digital mammography. *Br J Radiol*. 2016 Jun;89(1062):20150743.
PubMed: PM27072391

27. Choi JS, Han BK, Ko EY, et al. Comparison between two-dimensional synthetic mammography reconstructed from digital breast tomosynthesis and full-field digital mammography for the detection of T1 breast cancer. *Eur Radiol*. 2016 Aug;26(8):2538-2546.
PubMed: PM26628063

28. Mariscotti G, Durando M, Houssami N, et al. Digital breast tomosynthesis as an adjunct to digital mammography for detecting and characterising invasive lobular cancers: a multi-reader study. *Clin Radiol*. 2016 Sep;71(9):889-895.
PubMed: PM27210245

29. Seo M, Chang JM, Kim SA, et al. Addition of digital breast tomosynthesis to full-field digital mammography in the diagnostic setting: additional value and cancer detectability. *J Breast Cancer*. 2016 Dec;19(4):438-446.
PubMed: PM28053633

30. Urano M, Shiraki N, Kawai T, et al. Digital mammography versus digital breast tomosynthesis for detection of breast cancer in the intraoperative specimen during breast-conserving surgery. *Breast Cancer*. 2016 Sep;23(5):706-711.
PubMed: PM26198975

31. Gilbert FJ, Tucker L, Gillan MG, et al. Accuracy of digital breast tomosynthesis for depicting breast cancer subgroups in a UK retrospective reading study (TOMMY Trial). *Radiology*. 2015 Dec;277(3):697-706.
PubMed: PM26176654

32. Gilbert FJ, Tucker L, Gillan MG, et al. The TOMMY trial: a comparison of tomosynthesis with digital mammography in the UK NHS Breast Screening Programme--a multicentre retrospective reading study comparing the diagnostic performance of digital breast tomosynthesis and digital mammography with digital mammography alone. *Health Technol Assess*. 2015 Jan;19(4):i-xxv, 1-136.
PubMed: PM25599513

33. Nam KJ, Han BK, Ko ES, et al. Comparison of full-field digital mammography and digital breast tomosynthesis in ultrasonography-detected breast cancers. *Breast*. 2015 Oct;24(5):649-655.
PubMed: PM26292782

34. 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 Feb;202(2):273-281.
PubMed: PM24450665

35. Friedewald SM, Rafferty EA, Rose SL, et al. Breast cancer screening using tomosynthesis in combination with digital mammography. *JAMA*. 2014 Jun 25;311(24):2499-2507.
PubMed: PM25058084

Screening and Diagnostic Measures

36. Conant EF, Barlow WE, Herschorn SD, et al. Association of digital breast tomosynthesis vs digital mammography with cancer detection and recall rates by age and breast density. *JAMA Oncol*. 2019 Feb 28;28:28.
PubMed: PM30816931

37. Lee SH, Jang MJ, Kim SM, et al. Factors affecting breast cancer detectability on digital breast tomosynthesis and two-dimensional digital mammography in patients with dense breasts. *Korean J Radiol*. 2019 Jan;20(1):58-68.
PubMed: PM30627022

38. Bernardi D, Li T, Pellegrini M, et al. Effect of integrating digital breast tomosynthesis (3D-mammography) with acquired or synthetic 2D-mammography on radiologists' true-positive and false-positive detection in a population screening trial: a descriptive study. *Eur J Radiol*. 2018 Sep;106:26-31.
PubMed: PM30150047

39. Caumo F, Romanucci G, Hunter K, et al. Comparison of breast cancers detected in the Verona screening program following transition to digital breast tomosynthesis screening with cancers detected at digital mammography screening. *Breast Cancer Res Treat*. 2018 Jul;170(2):391-397.
PubMed: PM29557996

40. Hofvind S, Hovda T, Holen AS, et al. Digital breast tomosynthesis and synthetic 2D mammography versus digital mammography: evaluation in a population-based screening program. *Radiology*. 2018 Jun;287(3):787-794.
PubMed: PM29494322

