

1.5 Evolution of Breast Cancer Screening in the Medicare Population: Clinical and Economic Implications

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1.15 **Background** Newer approaches to mammography, including digital image acquisition and computer-aided detection (CAD), and adjunct imaging (e.g., magnetic resonance imaging [MRI]) have diffused into clinical practice. The impact of these technologies on screening-related cost and outcomes remains undefined, particularly among older women.

1.20 **Methods** Using the Surveillance, Epidemiology, and End Results–Medicare linked database, we constructed two cohorts of women without a history of breast cancer and followed each cohort for 2 years. We compared the use and cost of screening mammography including digital mammography and CAD, adjunct procedures including breast ultrasound, MRI, and biopsy between the period of 2001 and 2002 and the period of 2008 and 2009 using χ^2 and *t* test. We also assessed the change in breast cancer stage and incidence rates using χ^2 and Poisson regression. All statistical tests were two-sided.

1.25 **Results** There were 137 150 women (mean age = 76.0 years) in the early cohort (2001–2002) and 133 097 women (mean age = 77.3 years) in the later cohort (2008–2009). The use of digital image acquisition for screening mammography increased from 2.0% in 2001 and 2002 to 29.8% in 2008 and 2009 ($P < .001$). CAD use increased from 3.2% to 33.1% ($P < .001$). Average screening-related cost per capita increased from \$76 to \$112 ($P < .001$), with annual national fee-for-service Medicare spending increasing from \$666 million to \$962 million. There was no statistically significant change in detection rates of early-stage tumors (2.45 vs 2.57 per 1000 person-years; $P = .41$).

1.30 **Conclusions** Although breast cancer screening–related costs increased substantially from 2001 through 2009 among Medicare beneficiaries, a clinically significant change in stage at diagnosis was not observed.

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The imaging modalities available for breast cancer screening have evolved substantially. In addition to technological advances in mammography, such as digital image acquisition and computer-aided detection (CAD), the use of adjunct imaging modalities such as breast ultrasound and magnetic resonance imaging (MRI) has diffused into clinical practice in hopes of improving breast cancer detection (1,2). Digital mammography separates the processes of image acquisition and display and allows the reader to adjust the degree of contrast (3–7). CAD technology can be used with digital mammography and uses computer software to assist breast imagers in identifying mammographic abnormalities, such as calcifications and densities (8–11).

1.40 In addition to technological modifications to the mammographic approach, there has also been increased interest in the use of adjunct tests for screening in higher-risk populations or work-up of suspected lesions. The use of screening breast ultrasound, for example, has been described in women with dense breast tissue (12–14), and screening breast MRI has been shown to be valuable for women with known or suspected gene mutations (15–17). It is unclear how frequently these adjunct imaging modalities are used

among an older cohort of patients for whom ultrasound or MRI is not necessarily indicated (18).

Women aged greater than 65 years constitute almost one-third of the 37 million women who undergo screening in the United States each year (19). Given this large number, the evolution of breast imaging could affect Medicare screening-related costs substantially. Digital mammograms and CAD are reimbursed at higher rates than standard film, and breast MRI is much costlier than mammography (3). Second, adjunct imaging often leads to further imaging and/or biopsy, which carry additional costs (12,20). Therefore, in the context of rising health-care costs in the elderly population (21–24), it is important to identify temporal patterns in utilization of breast cancer imaging modalities and related costs (25–27).

To address these knowledge gaps, we evaluated temporal changes in breast cancer screening among women in the Medicare population between the period of 2001 and 2002 and the period of 2008 and 2009. We also assessed the use of adjunct tests, including diagnostic mammography, breast ultrasound, and MRI, and breast biopsy with respect to frequency and cost. Lastly, we determined

whether temporal changes in screening modalities and cost were associated with a change in detection of breast cancer.

2.5 Methods

Data Source

We used the Surveillance, Epidemiology, and End Results (SEER)–Medicare database, which was created by the National Cancer Institute and the Centers for Medicare and Medicaid Services and provides sociodemographic, diagnostic, and treatment information for patients diagnosed with cancer through 2009 who reside in SEER regions and are enrolled in Medicare (28). For this study, we only included women who were part of the SEER–Medicare 5% sample, which includes women regardless of whether they developed cancer or not. Yale’s Human Investigation Committee determined that this study did not directly involve human subjects.

