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The Effect of Immediate Reading of Screening Mammograms on Medical Care Utilization and Costs after False-Positive Mammograms

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Objective. To investigate whether decreased anxiety associated with immediate reading of screening mammograms resulted in lower downstream utilization and costs among women with false-positive mammograms.
Data Sources/Study Setting. We identified 1,140 women, ≥ age 40, with false-positive mammograms and 12-month follow-up after participating in a trial of immediate versus batch mammographic reading between February 1999 and January 2001 in a multispecialty group managed care practice in Massachusetts.
Study Design. We determined downstream utilization and costs for study participants by immediate and batch reading status.
Data Collection/Extraction Methods. Demographic, comorbidity, and medical care utilization data were obtained from survey data and computerized medical record databases. Costs included direct medical costs, patient time, travel and copayments, and additional professional time costs associated with immediate reading.
Principal Findings. Immediate reading cost an additional $4.40 per screening mammogram. Women with immediate readings had more follow-up mammograms (781 versus 750, $p = .018$) and fewer diagnostic ultrasounds (176 versus 219, $p = .016$) than women with batch readings. Costs to the health plan for breast care were approximately 10 percent higher for immediate readings in multivariable analyses ($p = .046$), but no significant difference was seen in total societal costs ($p = .072$).
Conclusions. Immediate mammogram reading was associated with increased costs to the health plan and changes in follow-up radiology procedures. These costs must be examined alongside beneficial effects of immediate reading.

Key Words. Mammography, immediate reading, controlled trial, utilization, costs

Mammography is an imperfect test, and false-positive mammograms, where the mammogram is read as abnormal in a woman who does not have breast cancer, happen frequently. On average, in the United States, about 10 percent of mammograms are read as abnormal (Brown, Houn et al. 1995). The cumulative probability of a false-positive mammogram after 10 screening mammograms may reach 49 percent (Elmore, Barton et al. 1998).

Women who are told that their mammograms are abnormal often remain anxious beyond the period of additional testing (Ellman, Angeli et al. 1989; Gram, Lund et al. 1990; Bull and Campbell 1991; Lerman, Rimer, and Engstrom 1991; Lerman, Trock, Rimer, Boyce et al. 1991; Lerman, Trock, Rimer, Jepson et al. 1991; Gram and Slenker 1992; Brown, Houn et al. 1995; Paskett and Rimer 1995; Sutton, Saidi et al. 1995; Lidbrink, Elfving et al. 1996; Lowe, Balanda et al. 1999; Cullen, Schwartz et al. 2004). Women with false-positive mammograms also seek more medical attention for breast-related concerns and other medical issues than women with normal mammograms (Barton, Moore et al. 2001). These adverse effects are important, given the large volume of women undergoing screening mammography each year and the sizeable number who are given false-positive results (Cullen, Schwartz et al. 2004). Small increases in anxiety at the individual level due to false-positive mammograms may have a large impact on overall anxiety in the community, as well as an adverse effect on health care costs. Developing ways to decrease anxiety after an abnormal mammogram might improve patient care.

We recently reported that among women with false-positive mammograms, those whose mammograms were read by a radiologist while the woman was still in the radiology suite ("immediate reading") had lower levels of anxiety at 3 weeks compared with women whose mammograms were read in the usual manner, in batches after the woman had left the radiology suite. A majority of women with immediate readings did not realize they had had abnormal readings, indicating that immediate completion of follow-up testing minimized the effect of a false-positive mammogram on anxiety (Barton, Morley et al. 2004). We therefore undertook the current study to determine the cost of lowering anxiety with immediate mammogram reading.

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We had two goals: first, we wanted to estimate the additional cost associated with immediate reading compared with batch reading based on all women undergoing screening mammography, i.e., both those with normal and false-positive results. Second, we wanted to evaluate the net impact of immediate reading on downstream health care utilization and costs among women with false-positive mammograms. We hypothesized that women with false-positive mammograms who had immediate mammogram readings and decreased anxiety would have lower downstream utilization for discretionary medical care, compared with women who had batch reading and higher anxiety. If medical care utilization and costs were lower, we wanted to determine whether these lower costs offset some of the increased costs associated with immediate reading. We evaluated all 12-month medical care costs borne by the health plan and costs such as time, travel, and copayments borne by the patients.

