What the Research Experts Say about Mammography

Although mammograms are the most common method used to find breast cancer, mammography is far from perfect. In fact, it is so far from perfect that it cannot be trusted as a scientifically valid process for breast cancer detection. Does mammography save lives? Yes, definitely, but it is not the only approach, and it has significant weaknesses that should encourage women to use a variety of screening methods.

The purpose of this annotated bibliography is to provide evidence that describes the effectiveness of mammograms for finding cancer.

Key Statistics

- Overall percentage of breast cancers found by mammograms: 79% (43% - 84.4%, depending on age)
- Overall percentage of breast cancers missed by mammograms: 21% (6% - 46% depending on age)
- Overall percentage of suspicious mammograms that were not cancer: 71% - 95.7%
- Percentage of women who will acquire breast cancer from their mammogram screenings: 0.1% (potentially 45,557 cases)

Key Terms

- *Sensitivity:* "...the percentage of breast cancers detected in a given population, when breast cancer is present." Sensitivity is the percentage of cancer cases the technology finds. A 100% sensitivity would mean the technology finds every case of cancer. A 0.50 (50%) sensitivity means the technology correctly finds cancer half the time. http://www.cancer.gov/cancertopics/pdq/screening/breast/healthprofessional/page4#Section_81)
- *Specificity:* "the likelihood of the test being normal when cancer is absent" (http://www.cancer.gov/cancertopics/pdq/screening/breast/healthprofessional/page4#Section_81) Specificity is the percentage of screenings that correctly indicate that no cancer is present—how good the technology is at identifying healthy, non-cancerous breasts. This rate is difficult to confirm because women who have "clean" screening findings are unlikely to get re-examined within a short enough time period to assess the accuracy of the initial screening. A 100% specificity would mean the technology never indicates cancer when there is no cancer. A 0.50 (or 50%) specificity means the technology correctly indicates the absence of cancer half the time.
- *False Positive:* "...the likelihood of the test being abnormal when cancer is absent" (http://www.cancer.gov/cancertopics/pdq/screening/breast/healthprofessional/page4#Section_81). With a false positive, the screening indicates abnormalities even through no cancer is present.
- *False Negative:* A finding of no abnormalities (i.e., no cancer) when cancer is present. This is the most "dangerous" statistic. A woman has breast cancer, but the technology doesn't find it. Doctors try to avoid false negatives because they can cause a woman not to seek treatment that she needs.

Annotated Bibliography

Breast Imaging: A Survey
Subbhuraam Vinitha Sree, Eddie Yin-Kwee Ng, Rajendra U Acharya, and Oliver Faust
World Journal of Clinical Oncology, reposted by the *National Institutes of Health* (2011)
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3100484/

"It is very difficult to detect cancer in the early stage using mammographic screening. However, additional screening tests may reduce the death rate from breast cancer."
Meaning: a mammogram, alone, may not find cancer, particularly in the early growth of cancer, and a single mammogram is not a good indicator of the presence or absence of cancer.

"Carcinoma *in situ* [non-invasive] was diagnosed in 78.9% and 68.4% of patients using mammography and MR [magnetic resonance] mammography, respectively."
Of the women with non-invasive cancer, mammograms found 78.9% of the cancers, which means the mammogram failed to find 21.1% of cancers. This corresponds with the finding that 1 in 5 cancers are missed.

Breast Cancer Screening Concepts
National Cancer Institute at the National Institutes of Health
http://www.cancer.gov/cancertopics/pdq/screening/breast/healthprofessional/page4#Section_81

"Overall sensitivity is approximately 79% but is lower in younger women and in those with dense breast tissue."
Mammograms find 79% of cancers, missing 21%, which is about 1 in 5, overall. However, the mammograms find even fewer cancers in younger women and in women with dense breasts at any age.

