HEALTH CARE REFORM

The Cost of Breast Cancer Screening in the Medicare Population

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Background: Little is known about the cost to Medicare of breast cancer screening or whether regional-level screening expenditures are associated with cancer stage at diagnosis or treatment costs, particularly because newer breast cancer screening technologies, like digital mammography and computer-aided detection (CAD), have diffused into the care of older women.

Methods: Using the linked Surveillance, Epidemiology, and End Results–Medicare database, we identified 137 274 women ages 66 to 100 years who had not had breast cancer and assessed the cost to fee-for-service Medicare of breast cancer screening and workup during 2006 to 2007. For women who developed cancer, we calculated initial treatment cost. We then assessed screening-related cost at the Hospital Referral Region (HRR) level and evaluated the association between regional expenditures and workup test utilization, cancer incidence, and treatment costs.

Results: In the United States, the annual costs to fee-for-service Medicare for breast cancer screening-related procedures (comprising screening plus workup) and treatment expenditures were $1.08 billion and $1.36 billion, respectively. For women 75 years or older, annual screening-related expenditures exceeded $410 million. Age-standardized screening-related cost per beneficiary varied more than 2-fold across regions (from $42 to $107 per beneficiary); digital screening mammography and CAD accounted for 65% of the difference in screening-related cost between HRRs in the highest and lowest quartiles of cost. Women residing in HRRs with high screening costs were more likely to be diagnosed as having early-stage cancer (incidence rate ratio, 1.78 [95% CI, 1.40-2.26]). There was no significant difference in the cost of initial cancer treatment per beneficiary between the highest and lowest screening cost HRRs ($151 vs $115; $P = .20$).

Conclusions: The cost to Medicare of breast cancer screening exceeds $1 billion annually in the fee-for-service program. Regional variation is substantial and driven by the use of newer and more expensive technologies; it is unclear whether higher screening expenditures are achieving better breast cancer outcomes.

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Because the spectrum of cancer care includes screening as well as treatment, a comprehensive understanding of breast cancer cost must incorporate the cost of screening and associated workup. While the body of evidence concerning Medicare expenditures for cancer treatment has grown, relatively little is known about cost associated with screening Medicare beneficiaries for breast cancer.[1-3] This is especially important among older women because recent guidelines have concluded that there is insufficient evidence to assess the benefits and harms of screening mammography in women 75 years or older.[4,5]

See Invited Commentary at end of article

It is particularly timely to consider the cost implications of breast cancer screening because newer breast cancer screening technologies, such as digital mammography and computer-aided detection (CAD), have expanded the options available to clinicians and are diffusing into clinical practice.[6,7] The adoption of these new technologies can increase costs directly through reimbursement for the tests and also lead to higher rates of supplementary imaging, biopsy, or cancer detection.[8,9] It is critical to assess the relation between screening expenditures and population outcomes since newer modalities can increase cancer detection rates but may not improve patient outcomes, particularly among older women.[10-14]

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Ideally, higher breast cancer screening expenditures at the population level should correspond to earlier stage at diagnosis, lower treatment cost, or both. This can be evaluated by comparing differences in screening cost and cancer outcomes across geographic regions, hypothesizing that women living in regions that "invest" more in screening services may be less likely to be diagnosed at a later stage. However, in actual practice, it is unclear whether higher screening costs are associated with earlier stage at diagnosis or lower cancer treatment costs at the population level.

To address these knowledge gaps, we estimated national breast cancer screening and treatment costs in the Medicare fee-for-service program. Our second objective was to assess regional variation in breast cancer screening cost, while our third objective was to determine the association between regional screening cost and breast cancer incidence and treatment costs. These data will inform clinicians and policy makers in a context of debate about Medicare reimbursement for various cancer screening modalities and concerns about growth in cancer expenditures.

