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Title: Lack of adherence to guideline-based imaging prior to subsequent radiation in patients with non-small cell lung cancer: Impact on patient outcomes

Running Title: PET/CT prior to subsequent radiation

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ABSTRACT

Lung cancer is the leading cause of cancer deaths within the United States, yet prior studies have shown a lack of adherence to imaging and treatment guidelines in patients with lung cancer. This paper evaluates the use of FDG PET/CT imaging prior to subsequent radiation therapy in patients with non-small cell lung cancer, as recommended by National Comprehensive Cancer Network (NCCN) guidelines, and whether the use of this imaging modality impacts cancer-specific survival.

Methods: This was a retrospective study of the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) program Medicare linked data in patients with non-small cell lung cancer. Hazard ratios (HRs) and 95% confidence intervals (CIs) for overall and cancer-specific survival were estimated for patients diagnosed between 2006-2015 who underwent either FDG PET/CT or CT based imaging prior to subsequent radiation therapy.

Results: Significant improvement in cancer-specific survival was found in patients who had FDG PET/CT imaging prior to subsequent radiation therapy, compared to those who underwent CT (HR, 1.43; 95% CI, 1.32-1.55, p <0.0001). While the NCCN recommends FDG PET/CT prior to subsequent radiation therapy, 43.6% of patients were imaged with CT alone.

Conclusion: Many patients with non-small cell lung cancer are not being imaged according to national guidelines prior to subsequent radiation, which is associated with a lower cancer specific survival.

Key Words: PET/CT, surveillance, radiation therapy, non-small cell lung cancer, guidelines

INTRODUCTION

Lung cancer remains the leading cause of cancer-related deaths within the United States. The most recent data from 2020 found that lung cancer caused more deaths than breast, prostate, and colorectal cancers combined, accounting for almost 1 out of 4 cancer deaths (*1*). Despite this statistic, there is reason for optimism: during 2016-2017 there was a 2.2% decrease in overall cancer mortality, the largest decline recorded in a single year with persistent declines in lung cancer mortality (*1*). Management of non-small cell lung cancer (NSCLC) is becoming more nuanced with molecular testing to guide therapy based on the patients' underlying mutations (*2*). This has led to the idea of limited metastatic burden at the time of diagnosis, also known as oligometastatic disease, and limited progressive disease of a few metastatic sites on systemic therapy, also known as oligoprogressive disease. Either form of limited baseline or progressive metastatic disease can potentially be treated with definitive local ablative therapy, such as minimally invasive surgery, radiation therapy (RT), radiofrequency ablation, or cryoablation. Local ablative therapy has been shown to improve patient outcomes and has the potential to decrease invasive surgeries (*3*).

Imaging with fluorodeoxyglucose positron emission tomography (FDG PET/CT) can provide additional information to guide treatment for patients with oligoprogressive disease. Multiple prior studies have established the superiority of PET/CT over CT alone for NSCLC staging and treatment planning. Specifically, PET/CT has high sensitivity of tumor, nodal, and metastatic staging (*4*); can differentiate between recurrent disease and radiation treatment changes (*5*); increases detection of oligoprogressive disease outside of the central nervous system (*6*); improves selection of patients for thoracotomy (*7-9*); and can change treatment decisions for up to 72% of patients with NSCLC (*10*). PET/CT also provides prognostic information pertinent to treatment planning. Patients with higher SUVmax on pre-treatment PET/CT have decreased overall survival and increased recurrence (*11-13*) and baseline use of FDG PET/CT at the time of diagnosis is associated with improved cancer specific survival (*14*).

Given these benefits, the National Comprehensive Cancer Network (NCCN) currently recommends that all patients regardless of stage should be routinely screened for recurrence using CT of the chest, with or without contrast enhancement. If there is evidence of recurrence, FDG PET/CT is recommended to evaluate for locoregional recurrence versus distant metastases (*15*)**.** Prior studies of various cancers including colon cancer, soft tissue sarcoma, epithelial ovarian cancer, pancreatic cancer, and NSCLC have shown that improved adherence to NCCN guidelines leads to improved outcomes in survival (*16-20*). Research has demonstrated a lack of compliance of

imaging and treatment recommendations in patients with lung cancer (*14,21,22*). We hypothesized that in the case of NSCLC being treated with subsequent RT, many patients are not receiving guideline recommended imaging and this lack of adherence is associated with lower patient survival.

