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Use of imaging and biomarker tests for post-treatment care of early stage breast cancer survivors

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Abstract

Background—The American Society of Clinical Oncology (ASCO) recently released a “Top Five” list of opportunities to improve the quality of cancer care. Item four on the list advises against using advanced imaging and biomarkers for surveillance in breast cancer patients treated with curative intent. We examined concordance with ASCO follow-up care guidelines for breast cancer survivors treated at an academic medical center.

Methods—Claims data and medical records were reviewed and abstracted for early stage breast cancer survivors starting one year post diagnosis. A trained abstractor classified imaging tests as diagnostic or surveillance. Proportions and frequencies were generated for receipt of services. Multilevel logistic regression was used to estimate factors associated with receiving recommended and non-recommended services and biomarker tests.

Results—Records were available for 258 patients. Mean age at diagnosis was 58 (SD 13), mean time since diagnosis was 6 years (SD 2), 71% were stage 0/1. Only 47% of the sample received a mammogram within one year of diagnosis. Fifty-five percent of the sample received at least one non-recommended imaging service for surveillance purposes. Seventy-seven percent of the sample received at least one non-recommended biomarker test. Regression results indicate that main treating physician, advanced disease stage, younger age at diagnosis, and greater number of years since diagnosis were associated with receiving non-recommended services for surveillance.

Conclusions—Use of non-recommended services for surveillance occurs frequently among early stage survivors. There are opportunities to increase use of guideline concordant post-treatment care for breast cancer survivors.

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Keywords

breast cancer post-treatment care; guideline adherence; surveillance health services

Introduction

There are approximately 3 million breast cancer survivors in the United States.¹ Mortality from breast cancer continues to decline due to improvements in screening and treatment, and the majority of breast cancer patients are diagnosed with early stage disease and can expect to have extended disease-free survival.² Having survived their disease, most patients enter into a prolonged post-treatment phase of care, where the value of active surveillance testing for cancer recurrence has a limited evidence base. Specifically, two large Italian randomized trials of breast cancer post-treatment surveillance strategies were conducted in during the 1990s and concluded that there was no significant difference in overall survival, time to detection of recurrence, and quality of life perception between the high intensity and control group monitoring.³⁻⁵ These studies were followed by two Cochrane systematic reviews that confirmed a lack of evidence for intensive surveillance for recurrence in this setting.^{6,7} These findings prompted the American Society of Clinical Oncology (ASCO) to issue serial guidelines and updates on this topic, with the first in 1996 with the most recent update in 2012.⁸⁻¹¹

Current evidence-based guidelines for post-treatment surveillance care of breast cancer patients from ASCO¹¹ and the National Comprehensive Cancer Network (NCCN)¹² include explicit recommendations for post-treatment care as well as non-recommended surveillance services, such as use of advanced imaging services and biomarker tests. Both ASCO and NCCN guidelines recommend annual mammography and a recommended schedule of physician visits that include medical history and physical examination: ASCO recommends a visit every 3 to 6 months for the first 3 years, every 6 to 12 months for years 4 and 5, and NCCN recommends a visit every 4 to 6 months for 5 years and then annually thereafter. Importantly, both guidelines specify that routine surveillance testing with imaging and/or blood tests are not indicated and should only be considered if symptoms arise. Despite these guidelines, the literature reflects a reliance on biomarker tests and advanced imaging for surveillance of breast cancer survivors, with increasing use of imaging services over time.^{13-16,17} To emphasize the importance of its breast cancer surveillance guideline, ASCO included the guideline recommendations in the recently released “Top Five” list as part of the American Board of Internal Medicine’s Choosing Wisely® campaign.¹⁸ The latter aims to promote evidence-based clinical care that has beneficial effects on patient health by improving treatment and/or reducing risks, and, where possible, reduces costs of care.¹⁹ The ASCO Top Five list advises against routine recurrence surveillance testing in early stage breast cancer survivors who have completed curative treatment, and discourages use of advanced imaging tests (positron emission tomography (PET), computerized tomography (CT) and radionuclide bone scans) and biomarker tests (carcinoembryonic antigen (CEA), cancer antigen (CA) 15-3, CA 27.29, CA 125).¹⁸ These are low value tests, given the lack of evidence available for benefit. In addition, it is important not to expose breast cancer survivors to unnecessary services that can cause significant harms: exposure to radiation from imaging services, such as computed tomography tests,²⁰ false positive results that can lead to further, more invasive testing,²¹ and increased patient anxiety.²¹

