Trends in Local Therapy Utilization and Cost for Early-Stage Breast Cancer in Older Women: Implications for Payment and Policy Reform

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Abstract

Purpose—Older women with early-stage disease comprise the most rapidly growing breast cancer demographic, yet it is not known which local therapy strategies are most favored by this population in the current era. Understanding utilization trends and cost of local therapy is important for informing design of bundled payment models as payers migrate away from fee-for-service. We therefore utilized the SEER-Medicare database to determine patterns of care and costs for local therapy among older women with breast cancer.

Materials and Methods—Treatment strategy and covariables were determined in 55,327 women age 66 with Tis-T2 N0-1 M0 breast cancer who underwent local therapy between 2000 and 2008. Trends in local therapy were characterized using Joinpoint. Polychotomous logistic regression determined predictors of local therapy. Median aggregate cost over the first 24 months after diagnosis was determined from Medicare claims through 2010 and reported in 2014 dollars.

Results—Median age was 75. Local therapy distribution was as follows: 27,896 (50.3%) lumpectomy with external beam radiation; 18,356 (33.1%) mastectomy alone; 6,159 (11.1%) lumpectomy alone; 1,488 (2.7%) mastectomy with reconstruction; and 1,455 (2.6%) lumpectomy

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with brachytherapy. Mastectomy alone declined from 39.0% in 2000 to 28.2% in 2008 while use of breast conserving local therapies rose from 58.7% to 68.2%. Mastectomy with reconstruction was more common among the youngest, healthiest patients, whereas mastectomy alone was more common among patients living in rural, low income regions. By 2008, cost was $36,749 for lumpectomy with brachytherapy, $35,030 for mastectomy with reconstruction, $31,388 for lumpectomy with external beam radiation, $21,993 for mastectomy alone, and $19,287 for lumpectomy alone.

Conclusions—The use of mastectomy alone in older women declined in favor of breast conserving strategies between 2000 and 2008. Using these cost estimates, price points for local therapy bundles can be constructed to incentivize treatment strategies which confer the highest value.

Introduction

Older women with early breast cancer comprise the most rapidly growing breast cancer demographic, with an estimated 114,000 cases annually and 57% growth forecast from 2010 to 2030 (1). Historically, the most common local-regional treatments for such women were lumpectomy followed by approximately 6 weeks of external beam radiation or mastectomy without reconstruction. However, recent literature suggests that many older women may be appropriate candidates for either brachytherapy, which conveniently decreases the radiation treatment course to 1 week, or complete omission of any radiation, which confers even more convenience (2–4). Despite increasing support for these convenient options for breast conservation, recent patterns of care studies have demonstrated increasing use of mastectomy in the overall breast cancer population, potentially driven by greater availability and utilization of breast reconstruction (5–9).

For older women with early breast cancer, it is not known whether the increasing availability of more convenient breast conservation strategies has led overall to increased use of breast conservation, or whether increasing availability of breast reconstruction has led to increased use of mastectomy. Understanding utilization and cost trends in this large and growing population of older women with early breast cancer is critically important for promoting value, defined as the quality of outcomes achieved per dollar spent, as payers migrate away from fee-for-service reimbursement toward bundled care payment models (10–12). We therefore used the SEER-Medicare cohort to characterize population trends in local therapy utilization and to characterize predictors and cost of local therapy for older women with early breast cancer who are Medicare beneficiaries.

Methods

Data Source

The SEER-Medicare database captures clinical, pathological, and insurance claims data for incident cancers diagnosed in Medicare beneficiaries who reside within one of 16 geographic areas that account for 26% of the US population. The case ascertainment rate is approximately 98% (13). In this study, demographic and tumor characteristics for incident

malignancies diagnosed from January 1, 2000 to December 31, 2008 were linked to Medicare treatment claims from January 1, 1999 to December 31, 2010.

Study Sample

From 2000–2008, 195,217 women age 66 years were diagnosed with invasive or in situ breast cancer and reported in the SEER-Medicare cohort. We applied standard exclusions as outlined in eTable 1 to create an analytic cohort of 55,327 patients with early stage disease (Tis-T2 N0–1). We required that all patients maintain fee-for-service Medicare coverage from 12 months prior through 24 months after diagnosis to permit ascertainment of comorbid illness before diagnosis and delayed breast reconstruction after diagnosis.

Outcomes

The primary outcome for this study was type of local treatment, defined as one of the following: (1) lumpectomy followed by external beam radiation, (2) mastectomy without reconstruction within 2 years of diagnosis, (3) mastectomy with reconstruction within 2 years of diagnosis, (4) lumpectomy followed by brachytherapy, or (5) lumpectomy with no adjuvant radiation therapy. For patients treated with mastectomy, we also required that they did not receive radiation within 12 months of surgery, as use of post-mastectomy radiation would likely indicate a more advanced cancer. Type of surgery (lumpectomy vs. mastectomy) was determined using both SEER data and Medicare claims within 12 months of diagnosis, with the most extensive surgery coded by either source considered to be the definitive surgery. Patients were considered to have received breast reconstruction if any claim for reconstruction was present within 24 months of diagnosis (eTable 2).

Baseline Covariables

Patient characteristics from the SEER data included age at diagnosis, race, sex, and year of diagnosis. Modified Charlson comorbidity index with Klabunde modification was determined from claims spanning an interval of 12 months to one month prior to diagnosis (14,15). Tumor characteristics extracted from SEER included T- and N-stage, grade, histology, estrogen receptor (ER) status, and laterality. Lymphovascular space invasion and margin status are not reported. Area-level characteristics included urban/rural residence, median income, educational attainment, and county-level surgeon and radiation oncologist density determined using the Area Resource File (16).

Determination of cost

Costs for each patient were calculated from a payer perspective using all inpatient, outpatient, and carrier claims within 2 years of diagnosis and were divided by calendar month to evaluate trends over time related to date of diagnosis. Costs were adjusted for geographic variation using the geographic adjustment factor for Part A claims and the geographic practice cost index for Part B claims and for inflation using the Prospective Pricing Index for Part A claims and the Medicare Economic Index for Part B claims (17,18). Costs were also adjusted for differences in use of chemotherapy by normalizing costs of each local therapy to the utilization rate of chemotherapy in patients treated with lumpectomy plus external beam radiation. All costs are reported in 2014 dollars.

Statistical Analysis

Baseline characteristics across treatment strata were compared with Pearson's χ^2 test. Trends in treatment utilization by calendar year quarter were determined using Joinpoint linear regression models (Joinpoint v3.4.3). Adjusted associations between baseline characteristics and treatment strategy were estimated using polychotomous logistic regression. Lumpectomy followed by external beam radiation served as the referent group for this model, as it was the most commonly used strategy and its use was relatively stable over time. Covariables were selected for inclusion in this model *a priori* based on clinical relevance or if associated with the outcome in univariate analysis at P<0.20. The model was iteratively refined to optimize fit.

To determine trends in costs, total median 2-year costs by treatment strategy and year of diagnosis were calculated. Linear regression was used to determine direction and magnitude of cost growth over time. The trend line for lumpectomy and brachytherapy started at 2002 to ensure adequate numbers for meaningful regression; the Food and Drug Administration first approved balloon brachytherapy for breast cancer in 2002.

All statistical tests were 2-sided with P   0.05 and conducted using SAS v. 9.3 (Cary, NC). Our institutional review board granted this study exempt status.

Results

Baseline Characteristics

Of 55,327 women, median age was 75 years and 48,792 (88.5%) were white. The number of patients receiving each treatment was as follows: 27,896 (50.3%) lumpectomy with external beam radiation; 18,356 (33.1%) mastectomy alone; 6,159 (11.1%) lumpectomy alone; 1,488 (2.7%) mastectomy with reconstruction; and 1,455 (2.6%) lumpectomy with brachytherapy (Table 1).