METHODS

STUDY OVERVIEW

We conducted a retrospective cohort study of female Medicare beneficiaries who were free of breast cancer as of December 31, 2005, and followed them for 2 years to assess breast cancer screening, workup of suspicious lesions, and incident breast cancer. For the subgroup of women who developed breast cancer during the study period, we estimated treatment cost during the initial 12 months after diagnosis.[3] At the regional level, we then evaluated the association between screening cost and outcomes (overall and stage-specific breast cancer incidence and treatment cost). The Yale Human Investigation Committee determined that this study did not directly involve human subjects.

DATA SOURCE AND STUDY SAMPLE

We used the Surveillance, Epidemiology, and End Results (SEER)-Medicare database, which links patient-level information on all patients with incident cancer reported to SEER registries with Medicare claims. SEER-Medicare also maintains a file of the 5% sample of Medicare beneficiaries with and without cancer who reside in SEER registry coverage area.[15] The population-based SEER registries account for approximately 28% of the US population.[16] To create a cohort eligible for breast cancer screening in whom we could measure cancer incidence, we selected female beneficiaries from Medicare's 5% sample (those with and without cancer) who lived in a SEER region during 2006 to 2007 and had not had breast cancer as of December 31, 2005, documented through either SEER or Medicare *International Classification of Diseases, Ninth Revision* (*ICD-9*) billing codes. To be included, a woman had to be 66 to 100 years old on January 1, 2006, have a valid zip code, and have continuous fee-for-service Medicare Part A and B coverage throughout the study period. Among women who developed breast cancer in 2006 to 2007, we excluded those women whose cancer was reported only on a death certificate or on autopsy or had missing diagnosis dates.

We categorized race/ethnicity as white, black, or other and median household income at zip code level according to quintiles. We used a modified list of Elixhauser comorbidity conditions to assess comorbidity (eTable 1; http://www.jamainternalmed.com).[17-19]

SCREENING AND WORKUP COST

We assessed the use and cost of breast cancer screening–related (comprised of screening plus workup) procedures using *ICD-9* procedure and diagnosis codes and Healthcare Common Procedure Coding System codes (HCPCS) (eTable 2).[20-25] Screening included screening mammography (digital and film) and CAD billed with screening mammography, while workup included diagnostic mammography (digital and film), CAD billed with diagnostic mammography, other breast imaging, and biopsy. We used a validated algorithm with updated procedure codes to identify whether a mammogram was screening or diagnostic.[26] We calculated the cost of these procedures according to the actual reimbursement by Medicare.[27-30] Costs were adjusted to 2009 US dollars accounting for temporal and geographic variation.[30,31]

TREATMENT COST

To assess cancer treatment costs, we used a matched control group approach to determine the difference in Medicare expenditures between women diagnosed as having breast cancer and women without a cancer diagnosis. This enabled us to account for "background" medical expenditures, with the difference in costs between the matched cancer and noncancer groups attributable to cancer-related costs. Women diagnosed as having their first breast cancer in 2006 or 2007 were matched 1:1 with women from Medicare's 5% sample who never had breast cancer based on SEER region, age quartile, comorbidity (0 vs $\geq$1 condition), and regional quartile Medicare expenditures in the 12 months before diagnosis. After assigning a matched pair, Medicare payments from the month of diagnosis through 12 months later were summed for both cases and controls.[3,30] We subtracted Medicare payments for the control and for screening during the month of diagnosis from the total payments for the case and refer to the difference as treatment cost.[3,30] To test the stability of treatment cost in the 5% sample, we calculated treatment cost as described for all women reported to SEER as having been diagnosed with their first breast cancer in 2006 or 2007; the difference in national treatment cost estimates was less than 2%.