The purpose of this study was to estimate the proportion of post-treatment breast cancer survivors receiving ASCO recommended and non-recommended surveillance procedures in a sample of patients treated and followed at an academic medical center. We sought to determine how frequently post-treatment breast cancer patients received biomarker tests and

imaging studies, and whether the latter were ordered for diagnostic or surveillance purposes. We also identified whether or not patients received mammographic surveillance as recommended by ASCO guidelines, since other studies have indicated poor adherence to this recommendation.

Methods

Identification of sample

Breast cancer survivors were identified within an academic medical center using an administrative data algorithm based on Current Procedural Terminology (CPT) and International Classification of Diseases (ICD) codes. The algorithm was applied to administrative claims data for the interval between 2001 and 2009. This time interval was chosen to allow for sufficient follow-up time after diagnosis and treatment for examination of post-treatment surveillance care. This study received Institutional Review Board approval for all activities (UCLA IRB# 10-000279).

Eligibility

All patients met the following eligibility criteria: female non-metastatic (stage 0-IIIa) breast cancer diagnosed between January 1, 2001 and June 30, 2009; 21 years of age and older at the time of diagnosis; no evidence of cancer recurrence or new primary cancer (any type) within the surveillance time frame, and no evidence of previous cancers; and at least two years of administrative and medical records in order to assess use of post-treatment services.

Data sources

We obtained data from administrative claims and medical record abstraction. Variables obtained from administrative data included insurance type, date of birth, breast cancer diagnosis date, and imaging service and biomarker test occurrences by date of test. Variables obtained from medical record data included stage of disease, treatments received, and main treating physician, either a medical oncologist or breast surgeon. A research assistant was trained to perform the medical record abstractions. The training and abstractions were overseen by the study principal investigator and a research nurse practitioner. We captured imaging service and biomarker test data for this protocol starting one year after the date of diagnosis to avoid capturing services performed as part of the diagnostic workup or possibly related to treatment complications during active treatment. There was an average of 5 years of surveillance data available per patient (range 2-10 years).

Variables

The dependent variables were receipt of services: mammograms, imaging (chest and abdominal CT, chest and abdominal MRI, abdominal ultrasound, chest x-ray, radionuclide bone scan, PET scan), and biomarker tests (CEA, CA 27.29, CA 125, CA 15-3). Independent variables were age at diagnosis, time since diagnosis (years from date of diagnosis to November 1, 2011), cancer stage (stage 0/1 or stage 2/3A), treatment type (mastectomy/lumpectomy, chemotherapy, radiation), insurance type (health maintenance organization (HMO), preferred provider organization (PPO), Medicare fee-for-service), and main treating physician (assigned a unique identification number). Twenty-two main treating physicians were identified. For patients treated with surgery only, the breast surgeon was considered the main treating physician. For all other patients, the medical oncologist with the majority of patient visits was considered the main treating physician. The medical oncologist was classified as the main treating physician for 90% of the sample. Insurance type was assigned based on the insurer covering the majority of services and visits during

the surveillance timeframe, based on the charges billed to the patient's insurance company. Patients enrolled in Medicare Advantage plans were categorized with the HMO group.