MATERIALS AND METHODS:

Data Sources

This was a retrospective study of patients with NSCLC in the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database. We compared outcomes of patients who underwent radiation for oligoprogressive or recurrent disease based on whether their most recent imaging was CT vs FDG PET/CT. SEER, a program of the National Cancer Institute, includes information on patient demographics, tumor characteristics at diagnosis, and treatment information from 18 population-based tumor registries that cover approximately 28% of the US population. Medicare claims provide information on the health services and facility where services were received, and census information are linked to the SEER data for additional geographically-based sociodemographic factors (*23,24*).

Cohort Selection

We selected patients aged 66 years or older at diagnosis, whose first primary tumor was NSCLC from 2007 through 2015. Patients were included at age 66 or older so there would be at least one year of data to identify patients who had cancer prior to enrolling in Medicare. We excluded patients who were diagnosed via death certificate or at autopsy, as well as patients who had an unknown diagnosis date. We required continuous enrollment in fee-for-service Medicare parts A and B for 12 months prior through 12 months after the month of diagnosis (or until death if it occurred within 12 months) to ensure complete claims history for comorbidities prior to diagnosis and services received after diagnosis. We also excluded patients who had no paid claims in the 12 months after diagnosis, patients who were stage 0, patients who were missing census tract, and patients who had an unknown stage, rural measure, or race.

To best identify patients with disease requiring subsequent RT, we required a specific sequence of events to have occurred after diagnosis. From the cohort, we identified anyone who received initial treatment within 6 months of diagnosis and had subsequent radiation within 36 months of the completion of initial treatment. A gap of 90 days and over was required to distinguish the initial treatment and subsequent treatment. As we were interested in

outcomes by modality of imaging for oligoprogressive disease, we further limited our sample to patients with imaging occurring within 60 days prior to the subsequent RT. Our final sample with qualifying treatment and imaging included 5,017 patients. All inclusion and exclusion criteria are outlined in Supplemental Figure 1. Per NCCN guidelines regarding treatment, this could include patients with local or metastatic recurrent disease or patients with progression at a limited number of sites (oligoprogressive disease).

We used International Classification of Diseases, 9th and 10th revision, Clinical Modification codes, Current Procedural Terminology codes, and Healthcare Common Procedure Coding System (HCPCS) codes to identify the diagnoses and procedures.

Treatment Identification

Initial treatment was defined as chemotherapy, radiation therapy, or surgery for NSCLC within 6 months after diagnosis. We categorized initial treatment as surgery alone, radiation therapy alone, chemotherapy alone, surgery and radiation, surgery and chemotherapy, chemo-radiotherapy, or surgery with chemo-radiotherapy. We required at least 90 days to define separate treatment periods; subsequent radiation after the initial treatment period was defined as having occurred at least 90 days after initial treatment. We also required this subsequent radiation to have occurred within 36 months of initial treatment. Codes used to identify initial treatment and subsequent radiation therapy can be found in Supplemental Table 1.

Imaging Identification

Imaging procedures of interest were defined as imaging occurring after initial treatment and within 60 days prior to subsequent RT. These were categorized into 2 groups: (1) CT or computed tomography angiography (CTA) of the Abdomen, Chest, and Pelvis, and, (2) any FDG PET either with or without CT/CTA. Initial imaging at the time of diagnosis was also assessed. The imaging codes used in this study can be found in Supplemental Table 1.

Statistical Analysis

For comparing baseline characteristics of demographic and diagnostic information, Chi-Square test were performed to test statistically significant differences in each categorical variables by imaging modalities. Categories tested were year of diagnosis, age at diagnosis (66-69, 70-74, and 75 years or older), race (White, Black, Hispanic, or other/unknown), sex (male/female), marital status (married/partner or single), region, residence (in an urban communing area or not), socioeconomic status (poverty level, percentage high school education or less), comorbidities prior to diagnosis, facility type (National Cancer Institute (NCI) designated center, teaching hospital

or other/no hospital), initial derived AJCC Stage Group 6th edition, initial imaging, histology subtype, and type of initial treatment. We used Medicare claims from the year before diagnosis to estimate the Charlson Comorbidity Index according to the NCI's adaptation of the Klabundle et al algorithm (*25*).

Logistic regression was performed to identify predictors of imaging type, adjusting for the covariates included in the univariate table, and odds ratios between groups were compared.

