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Cost of Breast-Related Care in the Year Following False Positive Screening Mammograms

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Abstract

Objective—We sought to estimate the direct cost, from the perspective of the health insurer or purchaser, of breast-care services in the year following a false positive screening mammogram compared with a true negative examination.

Design—We identified 21,125 women aged 40 to 80 years enrolled in an integrated healthcare delivery system in Washington State, who participated in screening mammography between January 1, 1998 and July 30, 2002. Pathology and cancer registry data were used to identify breast cancer diagnoses in the year following the screening mammogram. A positive examination was defined as a Breast Imaging Reporting and Data System assessment of 0, 4, or 5. Women with a positive screening mammogram but no breast cancer diagnosed within 1 year were classified as false positives. We used diagnostic and procedure codes in automated health plan data to identify services received in the year following the screening mammogram. Medicare reimbursement rates were applied to all services. We used ordinary least-squares linear regression to estimate the difference in costs following a false positive versus true negative screening mammogram.

Results—False positive results occurred in 9.9% of women; most false positives (87.3%) were followed by breast imaging only. The mean cost of breast-care following a false positive mammogram was $527. This was $503 (95% confidence interval, $490 –$515) more than the cost of breast-care services for true negative women.

Conclusions—The direct costs for breast-related procedures following false positive screening mammograms may contribute substantially to US healthcare spending.

Keywords

breast cancer; mammography; screening; false positives; cost; recall

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Mammography is an important breast cancer screening test.[1,2] The United States Preventive Services Task Force (USPSTF) recently revised its breast cancer screening recommendations,[3] generating substantial commentary and debate.[4–8] False positive results are one of the recognized potential harms of screening[9] and were cited in the recent USPSTF guidelines on screening for breast cancer as one of the factors behind the changes in recommendations.[3,9,10] The United States has a considerably higher false positive rate compared with other countries with similar cancer detection rates.[11,12] Previous US studies report up to half of women participating in screening over a decade have at least 1 false positive result.[13,14] Our intent is not to recommend for or against screening in any particular subgroup. Rather, the goal of this article is to estimate the financial implications of false positive screening mammograms and the costs that could be spared if women without cancer were not recalled for further evaluation.

Numerous studies have addressed the psychologic consequences of false positive mammograms,[2,15] but few describe economic consequences of false positive results. The Stockholm mammography screening trial estimated the mean follow-up cost per woman with a false positive as 5106 to 7488 Swedish Krona (~$664–$973 based on 0.13$/Krona in 1993[16]).[17] In 1998, Elmore et al calculated that diagnostic work-up cost $309,755 for 631 false positive mammograms (mean = $491 per person).[13,14]

Updating estimates of the cost of evaluating false positive mammograms is important for understanding the full economic consequences of high recall rates following breast cancer screening, as well as the cost-effectiveness of mammography and comparative effectiveness of different screening strategies.

METHODS

Study Sample

Participants for this study were women enrolled in Group Health, an integrated healthcare delivery system that provides comprehensive health and preventive services to ~550,000 members in Washington State. Computer linkage between Group Health and the Western Washington Surveil-lance, Epidemiology, and End Results (SEER) registry identified cancer cases for all Group Health enrollees residing in any of the 13 Western Washington SEER counties. We obtained complete information on breast-care services through Group Health encounter data and the Breast Cancer Screening Program, which manages risk factor surveys and tracks screening mammography.[18,19] During the study period,Group Health recommended initiating screening for average risk women at age 50 and high risk women at age 40.

The Group Health Institutional Review Board approved study procedures. We previously described methods for identifying the study sample[20]; briefly, we identified women who received at least 2 bilateral screening mammograms 11 to 26 months apart between January 1, 1998 and July 30, 2002. Screening included a 2-view mammogram at dedicated centers within the Group Health delivery system. The second mammogram was considered the index examination for this study. Women with missing assessments at either mammogram were excluded (n = 26).