Diagnostic versus surveillance status determination for imaging tests

We coded diagnostic versus surveillance use of post-treatment imaging services by medical record abstraction and review. We reviewed the entire medical record available from the academic medical center. Based on the strategy developed by Cooper et al,²² the abstractor categorized imaging services into three categories: 1) surveillance in absence of signs or symptoms suggestive of recurrence; 2) diagnostic with signs or symptoms suggestive of recurrence, metastatic disease, or other disease or problem; or 3) indeterminate with no associated physician note. Categorization was based on the physician note associated with the service and the associated ICD codes used for health insurance billing. Physician notes that contained an active statement describing routine follow-up care with an imaging service were categorized as surveillance. The lack of a definitive statement of a new symptom or problem was also considered reason to categorize an imaging service as surveillance. However, it is possible that some of the imaging services classified as surveillance were, in fact, ordered for a diagnostic reason that was not recorded in the medical record or reflected in the associated ICD code. This categorization strategy may have resulted in overestimation of surveillance imaging services. Services with associated notes describing a new symptom or problem were categorized as diagnostic. The 4% of services initially categorized as indeterminate due to missing physician notes were reviewed during group meetings that included the research assistant, research nurse practitioner, and the principal investigator. After discussion and review, consensus was reached on categorization of diagnostic or surveillance for the services initially categorized as indeterminate. The majority of indeterminate services were categorized as surveillance based on an associated ICD code indicating breast cancer (e.g., 174.xx). Our categorization approach was conservative: imaging services initially classified as diagnostic remained so throughout the surveillance timeframe, even though the subsequent follow-up could have been surveillance. A random sample of 15% of the records was also abstracted by the research nurse practitioner as a second coder comparison. A kappa statistic comparing the classification of surveillance versus diagnostic was calculated to measure agreement between the two sets of abstractions, yielding a $k=0.72$ ("substantial" agreement).²³

Data Analysis

All analyses were performed using Stata (version 12.0) software. Means, ranges, and percentages were generated to summarize patient demographics and cancer disease and treatment characteristics. Proportions and frequencies were generated for receipt of ASCO guideline recommended and non-recommended services. Time to receipt of first mammogram for eligible patients was estimated using Kaplan-Meier estimates. Use of surveillance versus diagnostic imaging services was examined with proportions. Multilevel logistic regression with a random effect for main treating physician was used to estimate the unique association of independent variables with receiving recommended and non-recommended imaging services and biomarker tests. A multilevel model was used in order to account for the clustering of patients within the main treating physician variable.

Results

Study sample

The study sample included 258 survivors after excluding 126. The most common reason for exclusion was less than two years of surveillance time at the academic medical center. Many patients were initially treated at the center, but then switched their care to a provider outside the academic health system. The mean age of the sample was 58 years (standard deviation

(SD) 13) and the mean time since diagnosis was 6 years (SD 2) (Table 1). The majority had stage 0/1 disease and was treated with lumpectomy and radiation. Fifty-nine percent were enrolled in a HMO insurance plan. Three physicians were identified as the main treating physician for more than half of the sample.

Use of imaging and biomarker tests

Overall, 83% of the sample received at least one mammogram during the post-treatment period of observation. The length of time to the first mammogram for all eligible patients after cessation of active treatment (assumed to be 12 months after the date of diagnosis) is shown in Figure 1. Those with bilateral mastectomy were excluded (n=19). Forty-seven percent of the sample received the first mammogram within a year of cessation of active treatment, and 67% of the sample received the first mammogram within two years. Of the 120 patients who had a first mammogram within one year of cessation of active treatment, 56 (47%) had a second mammogram within the next year (Table 2). We explored whether insurance status influenced the percentage receiving a follow-up mammogram within the first year post-treatment: 52% of HMO-insured patients received a mammogram within the first year versus 40% of those with PPO or Medicare insurance ($p=0.05$, data not shown).

Sixty-seven percent of the sample received at least one non-recommended imaging service. The most common non-recommended imaging service was chest x-ray, with 45% of the sample receiving at least one (Table 3). Thirty percent of the sample received at least one breast MRI, and 20% received at least one chest CT. Eighty percent of the sample received at least one non-recommended biomarker test. Seventy-seven percent of the sample received at least one CEA test, and 77% of the sample received at least one CA 27.29. The majority of CEA and CA 27.29 tests were performed within the first two years after cessation of active treatment (Figure 2). Sixteen percent of all CEA and CA 27.29 tests were performed 5 or more years after active treatment ended. CA-125 and CA 15-3 tests were used less commonly, with 18% and 5% receiving at least one of each test, respectively.

Surveillance versus diagnostic use of imaging services

Fifty-five percent of the sample received at least one non-recommended imaging service that was classified as surveillance. Four imaging services were classified as surveillance the majority of the time: 79 abdominal CTs (61%), 128 breast MRIs (82%), 79 chest CTs (57%), and 72 PET scans (93%) (Table 3). Only 28% of chest x-rays, the most commonly used imaging service, were classified as surveillance. The majority of abdominal MRI, abdominal ultrasound, and bone scans were classified as diagnostic. Out of all non-recommended imaging services captured, 48% (514 out of 1082) were classified as surveillance.