Overall survival and cancer-specific survival between imaging modalities was estimated at 36 months after diagnosis. Overall survival time was determined using Medicare-reported dates of death which are reported through December 2018. However, cancer-specific survival time was determined using SEER-reported dates of death, which include cause of death and are through December 2016. Patients living longer than 36 months were censored at 36 months.

The Kaplan-Meier method and unadjusted Cox proportional hazards were used for univariate survival analyses. Multivariate cancer-specific survival analyses were completed using Cox proportional hazard models, adjusting for covariates. The proportional hazards assumption was evaluated using Schoenfeld residuals and violations were addressed using time-dependent interaction terms in multivariable models. A forward stepwise analysis was completed. The base model included demographic characteristics, stratified model added stage, initial treatment and facility type to the base model and the full model included all previous covariates and imaging modality.

All statistical analyses were performed with SAS 9.4 (SAS Institute, Cary NC) and evaluated at a critical α of 0.05. This study was reviewed and approved by the University of Colorado Institutional Review Board. It was conducted under a data use agreement with National Cancer Institute.

RESULTS

We identified a total of 5,017 patients who underwent subsequent RT for oligoprogressive or recurrent NSCLC after completing initial therapy. Of these patients, 84.2% were non-Hispanic white, 6.7% were black, 3.6% were Hispanic, and 5.5% were other/unknown. 2,829 (56.3%) patients underwent FDG PET/CT prior to subsequent radiation, while 2,188 (43.6%) patients had imaging with CT/CTA alone (Table 1). Of note, patients with an initial treatment of surgery demonstrated increased PET/CT usage (65.4% had a PET/CT) while patients with an initial treatment of chemotherapy had decreased PET/CT usage (38.9% had PET/CT) (Table 1, Supplemental Table 2).

There was no difference in imaging use between NCI centers, teaching hospitals, or other/no hospital (Supplemental Table 3).

There was a significant difference in PET/CT use depending on initial patient stage and initial treatment regimen. Stages III and IV were less likely to be imaged with FDG PET/CT than stages I and II (OR 0.695, 95% CI 0.58-0.83, p <0.0001 and OR 0.455, 0.38-0.55, p <0.0001 respectively). Overall, patients who received initial treatment with chemotherapy or chemotherapy and radiation were less likely to undergo imaging with FDG PET/CT compared to radiation alone (OR 0.625, 95% CI 0.50-0.78, p <0.0001 and OR 0.827, 0.69-1.00, p 0.0464). Conversely, patient who received initial treatment of chemotherapy plus surgery were more likely to have imaging with FDG PET-CT (OR 1.337, 95% CI 1.04-1.72, p 0.0223). Patients of black or other/unknown ethnicity were less likely to have imaging with PET/CT than white non-Hispanic patients (OR 0.688, 95% CI 0.54-0.88, p 0.0023 and OR 0.752, 95% CI 0.58-0.98, p 0.0336). Patients initially imaged with CT/CTA alone were also less likely to have subsequent imaging with PET (OR 0.673, 95% CI 0.56-0.81, p<0.0001) (Table 2).

When survival was compared over a 3-year follow-up period, patients who had received a CT/CTA alone rather than FDG PET/CT prior to subsequent RT had lower overall survival (HR 1.417, 95% CI 1.32-1.52, p <0.0001) and cancer specific survival (HR 1.430, 95% CI 1.32-1.55, p <0.0001) (Figure 1, Table 3) when controlling for initial stage, initial diagnostic imaging, and histologic subtype. Other factors associated with decreased survival included male sex, increased age, histologic subtype other than adenocarcinoma, initial diagnostic imaging with CT/CTA alone, and stages II, III, or IV (Table 3, Supplemental Table 4). Our study found increased overall and cancer-specific survival in the other/unknown race category (HR 0.823, 95% CI 0.70-0.97, p 0.0195 and HR 0.799, 95% CI 0.67-0.96, p 0.0162).