Subjects resided in 1 of the 13 counties covered by the SEER registry in Western Washington and were continuously enrolled (defined as enrollment gaps of <2 months) in Group Health's integrated group practice for ≥1 year before and after the index mammogram; however, women who died in the year after the index examination were included. We excluded women diagnosed with breast cancer or who had had a mastectomy or breast augmentation before the index screening mammogram. Our final sample consisted of 21,125 eligible subjects.

Classification of Mammograms

A screening mammogram was positive if coded 0 (incomplete), 4 (suspicious abnormality), or 5 (highly suggestive of malignancy) by the radiologist and according to the American College of Radiology's Breast Imaging Reporting and Data System (BI-RADS) assessment categories.[21] A mammogram was considered negative if coded 1 (negative), 2 (benign), or 3 (probably benign).

We used Group Health pathology and SEER data to ascertain diagnoses of breast cancer in the year following the index mammogram. Women with a positive screening mammogram who did not develop breast cancer the following year were false positives (n = 2089). Women with a negative screening mammogram who were not diagnosed with breast cancer in the following year were true negatives (n = 18,844). There were also 160 true positives and 32 false negatives.

Identification of Procedures and Calculation of Costs

We identified breast-care services during the year following the index screening mammogram based on International Classification of Disease (ninth revision) Clinical Modification, Diagnosis-related group, and the American Medical Association's Current Procedural Terminology procedure codes for surgical consultations, imaging (screening and diagnostic mammograms, ultrasounds, and magnetic resonance imaging), fine needle aspiration, biopsies, pathology, and mastectomy (because some women may have had a prophylactic mastectomy) (Table A1; available online only, Supplemental Digital Content 1, available at: http://links.lww.com/MLR/A111).

Our analysis was conducted from the perspective of the health insurer or purchaser. We measured costs from Medicare's perspective as it is a large purchaser of breast cancer screening and treatment services in the United States.[22,23] Costs of specific procedures were based on Medicare reimbursement rates for 2007 for Seattle, Washington.[24] If a code was unavailable for 2007, we used the most recent prior year that it was available and applied the 2007 Medicare conversion factor. Cost estimates for diagnosis-related group were based on standardized Medicare reimbursement, and International Classification of Disease (ninth revision) Clinical Modification procedure cost estimates were based on a crosswalk to the comparable Current Procedural Terminology code to which the standardized Medicare reimbursement was applied.

Covariates

Reproductive history, screening history, personal and family history of breast cancer, use of hormone therapy, weight, height, race, and education were obtained from Group Health's Breast Cancer Screening Program electronic data.[18,25] Women participating in the Breast Cancer Screening Program completed breast cancer risk factor questionnaires at program enrollment and updated this information at the time of a mammogram. Approximately 85% of women ≥40 complete the questionnaires,[18] and the data are available in automated databases. Body mass index was computed using self-reported weight and height collected as part of the Breast Cancer Screening Program survey. Breast density was based on the 4 ratings of density recommended by American College of Radiology BI-RADS.[21] Comorbidity burden was measured using the pharmacy-based chronic disease score.[26] The chronic disease score assigns relative risk weights to individuals based on dispenses for ambulatory prescription drugs used to treat 27 chronic conditions. When validated against case mix models that rely both on self-reported information about health status and diagnostic data, the chronic disease score provides estimates of prospective and concurrent costs that are valid and stable prospectively.[27–29] The completeness of Group Health automated pharmacy data[30] facilitates the use of the chronic disease score as a case mix tool.