Variables associated with receiving imaging services and biomarker tests

Stage of disease, age at diagnosis, and years since diagnosis were significantly associated with receiving a non-recommended imaging service that was classified as surveillance (Table 4). The odds of receiving a non-recommended imaging service classified as surveillance were 2.70 times higher for those who had stage 2 or stage 3A disease than for those who had stage 0 or stage 1 disease ($p=0.01$). Younger age at diagnosis was associated with higher odds of receiving a non-recommended imaging service classified as surveillance, with a one-year increase in age at diagnosis associated with a 3% decrease in the odds of receiving a non-recommended imaging service classified as surveillance ($OR=0.97$, $p=0.05$). A one-year increase in years since diagnosis was associated with a 23% increase in the odds of receiving a non-recommended imaging service classified as surveillance ($OR=1.23$, $p=0.02$). Main treating physician was also important in explaining variation in receipt of non-recommended imaging services. The intraclass correlation (ρ)

for main treating physician was 0.19 and significantly different than zero, meaning that 19% of the variance in receiving a non-recommended imaging service classified as surveillance was accounted for by the main treating physician.

Radiation, age at diagnosis, and insurance type were all significantly associated with receiving a mammogram. The odds of receiving a mammogram were 1.98 times higher for those who received radiation than for those who did not ($p=0.08$), and the odds of receiving a mammogram for those with Medicare fee-for-service insurance were 8.99 times higher than those with HMO insurance ($p<0.001$). A one-year increase in age at diagnosis resulted in a 6% decrease in the odds of receiving a mammogram ($OR=0.94$, $p=0.001$). Main treating physician was also important in explaining variation in receipt of mammograms. The intraclass correlation was 0.22 and significantly different than zero, meaning that 22% of the variance in receiving a mammogram was accounted for by the main treating physician.

Stage and years since diagnosis were significantly associated with receiving non-recommended biomarker tests (CEA, CA 15-3, CA 27.29, and CA 125). The odds of receiving a non-recommended biomarker test for those with stage 2 or stage 3A disease were 4.24 times higher than those with stage 0 or stage 1 disease, ($p=0.04$), and a one-year increase in years since diagnosis was associated with a 42% increase in the odds of receiving a non-recommended biomarker test ($p=0.006$). Main treating physician was also important in explaining variation in receipt of non-recommended biomarker tests. The intraclass correlation for main treating physician was 0.56 and significantly different than zero, meaning that 56% of the variance in receiving a non-recommended biomarker test was accounted for by the main treating physician.

Discussion

We examined use of ASCO recommended and non-recommended post-treatment services in a group of breast cancer survivors treated and followed at an academic medical center. Only 47% of the sample received a recommended mammogram in the first year after cessation of active treatment, which falls well short of the ASCO recommendation of one mammogram one year after the initial diagnostic mammogram. However, some patients may have received mammograms outside of the academic medical center, leading to an overestimation of the length of time to the first mammogram. HMO-insured patients in the sample had a slightly higher percentage of mammograms by the end of the first year than PPO and Medicare insured patients (data not shown), although both groups are well below the ASCO recommendation. However, our overall mammogram findings are similar to other studies. A study using the Surveillance, Epidemiology, and End Results registry linked to Medicare claims to examine use of annual mammograms in a cohort of breast cancer survivors found that only 62% received annual mammograms.²⁴ Other studies have reported rates of annual mammograms for breast cancer survivors from 50%-80%.^{16,25-27} We also found that non-recommended imaging services were used frequently, particularly chest x-ray, with almost half of the sample receiving at least one. Non-recommended biomarker tests were also commonly used, particularly CEA and CA 27.29.

