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Surveillance Practice Patterns after Curative Intent Therapy for Stage I Non-Small-Cell Lung Cancer in the Medicare Population

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Abstract

Objectives—Recurrence after treatment for non-small cell lung cancer (NSCLC) is common, and routine imaging surveillance is recommended by evidence-based guidelines. Little is known about surveillance patterns after curative intent therapy for early stage NSCLC. We sought to understand recent practice patterns for surveillance of stage I NSCLC in the first two years after curative intent therapy in the Medicare population.

Materials and Methods—Using the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database we selected patients diagnosed with stage I NSCLC between 1998 and 2008. We studied adherence to surveillance guidelines based on specialty society recommendations for CXR and CT. We also tracked the use of PET scans, which are not recommended for surveillance. We calculated the percent of patients who received guideline-adherent surveillance imaging and used logistic regression to determine associations between patient and provider factors and guideline adherence.

Results—Overall, 61.4% of patients received guideline-adherent surveillance during the initial 2 years after treatment. Use of CT scans in the first year after treatment increased from 47.4% in 1998 to 78.5% in 2008, and PET use increased from 5.8% to 28.9%. Adherence with surveillance

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imaging was associated with younger age, higher income, more comorbidities, access to primary care, and receipt of SBRT as the primary treatment.

Conclusions—Adherence to specialty society guidelines for surveillance after treatment for stage I NSCLC was poor in this population of Medicare beneficiaries, with less than two-thirds of patients receiving recommended imaging, and almost 30% receiving non-recommended PET scans.

Keywords

Lung cancer; NSCLC; surveillance; imaging; PET

Introduction

Non-small cell lung cancer (NSCLC) is the leading cause of cancer mortality in the United States, with overall 5-year survival estimated at 18%. [1] Early stage NSCLC is generally treated with curative intent therapy, but 5-year recurrence rates are estimated in the range of 9%-46%, even with treatment. [2-7] Routine surveillance of these patients is recommended to enable early detection of recurrences or new cancers. [8-11]

Lung cancer surveillance has been recommended using two imaging modalities: chest radiography (CXR) and computed tomography (CT) scanning. Surveillance CT imaging as opposed to CXR has been more recently advocated to optimize detection of asymptomatic recurrence at an earlier stage [8], though a mortality benefit has not been consistently demonstrated. [4, 12-15] The National Comprehensive Cancer Network (NCCN) and the American College of Chest Physicians (ACCP) currently recommend a follow-up CT scan of the chest every 6 months for the first 2 years after curative intent therapy for early stage NSCLC, and annually thereafter. [8, 16] The grade of evidence for the ACCP recommendation is 2C (weak recommendation based on low-quality evidence), based on a limited number of studies and expert consensus.

Positron Emission Tomography (PET) scanning is a newer tool that has experienced a rapid increase in use in cancer care over the last decade. [17, 18] The use of PET for surveillance has been controversial because it is more expensive than conventional CXR or CT, it incurs a higher radiation exposure, and there is no evidence that it improves patient outcomes. [19-25] Consequently, neither NCCN nor ACCP recommend that PET be used for lung cancer surveillance after curative intent treatment.

Little is known about surveillance practice patterns after curative intent treatment for NSCLC on a population level in the United States, as prior work has focused on either single institution studies, patients who received a specific type of treatment, or on imaging use in the first 8 months after treatment – a relatively short time interval that may yield underestimates of overall surveillance imaging use. [26, 27] Thus, our aims were twofold; first, we evaluated clinical practice patterns for imaging surveillance of stage I NSCLC after curative intent therapy in the Medicare population by tracking the use of CXR, CT, and PET scans during the first 2 years after treatment. Second, we compared these practice patterns to

contemporaneous practice guidelines. We also investigated the association between clinical and sociodemographic factors and adherence to surveillance imaging guidelines.