EXTRAPOLATING TO NATIONAL COST

Using Medicare enrollment tables for the study period, we calculated the number of female fee-for-service Medicare beneficiaries ages 65 to 74 years, 75 to 84 years, and 85 years or older.[32] For each age group, we multiplied the number of beneficiaries by our calculated screening cost per beneficiary and summed to estimate total Medicare breast cancer screening cost. Similarly, we applied age-specific SEER cancer incidence to the number of beneficiaries and multiplied by treatment cost per diagnosed beneficiary to estimate total Medicare expenditures for the first year of breast cancer treatment.[33]

REGIONAL VARIATION

We used Hospital Referral Regions (HRRs) to examine geographic variation.[34] We assigned women to HRR based on the zip code of their residence, and a priori restricted the sample to HRRs with 50 or more women who were diagnosed as having breast cancer in the full SEER-Medicare data.[35] The age-standardized cost estimates for each HRR were generated by

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applying age-specific costs in each HRR to the national age distribution (described in the previous subsection, "Extrapolating to National Cost") of female fee-for-service Medicare beneficiaries.

STATISTICAL ANALYSIS

We assigned women to the quartile of their HRR screening-related cost and assessed use of screening and workup procedures according to screening-related cost using Cochrane-Armitage test of trend, as well as χ^2 tests. We then used Poisson regression to assess the relation between quartile of screening-related cost and breast cancer incidence rate, adjusting for age, race/ethnicity, comorbidity, and income. Women contributed person-time from January 1, 2006, until the earliest of breast cancer diagnosis, death, or December 31, 2007. At the HRR level, we used linear regression to determine whether higher quartile of screening-related cost was associated with increased treatment cost adjusting for mean age, income, and percentage of white patients at HRR level, as well as average annual Medicare expenditures for all care per capita within that HRR. We used SAS statistical software (version 9.2; SAS Institute Inc) to conduct all analyses.

Table 1. Demographic Characteristics of Study Sample[a]

Characteristic	No. (%)	% Receiving Screening Mammography
Total sample	137 274	
Age, y		
66-74	57 417 (41.8)	57.2
75-84	55 176 (40.2)	42.0
85-100	24 681 (18.0)	15.2
Race/ethnicity		
White	114 989 (83.8)	44.7
Black	9952 (7.3)	38.8
Other	12 333 (9.0)	36.4
Median household income, $		
<33 000	26 036 (19.0)	38.7
33 000-39 999	22 325 (16.3)	43.2
40 000-49 999	29 312 (21.4)	43.8
50 000-62 999	27 348 (19.9)	44.9
≥63 000	28 157 (20.5)	47.2
Unknown	4096 (3.0)	40.2
Comorbid conditions		
0	68 727 (50.1)	47.4
1-2	49 132 (35.8)	44.8
≥3	19 415 (14.1)	26.6

[a] χ^2 $P < .001$ for receipt of screening mammography and demographic characteristics for all comparisons.

RESULTS

There were 137 274 women in the study cohort, 41.8% were younger than 75 years, 83.8% were white, and half had 1 or more comorbid conditions (**Table 1**). During the study period, 43.5% of women had at least 1 screening mammogram, with women 66 to 74 years old being much more likely than women 85 to 100 years old to receive a mammogram (57.2% vs 15.2%, respectively; $P < .001$). A higher percentage of women with highest quintile of median household income received a screening mammogram, while a lower percentage of those with increased number of comorbid conditions had a screening mammogram ($P < .001$ for both comparisons). During that time, the average annual breast screening-related cost per beneficiary was $63. There was a strong inverse relation between age and cost, with breast cancer screening–related costs decreasing from $84 per beneficiary (for women at ages 66-74 years) to $60 (at ages 75-84 years) to $21 (at ages 85-100 years) ($P < .001$) (**Table 2**). During the same time period, the mean cost of initial treatment per diagnosed patient was approximately $16 600 for all ages and $21 300, $12 800, and $11 500 for women diagnosed at ages 66 to 74 years, 75 to 84 years, and 85 to 100 years, respectively ($P < .001$).