Statistical Analysis

We used the χ^2 test to compare the distribution of covariates between women with false positive and true negative screening mammograms. We calculated the frequency of all breast services by screening mammogram result. We then categorized each woman's receipt of breast-care services in the year following her index screening into the following mutually exclusive categories of increasingly invasive services: breast imaging only; surgical consultation for a breast issue (with/without imaging); fine needle aspiration (with/ without imaging or surgical consultation); breast biopsy (with/without imaging, surgical consultation, or fine needle aspiration); mastectomy (with/without other procedures). We applied Medicare reimbursement rates to these services and calculated the total cost of breast-care services for each woman based on her specific set of procedure codes. We then computed the mean and median cost overall and for women in the mutually exclusive groups of services; we used the Wilcoxon rank-sum test to test the null hypothesis that overall costs for false positives and true negatives are drawn from the same distribution. Multivariate analyses were performed using ordinary least-squares regression. Because ordinary least-squares provides unbiased coefficients and standard errors for cost analyses with samples sizes ≥500 observations,[31] we used linear regression to estimate the difference in costs following a false positive versus true negative screening mammogram with test status as the only predictor. We also estimated the difference in cost from a model that included factors that were assumed a priori to be strong confounders: age (40 – 49, ≥50) and ever-use of hormone therapy. We selected age 50 as the cut-point to be consistent with screening guidelines and because it seemed plausible that clinicians might treat women <50 differently from those ≥50 due to evidence from trials regarding the value of mammography to detect breast abnormalities. We also conducted an analysis adjusting for the full set of covariates listed in Table 1. Because we hypothesized that patterns of care, and thus costs, might differ by age or past hormone use status, we ran models that included an interaction term between test result and the potential effect modifier; we evaluated potential effect modification by age and past hormone use in separate models, both with and without adjustment for covariates in Table 1.

RESULTS

The distribution of initial BI-RADS assessment categories, taking each woman's most abnormal result, was: 1 (71.2%), 2 (17.2%), 3 (1.0%), 0 (10.5%), 4 (<0.1%), 5 (1%). Among the 21,125 women in this study, there were 160 true positives (0.8%), 2089 false positives (9.9%), 18,884 true negatives (89.2%), and 32 false negatives (0.2%). The positive predictive value of screening mammography in this population was 7.1%. Table 1 shows subject characteristics according to the main comparison groups in this analysis, false positive and true negative screening mammograms. Women with false positives were similar to true negatives with respect to age, race, family history of breast cancer, months since last screening mammogram, and comorbidity burden; however, body mass index, breast density, ever use of hormone therapy, and history of a false positive result at the previous screening mammogram differed between women with false positive and true negative exams.

In the year following the index screening mammogram, patterns of care differed according to mammogram results (Table 2). Most women with false positive exams received subsequent breast imaging (98.6%), with a smaller percent undergoing invasive testing via fine needle aspiration (1.6%) and breast biopsy (9.0%). Among women with true negative screening mammograms, 5.0% underwent additional breast imaging within the following year; fine needle aspiration (0.4%) and biopsy (0.9%) were also noted in a small fraction of these women.

Table 3 shows the median cost per women for breast services overall and by mutually exclusive groups of services. Among women with false positives, the median cost was $338 for the imaging only group and $2192 for women going on to have a breast biopsy with/without breast imaging, surgical consult, or fine needle aspiration. Overall, the median cost of breast-care services in the year following a false positive screening mammogram was $338 (interquartile range, $169–$554), compared with a median of $0 (inter-quartile range, $0–$0) for true negatives.

On average, the mean cost of breast-care services in the year following a false positive screening mammogram was $527, which was $503 (95% confidence interval [CI], $490–$515) higher than breast-care costs in the year following a true negative examination. Adjustment for age and past hormone therapy use did not alter results meaningfully ($502; 95% CI, $490–$514), nor did fully adjusting for all of the variables in Table 1 ($499; 95% CI, $487–$512).

In our effect modification analyses, the average difference in costs between a false positive and true negative screening examination was higher (by $64; 95% CI, $5–$123) in women 40 to 49 ($564; 95% CI, $506–$621) compared with women ≥50 years of age ($500; 95% CI, $487–$512). We also found that the average difference in cost was lower (by $54; 95% CI, $25–$83) in women who had ever used hormone therapy ($490; 95% CI, $476–$504) compared with never users ($544; 95% CI, $518–$569). Adjusted results did not differ meaningfully from these un-adjusted estimates.