Study Design and Participants

We created two cohorts of women aged 66 years or older from Medicare’s 5% random sample of beneficiaries who lived in a SEER region (Figure 1). The entry dates for these early and late cohorts were the beginning of 2001 and 2008, respectively. We selected these years because new screening tests were diffusing into clinical care during this time and they contain the most recent period to ascertain cancer incidence and stage shift from SEER–Medicare. Because the US Preventive Services Task Force

recommends biennial screening for women aged 65–74 years, we focused on a 2-year interval during each time period. We followed women in both cohorts until the earliest of death, breast cancer diagnosis, or 2 years after cohort entry. We included women who had fee-for-service (FFS) Medicare coverage, Parts A and B, throughout the study period. We a priori excluded women from the Greater Georgia Registry because we did not have all necessary claims for them. It is possible that women could be included in both cohorts. A modification of the Elixhauser method was used to assess comorbid conditions statistically significantly associated with mortality (29,30). We excluded women who had a prior history of breast cancer according to SEER or who had Medicare claims with a breast cancer International Classification of Disease, Ninth Revision (ICD-9) diagnosis code during the year before cohort entry (Supplementary Table 1, available online).

Construction of Variables

We assessed the use and cost of screening mammography, film and digital, with and without CAD. Additionally we considered adjunct testing procedures including diagnostic mammography, with and without CAD, breast ultrasound, breast MRI, other imaging, and breast biopsy. We used an adaptation of Smith–Bindman’s validated algorithm to differentiate screening from diagnostic mammograms, using procedure and diagnostic codes that were in use during the time periods we studied (31). When CAD was billed on the day of a screening mammogram, it was classified as screening; likewise for