Extrapolating these costs to the US fee-for-service Medicare population, the annual costs to Medicare for breast cancer screening and workup of suspicious lesions were $723.1 million and $359.0 million, respectively, with a screening-related total of $1.08 billion. This compares with an annual cost to Medicare of $1.36 billion for treatment. In the subgroup of women who were older than

Table 2. Average Annual Cost to Medicare for Breast Screening and Treatment (2009 US$), 2006-2007

	Age Group, y, No. of Beneficiaries[a]			
Cost to Medicare	66-74 8.04 M	75-84 5.84 M	85-100 2.87 M	All Ages
Screening cost,[b] $				
Cost per beneficiary	56	40	13	
Total cost	448.4 M	236.2 M	39.2 M	723.1 M
Workup cost,[c] $				
Cost per beneficiary	28	20	8	
Total cost	223.0 M	114.1 M	22.2 M	359.0 M
Screening-related = screening + workup cost, $				
Cost per beneficiary	84	60	21	
Total cost	671.4 M	350.3 M	60.3 M	1.08 B
Treatment cost				
No. diagnosed as having breast cancer	40 607	29 388	10 617	
Total cost, $	863.5 M	376.8 M	121.7 M	1.36 B

Abbreviations: B, billion; M, million.
[a] Number of national fee for service Medicare beneficiaries.
[b] Includes cost for screening mammogram (digital and film) and screening computer aided detection.
[c] Includes cost for diagnostic mammogram (digital and film), diagnostic computer-aided detection, other breast and related imaging and biopsy.

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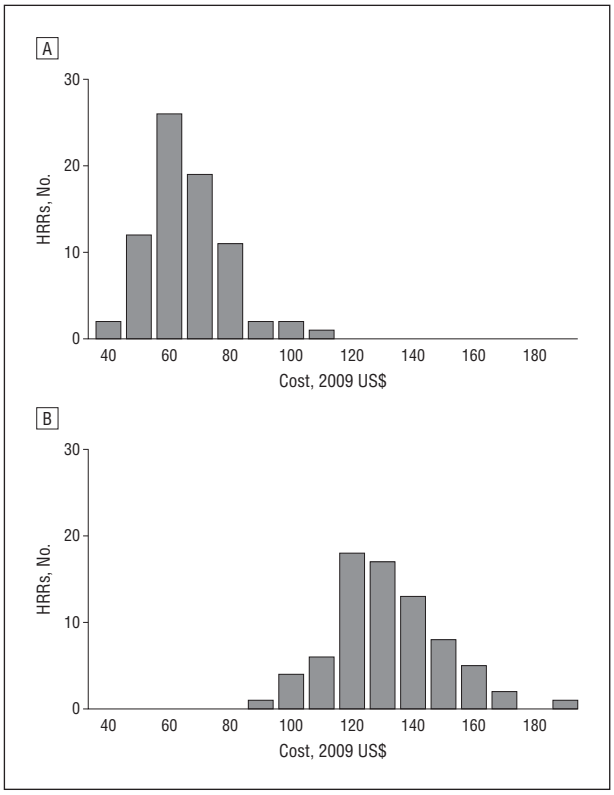

Figure 1. Regional variation in breast cancer screening costs. A, Screening cost per beneficiary. B, Screening cost per screened beneficiary. HRR indicates Hospital Referral Region.