METHODS

Setting and Cohort

This study was based on a controlled trial involving women aged 40 years and older undergoing screening mammography at Harvard Vanguard Medical Associates (HVMA) in Massachusetts between February 1999 and January 2001 (Barton, Morley et al. 2004). Harvard Vanguard Medical Associates is a multispecialty group managed care practice serving approximately 180,000 adults in 14 practices in the greater Boston metropolitan area.

Mammography facilities are located at seven sites from which patients were recruited; trained recruiters or technologists provided detailed information about the study to women after they checked-in for their mammogram appointment, and asked if they would participate. 8,854 patients agreed to participate in the study. Women were excluded if their study group designation could not be determined ($n = 169$), they were diagnosed with breast cancer ($n = 41$) or they were otherwise ineligible, i.e., non-English speaking, younger than 40 years, had a history of breast cancer, or underwent non-screening mammograms ($n = 101$). Women with false-positive mammograms ($n = 1,742$) and a random sample of women with normal mammograms ($n = 1,102$) were contacted for interviews to assess anxiety after the screening mammogram. The study sample included 2,390 respondents to the 3-week interviews (84 percent response rate), of whom 1,439 had false-positive mammograms (83 percent response rate) and 951 (86 percent response rate) had normal mammograms.

The Human Subjects Committee of Harvard Vanguard Medical Associates approved this study protocol.

Definition of False-Positive Mammograms

False-positive mammograms were defined as abnormal mammograms without a diagnosis of cancer in the following year, including mammograms for which women were told to return in 6 months for another mammogram.

Study Design and Screening Mammogram Readings

The design and intervention assignment process are described fully elsewhere (Barton, Morley et al. 2004). According to the appointment date and time, women who agreed to participate were allotted either to immediate reading or batch reading. A total of 18 radiologists supplied mammography services to the practice; most provided services at multiple sites in the course of a week. An educational intervention was also studied but is not included in this analysis. Assignment to immediate reading was nonrandom, as it was provided on a part-time basis according to radiologist availability.

Women in the immediate reading group had their mammograms read by a radiologist during their appointment and knew the initial results of their mammogram before leaving the office; in many cases, they had follow-up mammograms or ultrasounds taken during the same appointment. In standard radiology care, radiologists read screening mammograms in batches after patients left the office, and patients were notified of the results by telephone or post several days later.

Anxiety was lower 3 weeks after the screening mammogram for women with false-positive mammograms with immediate readings compared with women with batch readings. Because women with normal mammograms did not experience heightened anxiety attributable to abnormal mammogram results, we did not expect the type of mammography reading to affect their downstream utilization and costs. However, we used data from women with both normal and false-positive mammograms to estimate the cost of immediate reading.

Demographic data were gathered in the course of the telephone surveys assessing 3-week anxiety levels. Comorbidity data were assessed from claims information using a modified Charlson index (Charlson, Pompei et al. 1987; Deyo, Cherkin et al. 1992).

Health Care Utilization

Health care utilization after the screening mammogram was assessed for a 12-month follow-up period, and included breast imaging as well as primary care, medical specialist, surgical and mental health care utilization. Primary care utilization included services provided by nurses and physician assistants. Utilization data were obtained from computerized clinical encounter information (Automated Medical Record System [AMRS]; Barnett 1984; Donahue, Choo et al. 1995) and EPIC (Hajra 1998) as well as a claims database of visits and procedures associated with specialist and out-of-network providers. Information on additional mammographic views taken at the time of the screening mammogram was collected from technologists; mammograms and ultrasounds performed in the 6 months following the screening mammogram were available from a radiology department database. Data on mammograms and ultrasounds conducted between 6 and 12 months after the screening mammogram were obtained from AMRS, EPIC, and claims databases.