Evaluation of Contrast-Enhanced Digital Mammography
Felix Diekmann, Martin Freyer, Susanne Diekmann, Eva M. Fallenberg, Thomas Fischer, Ulrich Bick, Alexander Pöllinger
European Journal of Radiology (2009)
http://www.ejradiology.com/article/S0720-048X(09)00549-X/abstract?cc=y?cc=y

"On average, 5.66 more malignant lesions were detected with the addition of digital dynamic contrast mammography versus conventional mammography alone. The sensitivity was increased from an average of 0.43 in conventional mammography to an average of 0.62 with contrast mammography. Even in dense breast parenchyma, the sensitivity increased from an average of 0.35–0.59."
Researchers found only 0.43 sensitivity with standard mammograms, missing 57% of cancers. Even with the new CEDM approach, they only found 62% of cases, missing 38%. For women with dense breasts, only 35% of cancers were found through standard mammography, increasing to only 59% through the experimental technique..

Performance Measures for 1,838,372 Screening Mammography Examinations from 2004 to 2008 by Age -- based on BCSC data through 2009
Breast Cancer Surveillance Consortium, National Cancer Institute (2003)
NCI-funded Breast Cancer Surveillance Consortium (HHSN261201100031C). Downloaded from the Breast Cancer Surveillance Consortium Web site - http://breastscreening.cancer.gov/
http://breastscreening.cancer.gov/statistics/performance/screening/2009/perf_age.html

	Sensitivity	Specificity	Recall	PPV1	PPV2	PPV3
Total	84.40%	90.80%	9.60%	4.30%	25.00%	29.00%
Age 18-39	76.50%	83.80%	16.30%	1.40%	8.20%	9.40%
Age 40-44	73.40%	87.70%	12.50%	1.60%	11.20%	13.00%
Age 45-49	82.50%	88.50%	11.80%	2.50%	16.70%	19.20%
Age 50-54	82.60%	90.40%	10.00%	3.60%	20.30%	24.00%
Age 55-59	85.70%	91.70%	8.60%	4.60%	26.40%	30.10%
Age 60-64	84.70%	92.20%	8.20%	5.90%	30.70%	35.90%
Age 65-69	86.30%	92.70%	7.80%	6.80%	33.70%	39.20%
Age 70-74	86.30%	93.30%	7.30%	8.00%	37.70%	43.00%
Age 75-79	88.40%	93.50%	7.10%	8.90%	41.30%	48.10%
Age 80+	88.50%	93.80%	6.90%	10.90%	46.50%	55.00%

PPV: Positive Predictive Value, how accurately the screening predicted the existence of cancer.
*PPV1: The percentage of mammogram examinations with an abnormal interpretation that results in a tissue diagnosis of cancer within 1 year —only 4.3% of overall initial abnormal findings were diagnosed as cancer. The false positive rate for initial screening is 95.7%, meaning **95.7% of abnormal findings were not cancer**. In the 18–29 age group, 98.17% of initial abnormal findings were not cancer.*
PPV2: The percentage of examinations interpreted as suspicious or highly suggestive of malignancy that results in a tissue diagnosis of cancer within 1 year—only 25% of overall suspicious or highly suggestive findings were diagnosed as cancer. The false positive rate is 75%, meaning 75% of findings were not cancer. In the 18–29 age group, 87.97% of these findings were not cancer.
PPV3: The percentage of known biopsies performed as a result of an examination interpreted as suspicious or highly suggestive of malignancy that results in a tissue diagnosis of cancer within 1 year —based on biopsy findings, only 29% of cases were confirmed to be cancer. ***The false positive rate based on performed biopsies is 71%, meaning 71% of suspicious or highly suggestive mammogram findings were not cancer. In the 18–29 age group, 86.13% of these findings were not cancer.***

The final percentage (PPV3) is the most telling. Women with mammograms that appeared to indicate cancer underwent biopsies, which is the only technique to prove the existence of cancer. Although the mammograms seemed to indicate cancer, only 29% of mammograms actually did. All other cases, 71%, were not cancer, meaning 71% of women who received biopsies based on the mammographic findings underwent unnecessary procedures.

The overall conclusion is that mammograms are weak at predicting the existence of cancer, and women were over-treated based on mammogram screenings.