Trends in Local Therapy

During the study interval, the proportion of patients undergoing mastectomy alone declined from 39.0% in 2000 to 28.2% in 2008 while use of breast conserving local therapies rose from 58.7% to 68.2% (Figure 1A). Specifically, lumpectomy plus external radiation rose from 47.9% in 2000 to a peak of 52.6% in 2003 before declining modestly to 50.4% of cases in 2008. This later decline was accompanied by a rise in breast conservation utilizing brachytherapy. This strategy increased from less than 0.3% of cases in 2000 and 2001 to 6.1% of cases in 2008, which represented the fastest growth among all treatment options. Mastectomy followed by reconstruction accounted for 2.2% of cases in 2000 and 3.6% of cases in 2008, with most of this increase occurring during the final two years of the interval. Finally, utilization of lumpectomy alone rose slightly, from 10.6% to 11.7% of cases during the study period.

When limited to only those patients for whom all of these treatments are considered guideline-concordant (i.e. age 70 and older, stage T1N0, ER+), similar trends in local therapy strategies were observed, with the exception that there was a much more pronounced

increase in use of lumpectomy alone, with the percent of patients treated with this strategy stable between 2000 to 2003 at 12.9%, then increasing to a high of 18.7% in 2006, and subsequently falling slightly to 16.8% in 2008 (Figure 1B).

Predictors of Treatment

Polychotomous logistic regression employing lumpectomy plus external radiation as the referent was used to identify predictors for use of the other four treatment strategies (Table 2). The youngest patients and those with minimal comorbidities were more likely to undergo mastectomy with reconstruction. In contrast, older patients and those with more comorbidities were more likely to undergo shorter treatment strategies such as mastectomy alone, lumpectomy alone, or lumpectomy with brachytherapy. Additionally, lumpectomy with brachytherapy was strongly associated with a later year of diagnosis as well as tumor features including smaller size, lower grade, ER-positivity, node negativity, and ductal, rather than lobular, histology. Socioeconomic factors also correlated with treatment (Table 2). One notable finding was a correlation between regions with low incomes or rural settings and the use of mastectomy alone.

Cost of Treatment

For the year 2008, median total costs for each treatment strategy, from highest to lowest, are ranked as follows: lumpectomy with brachytherapy ($36,749), mastectomy with reconstruction ($35,030), lumpectomy with external beam radiation ($31,388), mastectomy alone ($21,993), and lumpectomy alone ($19,287). The majority of costs were accrued during the treatment phase (0–6 months following diagnosis) regardless of the chosen therapy (Figure 2A & B). However, qualitative differences were preserved during the period associated with managing complications (6–24 months), with combination therapies attendant with higher costs (Figure 2C). Cost of all treatment strategies grew at a rate faster than inflation with the exception of lumpectomy with brachytherapy, whose cost was stable over time (Figure 3).

Discussion

We utilized the SEER-Medicare database to characterize trends in local therapy and associated costs for older women with early-stage breast cancer diagnosed between 2000 and 2008 in the SEER-Medicare cohort. The main trend we observed was a steady decline in the use of mastectomy alone during this time frame, with increasing utilization of breast conserving strategies, particularly driven by increasing utilization of lumpectomy with brachytherapy and lumpectomy alone. Though lumpectomy with brachytherapy was the most costly intervention prior to 2007, its inflation-adjusted cost was roughly stable over time in contrast to the other strategies whose growth in cost regularly exceeded inflation.

The groundbreaking National Surgical Adjuvant Breast and Bowel Project B-6 study demonstrated that patients diagnosed with early-stage breast cancers had statistically equivalent survival whether they were treated with mastectomy or lumpectomy followed by adjuvant radiation (19). After the study's publication in 1985, a steady rise in breast conservation was observed in the United States (20–22). Patients benefited from less

extensive surgeries requiring shorter hospital stays, fewer operative complications, and likely better cosmetic outcomes. Costs during this era were comparable between the two approaches as savings from reduced length of hospitalization and faster surgical recovery were offset by the cost of radiotherapy among those who underwent breast conservation (23,24).

In 2004, two landmark randomized clinical trials were published that sought to evaluate the need for whole breast irradiation specifically in older women with stage I, estrogen receptor positive breast cancer (25,26). These studies found that whole breast irradiation conferred a small (<5%) absolute reduction in risk of local recurrence at 5 years for older women, without an accompanying benefit in overall breast preservation or survival. Entry criteria for one of these trials, the Cancer and Leukemia Group B (CALGB) 9343, were subsequently incorporated into the National Comprehensive Cancer Network guidelines to define a group of older patients for whom radiation could be omitted (27), specifically women age 70 and older with clinical T1 N0, estrogen receptor positive disease resected with negative margins. Omission of radiation continues to be debated, however, with some experts arguing that the modest local control benefit conferred by radiation may justify its use for older patients with longer life expectancy (28).

Yet despite the research demonstrating the safety of breast conservation, by the 2000s, the trend favoring adoption of breast conservation reversed in several single-institution and population-based studies (5–9). The reasons for the renewed popularity of mastectomy were unclear, but possibilities included better techniques for breast reconstruction and improved access to reconstruction after the passage of the Women's Health and Cancer Rights Act in 1998 (29). Psychological factors favoring mastectomy may have included patient anxieties over the malignant potential of residual breast tissue and the carcinogenicity of radiation. Advances in breast imaging, including the widespread use of breast MRI, may also have contributed to these concerns (30). Finally, the logistics of conventional radiotherapy, which requires 6 weeks of therapy, may have steered some patients to shorter interventions (31).

In contrast, among the older Medicare population, we identified a trend in the opposite direction, with an 11% decline in the proportion of patients opting for mastectomy alone accompanied by a 10% rise in use of breast conserving strategies. This finding is similar to recent analyses of the National Cancer Database (32) and the SEER-Medicare database (33). A unique contribution of this manuscript, however, is the incorporation of data about use of breast reconstruction following mastectomy and the accompanying cost data. For example, our data indicate that for each patient who chooses lumpectomy plus external beam radiation over mastectomy plus reconstruction, approximately $3,600 is saved. This vital information serves as an important reminder of the practical benefits of organ preservation facilitated by radiation.

Notably we did observe shifts over time in the relative proportions of the different breast conservation strategies used in the community. Breast conservation utilizing external beam radiation declined modestly after 2003 in favor of strategies employing lumpectomy alone or brachytherapy. The use of lumpectomy alone rose markedly after 2004, especially among favorable risk patients who fit CALGB 9343 entry criteria (25) . This observation is in

accordance with a prior study by Soulos et al, which also reported a modest trend towards the omission of radiation after the CALGB trial was published (34). However, another unique finding of the current study is that brachytherapy also rose significantly after 2004 among favorable risk patients (Figure 1B). This suggests that some practitioners, rather than omit radiation, may have instead selected brachytherapy, perhaps in an effort to garner the local control benefits of radiation while avoiding the toxicities and inconvenience of whole breast treatment.

In the larger cohort of patients not limited by CALGB criteria, there was also observed a movement in favor of breast brachytherapy in later years which appeared to be at the expense of external radiation (Figure 1A). The time and effort required of the patient for several weeks of traditional external radiotherapy as well as its inferior reimbursement relative to brachytherapy may have influenced the adoption of the latter after its approval for use in the United States by the FDA.