Importantly, we were able to categorize the non-recommended imaging services as surveillance or diagnostic using medical record abstraction. The majority of published studies examining adherence to breast cancer surveillance guidelines used administrative data only.^{14,16,28} A 2006 study characterized post-treatment care in cancer survivors as surveillance or diagnostic using medical record abstraction.²² The results showed that 49% of imaging services for breast cancer survivors were used for surveillance only. In our study, 48% of all imaging services were classified as surveillance. PET scans were almost uniformly classified as surveillance (93%), and breast MRIs (82%) and abdominal CTs

(61%) were classified as surveillance the majority of the time. These services were routinely ordered with 55% of the sample receiving at least one non-recommended imaging test classified as surveillance, despite the evidence showing little to no benefit of aggressive post-treatment surveillance programs.^{6,10,29} However, this may be an overestimation of services ordered for surveillance. Our classification scheme assigned imaging services that lacked a definitive statement of a new symptom or problem as surveillance, potentially misclassifying services that were in fact diagnostic. Most imaging services did have an associated note that contained an active statement of surveillance or diagnosis of a new symptom or problem, but some associated notes were vague, leading to uncertainty regarding classification.

The variables associated with receipt of a non-recommended imaging service for surveillance purposes show that ordering these services is influenced by a diverse set of factors (Table 4). For patients with higher stage disease and younger age at diagnosis, physicians and patients may elect a more aggressive surveillance approach with the hope of identifying recurrent or new disease early, although available evidence does not support this approach. The main treating physician was significant in each of the three models, accounting for 19%, 22%, and 56% of the variance in receiving a non-recommended imaging service for surveillance, receiving a mammogram, and receiving a non-recommended biomarker test, respectively. This finding suggests that appropriate feedback to individual physicians about their utilization patterns could influence subsequent adherence to guidelines. Patient demand for services may also play a role in these findings.

This study has several limitations. First, this is a relatively small sample of patients treated and followed at a single academic center. This allowed us to do detailed medical record abstractions, providing important data on use of post-treatment services. However, this limits the generalizability of our findings. Other types of institutions may have very different practices and customs for post-treatment follow-up care, although several larger studies have found poor adherence to post-treatment guidelines for cancer patients generally.^{13,16,22,30} Second, imaging services initially classified as diagnostic remained so throughout the surveillance timeframe, a conservative approach that potentially underestimates the number of surveillance services. Even using this conservative approach we found a high percentage of imaging services were used for surveillance purposes. Third, we used data solely from one academic medical center and did not seek outside records. Patients may have received care elsewhere, which could have led to underestimation of appropriate and inappropriate services. Our examination of the sample by insurance group shows that even HMO-insured patients who can be expected to receive all of their care within the academic medical center did not all receive mammograms within the first year after diagnosis, suggesting that underuse of recommended services is a systematic problem. Finally, we had limited patient-level variables. Potentially important demographic variables and patient awareness/desire for post-treatment care were not available from our data sources.

In conclusion, our findings show a high rate of non-recommended testing and underuse of mammographic screening in early-stage breast cancer survivors treated and followed at an academic medical center. These patterns were observed in a setting where individual physicians do not have a financial incentive for ordering tests and services, and should have access to evidence-based guidelines to direct follow-up care. This suggests that the ordering of non-recommended services is a complex process driven by multiple factors, only some of which were captured in this study. Overuse of post-treatment services is a persistent problem with potentially serious impacts: false positive results that may lead to use of unnecessary invasive procedures, financial costs, and heightened patient anxiety. As the population of breast cancer survivors continues to grow, it will be of even greater importance to base post-treatment care decisions on available evidence and guidelines.

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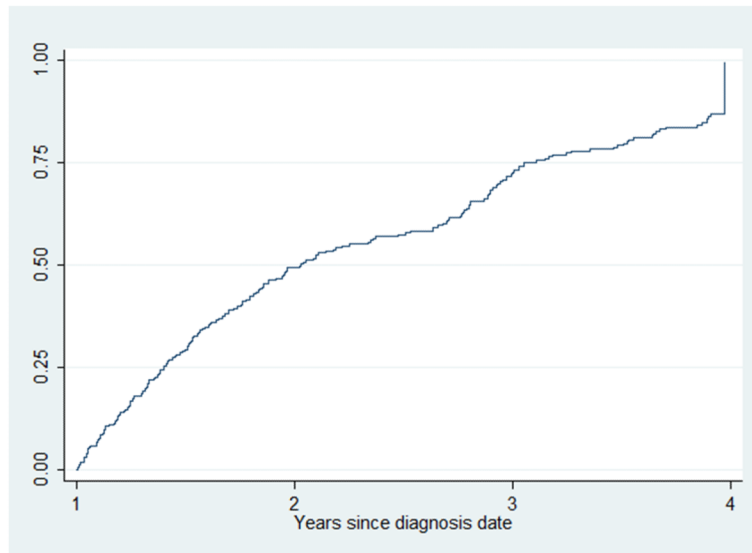