DISCUSSION

In our study, the direct breast-care costs in the year following a false positive screening mammogram were approximately $500 more than for a true negative result. In our study, most false positives were because of an initial assessment that was incomplete (BI-RADS = 0). Although only ~10% of these women received a biopsy, our study suggests that false positive screening mammograms are costly. We report cost estimates similar to those found by Elmore et al who also estimated costs from Medicare's perspective as well as that of an health maintenance organization.[14] These similarities are likely because of both analyses basing cost estimates on amounts payers reimburse providers, which have been relatively stable over time. In our study, the cost of false positive mammograms appeared to be higher among younger women and women who had never used hormone therapy. It is possible that the women under 50 who were screened in this health plan may have been at higher risk for breast cancer than the average population and therefore been evaluated more aggressively after a positive examination.

Our study has several strengths, including being restricted to a screening population. Because the reason for the mammogram (ie, screening or diagnostic) was reported, we can be fairly confident that our study was limited to consequences of false positive screening mammograms; studies that rely exclusively on procedure codes have difficulty distinguishing between screening and diagnostic mammograms.[32]

Our data on breast services following false positive mammograms are relatively complete because Group Health is both the provider and insurer of comprehensive health and preventive services received by enrollees. Since January 1990, Group Health has routinely captured and allocated health care costs for all services provided by physicians and other

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health care providers at Group Health owned and operated facilities, as well as claims for covered services that enrollees receive from contracted providers or facilities.[33]

Our estimates of costs following a false positive mammogram may be modestly inflated if our false positive group contained a few women with breast cancer diagnosed beyond the 1-year follow-up who did truly have cancer at the time of screening; however, 1 year is the standard follow-up interval used.

Though Group Health members are comparable demographically to the underlying population in the region,[34] they are members of a single integrated healthcare delivery system and patterns of care following a false positive screening mammogram may not reflect patterns in different types of settings. However, because we used Medicare costs, our cost estimates are likely similar to other settings where patterns of care are comparable.

An important issue to consider in analyses of economic consequences is which costs to include. We focused only on costs related to working up a false positive screen. We included all direct breast-care costs, including subsequent screening mammograms, incurred within 12-months of the index examination because differences in patterns of care between true negatives and false positives, including reduced intervals between screening mammograms, may be attributable to the false positive examination. We did not include costs from other services (eg, mental health services, pharmacy, etc.) or indirect costs such as missed work and family care, for which data were not available. The potential impact of false positive mammograms on other downstream costs such as mental health services and subsequent medication use, warrants future research.

The literature review prepared for the USPSTF identifies false positive results as an adverse effect of screening and comments that published data on this topic are limited.[9] The relatively low positive predictive value of screening mammography in our study population is consistent with other US reports.[11] International comparisons suggest the United States has among the highest rates of positive screening mammography exams but similar cancer detections rates.[11,12] Recall rates in the United States are thought to be higher than other countries because of differences in characteristics of the populations screened, the physicians interpreting the exams, and the healthcare delivery systems.[11] In the United Kingdom (UK), radiologists are required to read more mammograms annually, their performance is monitored by a quality assurance network, and many participate in an organized professional development program.[12] Furthermore, the rate of malpractice lawsuits arising from false negative exams is lower in the UK than the United States.[12]

Using a conservative estimate that half of the ~37 million mammograms performed annually in the United States[23] are for screening, if 10% result in false positives, a crude calculation suggests that false positives would account for nearly $1 billion annually in US healthcare spending. This is likely a conservative estimate, given that the ~37 million does not include mammograms at Veteran's Administration facilities. Furthermore, it is likely that more than half of the ~37 million mammograms performed in the United States are for screening purposes.