Breast and Nonbreast Health Care Utilization

Our definition of breast-related health care utilization included breast imaging procedures and outpatient visits. We identified breast procedures based on Current Procedural Terminology (CPT) codes (e.g., 76090, 76091, and 76092 for mammograms); we identified additional breast visits that did not involve a procedure based on ICD-9-CM and HVMA diagnoses codes (e.g., V76.1 for other screening breast examination). Outpatient visits were designated as breast related if the diagnosis or CPT code matched our list of breast-related diagnoses and procedures (Table 1). The final dataset included unique service events including breast-related radiology and outpatient utilization for 1 year following the screening mammogram. Nonbreast utilization included all other physician and primary care visits. Mental health utilization included visits to mental health professionals.

Costs

Cost analyses accounted for total societal costs, including both direct medical expenses incurred by the insurer, and patient-borne costs such as copayment, time, and transportation costs (Table 1). We used Medicare's 2000 Direct Practice Expense File and Resource Based Relative Value Scale (RBRVS) to estimate national average costs for physician and laboratory services (Direct Practice Expense File and Resource Based Relative Value Scale 2000). This was used to estimate the cost of additional views taken on the same day as the

Table 1: Cost Parameters

Resource	Source of Cost Estimate	Resource Units	Dollar Value (Base Case)
Physician services	Medicare 2000 Resource Based Relative Value Scale for Professional and Laboratory Services	Current Procedural Terminology (CPT) codes For breast procedures, we used the following CPT codes: Mammograms (76090, 76091, 76092) Ultrasounds (19030, 76093, 76094, 76645) Aspirations (19000, 19001, 76938, 88171) Biopsies (19020, 19100, 19101, 19110, 19112, 19120, 19125, 19126, 19290, 19291, 76095, 76096, 76098, 76942). Nonprocedure breast visits were identified using HVMA and ICD-9-CM diagnoses codes: 174, 174.1, 174.2, 174.3, 174.4, 174.5, 174.6, 174.8, 174.9, 202.6, 217, 233, 238.3, 383.1, 383.9, 451.89, 457, 610, 610.1, 610.3, 611, 611.1, 611.71, 611.72, 611.8, 611.9, 675.11, 675.2, 675.24, 676.2, 676.23, 676.24, 757.33B, 757.6, 676.34, 796.4, 879, 879.1, 922, 996.54, DY381, V10.3, V16.3, V43.82, V45, V45.71, V70.0, V76.1, V76.19	$ Varied
Copayments	Harvard Vanguard Medical Associates copayment rates for evaluation and management services	Each provider visit associated with a management and evaluation CPT code (99201, 99202, 99203, 99204, 99205, 99211, 99212, 99213, 99214, 99215, 99241, 99242, 99243, 99244, 99245, 99271, 99272, 99273, 99274, 99354, 99355, 99358, 99359, 99385, 99386, 99387, 99395, 99396, 99397, 99401, 99402, 99403, 99404, 99411, 99412, 99420, 99429, 99450, 99455, 99456, 99499)	$10
Travel	American Public Transportation Association, http://www.apta.com/stats/fares/fareavg.htm, last accessed March 25, 2003	Each date of associated with provider visit(s)	$2 roundtrip

continued

Table 1: *Continued*

Resource	*Source of Cost Estimate*	*Resource Units*	*Dollar Value (Base Case)*
Time costs	U.S. Department of Labor, Bureau of Labor Statistics. Highlights of Women's Earnings in 2000, Table 1. Median Usual Weekly Earnings of Full-time Wage and Salary Workers by Selected Characteristics, 2000 Annual Averages, August 2001	Breast travel-related time assumptions: 30 minutes roundtrip: screening mammograms and follow-up procedures at same site as screening mammogram 60 minutes roundtrip: follow-up breast visits at a site different from screening mammogram site Breast procedure-related units of time*: 20 minutes: extra views taken on the same day as screening mammogram 50 minutes: diagnostic mammograms 32.5 minutes: ultrasounds 50 minutes: aspirations Nonbreast travel-related time 30 minutes round trip Nonbreast visits 30 minutes	$13.00/hour: ages 35–44 $14.13/hour: ages 45–54 $12.63/hour: ages 55–64 $9.45/hour: age 65 and above
Marginal cost of radiology intervention	Medicare 2000 Direct Practice Expense File and authors' estimate (see Appendix online)		$4.40/screening mammogram

*Personal communication, Dr. Philip Arena, December 17, 1998.

screening mammogram by accounting for the additional time required for technologists and radiologists and additional use of the mammography equipment and supplies.