Figure 1. Kaplan-Meier estimate of time to first mammogram for eligible patients N=239

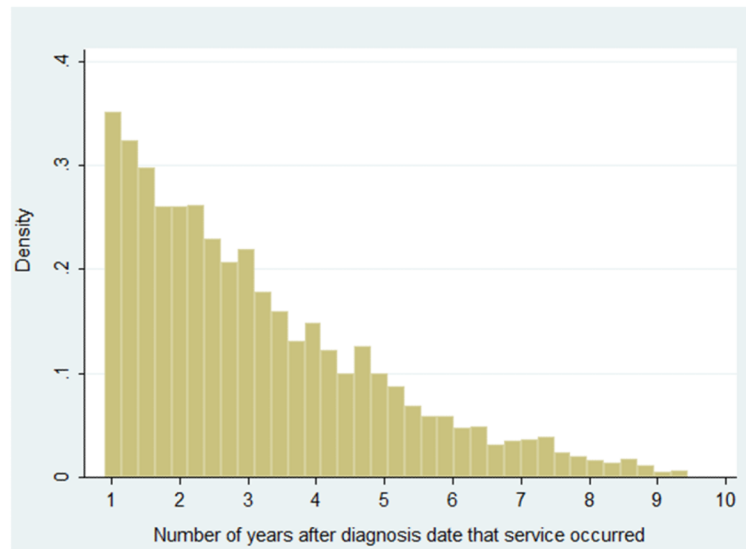


Figure 2.
Number of years since diagnosis date that carcinoembryonic antigen (CEA) and cancer antigen (CA) 27.29 tests occurred N=258

Table 1

Patient demographics and cancer disease and treatment characteristics, N=258

Characteristic	Number	%
Age at diagnosis, years	58	
Mean	13	
Standard deviation	[28, 95]	
Range		
Years from diagnosis date to November 1, 2011	6	
Mean	2	
Standard deviation	[2, 10]	
Range		
Disease stage	182	71
Stage 0 or 1	76	30
Stage 2 or 3A		
Lumpectomy	187	72
Yes	71	28
No		
Mastectomy	71	28
Yes	187	72
No		
Chemotherapy	104	40
Yes	154	60
No		
Radiation	188	73
Yes	70	27
No		
Insurance type	151	59
HMO	37	14
PPO	70	27
Medicare		
Main treating physician	24	9
Provider 1	67	26
Provider 2	39	15
Provider 4	25	10
Provider 5	6	2
Provider 6	34	13
Provider 7	7	3
Provider 8	9	4
Provider 9	5	2
Provider 10	5	2
Provider 11	17	7
Provider 13	20	8
Other*		

* Other includes providers with less than 3 patients

Abbreviations: HMO: Health maintenance organization PPO: Preferred provider organization

Table 2

Number of mammograms received by years after cessation of active treatment

Time Interval: Years after treatment cessation	Patients in interval	Patients that received a mammogram (% of total sample in interval)
1	258	120 (47%)
2	243	115 (47%)
3	217	127 (59%)
4	174	105 (60%)
5	121	55 (46%)

Table 3

Use of non-recommended imaging services and biomarker tests starting one year post-diagnosis including percent of imaging services used for surveillance N=258

Imaging service or biomarker test	Percent of sample that received at least one (number)	Total service count	Percent surveillance out of total service count (number)
Abdominal CT	19% (48)	129	61% (79)
Abdominal MRI	4% (11)	21	39% (8)
Abdominal ultrasound	15% (37)	53	13% (7)
Bone scan	17% (44)	64	26% (17)
Breast MRI	30% (77)	156	82% (128)
Chest CT	20% (52)	139	57% (79)
Chest x-ray	45% (114)	443	28% (124)
PET scan	12% (31)	77	93% (72)
CA 15-3	5% (14)	30	-
CA 125	18% (46)	91	-
CA 27.29	77% (199)	1661	-
CEA	77% (198)	1518	-