41. Houssami N, Bernardi D, Caumo F, et al. Interval breast cancers in the 'screening with tomosynthesis or standard mammography' (STORM) population-based trial. *Breast*. 2018 Apr;38:150-153.
PubMed: PM29328943

42. Pan HB, Wong KF, Yao A, et al. Breast cancer screening with digital breast tomosynthesis - 4 year experience and comparison with national data. *J Chin Med Assoc*. 2018 01;81(1):70-80.
PubMed: PM29129518

43. Romero Martin S, Raya Povedano JL, Cara Garcia M, Santos Romero AL, Pedrosa Garriguet M, Alvarez Benito M. Prospective study aiming to compare 2D mammography and tomosynthesis + synthesized mammography in terms of cancer detection and recall. From double reading of 2D mammography to single reading of tomosynthesis. *Eur Radiol*. 2018 Jun;28(6):2484-2491.
PubMed: PM29294150

44. Skaane P, Sebuodegard S, Bandos AI, et al. Performance of breast cancer screening using digital breast tomosynthesis: results from the prospective population-based Oslo Tomosynthesis Screening Trial. *Breast Cancer Res Treat*. 2018 Jun;169(3):489-496.
PubMed: PM29429017

45. Bernardi D, Houssami N. Breast cancers detected in only one of two arms of a tomosynthesis (3D-mammography) population screening trial (STORM-2). *Breast*. 2017 Apr;32:98-101.
PubMed: PM28107735

46. Freer PE, Riegert J, Eisenmenger L, et al. Clinical implementation of synthesized mammography with digital breast tomosynthesis in a routine clinical practice. *Breast Cancer Res Treat*. 2017 Nov;166(2):501-509.
PubMed: PM28780702

47. Houssami N, Bernardi D, Pellegrini M, et al. Breast cancer detection using single-reading of breast tomosynthesis (3D-mammography) compared to double-reading of 2D-mammography: evidence from a population-based trial. *Cancer Epidemiol*. 2017 04;47:94-99.
PubMed: PM28192742

48. Conant EF, Beaber EF, Sprague BL, et al. Breast cancer screening using tomosynthesis in combination with digital mammography compared to digital mammography alone: a cohort study within the PROSPR consortium. *Breast Cancer Res Treat*. 2016 Feb;156(1):109-116.
PubMed: PM26931450

49. Lang K, Andersson I, Rosso A, Tingberg A, Timberg P, Zackrisson S. Performance of one-view breast tomosynthesis as a stand-alone breast cancer screening modality: results from the Malmo Breast Tomosynthesis Screening Trial, a population-based study. *Eur Radiol*. 2016 Jan;26(1):184-190.
PubMed: PM25929946

50. Sharpe RE, Jr., Venkataraman S, Phillips J, et al. Increased cancer detection rate and variations in the recall rate resulting from implementation of 3D digital breast tomosynthesis into a population-based screening program. *Radiology*. 2016 Mar;278(3):698-706.
PubMed: PM26458206

51. McDonald ES, McCarthy AM, Akhtar AL, Synnestvedt MB, Schnall M, Conant EF. Baseline screening mammography: performance of full-field digital mammography versus digital breast tomosynthesis. *AJR Am J Roentgenol*. 2015 Nov;205(5):1143-1148.
PubMed: PM26496565

52. 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 May;50(7):1232-1238.
PubMed: PM24582915

53. 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 Roentgenology*. 2014 Sep;203(3):687-693.
PubMed: PM24918774

Economic Evaluations

54. Hunter SA, Morris C, Nelson K, Snyder BJ, Poulton TB. Digital breast tomosynthesis: cost-effectiveness of using private and Medicare insurance in community-based health care facilities. *AJR Am J Roentgenol*. 2017 May;208(5):1171-1175.
PubMed: PM28177646