Estimating the Additional Cost Associated with Immediate Reading

The costs associated with standard screening mammography included radiologists' time to read mammograms, technologists' time to provide instructions, capture the mammographic images and develop films, as well as costs for consumable mammography equipment and supplies. Extra time associated with immediate reading could result from an inefficient queue of screening mammograms that had to be developed and then read by radiologists during the appointment, compared with batch settings where radiologists read pre-hung rows of films from multiple women, as well as by any radiologist time spent giving preliminary results to patients. These factors could introduce delay in both technologists' and radiologists' work.

We developed a multivariable regression model using data on all women who agreed to participate in the study (i.e., women with normal and abnormal mammograms) to estimate the additional time it took to read mammograms in the immediate setting. The model estimated the percent change in the number of screening mammograms read per hour as a function of immediate reading while controlling for clinical site, daily volume of non-mammography work, and the available hours of observation on each date (details in Appendix online). We used these results to estimate a base-case percentage increase in personnel time associated with the immediate reading. We multiplied the professional fee component of the 2000 Medicare Practice Expense Files for screening mammograms by this estimate and added it to the cost of screening mammograms.

Previous analyses found that immediate reading was associated with a higher rate of false-positive mammograms compared with batch reading (Barton, Morley et al. 2004). We estimated the additional costs per woman attributable to the increased number of follow-up mammograms taken in the immediate reading setting (details in Appendix online).

Analysis

To assess differences in medical care utilization, we tested whether there was a difference in the number of breast procedures (i.e., number of mammograms, ultrasounds, aspirations, and biopsies) by screening mammography reading group. We also examined whether there was a difference in the proportion of women who had any additional imaging procedures after the screening mammogram and number of return visits for additional diagnostics by reading status. In addition, we evaluated whether there was a difference in all types of breast procedures, breast-related visits (i.e., without imaging procedures), nonbreast visits, and mental health visits.

For all medical care utilization analyses, nonparametric tests were used due to the skewed nature of the data. Bivariate analyses were conducted using the Wilcoxon two-sided *Z*-approximation. Multivariable analyses based on the negative binomial distribution were developed to evaluate whether any differences in utilization rates across groups existed after controlling for demographic variables, Charlson comorbidity score, and site. We used the negative binomial distribution for the multivariable models because it performs better than the Poisson distribution when there are different propensities of having events (i.e., incurring visits or procedures) across the study population (Glynn and Buring 1996) which is the case as some individuals tend to be higher users of medical care than others.

All cost analyses were conducted using Medicare 2000 fee schedules. We compared costs associated with all types of breast and nonbreast utilization by mammography reading group, including outpatient utilization and patient copayment, time, and transportation costs. We report costs separately for patients and the health plan as well as the sum of patient and plan costs as a measure of the total societal costs. All cost data were log transformed before conducting statistical comparisons. Bivariate cost comparisons were based on a simple linear regression of log costs on screening mammography reading group. Multivariable log-linear regression analyses of log costs on intervention group controlled for age, education, race, Charlson score, and site. There were relatively few women with no costs in the follow-up period; in order to include them in the analyses, we added 50 cents to each subject's total cost variables before conducting the log transformation.

We also conducted several sensitivity analyses. We estimated the effect of lowering the cost of the immediate reading by 25 percent and doubling its cost on health plan and societal costs. We also assessed the following manipulations on patient-borne and societal costs: women's time costs 40 percent higher than the base case, and transportation costs three times the base case. We ran several multiway sensitivity analyses with increases in women's time and transportation costs, and increases in immediate reading and women's time and transportation costs. Decisions about which parameters to vary and by how much were based on consensus agreement.