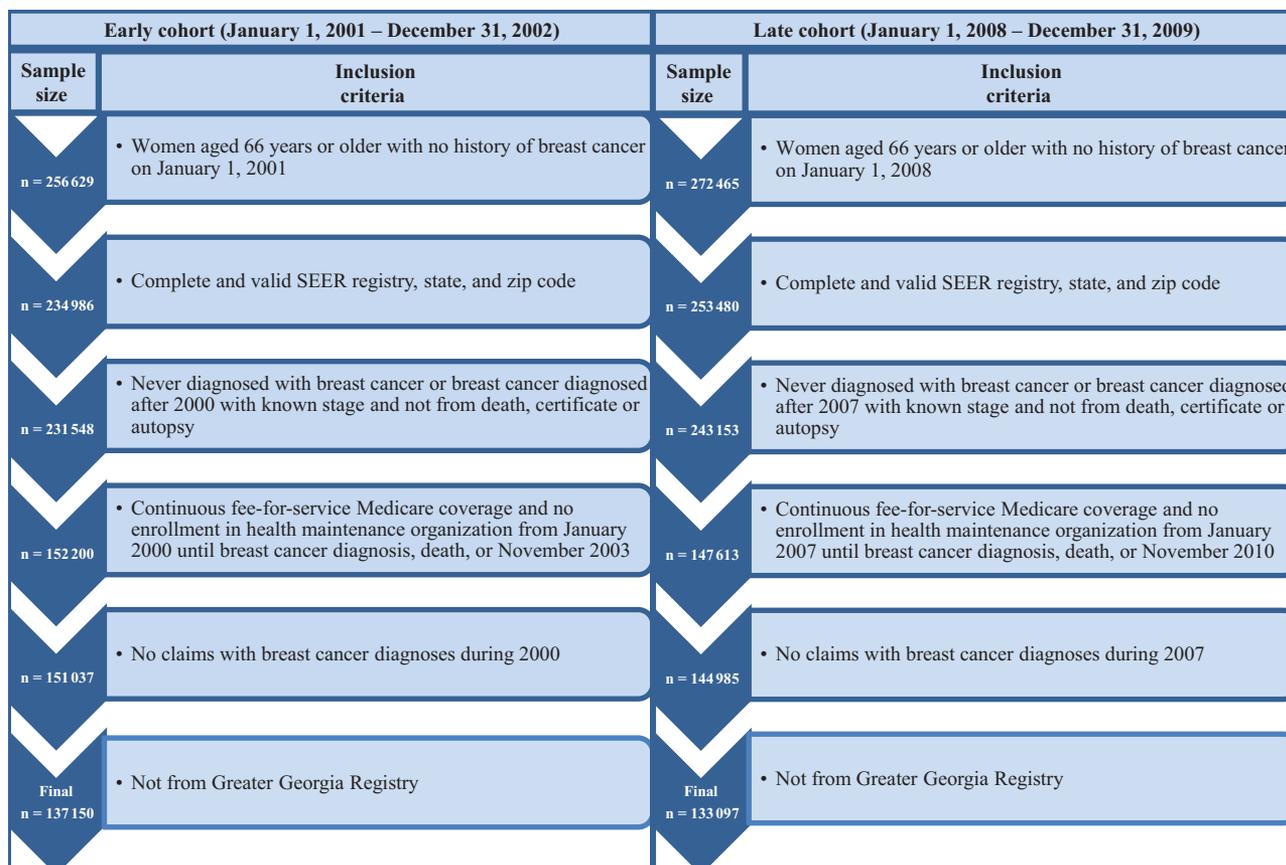


Figure 1. Creation of study sample. We included women who were part of the Surveillance, Epidemiology, and End Results–Medicare 5% sample, who did not have a history of breast cancer at the beginning of each study period. This sample includes some women who would later develop breast cancer, as well as women who did not develop breast cancer. We followed the steps in the figure to create the sample.

diagnostic mammograms. Other imaging included the following procedures for breast imaging and cancer workup: positron emitting tomography imaging; computed tomography of head, brain, thorax, abdomen; MRI of brain, brainstem; radiologic examination of surgical specimen; three-dimensional rendering; bone and joint imaging; and radiopharmaceutical localization of tumor (Supplementary Table 1, available online). When the description of included procedures did not specify breast, we required that these procedures be accompanied by a primary diagnosis that indicated breast involvement. The cost of breast biopsy included costs for anesthesiology, needle localization and image guidance, and pathology.

We used a payer perspective of Medicare reimbursements (payments) (21,23,32,33). We assigned the mean outpatient cost of procedures to those that were performed in the inpatient setting (biopsy, ultrasound, and bone and joint imaging). Costs were adjusted to 2009 US dollars and adjusted for geographic variation (23,24). We report cost per woman eligible for screening (per capita) which reflects both the utilization of the test and the cost of the test itself. We also report cost per procedure to more granularly assess changes in the cost of the procedures. Some women may have had a procedure more than once during the time period. Using Medicare enrollment tables, we calculated the average annual number of female FFS Medicare beneficiaries from each of the 2 years covered by each cohort (34–37). For each age group, we multiplied the number of beneficiaries by our calculated annual screening-related cost per capita and summed to estimate total Medicare breast cancer screening cost (38). Because the US Preventive Services Task Force does not recommend biennial screening for women aged 75 years or older, we also reported the results stratified by age (<75 vs ≥75 years).

Because all women were breast-cancer-free at the start of each time period, we identified women diagnosed with incident breast cancer of epithelial origin during the 2 years after cohort entry using SEER data. To categorize stage, we used American Joint Committee on Cancer (AJCC) stage variable available for that time. Both AJCC stage-specific incidence rates and overall stage distribution of incident cancers were included as outcomes.

Statistical Analysis

We used χ^2 tests to compare demographic characteristics and frequency of procedures between the early and late cohorts and Student *t* tests to assess differences in total costs, cost per capita, and cost per procedure. We used the standard error of the difference in per capita cost to calculate the confidence interval (CI) for the percent change. For those diagnosed with breast cancer, we used χ^2 tests to compare the distribution of stage and tumor size at diagnosis between cohorts. We assessed the difference in overall and stage-specific incidence of breast cancer using multivariable Poisson regression. We used SAS (version 9.2; SAS Institute, Cary, NC) to conduct all analyses. A *P* value of less than .05 was considered statistically significant, and all statistical tests were two-sided.

Results

Screening Mammography

There were 137 150 women in the early cohort (2001–2002) and 133 097 women in the later cohort (2008–2009). Women in the

early cohort were younger (mean age = 76.0 in the early cohort vs 77.3 years in the later cohort; *P* < .001) and had fewer comorbidities (10.8% of those in the early cohort have ≥3 comorbidities vs 15.6% of those in the later cohort; *P* < .001) (Table 1). The use of screening mammography increased minimally over time: 42.0% of female beneficiaries in the early cohort received a screening mammogram vs 42.6% in the later cohort (*P* < .001) (Figure 2A). With regard to the mammographic modality used for screening, the use of digital image acquisition increased from 2.0% to 29.8% (*P* < .001). Conversely, the use of film screening mammography decreased from 40.0% to 12.9% (*P* < .001). The use of CAD for screening increased from 3.2% in the early cohort to 33.1% in the later cohort (*P* < .001). We observed a considerable percentage of women aged 75 years or older receiving screening mammography in both 2001 and 2002 (32.4%) and 2008 and 2009 (32.6%; *P* = .35). There were similar increases in the use of digital image acquisition for screening mammography and CAD, as observed in the full sample.