Our findings suggest the costs of working-up a false positive screening mammogram are high and may be significant to a health system. Estimates in this report may help inform cost-effective analyses of mammography, weighing the strengths and limitations of mammography, and comparing different screening modalities and strategies. Our findings support calls to decrease unnecessary recall for false positive screening mammograms in the United States while maintaining high cancer detection rates.[35]

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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REFERENCES

1. Humphrey LL, Helfand M, Chan BKS, et al. Breast cancer screening: a summary of the evidence for the U. S. Preventive Services Task Force. Ann Intern Med. 2002; 137:347–360. [PubMed: 12204020]
2. Armstrong K, Moye E, Williams S, et al. Screening mammography in women 40 to 49 years of age: a systematic review for the American College of Physicians. Ann Intern Med. 2007; 146:516–526. [PubMed: 17404354]
3. U.S. Preventive Services Task Force. Screening for breast cancer: U. S. Preventive Services Task Force recommendation statement. Ann Intern Med. 2009; 151:716–726. [PubMed: 19920272]
4. DeAngelis CD, Fontanarosa PB. US Preventive Services Task Force and breast cancer screening. JAMA. 2010; 303:172–173. [PubMed: 20068215]
5. Berg WA. Benefits of screening mammography. JAMA. 2010; 303:168–169. [PubMed: 20068213]
6. Murphy AM. Mammography screening for breast cancer: a view from 2 worlds. JAMA. 2010; 303:166–167. [PubMed: 20068212]
7. Woolf SH. The 2009 breast cancer screening recommendations of the US Preventive Services Task Force. JAMA. 2010; 303:162–163. [PubMed: 20068210]
8. Woloshin S, Schwartz LM. The benefits and harms of mammography screening: understanding the trade-offs. JAMA. 2010; 303:164–165. [PubMed: 20068211]
9. Nelson HD, Tyne K, Naik A, et al. Screening for breast cancer: an update for the U. S. Preventive Services Task Force. Ann Intern Med. 2009; 151:727–737. [PubMed: 19920273]
10. Mandelblatt JS, Cronin KA, Bailey S, et al. Effects of mammography screening under different screening schedules: model estimates of potential benefits and harms. Ann Intern Med. 2009; 151:738–747. [PubMed: 19920274]
11. Elmore JG, Nakano CY, Koepsell TD, et al. International variation in screening mammography interpretations in community-based programs. J Natl Cancer Inst. 2003; 95:1384–1393. [PubMed: 13130114]
12. Smith-Bindman R, Chu PW, Miglioretti DL, et al. Comparison of screening mammography in the United States and the United Kingdom. JAMA. 2003; 290:2129–2137. [PubMed: 14570948]
13. Christiansen CL, Wang F, Barton MB, et al. Predicting the cumulative risk of false-positive mammograms. J Natl Cancer Inst. 2000; 92:1657–1666. [PubMed: 11036111]
14. Elmore JG, Barton MB, Moceri VM, et al. Ten-year risk of false positive screening mammograms and clinical breast examinations. N Engl J Med. 1998; 338:1089–1096. [PubMed: 9545356]
15. Brewer NT, Salz T, Lillie SE. Systematic review: the long-term effects of false-positive mammograms. Ann Intern Med. 2007; 146:502–510. [PubMed: 17404352]
16. OANDA Corporation. FxHistory. 2009 [Accessed October 12, 2009]. Available at: http://www.oanda. com/convert/fxhistory.
17. Lidbrink E, Elfving J, Frisell J, et al. Neglected aspects of false positive findings of mammography in breast cancer screening: analysis of false positive cases from the Stockholm trial. BMJ. 1996; 312:273–276. [PubMed: 8611781]