2. Materials and Methods

2.1 Data Source and Study Sample

Data were obtained from the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database, which contains tumor registry data linked to Medicare claims for patients representing 28% of the US population.[28, 29] We selected subjects aged 67 to 94 years who were diagnosed with stage I NSCLC between 1998 and 2008. Patients were identified as stage I using the American Joint Committee on Cancer (AJCC) stage variable before 2004 or the derived AJCC stage variable (based on collaborative staging variables) after 2004. Stage is based on data from both clinical staging techniques and surgical resection if performed. Exclusion criteria included the following: unknown month of diagnosis, diagnosis reported on death certificate or autopsy, prior cancer diagnosis, subsequent non-lung cancer diagnosis in the 12 months following the NSCLC diagnosis, or the absence of any claims billed to Medicare in the 2 years prior through 1 year after diagnosis. We also excluded patients from the Greater Georgia registry who were diagnosed prior to 2004, as we did not have complete claims for these patients.

Patients must have undergone curative intent therapy, defined as anatomical resection including pneumonectomy, lobectomy or segmentectomy, or definitive radiation therapy including traditional external beam radiation therapy, intensity-modulated radiation therapy, or stereotactic body radiation therapy.[30-32] To ensure complete reporting of Medicare claims, patients had to have been continuously enrolled in fee-for-service Medicare Parts A and B beginning 2 years prior to diagnosis through the end of the 2 year surveillance period. Finally, patients were included in the analysis if they were alive for the entire 2 year surveillance period, as we wanted to focus on those patients for whom imaging was most likely performed for surveillance; by excluding patients who died—including those who died from recurrence—we excluded patients for whom imaging was performed due to symptoms. The Yale Human Investigations Committee determined that this study did not constitute human subjects research.

2.2 Construction of variables

The primary outcome was receipt of guideline-adherent surveillance imaging during the 2 years after curative intent therapy. We used inpatient, outpatient, and physician Medicare claims to search for Healthcare Common Procedure Coding System codes for CXR, CT scan of the chest, and PET scan (Appendix 1). We defined patients as being eligible for surveillance starting at 3 months after the end of treatment in order to avoid capturing imaging tests that may have been related to treatment or complications. The end of treatment was defined as the date of surgical resection or the date of the last radiation therapy session.

Although the NCCN and ACCP guidelines changed slightly over the course of the study period, they were largely consistent (Appendix 2). In accordance with these guidelines, guideline-adherent surveillance was defined as at least four imaging studies (either CXR or

CT) performed during the two year period following curative intent therapy.[11, 16, 33] At least one of the studies needed to occur during the first six months of the surveillance period, and another during the last six months (Figure 1). The two additional imaging studies should have been obtained at least 120 days after the first and at least 120 days before the last. This strategy allowed for some leniency in the precise timing of the surveillance imaging. We also tested a more lenient scenario allowing for the last imaging study to occur up to 30 months after treatment, but this did not change our results. Although PET scans were not recommended in the guidelines, we also tested a model in which PET could substitute for a CXR or CT scan during the surveillance period, but giving “credit” for PET in this way did not significantly increase the estimates of guideline adherence (Appendix 3).

We selected patient, clinical, and cancer characteristics that we hypothesized might influence whether a patient received guideline-adherent lung cancer surveillance. Patient characteristics included age, sex, race, marital status, median household income at the census tract or zip code level, residence in a metro versus non-metro location, year of diagnosis, and SEER region. Clinical characteristics included number of comorbidities, health care system access, receipt of specific staging modalities, and whether primary curative treatment (either surgery or radiation) was received at a teaching hospital. Cancer characteristics included stage (IA v. IB v. I not otherwise specified), tumor size, histology, and type of treatment received.