Adjunct Imaging/Biopsy

The percentage of women who underwent diagnostic mammography increased slightly: 5.3% of those in the early cohort had diagnostic mammograms vs 7.1% in the later cohort (*P* < .001) (Figure 2B). The use of digital imaging and CAD for diagnostic mammography increased from 0.2% to 5.5% and 0.1% to 4.0%, respectively (*P* < .001 for both). The use of adjunct imaging modalities and breast biopsy changed little over time. Breast ultrasound use increased from 4.0% to 4.9%, and MRI use increased from 0.03% to 0.3% (*P* < .001 for both). The biopsy rate decreased from 2.0% to 1.7% (*P* < .001). There was a statistically significant decrease in the use of other imaging from 1.8% to 1.5% (*P* < .001).

Table 1. Demographic characteristics of study sample*

Characteristics	2001–2002	2008–2009
	No. (%)	No. (%)
Total sample	137 150	133 097
Age group, y		
66–69	24 944 (18.2)	26 014 (19.5)
70–74	33 646 (24.5)	29 703 (22.3)
75–79	32 009 (23.3)	27 507 (20.7)
80–84	23 367 (17.0)	24 040 (18.1)
≥85	23 184 (16.9)	25 833 (19.4)
Race		
White	116 125 (84.7)	110 977 (83.4)
Black	10 407 (7.6)	9 169 (6.9)
Other	10 618 (7.7)	12 951 (9.7)
Median income of zip code		
<\$33 000	29 110 (21.2)	24 813 (18.6)
\$33 000–\$40 000	23 543 (17.2)	21 401 (16.1)
\$40 000–\$50 000	29 852 (21.8)	28 433 (21.4)
\$50 000–\$63 000	26 100 (19.0)	26 527 (19.9)
≥\$63 000	25 772 (18.8)	27 774 (20.9)
Unknown	2 773 (2.0)	4 149 (3.1)
Comorbidity		
0	78 852 (57.5)	64 313 (48.3)
1–2	43 442 (31.7)	48 031 (36.1)
≥3	14 856 (10.8)	20 753 (15.6)

* Two-sided χ^2 for all comparisons *P* < .001.