18. Taplin SH, Ichikawa L, Buist DS, et al. Evaluating organized breast cancer screening implementation: the prevention of late-stage disease? Cancer Epidemiol Biomarkers Prev. 2004; 13:225–234. [PubMed: 14973097]
19. Taplin SH, Thompson RS, Schnitzer F, et al. Revisions in the risk-based breast cancer screening program at group health cooperative. Cancer. 1990; 66:812–818. [PubMed: 2386908]
20. Boudreau DM, Buist DS, Rutter CM, et al. Impact of hormone therapy on false-positive recall and costs among women undergoing screening mammography. Med Care. 2006; 44:62–69. [PubMed: 16365614]
21. American College of Radiology. BI-RADS Breast Imaging Reporting and Data System. American College of Radiology; Reston, VA: 2003.
22. Centers for Medicare & Medicaid Services. Mammography claims data tables: bienniel national and state data for women 49 and under, 50–67, and older, and all women, 2000–2001. 2002 [Accessed October 14, 2009]. Available at: http://www.cms.hhs. gov/Mammography/downloads/00-01biennialnatstate3agegroupsHEDIS02. pdf.
23. U.S. Food and Drug Administration. Mammography Quality Standards Act and Program National Statistics. 2009 [Accessed October 12, 2009]. Available at: http://www.fda.gov/Radiation-EmittingProducts/MammographyQualityStandards ActandProgram/FacilityScorecard/ucm113858.htm.
24. Hsiao WC, Braun P, Dunn DL, et al. An overview of the development and refinement of the Resource-Based Relative Value Scale. The foundation for reform of U.S. physician payment. Med Care. 1992; 30:NS1–NS12. [PubMed: 1434963]
25. Ballard-Barbash R, Taplin SH, Yankaskas BC, et al. Breast cancer surveillance consortium: a national mammography screening and outcomes database. Am J Roentgenol. 1997; 169:1001–1008. [PubMed: 9308451]
26. Clark DO, Von Korff M, Saunders K, et al. A chronic disease score with empirically derived weights. Med Care. 1995; 33:783–795. [PubMed: 7637401]
27. Fishman PA, Goodman MJ, Hornbrook MC, et al. Risk adjustment using automated ambulatory pharmacy data: the RxRisk model. Med Care. 2003; 41:84–99. [PubMed: 12544546]
28. Hornbrook MC, Goodman MJ. Chronic disease, functional health status, and demographics: a multi-dimensional approach to risk adjustment. Health Serv Res. 1996; 31:283–307. [PubMed: 8698586]
29. Hornbrook MC, Goodman MJ, Bennett MD, et al. Assessing health plan case mix in employed populations: self-reported health status models. Adv Health Econ Health Serv Res. 1991; 12:233–272. [PubMed: 10122804]
30. Boudreau DM, Doescher MP, Saver BG, et al. Reliability of group health cooperative automated pharmacy data by drug benefit status. Pharmacoepidemiol Drug Saf. 2005; 14:877–884. [PubMed: 15931653]
31. Lumley T, Diehr P, Emerson S, et al. The importance of the normality assumption in large public health data sets. Annu Rev Public Health. 2002; 23:151–169. [PubMed: 11910059]
32. Lee DW, Stang PE, Goldberg GA, et al. Resource use and cost of diagnostic workup of women with suspected breast cancer. Breast J. 2009; 15:85–92. [PubMed: 19120378]
33. Fishman PA, Wagner EH. Managed care data and public health: the experience of Group Health Cooperative of Puget Sound. Annu Rev Public Health. 1998; 19:477–491. [PubMed: 9611629]
34. Saunders, KW.; Davis, RL.; Stergachis, A. Group health cooperative. In: Strom, BL., editor. Pharmacoepidemiology. John Wiley & Sons Ltd; Chichester, United Kingdom: 2005. p. 223-239.
35. Fletcher SW, Elmore JG. False-positive mammograms— can the USA learn from Europe? Lancet. 2005; 365:7–8. [PubMed: 15639661]