RESULTS

The analysis was limited to the 1,140 women who had false-positive mammograms and for whom complete utilization data were available (determined by continuous enrollment throughout the 12-month follow-up). Five hundred and sixty-four women were assigned to immediate reading and 576 were assigned to batch reading. Compared with women receiving batch reading, women with immediate reading were older (54.1 versus 52.7 years) and less likely to be college educated (77.5 versus 84.7 percent). There were no significant differences between groups by smoking status, family history of breast cancer, race, marital status, or mean Charlson score (Table 2).

Utilization

Breast Procedures and Visits. In unadjusted analyses, the number of mammograms and ultrasounds over the 12-month follow-up period differed significantly by reading group (Table 3). Women with immediate reading had significantly more mammograms (781 versus 750; $p = .018$) and fewer ultrasounds (176 versus 219; $p = .016$). There were no significant differences in the number of aspirations and biopsies by reading group. When all breast procedures were added together, there was no significant difference in the number of breast procedures.

The number of breast visits that did not involve a procedure was similar across groups (554 for immediate reading group versus 586 for batch group;

Table 2: Demographic information

	Immediate Reading		
	Yes (n = 564)	*No (n = 576)*	*p-Value*
Age (%)			
40–49	37.8	41.7	
50–64	44.7	46.2	
65–74	12.4	10.1	
75+	5.1	2.1	.020
Current smokers, (%)	11.5	10.6	.615
Ever smoked (%)	48.8	47.9	.776
Family history of breast cancer (%)	33.2	31.8	.618
Caucasian (%)	79.1	79.3	.913
Married (%)	58.7	62.3	.209
Some college or higher (%)	77.5	84.7	.002
Charlson score, mean (SD)	0.25 (0.51)	0.26 (0.53)	.985

t-Test for continuous data, chi square for count/categorical data

Table 3: Number and Mean Breast Utilization and Mean Nonbreast Utilization by Immediate Reading Status

	Immediate Reading			
	Yes (n = 564)	*No (n = 576)*	*Unadjusted p-Value**	
Number breast procedures and visits				
Mammograms				
Same day extra views	501	330	<.001	
Different mammogram date(s)	280	420	<.001	
Total mammograms	781	750	.018	
Ultrasounds	176	219	.016	
Aspirations	42	38	.416	
Biopsies	64	83	.474	
Sub-total: breast-related procedures	1,063	1,090	.839	
Nonprocedure breast visit	554	586	.680	
Total: all breast procedures and nonprocedure visits	1,617	1,676	.641	
				Adjusted Incidence Ratio[†]
Mean breast and nonbreast utilization				
Breast utilization				
Mean (SD)	2.87 (1.85)	2.91 (2.07)		
Median	2	2	.641	0.97 (0.89, 1.06)
Nonbreast utilization				
Mean (SD)	9.48 (10.31)	9.69 (13.13)		
Median	7	6	.115	0.93 (0.82, 1.05)
Mental health utilization				
Mean (SD)	0.81 (3.64)	0.48 (2.20)		
Median	0	0	.462	N/A[‡]

*Wilcoxon's two-sided *Z*-approximation.

[†]Negative binomial model with covariates for age, education (high school or less versus at least some college), race (white versus other), Charlson comorbidy score, and site. The incidence ratio gives the ratio of the number of visits in 1 year after the screening mammogram by women in the immediate reading group relative to the number of visits by women in the batch reading group.

[‡]No multivariable analyses of mental health visits were conducted due to the limited number of women with any mental health visits.

$p = .680$). Total breast utilization, including all breast procedures and all breast nonprocedure visits, was not significantly different across groups (1,617 for the immediate reading group versus 1,676 for the batch reading group; $p = .641$). In multivariable analyses of breast utilization, no significant differences in breast-related utilization were found between the groups (Table 3).

Return Trips to Mammography Unit. Women in the immediate reading group made fewer return trips to the mammography unit for additional imaging. Of the women with immediate reading, 25 percent made one additional trip while another 25 percent made two or more return trips, compared with 32 and 31 percent, respectively, for women with batch reading ($p < .0001$).