Comorbidity was assessed using International Classification of Diseases, 9th revision (ICD-9), diagnosis codes reported on inpatient, outpatient, and physician Medicare claims in the period 24 through 3 months before NSCLC diagnosis. We calculated a comorbidity index score using the conditions suggested by Elixhauser that we had previously determined were significantly associated with survival in a sample of non-cancer patients.[34, 35] ICD-9 diagnosis codes had to appear on at least one inpatient claim or 2 outpatient/physician claims in order to be counted. We created a sum score of the number of comorbidities for each patient and then stratified patients into three groups: 0, 1 to 2, or 3 comorbidities.

Receipt of CT or PET for diagnosis or staging was assessed in the 6 months prior to start of treatment. Receipt of invasive staging procedures was assessed from 6 months prior to diagnosis through the start of treatment. To measure health care system access, we assessed whether patients had received a flu vaccine or had a primary care visit in the 24 through 3 months prior to diagnosis.[36]

2.3 Statistical Analysis

We calculated the distribution of the sample according to all covariates listed above and compared the percent of patients receiving guideline-adherent surveillance within each strata of the covariates using chi-squared tests. To analyze trends over time, we calculated the percent of the sample receiving each of the 3 imaging modalities (CXR, CT, and PET) during the first year of surveillance for each year of diagnosis (1998-2008), as well as temporal trends in guideline adherence with and without the inclusion of PET as a qualifying study in the definition of guideline adherence. We also calculated the mean and median number of CXR and CT scans patients received during the 2-year surveillance period. Finally, we used bivariate logistic regression to identify patient, health system, and

treatment factors that were associated with receipt of guideline-adherent surveillance. We subsequently constructed a multivariable logistic regression model, including all covariates that were significantly associated with the outcome in the bivariate models at $p < .05$. All analysis was performed using SAS version 9.2.

3. Results

Our sample included 9,321 patients diagnosed with stage I NSCLC from 1998 through 2008 (Table 1). Approximately 81% of our sample was 67 to 80 years old, 56.4% were female, and 90.9% were white. Over half (55.6%) of patients were stage IA and 58.8% had adenocarcinomas. Almost eighty percent (79.1%) of patients underwent lobectomy, 10.1% sublobar resection, 1.6% complete pneumonectomy, and 9.2% radiation therapy.

Overall, 95.7% of this population received either a CXR or CT scan during the first year of follow-up (Figure 2). Over the course of the study period, the use of CT during the first year post-treatment increased from 32.3% in 1998 to 78.9% in 2008, while the use of CXR decreased from 92.5% to 72.4%. The median number of imaging studies (either CXR or CT) during the 2-year surveillance period was 6, and 80.9% of patients received 4 or more tests during the first 2-years after treatment (Table 2).

Throughout the study period, 61.4% of patients received surveillance imaging consistent with guidelines. Guideline adherence ranged from 58.2% to 64.8% annually with no clear trend over time (Figure 2). In unadjusted analysis, factors associated with higher guideline adherence (Table 1) included white versus black race (61.8% vs 56.6%; $p = .03$), 3 versus no comorbidities (64.3% vs 58.4%; $p < .001$), prior flu vaccine or primary care visit (both $p < .001$), and pneumonectomy versus sublobar section (72.6% vs 62.3%; $p < .001$). Increasing age was associated with significantly lower adherence with surveillance guidelines.

In the multivariable model, factors associated with guideline adherence (Table 3) included access to primary care (OR 1.32; CI 1.20-1.44 for flu vaccine; OR 1.83; CI 1.44-2.31 for primary care visit), having 3 versus 0 comorbidities (OR 1.23; CI 1.08-1.40), receipt of radiation therapy versus sublobar section (OR 1.28; CI 1.02-1.62), and receiving care in a teaching versus non-teaching hospital (OR 1.11; CI 1.01-1.22). Older age was significantly associated with lower adherence (OR for 85-94 vs 67-69 0.51; CI 0.40-0.64). Race, non-metro residence, tumor size, stage, and histology were not associated with adherence when adjusted for other covariates.