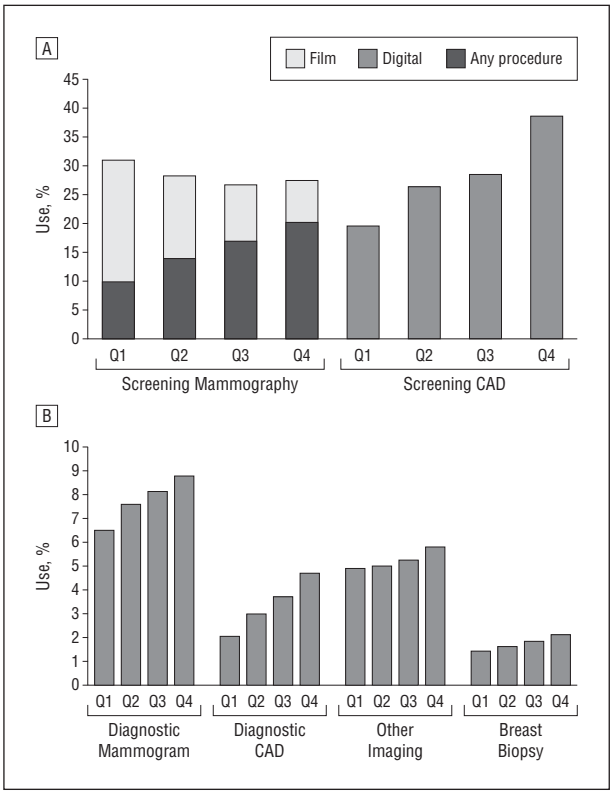

Figure 2. Correlation of the use of specific screening tests per quartile (Q) of regional-level screening-related cost. A, Use of film and digital screening mammography and computer-aided detection (CAD) according to Hospital Referral Region (HRR) screening-related cost. B, Use of workup (breast imaging and biopsy) according to HRR screening-related cost. Other imaging includes: breast ultrasound, breast magnetic resonance imaging (MRI), positron emission tomography imaging; computed tomography of head, brain, thorax, abdomen; MRI of brain, brainstem; radiologic examination, consultation, report; 3-dimensional rendering; bone and joint imaging; radiopharmaceutical localization of tumor. First quartile screening plus workup cost per beneficiary, less than $57; second quartile, $57 to $64; third quartile, $65 to $70; fourth quartile, more than $70.

75 years, total screening-related and treatment costs were $410.6 million and $498.5 million, respectively.

REGIONAL VARIATION

There was substantial regional variation in screening-related cost per beneficiary among the 75 HRRs in this analysis (**Figure 1**). At the HRR level, the mean screening-related cost per beneficiary ranged from approximately $40 to $110, with a median cost of $64 (interquartile range [IQR], $57-$72). Similarly, there was nearly a 2-fold difference in cost per screened beneficiary between the highest and lowest HRRs, with a median HRR-level cost of $129 (IQR, $120-143).

At the regional level, the use of specific screening tests was correlated with regional-level screening-related cost. The use of screening mammography increased from 40.9% of women in the lowest quartile of HRR screening-related expenditures, to 47.6% in the highest quartile ($P < .001$; **Figure 2**A). Although there was no significant relation between quartile of regional screening-related costs and the use of film screening mammography (P value for trend, .92), women living in higher-cost regions were significantly more likely to undergo digital screening mammography. Approximately 10% of women who lived in the lowest quartile region received at least 1 digital screening mammogram, increasing to 13.9%, 16.9%, and 20.2% in the second, third, and fourth quartiles of screening-related costs, respectively ($P < .001$). There was a 2-fold difference in the screening CAD use between women in the highest and lowest quartiles of HRR screening-related cost, 38.6% vs 19.6%, respectively ($P < .001$).

Patients in HRRs with the highest screening-related cost also tended to have higher utilization of workup procedures such as diagnostic mammography, other breast imaging, or biopsy when compared with lower-cost regions (Figures 2B). For instance, while 2.1% of all women who lived in the highest-quartile HRRs underwent biopsy, 1.4% of women in the lowest-cost regions underwent biopsies during the study period ($P < .001$).

Digital screening mammography accounted for 47% of the difference in costs between women living in HRRs with the highest and lowest quartiles of screening-related cost. Breast biopsy (21%) and CAD (18%) were also major contributors to regional cost difference, while utilization of film screening mammography (5%), diagnostic mammography (7%), or other imaging modalities (2%) did not contribute substantively.