Nonbreast Utilization. There were no significant differences between groups in the unadjusted or adjusted analyses of nonbreast utilization (Table 3). Women with immediate reading had a median of 7 nonbreast visits compared with 6 for women with batch reading ($p = .115$), and there were no significant differences in multivariable analyses (incidence ratio = 0.93; 95 percent CI [0.82, 1.05]).

Few women incurred mental health visits; the median number of visits for both groups was zero ($p = .462$). No further analyses of mental health visits were conducted.

Costs of Immediate Reading

We estimated that the base-case cost of immediate reading was $4.40 per screening mammogram, and we attributed that amount to each woman who had her mammogram read immediately (see Appendix online for further details). The total cost accounted for the decrease in efficiency ($2.22) and the increased odds of extra mammographic views in the immediate reading setting ($2.18).

Breast and Nonbreast Utilization Costs

In bivariate analyses of breast utilization costs, there were no differences in patient costs across groups, but costs were approximately 10 percent higher to the health plan for women with immediate reading ($p = .014$; Table 4). In multivariable analyses using log-linear regression, the magnitude of the cost difference to the health plan was similar (i.e., approximately 9 percent), and remained statistically significant ($p = .046$). Total societal breast-related costs were approximately 9 percent higher for the immediate reading group in crude analyses ($p = .031$), but were nonsignificant in multivariable analyses ($p = .072$).

Patient-borne costs for nonbreast utilization were not statistically different across groups in unadjusted or adjusted analyses ($p = .071$ and .119, respectively). Costs to the health plan for nonbreast utilization were approximately 25 percent higher for the immediate reading group in unadjusted analyses ($p = .036$). After adjusting for demographics, Charlson score and site, the difference was nonsignificant ($p = .056$). Total societal nonbreast

Table 4: Estimated 12-Month Costs in Dollars ($), by Immediate Reading Status

	Immediate Reading		
	Yes (n = 564)	*No (n = 576)*	*p-Value*
Breast-related costs			
Patient costs (i.e., time, transportation, and copayments)			
Mean (SD)*	55 (45)	56(49)	
Unadjusted β (SE)†	0.073 (0.06)	Reference	.233
Adjusted β (SE)‡	0.082 (0.07)	Reference	.218
Health plan costs (i.e., intervention costs, procedure, and visit costs)			
Mean (SD)*	280 (245)	280 (295)	
Unadjusted β (SE)†	0.114 (0.05)	Reference	.0135
Adjusted β (SE)‡	0.101 (0.05)	Reference	.046
Total breast-related costs			
Mean (SD)*	335 (279)	335 (334)	
Unadjusted β (SE)†	0.102 (0.05)	Reference	.031
Adjusted β (SE)‡	0.093 (0.05)	Reference	.072
Nonbreast-related costs			
Patient costs (i.e., time, transportation, and copayments)			
Mean (SD)*	198 (197)	200 (248)	
Unadjusted β (SE)†	0.175 (0.10)	Reference	.071
Adjusted β (SE)‡	0.161 (0.10)	Reference	.119
Health plan costs (i.e., intervention costs, procedure, and visit costs)			
Mean (SD)*	742 (994)	758 (1,171)	
Unadjusted β (SE)†	0.258 (0.12)	Reference	.036
Adjusted β (SE)‡	0.248 (0.13)	Reference	.056
Total nonbreast-related costs			
Mean (SD)*	940 (1,154)	958 (1388)	
Unadjusted β (SE)†	0.240 (0.12)	Reference	.045
Adjusted β (SE)‡	0.229 (0.13)	Reference	.072
All Costs			
Patient costs (i.e., time, transportation, and copayments)			
Mean (SD)*	253 (199)	256 (255)	
Unadjusted β (SE)†	0.083 (0.05)	Reference	.124
Adjusted β (SE)‡	0.046 (0.06)	Reference	.420
Health plan costs (i.e., intervention costs, procedure, and visit costs)			
Mean (SD)*	1,022 (1,010)	1,038 (1239)	
Unadjusted β (SE)†	0.104 (0.05)	Reference	.054
Adjusted β (SE)‡	0.048 (0.06)	Reference	.386
Total nonbreast-related costs			
Mean (SD)*	1,275 (1,173)	1,294 (1463)	
Unadjusted β (SE)†	0.096 (0.05)	Reference	.068
Adjusted β (SE)‡	0.044 (0.05)	Reference	.413

*Based on actual cost data.