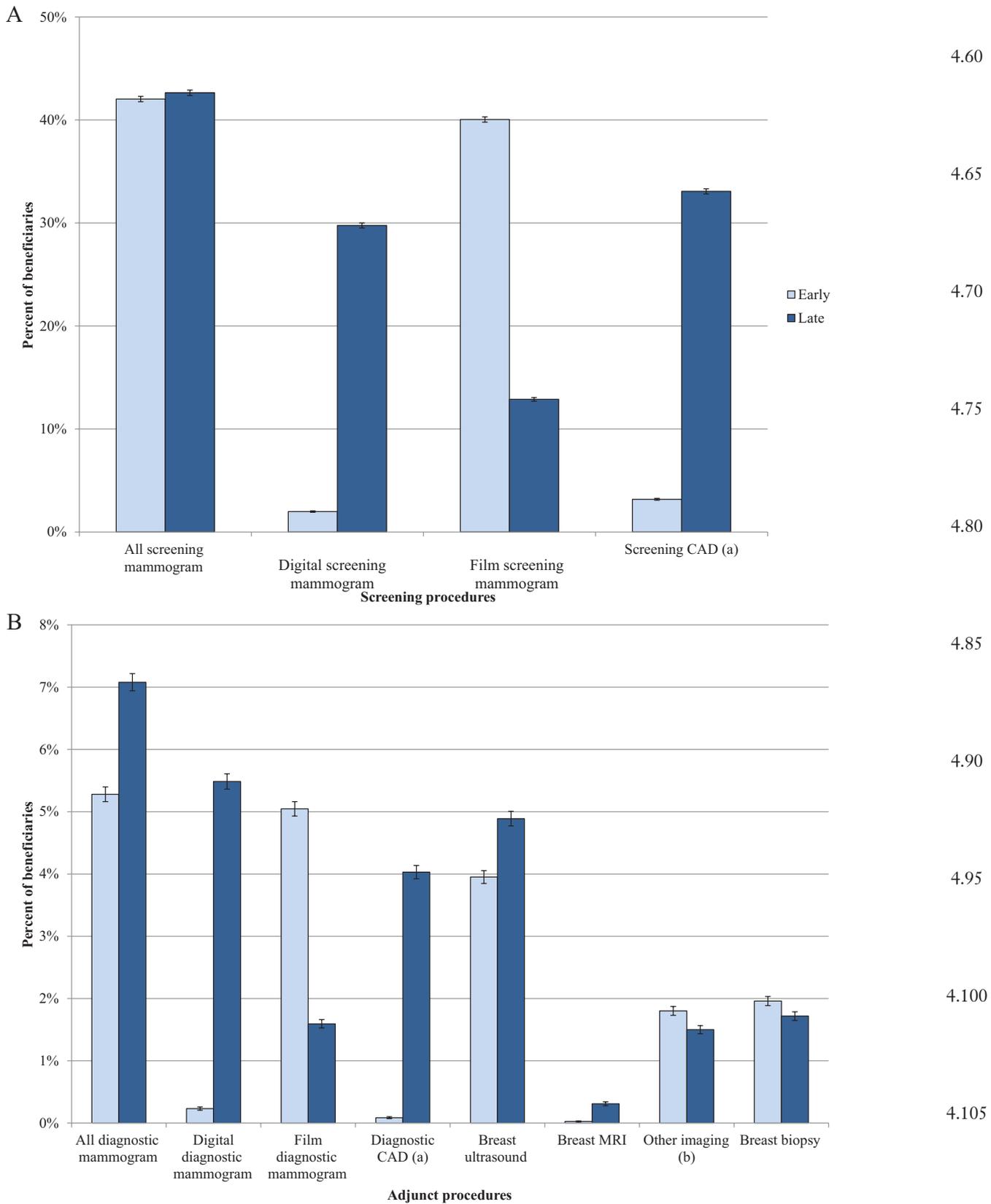


Figure 2. Use of breast cancer procedures according to time period. There were 137 150 women in the early cohort (2001–2002) and 133 097 women in the later cohort (2008–2009). The percentages of women in the early and late cohorts who underwent screening (A) and adjunct testing procedures (B) are shown. Other imaging includes positron emitting tomography imaging; computed tomography of head, brain, thorax, abdomen; magnetic resonance imaging (MRI) of brain, brainstem; radiologic examination of surgical specimen; three-dimensional rendering; bone and joint imaging; and radiopharmaceutical localization of tumor. Error bars represent 95% confidence intervals. CAD = computer-aided detection.

Cost Implications

The cost of screening mammography per capita increased 43% over the study period, from \$44 to \$63 per capita ($P < .001$) (Table 2). Although the cost associated with film mammography decreased from \$41 to \$15 per capita (63%), the cost for digital mammography increased by a factor of 15, from \$3 to \$48 per capita. The cost per screening mammogram increased 35% from \$75 to \$101 per mammogram ($P < .001$). This increase was primarily due to the uptake of digital imaging for screening mammography because the cost of digital screening mammography remained stable between time periods.

The cost of adjunct testing, including imaging and biopsy, increased 34%, from \$32 to \$43 per beneficiary. There was an increase in the cost of diagnostic mammography between the two time periods (\$61 to \$96 per procedure; $P < .001$). The cost of ultrasound, other imaging, and biopsy increased statistically significantly between the study periods, whereas the cost of CAD for diagnostic mammography decreased by 50%. There was no change in the cost of digital diagnostic mammography or MRI; however, the increased use of these technologies resulted in higher costs per capita in the second period.

Overall, the screening-related cost per capita (including screening and work-up procedures) for 2 years of follow-up increased 47.4% (95% CI = 44.7% to 50.0%) between study cohorts, from \$76 in 2001 and 2002 to \$112 in 2008 and 2009 ($P < .001$). This translates to an absolute increase in Medicare spending for breast screening-related procedures from \$666 million in the early period to \$962 million in the later period, a 44% increase (Figure 3).