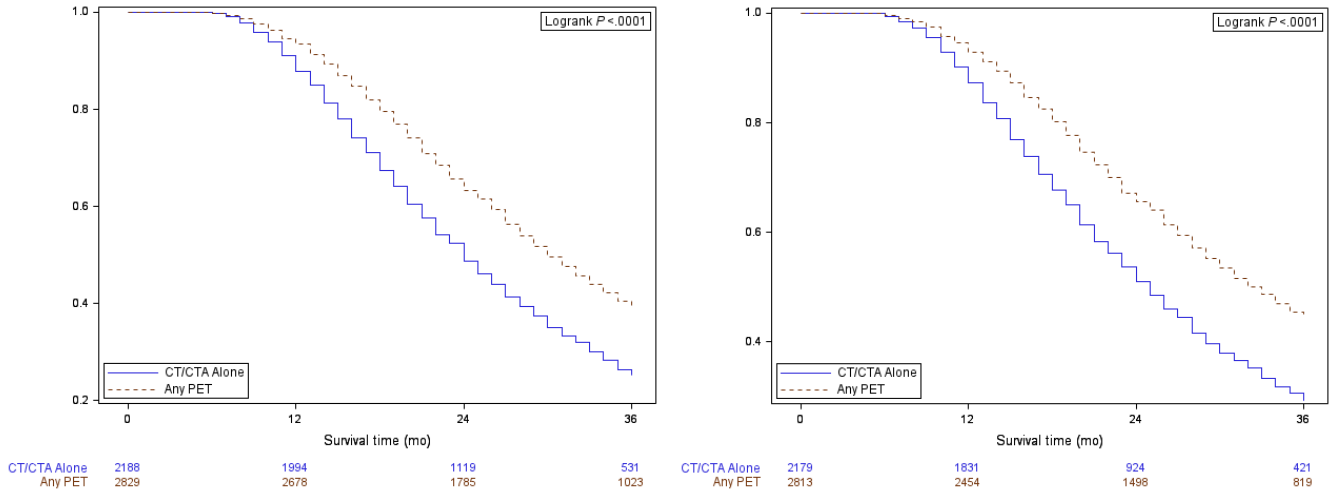

Figure 1: Impact of Imaging Modality (CT/CTA alone versus any PET) on 3-year Survival in Patients with NSCLC, SEER 2007-1015. Left: Overall survival; Right: Cancer-specific survival.

DISCUSSION

This study demonstrates a significant lack of adherence to guideline-based imaging recommendations, which negatively impacts the survival of patients with NSCLC. Approximately one out of every two patients who undergo subsequent RT do not receive the recommended pre-radiation FDG PET/CT examination. This lack of adherence is present throughout all institutions, regardless of patient volume or frequency of patient encounters.

In general, patients with higher stages of disease, especially stage III or IVA, were less likely to undergo FDG PET/CT prior to subsequent RT. Patients who initially received treatment with chemotherapy or chemotherapy and radiation were less likely to be imaged with PET/CT. Patients who initially received chemotherapy with or without radiation instead of surgery likely had higher stage of disease at initial diagnosis. This disparity in the lack of FDG PET/CT in patients with higher stages of disease could be a result of provider bias toward patients with advanced disease for whom CT or CTA is considered adequate for monitoring rather than the more sensitive FDG PET/CT imaging, which is utilized more for lower stage patients who are more carefully evaluated for disease recurrence. These trends suggest specific areas for improvement of practice patterns, with focused efforts to increase adherence to NCCN guidelines.

The advantage of PET/CT lies in its superior ability to detect metabolically active target sites for RT, which improves disease control and in turn results in improved survival. Prior studies have suggested PET/CT improves

detection of sites in oligoprogressive disease (*6*). The survival benefit associated with hybrid imaging was again demonstrated in this study, regardless of disease stage. Patients who received a FDG PET/CT for either initial or subsequent imaging experienced improved overall and cancer-specific survival over a 3-year period compared to CT/CTA alone or other imaging. Greater adherence to NCCN guidelines was associated with improved survival for NSCLC patients.

In addition to institutional practices which may influence PET/CT usage, insurance denials are a common barrier to utilization of advanced diagnostic imaging. While exact clinical circumstances vary between patients, in general, PET/CT scans are covered under Medicare for the diagnosis, staging, and restaging of NSCLC (*26*). The population in our study should have met PET/CT insurance coverage criteria for purposes of restaging after recurrence or progression and prior to subsequent RT.

Our findings are relevant as they support the importance of following current clinical NCCN guidelines, while also demonstrating a lack of guideline adherence in many circumstances. There is an opportunity to improve PET/CT use and possibly cancer specific survival through increased provider awareness and active intent to change. Prior studies have suggested routine chart review and audits (*27*) or the use of a tumor board with a dedicated oncology nurse navigator to improve adherence to NCCN guidelines (*28*). Our study suggests that there is still substantial effort required to improve adherence on a national scale.