†Estimates from crude log-linear regression.

‡Estimates from log-linear regression adjusted for age, education (high school or less versus at least some college), race (white versus other), Charlson comorbidity score, and site.

costs were, like health plan costs, higher in unadjusted analyses, but not statistically significant in adjusted analyses.

Despite the higher costs to the health plan for the immediate reading group, total 12-month costs borne by patients, the health plan, and total societal costs did not differ significantly across groups in adjusted analyses ($p = .420$, .386, and 0.413, respectively).

Sensitivity Analyses

Sensitivity analyses included (1) decreasing the marginal cost of immediate reading from $4.40 to $3.30; (2) doubling the marginal cost of immediate reading from $4.40 to $8.80; (3) increasing women's time costs by 40 percent; (4) tripling travel costs from $2 to $6; (5) increasing women's time costs by 40 percent and tripling travel costs from $2 to $6; and (6) doubling the marginal cost of immediate reading and increasing women's time costs by 40 percent and tripling transportation costs. We no longer found a significant difference in total breast costs to the health plan by reading group when the marginal cost of immediate reading was decreased to $3.30 ($p = .061$). Doubling the marginal cost of immediate reading significantly increased breast-related costs by approximately 13 and 12 percent to the health plan and society, respectively, in multivariable analyses ($p = .013$ and .028, respectively). Varying women's time and transportation costs, (3)–(5), did not produce statistically significant differences in patient-borne or total societal costs in multivariable breast, nonbreast or total cost analyses. Sensitivity analysis (6) resulted in approximately 12 percent higher health plan costs in the immediate reading group ($p = .013$) and 10 percent higher total societal costs ($p = .040$).

DISCUSSION

We found that immediate reading of screening mammograms had several effects on health care costs and utilization. First, we estimated the additional cost per screening mammogram under immediate reading was $4.40. Approximately 50 percent of these costs were attributable to a higher rate of false-positive mammograms in the immediate reading setting (22.8 percent) compared with batch reading (18.5 percent). The cause of the higher rate is not clear, but perhaps mammographers knew it was easy to check any questionable findings when the patient was still in the mammography suite. Whether the increase in follow-up testing in the immediate reading setting can be minimized or eliminated is an important consideration.

Although immediate reading resulted in more false-positive mammograms, it also provided instantaneous resolution for many women and led to significantly lower anxiety in this group compared with women with batch readings. In particular, 56 percent of women in the immediate reading group reported they understood that their screening mammogram had been normal compared with 41 percent in the batch reading group, and, 3-week anxiety levels among women who believed their mammogram to be normal were nearly the same as anxiety levels among women with normal mammograms (2.10 versus 1.82; Barton, Morley et al. 2004)

In addition to lowered anxiety, women with immediate mammogram readings made fewer return visits compared with women with standard care. Although this did not result in lower costs for the immediate reading group, women may value the reduced hassle associated with repeat visits in ways not quantified in our analyses. Further, if women know they will leave the mammography unit with the results of their mammograms, they may be more satisfied with the services and more likely to follow future screening recommendations. Increased patient satisfaction may improve member retention among health plans. It is also possible that immediate reading decreases the time to breast cancer diagnosis, which may improve patient care and outcomes.

There were no differences in the total number of breast procedures, nonprocedure breast visits, and nonbreast visits across groups during the 12-month follow-up. Immediate reading was more expensive to the health plan for breast-related costs compared with batch reading, but did not result in differences in patient-borne costs (i.e., copayments, lost time, or transportation costs), nor were there statistically significant differences across groups when we accounted for total societal costs. We conclude that immediate reading was neutral in terms of overall costs among women with false-positive mammograms. It did not produce cost-savings to the health plan or society, but it also did not increase total societal costs.