Use of PET during the first year of surveillance increased from <2.7% to 24.8% between 1998 and 2008 (Figure 2 and Appendix 3). To test whether the substitution of PET scans for CT scans or CXRs was associated with increased guideline adherence, we performed a sensitivity analysis including PET as part of guideline-adherent surveillance. The estimate of adherence did not change significantly (64.3% with PET versus 61.4% without PET) (Appendix 3).

4. Discussion

Our study suggests that significant discrepancies exist between clinical practice guidelines and real world practice related to surveillance after treatment for early stage lung cancer. In our analysis, 61.4% of Medicare beneficiaries treated for stage I NSCLC received surveillance imaging as recommended by national guidelines, with no trend toward improvement over time. In addition, we found that the use of PET scans rose rapidly throughout the study period, despite little evidence to support this practice and published guidelines that specifically recommended against using PET for surveillance.

Although adherence to surveillance guidelines has been well characterized for breast and colorectal cancer and other areas of lung cancer care,[27, 37-46] few studies have examined surveillance practice patterns after curative therapy for NSCLC. Most of these studies have relied on small patient-populations[47] or physician surveys.[48-51] One study reporting the use of surveillance imaging in a large, nationally representative population found that 86.8% of patients received some kind of imaging study from 4 to 8 months after surgical resection of early stage NSCLC (47.6% CT and 68.5% CXR).[26] Although these findings highlight the use of imaging early in the surveillance period, adherence to guidelines over the entire 2 year surveillance period recommended by NCCN and ACCP was not measured. We used a more complete definition of adherence, taking the entire two-year period into account, and found substantially lower adherence with surveillance guidelines.

The increased use of PET scanning over the study period was noteworthy. By the end of our study period, roughly 30% of patients received at least one PET scan during the first year of follow-up. Whether this reflects a heavier reliance on the use of PET for evaluation of new symptoms or abnormal imaging after treatment for lung cancer, or an enthusiasm for PET as a surveillance modality, is unclear. It parallels a similar increase in the use of PET during the diagnostic and staging phases of lung cancer care,[18] though in those settings PET is recommended by guidelines.[52] It may be that the use of PET for surveillance is part of a pattern of non-guideline-based care that has recently been described in other areas of cancer care, including rates of excess, non-guideline-based care for colorectal and breast cancer of 73.3% and 67.7%, respectively.[53] Future studies should address the cost implications of this increased use of PET scans during the post-treatment surveillance period while clarifying their value in detecting progression or recurrence of disease.

Our findings add to a growing body of literature showing low adherence to clinical practice guidelines in medicine generally, and in lung cancer in particular.[27, 37, 46, 54] We found several factors to be associated with guideline adherence, including age, access to primary care, and comorbidities. Elderly patients may be particularly at risk of not receiving guideline-based lung cancer care.[55, 56] Notably, advancing age was associated with lower adherence with surveillance guidelines. The fact that older patients received less guideline-adherent care may reflect their own choices about how aggressive to be when faced with healthcare decisions, or may be related to physician decisions about what care to offer elderly patients.[44, 53, 57, 58] The fact that a prior visit with a primary care provider and the presence of comorbidities was associated with increased surveillance may simply reflect that these patients have more interactions with the healthcare system and thus have more

opportunities for receiving surveillance scans. In general, deviation from practice guidelines has been attributed to variations in patient or physician preferences, skepticism about the evidence behind the guidelines, and regional practice variation.[43, 45, 59-62]

It is reasonable for clinicians to question the evidence behind clinical practice guidelines for lung cancer surveillance, as the level of evidence in the most recent update of the ACCP guidelines was 2C, representing a weak recommendation based on low-quality evidence.[8] There is a lack of randomized clinical trials evaluating alternative lung cancer surveillance strategies.[12, 13] A meta-analysis suggested a slight mortality benefit to surveillance, but cautioned against drawing definitive conclusions given the wide range of study designs.[63] In a recent analysis of surgically treated early stage NSCLC patients, stage I patients who received early follow-up had significantly improved 5-year survival,[64] but whether ongoing surveillance over the entire recommended two-year post-treatment period was associated with improved survival was not assessed.