There are several limitations to our current study. Our analyses were based on SEER registry data in a Medicare fee-for-service population, with required coverage 12 months prior to and following diagnosis, decreasing our sample size and limiting generalizability to all Medicare patients. Application to younger patients or patients with other forms of insurance (or uninsured) requires further study. The SEER data available for analysis includes treated patients between 2005-2014, which limits our staging analysis to AJCC 6th edition rather than the more recently updated 8th edition. SEER data also only includes initial stage, so we are unable to account for extent of disease at the time of subsequent RT. SEER registries are reported to have greater economic disadvantage, and greater racial and ethnic diversity, which may limit the results generalizability to the national population (*29*). Although our multivariable analysis controlled for numerous independent variables such as age, stage, sex, and facility, there may be unobservable characteristics that also impact the disparate usage of imaging (*30*).

CONCLUSION

Nearly half of Medicare patients with NSCLC who undergo subsequent radiation therapy are not being staged according to NCCN guidelines. There is decreased overall and cancer specific survival for patients who receive imaging with CT/CTA alone rather than FDG PET/CT. Further research is needed to identify additional factors which contribute to overall survival, causes of current disparities in PET/CT use, and interventions to improve adherence to NCCN guidelines.

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KEY POINTS

Question: Are patients with recurrent non-small cell lung cancer being imaged according to national guidelines and if not, is this affecting mortality outcomes?

Pertinent Findings: This is a retrospective analysis of patients in the SEER-Medicare database which looks at the use of CT/CTA alone versus PET/CT imaging for patients with non-small-cell lung cancer. 43.6% of patients did not receive guidelines recommended imaging with PET/CT, and patients with CT/CTA alone had statistically significant decreased overall and cancer-specific survival.

Implications for Patient Care: These findings find a lack of guidelines-recommended PET/CT imaging for non-small cell lung cancer patients which affects survival rates.

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TABLES

Table 1. Characteristics by imaging modality before subsequent radiation therapy of NSCLC patients

Characteristic	Total	CT/CTA Alone	Any PET	p-value
All Patients	**5,017**	**2,188**	**2,829**	**.**
Race/Ethnicity Category				
White NH	4,223 (84.2)	1,786 (81.6)	2,437 (86.1)	<.0001
Black NH	337 (6.7)	183 (8.4)	154 (5.4)	.
Hispanic	179 (3.6)	80 (3.7)	99 (3.5)	.
Other/Unknown	278 (5.5)	139 (6.4)	139 (4.9)	.
Patient Region at Diagnosis				
East	1,061 (21.1)	493 (22.5)	568 (20.1)	0.0215
Midwest	617 (12.3)	285 (13.0)	332 (11.7)	.
South	1,510 (30.1)	618 (28.2)	892 (31.5)	.
West	1,829 (36.5)	792 (36.2)	1,037 (36.7)	.
Facility Types				
NCI Center	605 (12.1)	296 (13.5)	309 (10.9)	0.0179
Teaching Hospital	2,021 (40.3)	873 (39.9)	1,148 (40.6)	.
Other/No Hospital	2,391 (47.7)	1,019 (46.6)	1,372 (48.5)	.
Derived AJCC Stage Group 6th Edition				
Stage I	1,597 (31.8)	518 (23.7)	1,079 (38.1)	<.0001
Stage II	472 (9.4)	160 (7.3)	312 (11.0)	.
Stage III	1,511 (30.1)	675 (30.9)	836 (29.6)	.
Stage IVA	1,437 (28.6)	835 (38.2)	602 (21.3)	.
Initial Treatment				
Radiation	943 (18.8)	385 (17.6)	558 (19.7)	<.0001
Surgery	1,217 (24.3)	421 (19.2)	796 (28.1)	.
Chemotherapy	659 (13.1)	402 (18.4)	257 (9.1)	.
Surgery and Radiation	112 (2.2)	39 (1.8)	73 (2.6)	.
Chemotherapy and Radiation	1,348 (26.9)	676 (30.9)	672 (23.8)	.
Chemotherapy and Surgery	488 (9.7)	158 (7.2)	330 (11.7)	.
Chemotherapy, Surgery and Radiation	250 (5.0)	107 (4.9)	143 (5.1)	.
Diagnostic Imaging Category				
CT/CTA Alone	531 (10.6)	285 (13.0)	246 (8.7)	<.0001
Any PET	4,440 (88.5)	1,885 (86.2)	2,555 (90.3)	.
No related imaging	46 (0.9)	18 (0.8)	28 (1.0)	.
Histologic Subtype of NSCLC				
Adenocarcinoma	2,546 (50.7)	1,157 (52.9)	1,389 (49.1)	<.0001
Adenosquamous	120 (2.4)	47 (2.1)	73 (2.6)	.
Large cell carcinoma	117 (2.3)	54 (2.5)	63 (2.2)	.
Neuroendocrine	89 (1.8)	57 (2.6)	32 (1.1)	.
Squamous cell carcinoma	1,542 (30.7)	601 (27.5)	941 (33.3)	.
Other/Not-specified	603 (12.0)	272 (12.4)	331 (11.7)	.