Our second objective was to determine predictors of treatment strategy. We found that the youngest patients and those with the least comorbidities were more likely to receive mastectomy with reconstruction, echoing the findings of previously published studies that examined younger cohorts (5–9). We also found that patients with the least aggressive tumors (smaller size, lower grade, ER-positive, node-negative) were the most likely to undergo brachytherapy instead of conventional radiation, which may reflect published consensus statements and general caution employing a new technology during its early-adoption phase (3,35,36). A later year of diagnosis was very strongly correlated with brachytherapy, which, in similar fashion, implies improving physician comfort with this newer technique. Another important observation is that factors signifying lower socioeconomic status such as low area-level income and rural residence were associated with the use of mastectomy alone in lieu of combination strategies employing radiation or reconstruction. This finding reiterates an oft-described failure in the United States to diffuse innovations in breast cancer care to the least advantaged (37–39).

Our third objective was to examine costs of these treatments. Lumpectomy plus brachytherapy was associated with the highest cost. However, examination of trends revealed that brachytherapy exhibited stable cost during the study period in contrast to other treatments whose cost curves consistently exceeded inflation. The relative stability in the cost of brachytherapy may be attributable to predictable Medicare fee schedules and a limited number of procedure codes. Declines in reimbursement for brachytherapy may have also offset inflationary trends. In contrast, costs associated with lumpectomy and conventionally delivered radiation grew at a rate exceeding inflation. This trend is likely due to adoption of 3-dimensional conformal and intensity modulated radiation techniques over the study period (40,41). In the future, the cost curve for external beam radiation may more closely track with inflation as a result of bundled payments prompted by the Accountable Care Act and the publication of convincing studies supporting the use of hypofractionation in postmenopausal women (41–43).

This highlights a larger point: policymakers, payers, and physicians can control costs by promoting payment structures that encourage high value interventions such as

hypofractionation (44). For example, a potential policy intervention based on this data would be to develop a bundle for local therapy for older women with early breast cancer amenable to breast conserving therapy. Setting a price point comparable to the cost of lumpectomy plus hypofractionated whole breast irradiation in patients with life expectancy greater than ten years could incentivize this high value treatment while discouraging more expensive treatment. Setting a price point comparable to lumpectomy alone in patients with life expectancy less than 10 years and estrogen receptor positive disease could incentivize this high value treatment in patients unlikely to benefit from radiation. Importantly, the use of qualifiers such as life expectancy or other pertinent characteristics can help ensure that bundled payments do not fail to account for meaningful differences among individual patients.

We used a combination of SEER data plus Medicare billing claims to classify treatment, thereby reducing the likelihood of misclassification bias when compared to studies that rely only on SEER coding (45,46). Nevertheless, our study has certain limitations. First, the study cohort is limited to fee-for-service Medicare patients and may not generalize to younger patients or those covered by private insurance. Second, our cost analysis only measures expenses for which claims data are available. It does not include lost work time or discretionary health care expenses. Third, the period of time studied for cost calculations captures treatment-related costs as well as the costs of complications over the medium term. Since differences in disease-free survival emerge later in the course of treated early-stage breast cancer, it is possible that expenses attributable to salvage therapy could change the relative cost profiles observed in our study. Cost of salvage therapy is expected to approximate initial costs of therapy, for example cost of salvage mastectomy is likely to be similar to the cost of mastectomy alone. However, as risk of local recurrence is low, and difference in local recurrence risk between treatments is small (4,26), the overall impact of salvage therapies on cost differences is expected to be minimal. Fourth, claims for external beam partial breast irradiation are indistinguishable from claims for whole breast irradiation, and thus we did not attempt to distinguish between these two treatments. However, other studies indicate that utilization of external beam partial breast irradiation was quite low during this time interval, and thus our findings regarding lumpectomy followed by external beam radiation likely primarily reflect the experience with delivering whole breast irradiation. Fifth, costs of endocrine therapy were not included and can vary widely, from as little as $600 for five years of tamoxifen to as much as approximately $36,000 for five years of letrozole (47). Notably, given the expense of aromatase inhibitors, hypofractionated radiation may be a higher value alternative for those at very low risk of distant recurrence, for whom the primary intent of adjuvant therapy is to improve local disease control in the breast (41,48). Finally, our discussion of value and bundled payments assumes that costs are defined by reimbursement dollars. Other models for calculating costs, such as time-driven activity-based costing, are also under investigation. Such diligence by health economists and policymakers is necessary when creating value-based payment models in order to ensure that those models benefit patients rather than deny needed care.

Conclusion

In this population-based cohort of older women with early breast cancer, use of mastectomy decreased, accompanied by increases in breast conserving approaches, including both standard external beam radiation and newer treatment strategies such as lumpectomy with brachytherapy or lumpectomy alone. Although mastectomy with reconstruction has become more popular in younger women, it has not yet gained significant traction among the population studied here. Using the cost estimates provided in this manuscript, price points for local therapy bundles can be constructed to incentivize treatment strategies which confer the highest value to patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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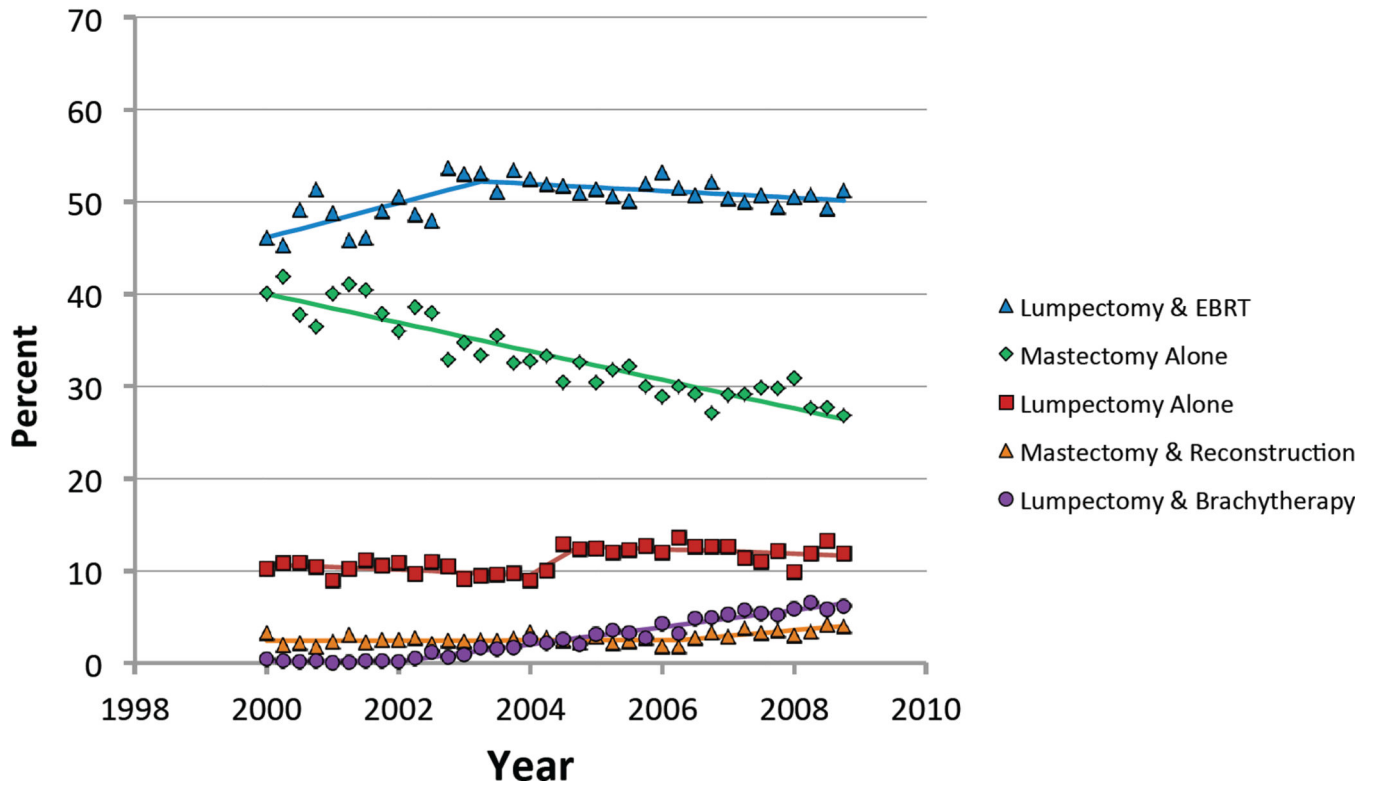Author Manuscript   Author Manuscript   Author Manuscript   Author Manuscript

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Summary

A population-based database of 55,327 older women with early-stage breast cancer treated during 2000–2008 was utilized to determine trends in local therapies and their associated costs. During this interval, the use of mastectomy in the elderly declined in favor of breast conserving strategies. Mastectomy with reconstruction was infrequently utilized. Costs generally grew faster than inflation and varied substantially by chosen local therapy, suggesting that policies encouraging high value care are needed.