The modalities that contributed most to the total cost increase were digital image acquisition, with a \$45 increase per capita, and CAD for screening mammography, with a \$5 increase per capita. There was no statistically significant change in the cost of breast biopsy, from \$23 to \$25 over the study period ($P = .75$). In women

aged 67 to 74 years, there was an increase of 50% in screening-related cost per capita, from \$101 to \$151 ($P < .001$). Meanwhile, women aged 75 years or older had a 43% increase, from \$58 to \$83 ($P < .001$). 5.60

Clinical Implications

Cancer detection rates did not change over the study period. There was no statistically significant change in the overall incidence of breast cancer (any stage), which was 4.22 per 1000 person-years (258 118 person-years) in the early cohort compared with 4.30 per 1000 person-years (251 114 person-years) in the late cohort (adjusted rate ratio [ARR] = 1.04; 95% CI = 0.96 to 1.14). There was also no statistically significant change in the incidence of early-stage (in situ and stage I) disease (2.45 per 1000 person-years in the early cohort vs 2.57 per 1000 person-years in the late cohort; $P = .41$; ARR = 1.07; 95% CI = 0.96 to 1.20) (Figure 3). Similarly, the incidence of late-stage (stage IV) disease did not change statistically significantly over time; it was 0.20 per 1000 person-years in the early cohort and 0.23 per 1000 person-years in the late cohort (ARR = 1.24; 95% CI = 0.85 to 1.82). Among women diagnosed with breast cancer, there was no statistically significant change in stage distribution or tumor size over time (Supplementary Table 2, available online). 5.65 5.70 5.75

Discussion

Prior studies have shown that older women, including those with a significant comorbidity burden, undergo screening mammography despite conflicting evidence regarding benefit (39–41). We found that not only is mammography performed relatively frequently among older women but also there has been a substantial increase in the use of newer breast screening technologies in this population. Although digital mammography, CAD, and other newer 5.80 5.85

Table 2. Cost of breast screening and adjunct testing in early and late cohorts* 5.90

Category	Cost per beneficiary			Cost per procedure		
	2001–2002	2008–2009	P	2001–2002	2008–2009	P
Screening mammography	44 (61)	63 (83)	<.001	75 (33)	101 (25)	<.001
Digital	3 (20)	48 (80)	<.001	116 (42)	115 (15)	<.001
Film	41 (58)	15 (37)	<.001	73 (31)	73 (13)	<.001
Screening computer-aided detection	1 (3)	6 (9)	<.001	18 (7)	12 (2)	<.001
Screening cost subtotal	44 (62)	68 (91)	<.001	76 (33)	110 (28)	<.001
Diagnostic mammography	4 (22)	9 (39)	<.001	61 (32)	96 (35)	<.001
Digital	<1 (7)	8 (37)	<.001	110 (43)	106 (32)	.28
Film	4 (21)	2 (13)	<.001	59 (30)	65 (26)	<.001
Diagnostic computer-aided detection	<1 (1)	1 (3)	<.001	22 (11)	11 (4)	<.001
Breast ultrasound	3 (18)	4 (20)	<.001	64 (27)	67 (21)	<.001
Breast MRI	<1 (14)	2 (42)	<.001	624 (430)	524 (377)	.12
Other imaging †	2 (25)	3 (43)	.07	73 (132)	148 (235)	<.001
Breast biopsy ‡	23 (189)	25 (201)	.75	897 (687)	1034 (600)	<.001
Adjunct testing cost subtotal	32 (210)	43 (254)	<.001	221 (434)	259 (428)	<.001
TOTAL screening-related costs	76 (225)	112 (275)	<.001	105 (201)	140 (199)	<.001
Aged <75 y total cost	101 (248)	151 (318)	<.001	105 (192)	141 (204)	<.001
Aged ≥75 y total cost	58 (204)	83 (236)	<.001	106 (212)	139 (191)	<.001

* Costs presented in 2009 US dollars, mean (SD). MRI = magnetic resonance imaging. 5.110

† Other imaging includes positron emitting tomography imaging; computed tomography of head, brain, thorax, abdomen; magnetic resonance imaging of brain, brainstem; radiologic examination of surgical specimen; three-dimensional rendering; bone and joint imaging; and radiopharmaceutical localization of tumor. 5.114

‡ Biopsy cost includes cost for anesthesia, pathology, breast-related procedures, and hospitalization on day of biopsy as indicated in Supplementary Table 1 (available online). In per procedure analysis, these costs are assigned to the day of biopsy if they occurred within 1 day before through 7 days after biopsy but are not otherwise included.