Despite the lack of definitive evidence that surveillance improves outcomes, it is possible that the low rates of adherence to surveillance adversely affect patients. The 5-year survival rate for “curable” early stage patients is only 50-70%, and much of this difference may be related to practice variation.[5, 45, 54, 65] A more nuanced approach to surveillance for lung cancer may be needed. If we could predict which patients are more likely to experience recurrence of disease or development of a second primary lung cancer,[2, 66] we might offer more aggressive surveillance to those individuals. Future work should explore risk stratification schemata based on patient, tumor, and other clinical factors that could guide tailored surveillance strategies.

It is also important to consider the potential adverse effects of excessive surveillance imaging. The median number of tests received by patients during the 2 year surveillance period was six. Although some of these tests may have been for clinical evaluation, rather than surveillance, excessive surveillance can harm patients. Overuse of radiographic studies leads to increased costs without a significant impact on meaningful clinical outcomes.[38] and there is evidence that excess radiation from serial CT scanning can lead to increased cancer risk,[67] although this risk may be more relevant for younger patients undergoing lung cancer screening programs than for our sample of older Medicare patients with shorter life expectancy. These are tangible risks in our population of patients who remain at increased risk of cancer even after definitive treatment, and who are more likely to undergo radiographic evaluation throughout the course of their future care.

Suggestions about how to enhance post-treatment lung cancer care in general and surveillance care in particular include having patients follow up with the original treating physician or with a specialist in pulmonology, thoracic surgery, or oncology for their surveillance care.[8] In addition, given that we found that access to primary care services was associated with increased adherence overall, a strategy to support primary care providers in managing or coordinating the surveillance care, such as clinical reminders in the electronic medical record, may be a reasonable approach, especially in locations where a comprehensive, multidisciplinary lung cancer program is not readily available.

Our study has several limitations. First, complete data were available only for patients diagnosed through 2008, so the impact of new research findings and guideline updates since that time were not assessed. Second, our study was limited to the Medicare population, and the results may not be generalizable to younger patients with other types of insurance. However, most lung cancer patients are older than 65, and thus our findings should be relevant to the majority of patients with lung cancer. Third, we assessed surveillance using Medicare data, which is based on administrative billing codes and is subject to coding errors. In addition, this dataset does not include explanations of why particular studies were ordered, so we cannot be certain that any given imaging study was ordered for surveillance or for another indication. Fourth, despite controlling for comorbidities and other demographic variables in our analysis, we cannot determine the causes of the difference in surveillance practice patterns that we observed in this retrospective analysis.

4.1. Conclusions

We found low adherence to clinical practice guidelines for follow-up surveillance imaging after curative intent therapy for stage I NSCLC in the Medicare population. At the same time, there was a dramatic increase in the use of PET during the early surveillance period, despite a lack of evidence to support its use. Ultimately, the goal is to improve survival for patients with lung cancer. Improving adherence to clinical practice guidelines may be one way to do that, but more work is needed to determine whether better adherence to clinical practice guidelines for lung cancer surveillance is associated with improved survival.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Dr. Erb was involved in all aspects of the work, from conception of the research questions to data analysis to writing the manuscript and final preparation for publication.

Mr. Su contributed to data interpretation and manuscript preparation and figure design.

Ms. Soulos was involved in all aspects of the work, from conception of the research questions to data analysis to writing the manuscript and final preparation for publication.

Dr. Tanoue was involved in all aspects of the work, from conception of the research questions to data analysis to writing the manuscript and final preparation for publication.

Dr. Gross was involved in all aspects of the work, from conception of the research questions to data analysis to writing the manuscript and final preparation for publication.