A
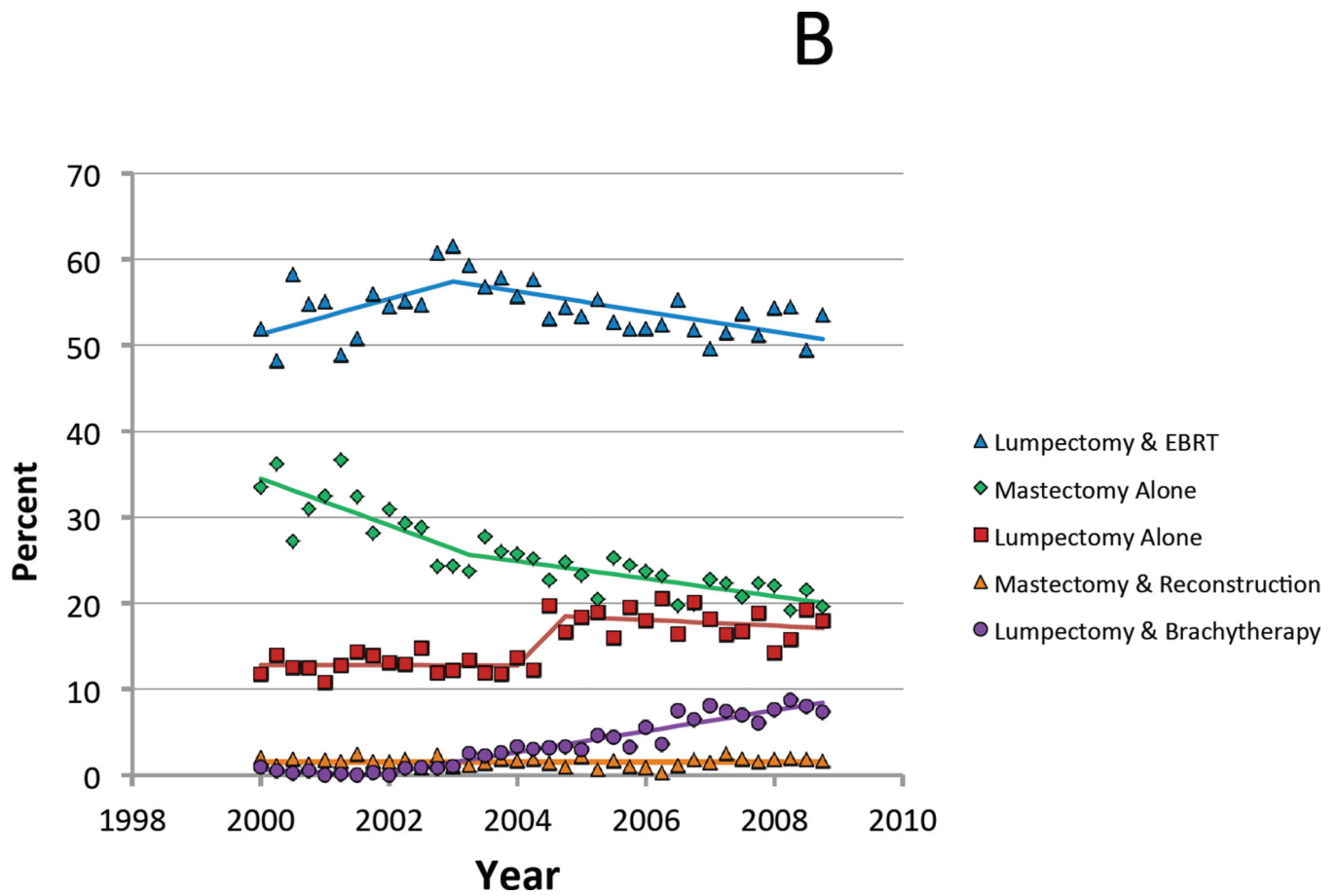
Figure 1.
A. Proportion of Medicare patients who received each treatment for each annual quarter between 2000 and 2008. B. Limited to favorable risk patients with T1 N0 estrogen receptor positive breast cancer age 70 and older at diagnosis.

A
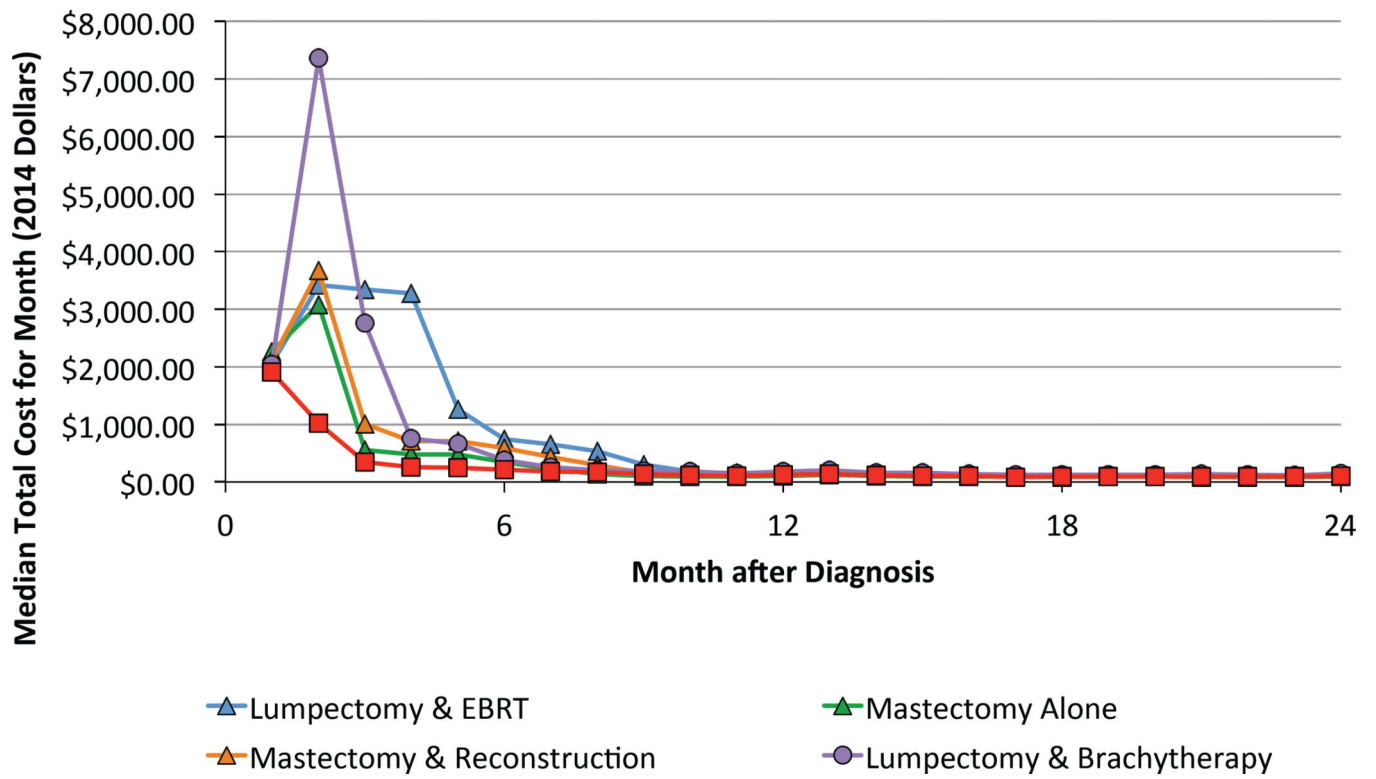
Median Total Cost for Month (2014 Dollars)