Our analyses found radiologists' choice of follow up examinations for women with abnormal mammograms in the immediate reading group shifted away from ultrasound towards mammography. This suggests that radiologists may consider extra mammographic views and ultrasounds roughly equivalent substitutes for the evaluation of certain abnormal mammograms, and that the use of one test over the other may have depended in part on whether the patient was in the office when the mammogram was read. The total mean number of mammograms plus ultrasounds among immediate and batch reading groups was 1.69 and 1.68, respectively, providing further evidence of one-to-one substitution between mammograms and ultrasounds. Unilateral mammograms and breast ultrasounds were reimbursed at similar rates ($68.83 and $69.57, respectively, based on the Medicare RBRVS 2000 schedule); thus, substitution between mammograms and ultrasounds would be unlikely to cause cost differences between groups. However, understanding whether substitution between mammograms and ultrasounds is desirable and whether it affects women who are diagnosed with breast cancer is important to evaluate.

Our study has important strengths. Because the immediate reading setting occurred on a part-time basis, we could compare immediate and batch reading mammography care on the same patient population at the same time, a major strength of the study. In practice, it is unlikely that a radiology practice would implement immediate reading full time because of personnel issues as well as the additional costs associated with it. Thus, we were able to analyze the cost implications of immediate reading under a realistic scenario. In addition, mammography screening participation rates at Harvard Vanguard Medical Associates were high (Committee on Performance Measurement. National Committee on Quality Assurance 1999), minimizing the possibility of selection bias within the universe of women undergoing screening mammography. The available managed care databases allowed us to better understand the downstream consequences of false-positive mammograms in terms of utilization and costs.

Several study limitations should be mentioned. Our estimates suggest that the marginal cost per mammogram in the immediate reading setting was approximately $4.40. Because immediate reading was implemented on a part-time basis, this estimate may not apply if all mammograms were read immediately. It is likely that costs would be substantially higher if all mammograms were read immediately due to greater inefficiency. Further, the increased time and personnel costs associated with the immediate reading program may lower the number of machines and radiologists available for screening mammography and may adversely affect access to screening mammography. Finally, if immediate reading were implemented at times when the volume of other radiology procedures was relatively low, this would have biased our efficiency and cost estimates downward; however we think this is unlikely as the radiologist's scheduled presence usually led to increased volume of elective radiology procedures (e.g., fluoroscopy).

The population of women enrolled in this managed care group practice was fairly racially homogenous and well educated. This limits our ability to generalize the results to different female populations. We had incomplete information on some covariates (e.g., hormone replacement therapy) among study participants. We used a Charlson index based on administrative claims data to assess comorbidity; this measure may be influenced by differences in care-seeking across patients and clinician coding. It also contains a limited number of diagnoses and little indication of overall disease burden (Klabunde, Warren et al. 2002). We also used the Medicare fee schedule to estimate costs, which may not accurately reflect the actual costs incurred by the managed care plan.

Our results suggest that immediately reading mammograms while the woman remains in the mammography suite had little effect on downstream utilization and costs among women with false-positive mammograms. Thus, the increased cost associated with the immediate reading program compared with batch reading was not offset by lowered medical care utilization and costs among women with false-positive mammograms. Immediate reading was more costly to the health plan compared with batch reading, due to both increased personnel time and materials and a higher rate of false positives, but it was not more expensive in terms of total societal costs. Whether immediate reading can be implemented on a part-time basis in a radiology practice or health plan that currently provides only batch reading still merits consideration, as the incremental cost of immediate reading may be reduced by lowering the rate of extra views ordered. Our study found that immediate mammogram reading decreased patient anxiety and decreased the number of return trips to the mammography unit. It also may have resulted in other economic and noneconomic benefits such as increased patient satisfaction and health plan retention, better adherence to screening recommendations and improved health outcomes that were not included in these analyses and deserve further evaluation.

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Supplementary Material

The following supplementary material for this article is available online:

Appendix: Estimating the Incremental Cost of Immediate Reading Mammography.