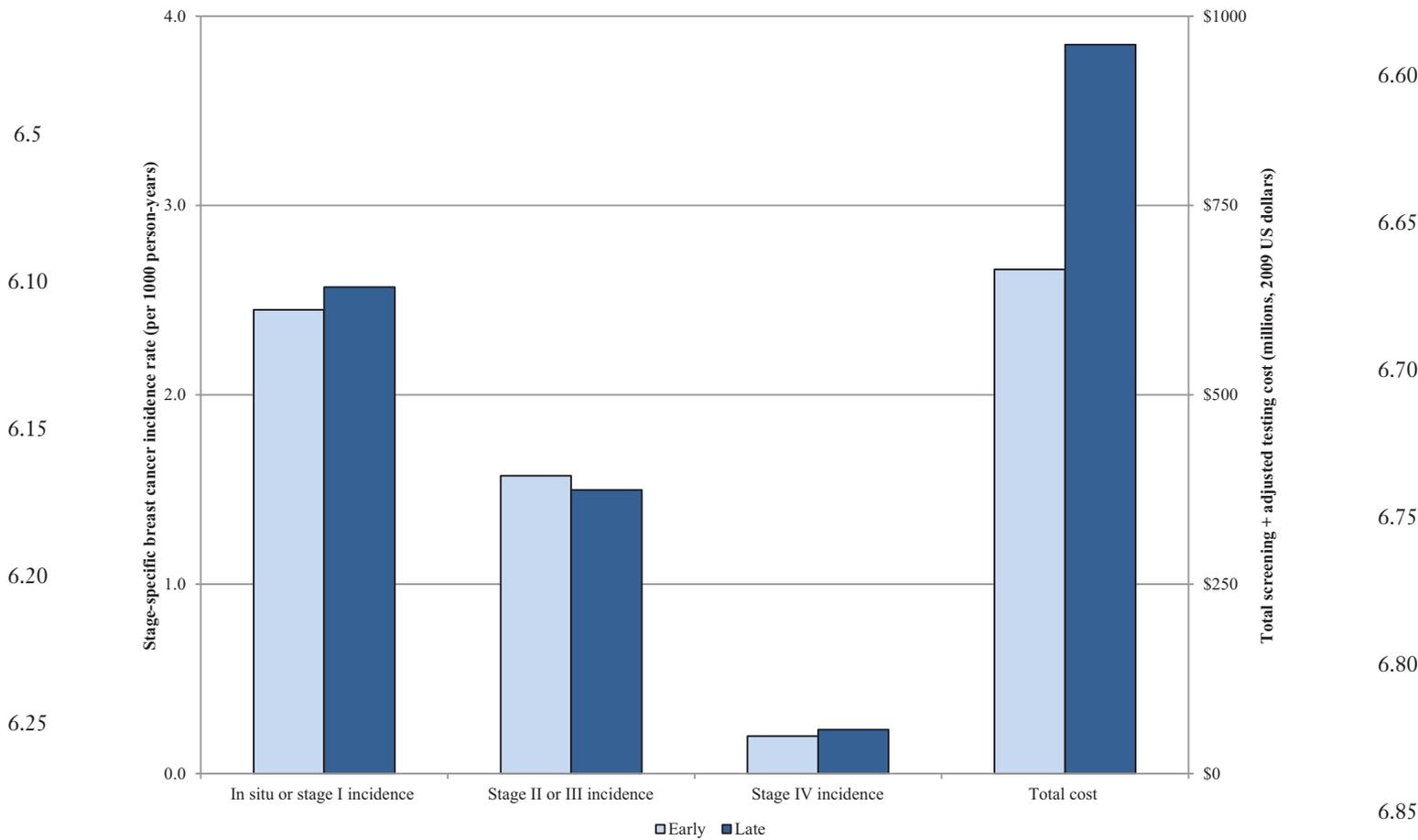


Figure 3. Stage-specific cancer incidence and total Medicare screening-related cost according to time period. There was no statistically significant change in the incidence of early-stage (in situ and stage I) disease (2.45 per 1000 person-years in the early cohort [258 118 person-years] to 2.57 per 1000 person-years in the late cohort [251 114 person-years]). Similarly, the incidence of late-stage (stage IV) disease did not change

statistically significantly over time; it was 0.20 per 1000 person-years in the early cohort and 0.23 per 1000 person-years in the late cohort. During this same time period, there was an absolute increase in Medicare spending for breast screening-related procedures from \$666 million in the early period to \$962 million in the later period, a 44% increase.

breast imaging modalities have not been in use long enough to draw meaningful conclusions regarding mortality reduction for breast cancer, we hypothesized that the increased use of more-sensitive modalities would lower the stage at diagnosis and/or increase the incidence of in situ/stage I disease. However, our data suggest that the use of these newer modalities was accompanied by a statistically significant increase in costs but no change in stage at diagnosis.

of early- (vs late-) stage cancer (48). We found considerably higher CAD use in the later cohort, without increased detection of early-stage cancer.