Month after Diagnosis

△— Lumpectomy & EBRT △— Mastectomy Alone

△— Mastectomy & Reconstruction ⬤— Lumpectomy & Brachytherapy

B
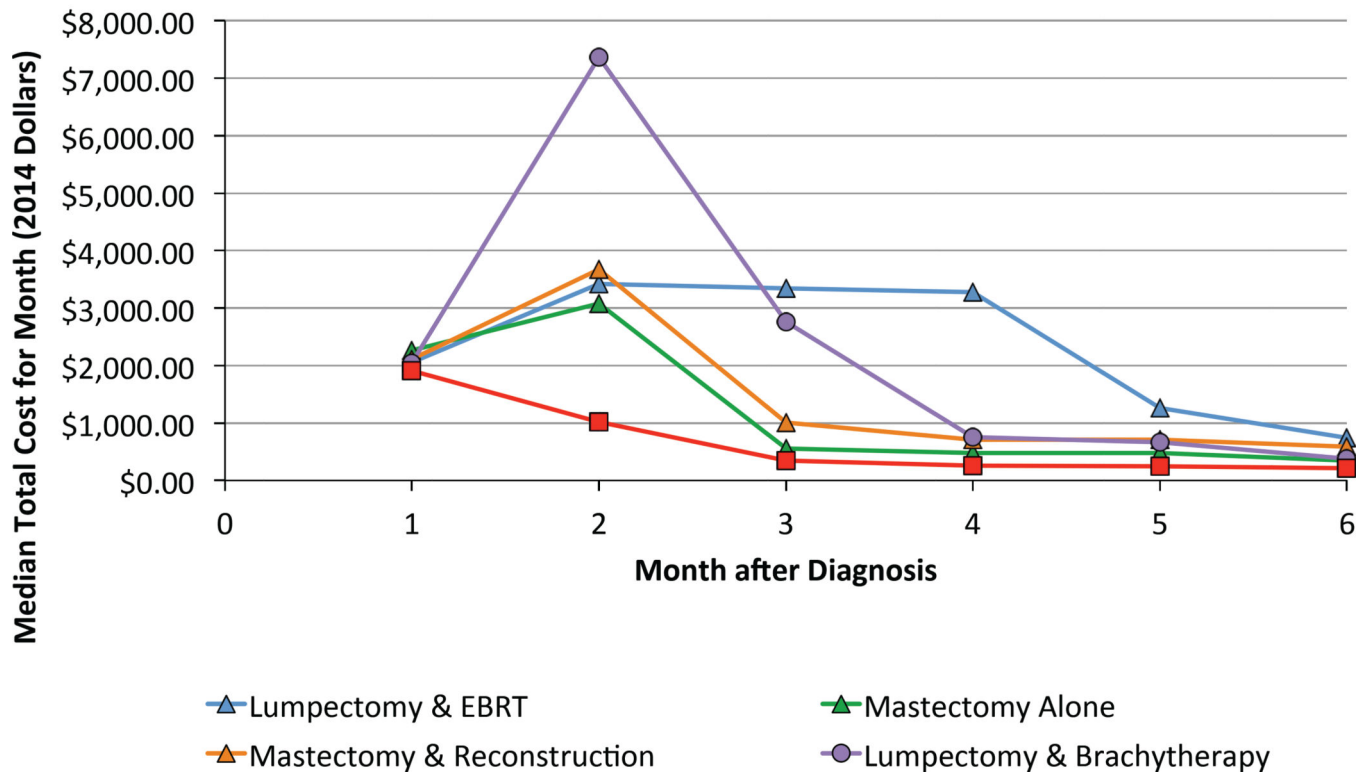
C
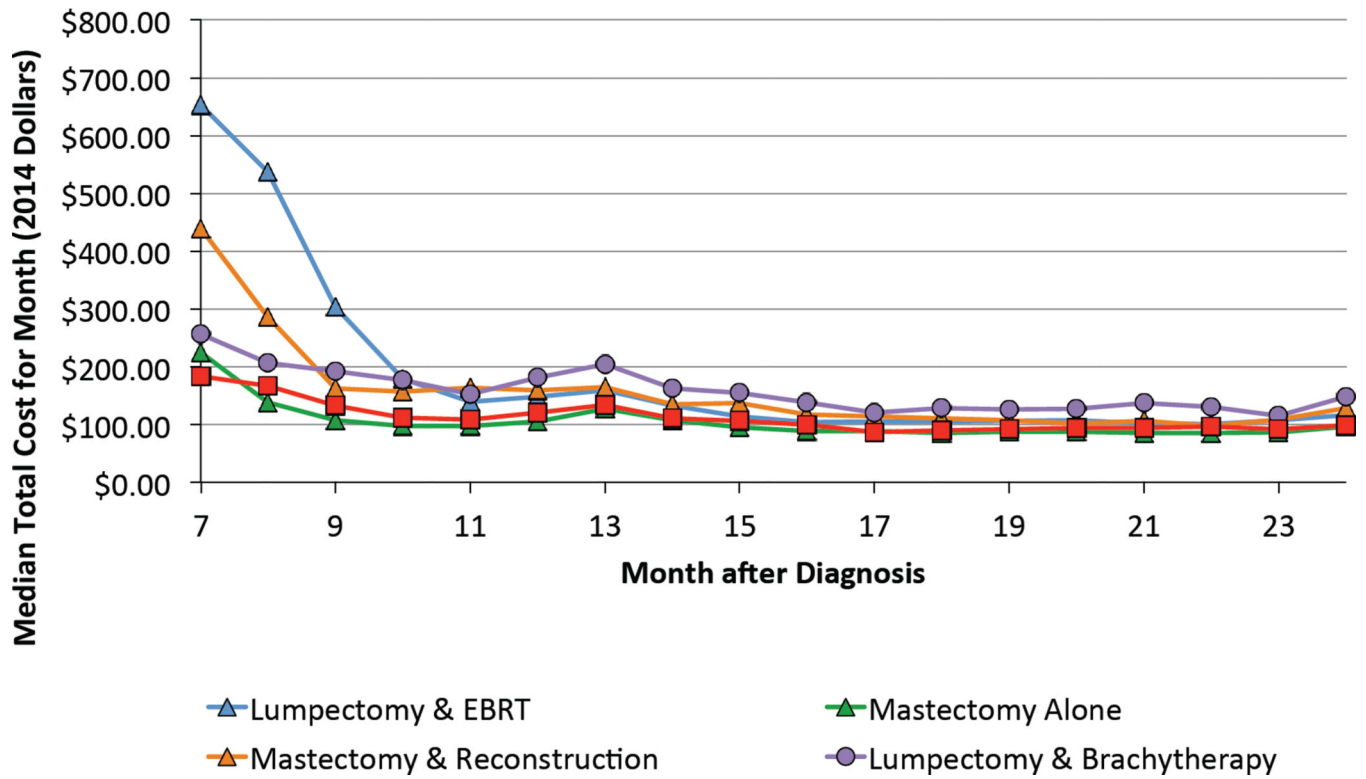
Figure 2.
A. Median total cost by month of each treatment strategy during the first 24 months following diagnosis. B and C highlight trends during the first 6 months and between months 7 and 24, respectively.
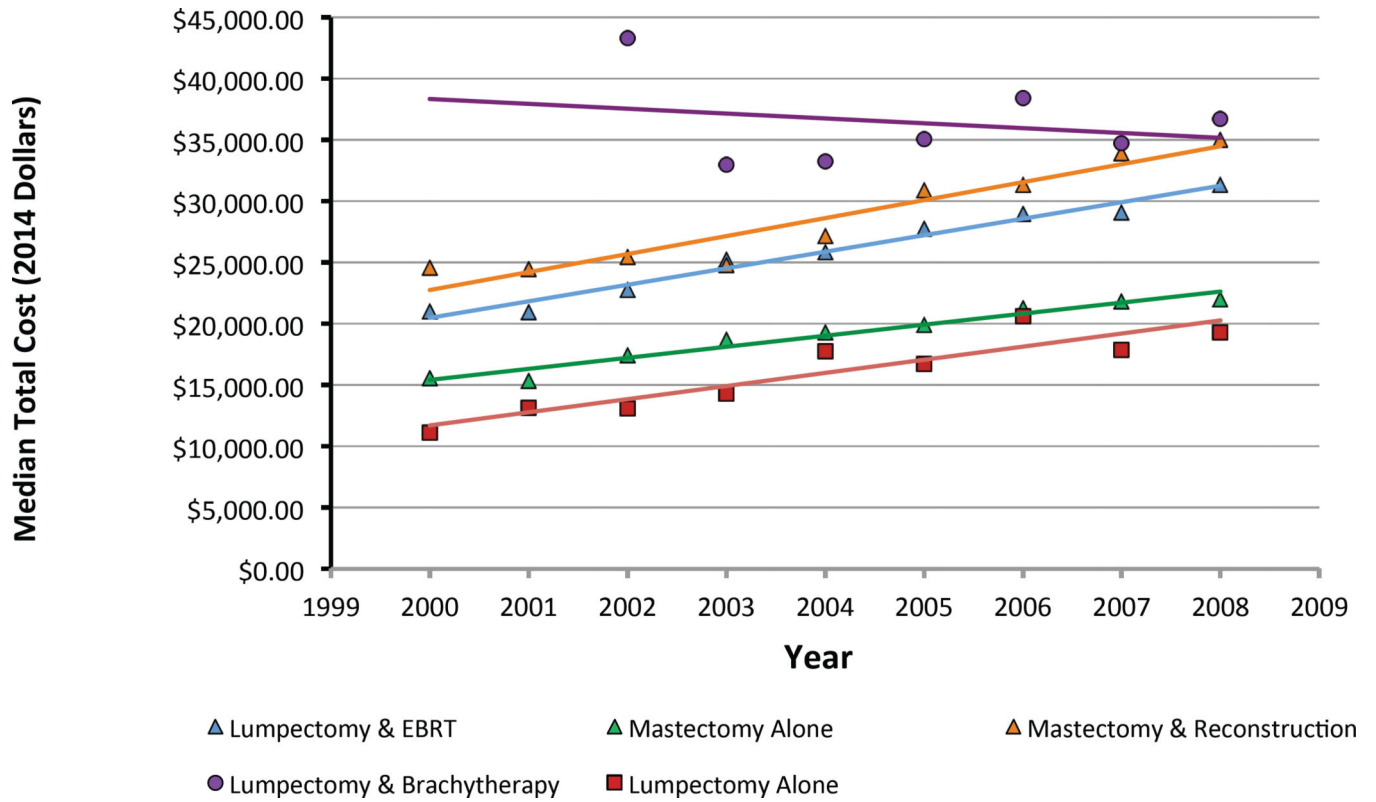
Figure 3.
Trends in median total cost for each treatment during the study interval. The lumpectomy and brachytherapy trend line starts in 2002 when FDA approval of a balloon-based breast brachytherapy occurred.