Abbreviations: CT: Computed tomography MRI: Magnetic resonance imaging PET: Positron emission tomography CA: Cancer antigen CEA: Carcinoembryonic antigen

Table 4

Multilevel logistic regression with random effects for the main treating physician: Model 1) received any non-recommended imaging service determined to be for surveillance purposes (computed tomography scan, magnetic resonance imaging, ultrasound, bone scan, positron emission tomography scan); Model 2) received any post-treatment mammogram; and Model 3) received any non-recommended biomarker test: carcinoembryonic antigen (CEA), cancer antigen (CA) 15-3, CA 27.29, and CA 125 tests. The group variable is the main treating physician. N=258

Model 1: Received any non-recommended imaging service for surveillance				
Variable	Odds ratio	Standard error	p-value	95% confidence interval
Mastectomy	1.97	0.89	0.13	[0.81, 4.76]
Radiation	1.77	0.76	0.19	[0.76, 4.12]
Chemotherapy	1.34	0.34	0.24	[0.82, 2.18]
Stage 2/3A	2.70	1.04	0.01	[1.27, 5.74]
Age at diagnosis	0.97	0.02	0.05	[0.93, 0.99]
PPO insurance	0.55	0.28	0.23	[0.20, 1.48]
Medicare	0.79	0.37	0.61	[0.31, 1.97]
Years since diagnosis	1.23	0.11	0.02	[1.03, 1.46]
Sigma_u	0.89	0.29		[0.47, 1.68]
Intraclass correlation (rho)*	0.19	0.10		[0.06, 0.46]
Likelihood ratio test: rho=0 chibar2(01)=17.33 Prob >=chibar2 = 0.000				
Model 2: Received any post-treatment mammogram				
Variable	Odds ratio	Standard error	p-value	95% confidence interval
Mastectomy	0.88	0.36	0.76	[0.39, 1.97]
Radiation	1.98	0.78	0.08	[0.92, 4.30]
Chemotherapy	0.93	0.22	0.77	[0.59, 1.48]
Stage 2/3A	1.17	0.46	0.69	[0.54, 2.52]
Age at diagnosis	0.94	0.02	0.001	[0.91, 0.98]
PPO insurance	1.21	0.59	0.70	[0.46, 3.16]
Medicare	8.99	4.82	0.000	[3.14, 25.72]
Years since diagnosis	1.06	0.09	0.51	[0.89, 1.26]
Sigma_u	0.97	0.36		[0.47, 2.01]
Intraclass correlation (rho)*	0.22	0.13		[0.06, 0.56]
Likelihood ratio test: rho=0 chibar2(01)=10.18 Prob >=chibar2 = 0.001				
Model 3: Received any non-recommended biomarker test				
Variable	Odds ratio	Standard error	p-value	95% confidence interval
Mastectomy	1.27	0.79	0.70	[0.38, 4.28]
Radiation	0.94	0.54	0.91	[0.30, 2.93]
Chemotherapy	1.59	0.50	0.14	[0.86, 2.93]
Stage 2/3A	4.24	2.93	0.04	[1.10, 16.43]
Age at diagnosis	1.02	0.03	0.43	[0.97, 1.07]

Model 1: Received any non-recommended imaging service for surveillance				
Variable	Odds ratio	Standard error	p-value	95% confidence interval
PPO insurance	1.17	0.78	0.82	[0.31, 4.35]
Medicare	0.99	0.67	0.99	[0.26, 3.75]
Years since diagnosis	1.42	0.18	0.006	[1.11, 1.83]
Sigma_u	2.04	0.59		[1.16, 3.59]
Intraclass correlation (rho)*	0.56	0.14		[0.29, 0.80]
Likelihood ratio test: rho=0	chibar2(01)=33.11 Prob >=chibar2 = 0.000			

Reference groups: Lumpectomy, health maintenance organization (HMO) insurance, stage 0/1 disease

* The intraclass correlation (rho) is the amount of variance in the outcome accounted for by the group variable, main treating physician

Abbreviations: PPO: Preferred provider organization