55. Kalra VB, Wu X, Haas BM, Forman HP, Philpotts LE. Cost-effectiveness of tomosynthesis in annual screening mammography. *AJR Am J Roentgenol*. 2016 Nov;207(5):1152-1155.
PubMed: PM27547861

56. Lee CI, Lee JM, Tosteson AN. Annual combined mammography and tomosynthesis screening: is it really cost-effective? *AJR Am J Roentgenol*. 2016 11;207(5):1156-1158.
PubMed: PM27533738

Guidelines and Recommendations

57. Migowski A, Silva GAE, Dias MBK, Diz M, Sant'Ana DR, Nadanovsky P. Guidelines for early detection of breast cancer in Brazil. II - New national recommendations, main evidence, and controversies. *Cad Saude Publica*. 2018 06 21;34(6):e00074817.
PubMed: PM29947654

58. Klarenbach S, Sims-Jones N, Lewin G, et al. Recommendations on screening for breast cancer in women aged 40–74 years who are not at increased risk for breast cancer. *CMAJ.* 2018 Dec 10;190(49):E1441-E1451.
http://www.cmaj.ca/content/cmaj/190/49/E1441.full.pdf. Accessed 2019 Jun 10.
See: Box 2 Recommendations and Screening using modalities other than mammography, page E1444

CADTH

Appendix — Further Information

Previous CADTH Reports

59. Recall rates for digital mammography for patients undergoing screening for breast cancer: evidence-based guidelines. *(CADTH rapid response report: summary of abstracts)*. Ottawa (ON): CADTH; 2015: https://www.cadth.ca/recall-rates-digital-mammography-patients-undergoing-screening-breast-cancer. Accessed 2019 Jun 10.

60. Tomosynthesis (3D mammography) for breast cancer screening. *(CADTH issues in emerging health technologies no. 135)*. Ottawa (ON): CADTH; 2015: https://www.cadth.ca/sites/default/files/pdf/EH0026_Tomosynthesis_Breast_Cancer_Screening_e.pdf. Accessed 2019 Jun 10.

61. Digital tomosynthesis for the screening and diagnosis of breast cancer: diagnostic accuracy and guidelines. *(CADTH rapid response report: reference list)*. Ottawa (ON): CADTH; 2014: https://www.cadth.ca/sites/default/files/pdf/htis/jan-2015/RA0720%20Tomosynthesis%20Final.pdf. Accessed 2019 Jun 10.

62. Digital tomosynthesis for the screening and diagnosis of breast cancer: a review of the diagnostic accuracy. *(CADTH rapid response report: summary with critical appraisal)*. Ottawa (ON): CADTH; 2013: https://www.cadth.ca/sites/default/files/pdf/htis/oct-2013/RC0482-Tomosynthesis-Final.pdf. Accessed 2019 Jun 10.

Non-Randomized Studies - Screening

Alternative Outcomes

63. Powell JL, Hawley JR, Lipari AM, Yildiz VO, Erdal BS, Carkaci S. Impact of the addition of digital breast tomosynthesis (DBT) to standard 2D digital screening mammography on the rates of patient recall, cancer detection, and recommendations for short-term ollow-up. *Acad Radiol*. 2017 03;24(3):302-307.
PubMed: PM27919540

64. McDonald ES, Oustimov A, Weinstein SP, Synnestvedt MB, Schnall M, Conant EF. Effectiveness of digital breast tomosynthesis compared with digital mammography: outcomes analysis from 3 years of breast cancer screening. *JAMA Oncol*. 2016 Jun 01;2(6):737-743.
PubMed: PM26893205

Clinical Practice Guidelines – Unspecified Methodology

65. Siu AL, U.S. Preventive Services Task Force. Screening for breast cancer: U.S. Preventive Services Task Force Recommendation Statement. *Ann Intern Med*. 2016 Feb 16;164(4):279-296.
PubMed: PM26757170