Baseline Characteristics

Table 1

Patient and Treatment Factors	Lumpectomy & External Radiation N=27,869		Mastectomy Alone N=18,356		Mastectomy & Reconstruction N=1488		Lumpectomy & Brachytherapy N=1455		Lumpectomy Alone N=6159		All Patients N=55,327		P
Age													
66–69	7615	27.3%	3460	18.8%	690	46.4%	385	26.5%	545	8.8%	12695	22.9%	<0.001
70–74	8214	29.5%	4535	24.7%	469	31.5%	410	28.2%	774	12.6%	14402	26.0%	
75–79	6919	24.8%	4664	25.4%	236	15.9%	349	24.0%	1159	18.8%	13327	24.1%	
80–84	3908	14.0%	3543	19.3%	63	4.2%	221	15.2%	1608	26.1%	9343	16.9%	
85+	1213	4.4%	2154	11.7%	30	2.0%	90	6.2%	2073	33.7%	5560	10.0%	
Race													<0.001
White	25002	89.7%	15778	86.0%	1368	91.9%	1329	91.3%	5495	89.2%	48972	88.5%	
Black	1515	5.4%	1454	7.9%	74	5.0%	75	5.2%	400	6.5%	3518	6.4%	
Other/Unknown	1352	4.9%	1124	6.1%	46	3.1%	51	3.5%	264	4.3%	2837	5.1%	
Charlson Comorbidity Index													<0.001
0	18694	67.1%	10612	57.8%	1067	71.7%	971	66.7%	3365	54.6%	34709	62.7%	
1	6110	21.9%	4599	25.1%	298	20.0%	337	23.2%	1542	25.0%	12886	23.3%	
2	2585	9.3%	2529	13.8%	100	6.7%	147	10.1%	1030	16.7%	6391	11.6%	
Incomplete	480	1.7%	616	3.4%	23	1.5%	0	0.0%	222	3.6%	1341	2.4%	
Chemotherapy													<0.001
No	23486	84.4	15365	83.8	1130	75.9	1347	92.6	5947	96.6	47275	85.5%	
Yes	4356	15.7	2978	16.2	358	24.1	108	7.4	209	3.4	8009	14.5%	
Year of Diagnosis													<0.001
2000	2777	10.0%	2262	12.3%	<150	<9%	<20	<2%	612	9.9%	5795	10.5%	
2001	2978	10.7%	2502	13.6%	<170	<11%	<11	<1%	640	10.4%	6283	11.4%	
2002	3125	11.2%	2262	12.3%	150	10.1%	38	2.6%	653	10.6%	6228	11.3%	
2003	3223	11.6%	2082	11.3%	152	10.2%	87	6.0%	577	9.4%	6121	11.1%	
2004	3233	11.6%	2015	11.0%	166	11.2%	144	9.9%	690	11.2%	6248	11.3%	
2005	3062	11.0%	1864	10.2%	150	10.1%	187	12.9%	740	12.0%	6003	10.9%	