Breast Cancer Screening (PDQ)
National Cancer Institute at the National Institutes of Health
http://www.cancer.gov/cancertopics/pdq/screening/breast/healthprofessional/page1

"Of all breast cancers detected by screening mammograms, up to 54% are estimated to be results of overdiagnosis."
Overdiagnosis is defined as "diagnosis of cancers that would otherwise never have caused symptoms or death in a woman's lifetime" *which* "can expose a woman to the immediate risks of therapy (surgical deformity or toxicities from radiation therapy, hormone therapy, or chemotherapy), late sequelae (lymphedema), and late effects of therapeutic radiation (new cancers, scarring, or cardiac toxicity)."
About half of all cancers found by mammograms are not clinically significant but the mammogram findings will lead to potentially harmful treatment anyway.

"6% to 46% of women with invasive cancer will have negative mammograms, especially if they are young, have dense breasts, or have mucinous, lobular, or rapidly growing cancers."
These are false negatives. For every 100 women with breast cancer, 6 to 46 cancers will be missed. The lower rate reflects findings for older women and the higher rate reflects findings for younger women and women with the special cases listed.

"The breast dose associated with a typical two-view mammogram is approximately 4 mSv and extremely unlikely to cause cancer. One Sv is equivalent to 200 mammograms. Latency is at least 8 years, and the increased risk is lifelong. Magnitude of Effect: Theoretically, annual mammograms in women aged 40 to 80 years may cause up to one breast cancer per 1,000 women."
A single mammogram is highly unlikely to cause cancer, but, as noted, the effects are cumulative lifelong. Statistical analysis results in 0.1% of women acquiring breast cancer from mammogram screenings. The U.S. population of women aged 40 to 79 is 67,995,242. Approximately 67% of women in this age range get mammograms, which is 45,556,815 women. If 1 in 1,000 get breast cancer from mammograms, then **mammograms may cause 45,557 cases of breast cancer**.
With a 5-year breast cancer survival rate of 89.2%, 10.8% do not survive 5 years after the initial diagnosis of cancer. 10.8% of 45,557 means **4,920 women may die from breast cancer caused by mammograms**.

Individual and combined effects of age, breast density, and hormone replacement therapy use on the accuracy of screening mammography
Carney PA1, Miglioretti DL, Yankaskas BC, Kerlikowske K, Rosenberg R, Rutter CM, Geller BM, Abraham LA, Taplin SH, Dignan M, Cutter G, Ballard-Barbash R.
Annual of Internal Medicine (2003)
http://www.ncbi.nlm.nih.gov/pubmed/12558355?dopt=Abstract

"Adjusted sensitivity ranged from 62.9% in women with extremely dense breasts to 87.0% in women with almost entirely fatty breasts; adjusted sensitivity increased with age from 68.6% in women 40 to 44 years of age to 83.3% in women 80 to 89 years of age."
Adjusted sensitivity reflects statistical manipulation of the data to remove the effects of other conditions. For example, to determine the effect of breast density, the adjustment factors out the

effects of age and hormone replacement therapy. Fatty breasts, which are easiest to screen accurately with mammography only yield a sensitivity of 87%, missing 13% of cancers. Older women are more likely to have an accurate screening, but the sensitivity is still only 83.3%, missing 16.7% of cancers. When the effects of density and age are combined, the sensitivity rates are less, with the lowest sensitivity for younger women with dense breasts.

Effects of age, breast density, ethnicity, and estrogen replacement therapy on screening mammographic sensitivity and cancer stage at diagnosis: review of 183,134 screening mammograms in Albuquerque, New Mexico.
Rosenberg RD1, Hunt WC, Williamson MR, Gilliland FD, Wiest PW, Kelsey CA, Key CR, Linver MN.
Radiology (1998)
http://www.ncbi.nlm.nih.gov/pubmed/9807581?dopt=Abstract

"Sensitivity was 54% (13 of 24) in women younger than 40 years, 77% (121 of 157) in women aged 40-49 years, 78% (224 of 286) in women aged 50-64 years, and 81% (277 of 340) in women older than 64 years. Sensitivity was 68% (162 of 237) for dense breasts and 85% (302 of 356) for nondense breasts and 74% (180 of 244) in estrogen replacement therapy users and 81% (417 of 513) in nonusers."
Sensitivity is very low for women under 40 years of age, with nearly 1/2 of all cancers not identified, and only 81% identified in the oldest age group. Among women with dense breasts, 32% of cancers were missed, with 15% of cancers missed for the group with the least dense breasts.