CANCER INCIDENCE AND TREATMENT COST

Women residing in areas with higher screening-related cost per beneficiary were significantly more likely to be diagnosed as having breast cancer (adjusted incidence rate ra-

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Table 3. The Association of Regional Screening-Related Cost and Breast Cancer Incidence and Treatment Cost

Quartile	Overall Incidence		In Situ or Stage I Incidence		Stage IV Incidence		Treatment Cost,[e] Per Beneficiary	
	AI[c]	IRR[d] (95% CI)	AI	IRR (95% CI)	AI	IRR (95% CI)	Cost, US$	*P* Value
Screening + workup cost,[a] per beneficiary								
1	3.3	1.00 [Reference]	1.8	1.00 [Reference]	0.2	1.00 [Reference]	115	Reference
2	4.7	1.34 (1.13-1.60)	2.5	1.41 (1.11-1.80)	0.2	0.87 (0.45-1.71)	157	.37
3	5.0	1.40 (1.17-1.68)	2.7	1.48 (1.16-1.90)	0.3	1.11 (0.57-2.17)	136	.50
4	4.6	1.54 (1.29-1.84)	2.8	1.78 (1.40-2.26)	0.2	0.84 (0.40-1.75)	151	.20
Screening + workup cost,[b] per screened beneficiary								
1	3.6	1.00 [Reference]	1.8	1.00 [Reference]	0.2	1.00 [Reference]	148	Reference
2	4.1	1.12 (0.94-1.34)	2.3	1.35 (1.06-1.71)	0.3	0.68 (0.34-1.36)	138	.96
3	5.1	1.29 (1.09-1.52)	2.8	1.44 (1.14-1.82)	0.3	0.98 (0.53-1.83)	116	.55
4	4.8	1.35 (1.14-1.60)	2.9	1.66 (1.32-2.09)	0.2	0.70 (0.35-1.43)	161	.73

Abbreviations: AI, annual incidence; IRR, incident rate ratio.

[a] First quartile screening + workup cost per beneficiary, less than $57; second quartile, $57 to $64; second quartile, $65 to $70; fourth quartile, more than $70.

[b] First quartile screening + workup cost per screened beneficiary, less than $121; second quartile, $121 to $131; third quartile, $131 to $143; fourth quartile: more than $143.

[c] Annual incidence per 1000 person-years.

[d] The IRR adjusted for age, race/ethnicity, comorbidity, and income.

[e] Treatment cost *P* value adjusted for mean age, income, percentage who were white, and average annual total Medicare expenditures per capita of Hospital Referral Region.

tio [IRR], 1.54 for the highest vs lowest quartile [95% CI, 1.29-1.84]) (**Table 3**). The increase in breast cancer diagnoses was attributable to early-stage cancers, because women residing in HRRs with higher screening-related cost tended to have a significantly higher incidence rate of in situ or stage I cancers. When we assessed in situ and stage I cancer incidence separately, those in the second, third, and fourth quartiles had significantly increased risk of being diagnosed as having stage I breast cancer compared with those in the first quartile: 40%, 49%, and 65%, respectively. A similar trend was found for incidence of in situ disease, but only those in the fourth quartile of screening cost had significantly higher incidence of in situ disease than those in the first quartile (IRR, 2.12; 95% CI, 1.36-3.30). There was no significant association between quartile of screening-related cost and the incidence of stage IV breast cancer. The incidence of stage IV cancer was 0.19 and 0.18 per 1000 in the highest and lowest quartiles, respectively. The results were similar when we defined HRRs by quartile of screening-related cost per screened beneficiary.

There was no significant relation between screening and treatment costs at the regional level. Even after adjustment for mean age, income, percentage of white patients within the HRR, and average annual total Medicare expenditures per capita, the difference in cost between the highest and lowest quartiles of screening-related cost per beneficiary was not significant ($115 vs $151; $P = .20$). Findings were similar when HRRs were classified according to screening-related cost per screened beneficiary.