	Lumpectomy & External Radiation N=27,869		Mastectomy Alone N=18,356		Mastectomy & Reconstruction N=1488		Lumpectomy & Brachytherapy N=1455		Lumpectomy Alone N=6159		All Patients N=55,327		P
2006	3182	11.4%	1763	9.6%	148	9.9%	263	18.1%	779	12.6%	6135	11.1%	
2007	3123	11.2%	1835	10.0%	209	14.0%	334	23.0%	733	11.9%	6234	11.3%	
2008	3166	11.4%	1771	9.6%	227	15.3%	381	26.2%	735	11.9%	6280	11.4%	
Tumor Factors													
Tumor Size													
T1 (0.0 – 2.0 cm)	22995	82.5%	11866	64.6%	1026	69.0%	1312	90.2%	4898	79.5%	42097	76.1%	<0.001
T2 (2.1 – 5.0 cm)	4676	16.8%	6326	34.5%	443	29.8%	132	9.1%	1202	19.5%	12779	23.1%	
Not specified	198	0.7%	164	0.9%	19	1.3%	11	0.8%	59	1.0%	451	0.8%	
Nodal Status													
Pathological N0	21386	76.7%	13493	73.5%	1192	80.1%	1301	89.4%	2737	44.4%	40109	72.5%	<0.001
Clinical N0	2524	9.1%	1184	6.5%	46	3.1%	95	6.5%	3090	50.2%	6939	12.5%	
Pathologic N1	3959	14.2%	3679	20.0%	250	16.8%	59	4.1%	332	5.4%	8279	15.0%	
Histology													
Ductal, tubular, mucinous	20920	75.1%	12653	68.9%	884	59.4%	1156	79.5%	4546	73.8%	40159	72.6%	<0.001
Lobular	2282	8.2%	1815	9.9%	184	12.4%	71	4.9%	480	7.8%	4832	8.7%	
Other invasive	3959	14.2%	2804	15.3%	260	17.5%	184	12.6%	923	15.0%	8130	14.7%	
DCIS	708	2.5%	1084	5.9%	160	10.8%	44	3.0%	210	3.4%	2206	4.0%	
Grade													
Low-intermediate	19933	71.5%	11438	62.3%	925	62.2%	1175	80.8%	4548	73.8%	38019	68.7%	<0.001
High	6197	22.2%	5249	28.6%	428	28.8%	223	15.3%	1069	17.4%	13166	23.8%	
Other/unknown	1739	6.2%	1669	9.1%	135	9.1%	57	3.9%	542	8.8%	4142	7.5%	
Estrogen Receptor Status													
ER+	22136	79.4%	12722	69.3%	1086	73.0%	1245	85.6%	4717	76.6%	41906	75.7%	<0.001
ER-	3291	11.8%	2568	14.0%	228	15.3%	108	7.4%	466	7.6%	6661	12.0%	
Unspecified	2442	8.8%	3066	16.7%	174	11.7%	102	7.0%	976	15.8%	6760	12.2%	
Area-level Factors													
Type of Patient Residence													
Urban	25823	92.7%	15477	84.3%	1373	92.3%	1369	94.1%	5550	90.1%	49592	89.6%	<0.001

	Lumpectomy & External Radiation N=27,869		Mastectomy Alone N=18,356		Mastectomy & Reconstruction N=1488		Lumpectomy & Brachytherapy N=1455		Lumpectomy Alone N=6159		All Patients N=55,327		P
	>5	<5									>5	<5	
	>2025	<11									>5725	<11	
Rural			2879 15.7%		115 7.7%		86 5.9%		609 9.9%		609	>5	<0.001
Unknown	<11	<5	0 0.0%		0 0.0%		0 0.0%		0 0.0%		0	<5	
Density of Surgeons													
Highest Quartile	6125 22.0%		5598 30.5%		348 23.4%		351 24.1%		1413 22.9%		13835	25.0%	<0.001
Second Quartile	7222 25.9%		4542 24.7%		364 24.5%		414 28.5%		1711 27.8%		14253	25.8%	
Third Quartile	7184 25.8%		3942 21.5%		375 25.2%		323 22.2%		1569 25.5%		13393	24.2%	
Fourth Quartile	7338 26.3%		4274 23.3%		401 26.9%		367 25.2%		1466 23.8%		13846	25.0%	
Density of Radiation Oncologists													
Highest Quartile	5552 19.9%		6088 33.2%		328 22.0%		334 23.0%		1495 24.3%		13797	24.9%	<0.001
Second Quartile	7416 26.6%		4167 22.7%		393 26.4%		458 31.5%		1582 25.7%		14016	25.3%	
Third Quartile	7600 27.3%		3764 20.5%		382 25.7%		298 20.5%		1642 26.7%		13686	24.7%	
Fourth Quartile	7301 26.2%		4337 23.6%		385 25.9%		365 25.1%		1440 23.4%		13828	25.0%	
Residents with Some College Education													
1st Quartile (0 – 8.1%)	8117 29.1%		3409 18.6%		517 34.7%		490 33.7%		1545 25.1%		14078	25.4%	<0.001
2nd Quartile (8.2% – 14.4%)	7190 25.8%		4108 22.4%		387 26.0%		375 25.8%		1527 24.8%		13587	24.6%	
3rd Quartile (14.5 – 24.0%)	6755 24.2%		4979 27.1%		294 19.8%		308 21.2%		1500 24.4%		13836	25.0%	
4th Quartile (>24.1%)	5807 20.8%		5860 31.9%		290 19.5%		282 19.4%		1587 25.8%		13826	25.0%	
Income Level													
1st Quartile ($0 – $35,453)	5672 20.4%		6069 33.1%		279 18.8%		258 17.7%		1556 25.3%		13834	25.0%	<0.001
2nd Quartile ($35,454 – $46,559)	6619 23.8%		4967 27.1%		317 21.3%		370 25.4%		1557 25.3%		13830	25.0%	
3rd Quartile ($46,560 – $62,311)	7451 26.7%		4135 22.5%		371 24.9%		369 25.4%		1505 24.4%		13831	25.0%	
4th Quartile (>$62,312)	8127 29.2%		3185 17.4%		521 35.0%		458 31.5%		1541 25.0%		13832	25.0%	

Abbreviations: DCIS (ductal carcinoma in situ), ER (estrogen receptor). Cell sizes < 11 have been suppressed in accordance with guidelines from SEER-Medicare.

Table 2

Predictors of Treatment Strategy using Polychotomous Logistic Regression with Lumpectomy plus External Beam Radiation Designated as Referent Group.

	Mastectomy Alone			Mastectomy & Reconstruction			Lumpectomy & Brachytherapy			Lumpectomy Alone		
	HR	95% CI	P-value	HR	95% CI	P-value	HR	95% CI	P-value	HR	95% CI	P-value
Patient Factors												
Age												
66–69	1			1			1			1		
70–74	1.23	1.17–1.31	<.0001	0.65	0.57–0.73	<.0001	1.02	0.89–1.18	0.7611	1.28	1.14–1.44	<.0001
75–79	1.57	1.49–1.67	<.0001	0.4	0.34–0.46	<.0001	1.07	0.92–1.25	0.3754	2.05	1.83–2.29	<.0001
80–84	2.22	2.08–2.37	<.0001	0.19	0.15–0.25	<.0001	1.14	0.96–1.36	0.1338	4.21	3.77–4.70	<.0001
85+	4.4	4.04–4.81	<.0001	0.31	0.21–0.45	<.0001	1.56	1.22–2.00	0.0003	12.69	11.3–14.3	<.0001
Race												
White	1			1			1			1		
Black	1.18	1.09–1.29	<.0001	0.85	0.66–1.1	0.22	1.12	0.87–1.44	0.38	1.12	0.98–1.29	0.089
Other/Unknown	1.57	1.44–1.72	<.0001	0.6	0.44–0.81	0.0009	0.67	0.5–0.9	0.0069	0.99	0.85–1.15	0.86
Charlson Comorbidity Index												
0	1			1			1			1		
1	1.25	1.19–1.31	<.0001	0.92	0.81–1.06	0.25	1.03	0.91–1.18	0.6307	1.63	1.48–1.78	<.0001
2	1.52	1.42–1.62	<.0001	0.78	0.63–0.96	0.021	1.04	0.86–1.25	0.7006	NA	NA	NA
Incomplete	1.54	1.34–1.76	<.0001	0.85	0.55–1.32	0.47	1.19	1.1–1.28	0.8575	3.43	2.84–4.15	<.0001
Year of Diagnosis												
2000	1			1			1			1		
2001	1.04	0.96–1.13	0.37	1.09	0.86–1.40	0.47	0.46	0.19–1.15	0.098	1.05	0.91–1.20	0.52
2002	0.92	0.84–0.99	0.042	0.98	0.77–1.25	0.87	2.25	1.21–4.17	0.0098	1.21	1.06–1.40	0.0068
2003	0.78	0.72–0.85	<.0001	0.98	0.77–1.25	0.87	5.02	2.85–8.85	<.0001	1	0.86–1.15	0.95
2004	0.78	0.71–0.85	<.0001	1.05	0.82–1.33	0.73	8.55	4.92–14.85	<.0001	1.41	1.23–1.62	<.0001
2005	0.75	0.69–0.82	<.0001	0.95	0.75–1.22	0.70	12.09	7.00–20.90	<.0001	1.67	1.45–1.91	<.0001
2006	0.69	0.63–0.75	<.0001	0.92	0.72–1.18	0.50	16.44	9.56–28.26	<.0001	1.76	1.54–2.02	<.0001
2007	0.71	0.65–0.78	<.0001	1.31	1.04–1.65	0.023	21.25	12.4–36.4	<.0001	1.67	1.45–1.92	<.0001