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Highlights

- Adherence to surveillance guidelines for stage I NSCLC was 61.4%.
- Receipt of appropriate surveillance was stable over time.
- Use of PET scans for surveillance increased from 1998 to 2008.

* Surveillance period extended to 27 months from the end of treatment, taking into account a 3-month lead-in period after treatment. In a "lenient" sensitivity analysis (allowing last study to occur as late as 30 months after curative treatment) there was no difference in the estimates of guideline adherence compared to the 27-month period.

Figure 1. Definition of Guideline Adherence

Guideline-adherent surveillance was defined as at least four imaging studies (either CXR or CT) performed during the two year period following curative intent therapy. At least one of the studies needed to occur during the first six months of the surveillance period, and another during the last six months. The two additional imaging studies should have been obtained at least 120 days after the first and at least 120 days before the last. This strategy allowed for some leniency in the precise timing of the surveillance imaging, in an effort to account for the uncertainties of clinical patient care.

* The Centers for Medicare and Medicaid Services prohibits reporting patient group sizes of fewer than 11 patients. Percent displayed for PET in 1998 and 1999 represents the minimum reportable value (2.7% and 2.6%, respectively), of which the actual percent is less.

Figure 2.
Use of chest radiography (CXR), computed tomography (CT), and Positron Emission Tomography (PET)* imaging during the first year of surveillance, and adherence with surveillance guidelines over the recommended two-year surveillance period, 1998-2008.

Table 1

Patient Characteristics and Receipt of Guideline-Adherent Surveillance

	Total		Received Guideline-Adherent Surveillance	
	N	%	%	<i>p</i>
Total	9321		61.4	
Patient Characteristics				
Age				<.001
67-69	1725	18.5	65.1	
70-74	3116	33.4	63.3	
75-79	2702	29.0	60.8	
80-84	1355	14.5	56.3	
85-94	423	4.5	52.0	
Sex				.47
Male	4062	43.6	61.8	
Female	5259	56.4	61.1	
Race				.03
White	8472	90.9	61.8	
Black	440	4.7	56.6	
Other	409	4.4	58.0	
Marital status				<.001
Married	5206	55.9	64.2	
Not married	3835	41.1	57.4	
Unknown	280	3.0	63.6	
Income (\$)				.06
<33,000	1883	20.2	59.0	
33,000-40,000	1324	14.2	62.8	
40,000-50,000	1995	21.4	62.1	
50,000-63,000	1820	19.5	60.3	
>63,000	2299	24.7	62.8	
Residence				.02
Metro	7792	83.6	60.9	
Non-metro	1529	16.4	64.0	
Clinical Characteristics				
Comorbid conditions				<.001
0	3421	36.7	58.4	
1-2	4196	45.0	62.7	
3	1704	18.3	64.3	
Prior flu vaccine				<.001
No	3368	36.1	56.0	
Yes	5953	63.9	64.4	

	Total		Received Guideline-Adherent Surveillance	
	N	%	%	<i>p</i>
Prior primary care visit				<.001
No	348	3.7	41.7	
Yes	8973	96.3	62.1	
Receipt of PET for tumor staging				<.001
No	3448	37.0	57.7	
Yes	5873	63.0	63.6	
Receipt of CT for tumor staging				<.001
No	400	4.3	43.5	
Yes	8921	95.7	62.2	
Receipt of invasive tumor staging				.02
No	8554	91.8	61.02	
Yes	767	8.2	65.35	
Hospital teaching status				<.001
Non-teaching	3636	39.0	59.1	
Teaching	5412	58.1	62.6	
Free-standing facility	273	2.9	67.8	
Cancer Characteristics				
Stage				.02
IA	5195	55.7	60.2	
IB	4086	43.8	62.8	
I NOS	40	0.4	72.5	
Tumor size (cm)				.03
2.0	3548	38.1	60.5	
2.1-3.0	2810	30.2	59.9	
3.1-5.0	2201	23.6	63.3	
5.1-7.0	486	5.2	65.0	
7.1	188	2.0	67.0	
Unknown	88	0.9	63.6	
Histology				.74
Adenocarcinoma	5484	58.8	60.9	
Squamous Cell	2788	29.9	62.2	
Large Cell	351	3.8	61.0	
Other	698	7.5	61.9	
Type of treatment				<.001
Sublobar	942	10.1	62.3	
Lobectomy	7372	79.1	60.3	
Pneumonectomy	146	1.6	72.6	
Radiation therapy	861	9.2	67.7	