COMMENT

We found that the Medicare fee-for-service program is spending over $1 billion per year on breast cancer screening and workup of suspicious lesions. This accounted for over 45% of the $2.42 billion total spent by Medicare on screening and the initial treatment phase of breast cancer, suggesting that analyses that focus exclusively on treatment have overlooked a significant contributor to cancer costs. Moreover, $410.6 million annually is being spent on screening and workup of women 75 years or older, although there is insufficient evidence to assess the benefits and harms of screening mammography in this age group.[5] This reinforces the need to develop evidence to guide both clinical decision making and coverage decisions.

There was substantial variation in screening-related cost across regions, which was largely attributable to digital screening mammography and CAD rather than to differential use of screening mammography. Although breast biopsy was rarely performed, the 50% relative difference in biopsy rates across regions was notable and may represent increased workup associated with the use of CAD or digital mammography in high-cost regions. Data suggest these modalities can increase recall rate, including biopsy, but results have been mixed.[36-38]

Women residing in high screening-cost regions were as much as 78% more likely to be diagnosed as having early-stage or in situ breast cancer as women in lower-cost regions. The difference in crude incidence of overall and early-stage cancers between high- and low-cost areas was approximately 1 per 1000 women, which was statistically significant. Notably, the difference in the incidence of diagnosed stage IV cancer was not significant, and the absolute difference between highest- and lowest-cost areas was approximately 1 in 100 000 women. Taken together, these findings suggest overdiagnosis of breast cancer in the higher-cost regions. This is consistent with recent findings from the Norwegian Screening Trial, which found that women residing in areas that implemented a mammography screening program were significantly more likely to be diagnosed as having breast cancer, and that 15% to 25% of cases were overdiagnosed.[39]

Although our study did not set out to assess the effectiveness of CAD or digital mammography, our findings suggest limited effectiveness of these modalities in older, average-risk women. For example, the Digital Mam-

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mographic Imaging Screening Trial found that digital mammography does not perform better than film mammography in women 65 years or older.[40] As the field of radiology moves toward digital technology, it is important to note that digital mammography will frequently be the only option available. Our results suggest that the cost and effectiveness of such evolutions of technology should be promptly and rigorously evaluated; higher costs associated with adoption of newer modalities may not necessarily yield superior outcomes.

We found that higher screening-related cost did not translate into lower treatment cost at the population level. There was a nonsignificant trend toward the higher screening-related cost areas having higher treatment costs, which may be associated with the higher rate of diagnosing early-stage cancer in the higher screening expenditure areas. Because cancer diagnosis was a rare event, there were not enough patients with incident cancer to affect treatment costs at the population level. In addition, the costs associated with higher detection rates for early-stage cancer could have been partially balanced out by the slightly (and nonsignificantly) lower rates of metastatic cancer detected in the higher-cost regions.

There are several important considerations. We have only 2 years of follow-up to measure cancer incidence, which may not be long enough to assess advanced-stage incident cancer or determine causality between increased spending and breast cancer incidence. Future work should explore this relation over a longer follow-up period, including longer assessment of cost and outcomes. It is also important to note that this study relied on administrative claims and may not capture all procedures performed, but our results are similar to those of a prior large registry study.[41] The SEER-Medicare database relies on physician report and an algorithm to identify Hispanic ethnicity of patients; this method has been questioned, so we chose to categorize race as white, black, or other without respect to ethnicity.[42] Our estimates of cancer incidence (4.40 per 1000 person-years) were slightly lower than those in the overall SEER program (4.82 per 1000 person-years), but this is primarily due to SEER's inclusion of first and subsequent breast cancers, whereas our study sample was restricted to women with first breast cancer only.[33]

In summary, the costs of breast cancer care in the Medicare population, when incorporating screening costs, are substantially higher than previously documented and the adoption of newer screening modalities will likely contribute to further growth. The growth trajectory may be steeper than projected owing to Medicare's reimbursement strategy, which supports rapid adoption of newer modalities, frequently without adequate data to support their use.[1]

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