	Mastectomy Alone			Mastectomy & Reconstruction			Lumpectomy & Brachytherapy			Lumpectomy Alone		
	HR	95% CI	P-value	HR	95% CI	P-value	HR	95% CI	P-value	HR	95% CI	P-value
2008	0.68	0.62–0.74	<.0001	1.37	1.09–1.73	0.0081	23.58	13.8–40.4	<.0001	1.78	1.55–2.05	<.0001
Tumor Factors												
Tumor Size												
T1 (0.0 – 2.0 cm)	1			1			1			1		
T2 (2.1 – 5.0 cm)	2.27	2.17–2.38	<.0001	2.01	1.78–2.27	<.0001	0.58	0.48–0.7	<.0001	1.04	0.96–1.13	0.33
Not specified	1.71	1.37–2.14	<.0001	1.71	1.05–2.78	0.032	0.65	0.35–1.2	0.168	0.91	0.65–1.27	0.58
Nodal Status												
Pathological N0	1			1			1			1		
Clinical N0	0.49	0.45–0.53	<.0001	0.48	0.35–0.65	<.0001	0.77	0.62–0.96	0.018	5.66	5.25–6.1	<.0001
Pathological N+	1.32	1.25–1.40	<.0001	1.1	0.95–1.27	0.21	0.28	0.21–0.36	<.0001	0.7	0.62–0.79	<.0001
Histology												
Ductal, tubular, mucinous	1			1			1			1		
Lobular	1.27	1.18–1.36	<.0001	1.79	1.5–2.13	<.0001	0.54	0.42–0.69	<.0001	0.83	0.74–0.94	0.0034
Other invasive	1.17	1.11–1.24	<.0001	1.53	1.32–1.77	<.0001	0.9	0.76–1.05	0.1844	1.02	0.94–1.12	0.62
DCIS	2.27	2.04–2.53	<.0001	4.06	3.33–4.96	<.0001	0.9	0.65–1.23	0.5041	2.47	2.08–2.92	<.0001
Grade												
Low-intermediate	1			1			1			1		
High	1.16	1.10–1.22	<.0001	1.16	1.02–1.33	0.027	0.75	0.64–0.88	0.0005	0.79	0.72–0.86	<.0001
Other/unknown	1.23	1.13–1.33	<.0001	1.29	1.06–1.58	0.012	0.82	0.62–1.09	0.1678	1.14	1.01–1.28	0.039
Estrogen Receptor Status												
ER+	1			1			1			1		
ER–	1.19	1.12–1.27	<.0001	1.2	1.02–1.41	0.032	0.65	0.52–0.8	<.0001	0.77	0.69–0.87	<.0001
Unspecified	1.82	1.71–1.94	<.0001	1.26	1.06–1.51	0.011	1.34	1.08–1.66	0.0076	1.64	1.49–1.8	<.0001
Area-Level Factors												
Type of Patient Residence												
Metropolitan	1			1			1			1		
Non-metropolitan	1.4	1.3–1.52	<.0001	0.96	0.76–1.22	0.73	0.62	0.48–0.8	0.0003	1.14	1–1.3	0.053

	Mastectomy Alone			Mastectomy & Reconstruction			Lumpectomy & Brachytherapy			Lumpectomy Alone		
	HR	95% CI	P-value	HR	95% CI	P-value	HR	95% CI	P-value	HR	95% CI	P-value
Density of Surgeons												
Highest Quartile	1			1			1			1		
Second Quartile	0.9	0.85–0.95	<.0001	0.95	0.8–1.12	0.031	1.19	1.01–1.41	0.0331	1.16	1.06–1.28	0.002
Third Quartile	0.9	0.84–0.96	0.51	1.03	0.86–1.24	0.74	1.13	0.94–1.35	0.2116	1.09	0.98–1.21	0.13
Fourth Quartile	0.92	0.86–0.99	0.002	1.12	0.92–1.37	0.2631	1.42	1.16–1.74	0.0008	1.03	0.91–1.16	0.64
Density of Radiation Oncologists												
Highest Quartile	1			1			1			1		
Second Quartile	0.68	0.63–0.73	<.0001	0.85	0.71–1.03	0.093	0.86	0.72–1.02	0.083	0.86	0.77–0.95	0.0051
Third Quartile	0.58	0.54–0.62	<.0001	0.76	0.62–0.92	0.0064	0.53	0.43–0.65	<.0001	0.85	0.76–0.96	0.0082
Fourth Quartile	0.75	0.7–0.81	<.0001	0.76	0.62–0.95	0.015	0.55	0.44–0.68	<.0001	0.73	0.64–0.83	<.0001
Residents with Some College Education												
1st Quartile (0 – 8.1%)	1			1			1			1		
2nd Quartile (8.2% – 14.4%)	1.04	0.97–1.1	0.28	0.88	0.76–1.03	0.104	0.83	0.71–0.97	0.018	0.97	0.88–1.07	0.58
3rd Quartile (14.5 – 24.0%)	1.12	1.05–1.21	0.001	0.73	0.61–0.88	0.001	0.69	0.57–0.83	<.0001	0.94	0.84–1.05	0.24
4th Quartile (>24.1%)	1.2	1.11–1.3	<.0001	0.82	0.66–1.02	0.067	0.74	0.59–0.91	0.0057	1.07	0.95–1.21	0.28
Income Level												
1st Quartile ($0 – $35,453)	1			1			1			1		
2nd Quartile ($35,454 – $46,559)	0.87	0.82–0.92	<.0001	0.97	0.8–1.16	0.72	1.15	0.96–1.38	0.1371	0.98	0.89–1.08	0.70
3rd Quartile ($46,560 – $62,311)	0.74	0.69–0.79	<.0001	0.98	0.8–1.21	0.86	0.91	0.74–1.12	0.3808	0.86	0.77–0.96	0.0084
4th Quartile (>$62,312)	0.59	0.54–0.64	<.0001	1.1	0.88–1.38	0.40	0.94	0.75–1.18	0.5801	0.86	0.76–0.98	0.024

Abbreviations: CI (confidence interval), DCIS (ductal carcinoma in situ), ER (estrogen receptor), HR (hazard ratio)