Some studies suggest that digital mammography and CAD may improve the detection of breast cancer, but there is less evidence demonstrating a benefit for older women (3–5,7,42,43). In fact, the Digital Mammographic Imaging Screening Trial found that for the subgroup of women aged 65 years or older who did not have dense breasts, there was a non-statistically significant tendency toward digital performing worse than film mammography (specificity: digital = 93.8% vs film = 94.5%; $P = .12$) (44). Similarly, evidence regarding the impact of CAD on accuracy and sensitivity is mixed (45,46). Because CAD may increase false positives, it is possible that the increased use of diagnostic mammography that we observed might be related to the increase in CAD (47). A recent study demonstrated that increased CAD use among Medicare beneficiaries from 2001 to 2006 was associated with an increase in the detection of in situ but not invasive disease, and increased detection

In the absence of data supporting the superiority of digital mammography for older women, we can only speculate that there might be several reasons for the rapid adoption in the older population. These include the convenience of digital data storage, higher insurance reimbursement rates, and marketing successes for new technologies. Also, as mammography facilities transition to digital image acquisition for younger patients, it is unlikely that film machines will be retained for separate use in older patients.

With regard to trends in adjunct imaging and testing, we observed only slight changes between the two time periods. The addition of breast ultrasound and breast MRI to mammography among women who have dense breasts has been shown to increase the detection of small, mammographically occult, early-stage cancers, but their use in older women has not been evaluated (1,7,14–16). The relatively slow adoption of these modalities in the older population seems clinically appropriate, given that many do not have increased breast density. This is also consistent with screening breast MRI not being covered by Medicare. The observed decline in the breast biopsy rate, by approximately 0.3%, merits further

consideration. It is possible that more experience with newer imaging modalities has helped to distinguish which abnormalities are benign and which are malignant, decreasing the biopsy rate.

Our study is distinguished by the inclusion of large, population-based cohorts, the comprehensive assessment of both screening and adjunct procedures, and the ability to calculate and compare costs and cancer incidence from two time periods. With such a large sample, there is a potential to find results that are statistically significant but not as meaningful clinically. The female Medicare population is older than the general population of females at risk for breast cancer, and our findings therefore may not be applicable to women aged 40 to 65 years. Additionally, only FFS Medicare beneficiaries are included in our study, and there was a decrease in FFS enrollment during the study period from 83% of beneficiaries aged 65 years or older in 2001 to 76% in 2008 (34,37). It is unclear whether the adoption of new imaging modalities and costs are similar in the managed-care setting. Our study is also limited by the fact that 2 years may be an insufficient time period over which to measure breast cancer incidence, particularly for late-stage (stage IV) disease. Future studies with longer follow-up will be necessary to assess this trend. Our analysis relied on administrative claims data, which do not allow for distinction of specific mammography results or adjustment for breast cancer risk factors, including the use of hormone replacement therapy. We believe that given the small number of women taking hormone replacement therapy and the small increase in absolute risk of breast cancer, the effect on incidence of breast cancer related to the decrease in combined hormone replacement therapy use during our study period would be relatively small (49,50). Finally, it is important to note that the assessment of trends in cost and stage-specific cancer incidence is ecological in nature; unmeasured secular trends in breast cancer risk factors could have confounded the relation between cost and cancer incidence. Future work using more granular patient-level data should build upon these findings.

In this large, population-based study we observed a 47% increase in per-capita costs associated with breast cancer screening among Medicare beneficiaries from 2001 through 2009 without a statistically or clinically significant difference in the incidence of early-stage breast cancer. We observed that mammography rates remained stable over time in the older population, but screening-related costs increased. Future studies that address the costs and value of screening mammography are needed, in light of the rapid increase in technology. Although an evaluation of the overall effectiveness of screening vs no screening was not a goal of our study, longer follow-up data with regard to stage-specific incidence, cost, and patient-reported experiences relating to both screening and treatment are needed to inform decisions about screening Medicare beneficiaries for breast cancer (51–53).

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Notes

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