TABLE 1

Subject Characteristics at Screening Mammogram, by Screening Mammogram Result

	False Positives N = 2089 n (%)	True Negatives N = 18,844 n (%)	χ^2p
Age (yr)			
40–49	95 (4.5)	950 (5.0)	*P* = 0.58
50–59	729 (34.9)	6532 (34.7)	
60–69	605 (29.0)	5265 (27.9)	
70–80	660 (31.6)	6097 (32.4)	
Race			
White	1908 (91.3)	17,116 (90.8)	*P* = 0.49
Black	65 (3.1)	552 (2.9)	
Asian/Pacific Islander	101 (4.8)	987 (5.2)	
Other/unknown	15 (0.7)	189 (1.0)	
BMI (kg/m^2)*			
<25	748 (37.6)	809 (32.7)	*P* = 0.02
25–30	696 (35.0)	5809 (32.7)	
>30	543 (27.3)	5352 (30.1)	
First-degree family history of breast cancer*	374 (17.9)	3366 (17.9)	*P* = 0.96
Ever used hormone therapy*	1611 (77.7)	13,316 (71.2)	*P* < 0.001
Breast density			
Almost entirely fat	86 (4.1)	128 (43.1)	*P* < 0.001
Scattered fibroglandular tissue	785 (37.6)	8128 (43.1)	
Heterogeneously dense	1098 (52.6)	8007 (42.5)	
Extremely dense	120 (5.7)	1179 (6.3)	
False positive recall at previous screen	265 (12.7)	1548 (8.2)	*P* < 0.001

	Mean (SD)	Mean (SD)	*t* Test *p*
Months since previous screening mammogram	22 (4)	22 (4)	*P* = 0.13
Chronic disease score†	2769 (2728)	2667 (2630)	*P* = 0.10

BMI indicates body mass index; SD, standard deviation.

*Missing values for false positives and true negatives, respectively: BMI (102, 1088); first-degree family history of breast cancer (1, 7); hormone therapy (16, 140).

†Pharmacy-based chronic disease score.[26]

TABLE 2

Percent of Women Receiving Breast-Related Procedures and Surgical Consults in the Year After a Screening Mammogram, by Screening Mammogram Result†

	False Positives N (Women) = 2089 n (%)	True Negatives N (Women) = 18,844 n (%)
Breast imaging	2060 (98.6)	934 (5.0)
Diagnostic mammogram	1870 (89.5)	623 (3.3)
Screening mammogram	35 (1.7)	237 (1.3)
MRI	1 (0.1)	2 (<0.1)
Ultrasound	975 (46.7)	319 (1.7)
Ductogram	2 (0.1)	4 (<0.1)
Surgical consult for a breast issue	116 (5.6)	135 (0.7)
Fine needle aspiration	33 (1.6)	71 (0.4)
Biopsy	188 (9.0)	161 (0.9)
Mastectomy	3 (0.1)	1 (<0.1)

*Column percents will not add to 100% because categories are not mutually exclusive.

TABLE 3

Median Cost per Person in Year Following Screening Mammogram, by Screening Mammogram Result

	False Positives		True Negatives	
Procedure(s) Received	**N (col. %)**	**Median$/Person (q25, q75)**	**N (col. %)**	**Median$/Person (q25, q75)**
None	28 (1.3)	0 (0, 0)	17,725 (94.1)	0 (0, 0)
Breast imaging only	1824 (87.3)	338 (169, 420)	824 (4.4)	210 (185, 379)
Surgery consult with/without imaging	37 (1.8)	628 (510, 898)	83 (0.4)	374 (177, 459)
Fine needle aspiration with/without imaging or surgical consult	12 (0.6)	642 (434, 781)	51 (0.3)	518 (210, 583)
Breast biopsy with/without imaging, surgical consult, or fine needle aspiration	185 (8.9)	2192 (1600, 2500)	160 (0.8)	762 (458, 1330)
Mastectomy with/without other procedures	3 (0.1)	6226 (5711, 12,641)	1 (<0.1)	2471 (2471, 2471)
Total	2089 (100)	338* (169, 554)	18,844 (100)	0 (0, 0)

q25 indicates 25th percentile; q75, 75th percentile.

* $P < 0.01$ from Wilcoxon rank-sum test of null hypothesis that overall costs for false positives and true negatives are drawn from the same distribution.