Table 2

Number of chest radiographs and computed tomography scans per person during the 2-year post-treatment surveillance period

Mean (SD)	7.4 (5.8)
Median (IQR)	6 (4-9)
N (%) received 1 test	9158 (98.3)
N (%) received 2 tests	8866 (95.1)
N (%) received 3 tests	8328 (89.3)
N (%) received 4 tests	7540 (80.9)
N (%) received 6 tests	5355 (57.5)
N (%) received 8 tests	3445 (37.0)
N (%) received 10 tests	2141 (23.0)

Table 3

Association between patient, clinical, and cancer characteristics and receipt of guideline-adherent surveillance.

	Odds Ratio	95% Confidence Interval		P-value
Patient Characteristics				
Age				<.001
67-69	1.00	--	--	
70-74	0.89	0.78	1.01	
75-79	0.76	0.67	0.87	
80-84	0.63	0.54	0.74	
85-94	0.51	0.40	0.64	
Race				.29
White	1.00	--	--	
Black	0.85	0.69	1.05	
Other	0.93	0.73	1.17	
Marital status				<.001
Married	1.00	--	--	
Not married	0.78	0.72	0.86	
Unknown	0.87	0.67	1.14	
Income (\$)				<.001
<33,000	1.00	--	--	
33,000-40,000	1.22	1.05	1.42	
40,000-50,000	1.25	1.08	1.44	
50,000-63,000	1.22	1.05	1.43	
>63,000	1.43	1.23	1.67	
Residence				.67
Metro	1.00	--	--	
Non-metro	1.03	0.90	1.19	
Clinical Characteristics				
Comorbid conditions				.002
0	1.00	--	--	
1-2	1.13	1.03	1.25	
3	1.24	1.09	1.41	
Prior flu vaccine				<.001
No	1.00	--	--	
Yes	1.32	1.20	1.44	
Prior primary care visit				<.001
No	1.00	--	--	
Yes	1.83	1.44	2.31	
Receipt of PET for tumor staging				<.001
No	1.00	--	--	

	Odds Ratio	95% Confidence Interval		P-value
Yes	1.37	1.23	1.53	
Receipt of CT for tumor staging				<.001
No	1.00	--	--	
Yes	1.77	1.42	2.19	
Receipt of invasive tumor staging				.06
No	1.00	--	--	
Yes	1.17	0.99	1.37	
Hospital teaching status				.12
Non-teaching	1.00	--	--	
Teaching	1.11	1.01	1.22	
Free-standing facility	1.08	0.78	1.49	
Cancer Characteristics				
Stage				.24
IA	1.00	--	--	
IB	1.05	0.92	1.20	
INOS	2.10	0.83	5.32	
Tumor size (cm)				.33
2.0	1.00	--	--	
2.1-3.0	1.00	0.90	1.11	
3.1-5.0	1.13	0.97	1.33	
5.1-7.0	1.16	0.92	1.47	
7.1	1.27	0.90	1.78	
Unknown	0.72	0.40	1.31	
Type of treatment				<.001
Sublobar	1.00	--	--	
Lobectomy	0.89	0.76	1.03	
Pneumonectomy	1.39	0.92	2.09	
Radiation therapy	1.28	1.02	1.62	

* Also adjusted for SEER registry and year of diagnosis.