Note: Data presented as No. (Column %), highlighted significance level of $p < 0.05$ in red.

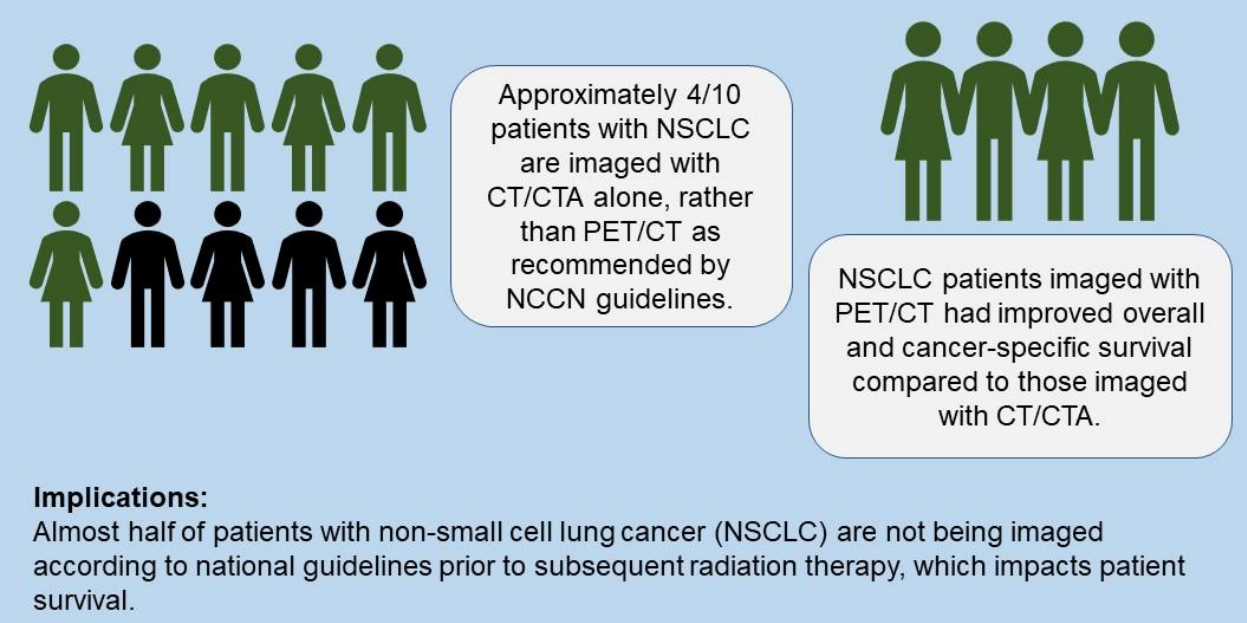
Abbreviations: CT, Computerized tomography imaging; PET, Positron emission tomography imaging; HS, High school; NCI, National Cancer Institute; AJCC, American Joint Committee on Cancer.

Table 2: Logistic regression predicting whether patients received PET or not

Characteristics	OR (95% CI)	p-value	Global p-value
Race/Ethnicity Category			
White NH (ref))		.	0.0044
Black NH vs White NH	0.688 (0.54, 0.88)	0.0023	.
Hispanic vs White NH	0.958 (0.70, 1.32)	0.7944	.
Other/Unknown vs White NH	0.752 (0.58, 0.98)	0.0336	.
Patient Region at Diagnosis			
West (ref)		.	0.0374
East vs West	0.799 (0.67, 0.95)	0.0111	.
Midwest vs West	0.856 (0.70, 1.05)	0.1390	.
South vs West	0.996 (0.85, 1.17)	0.9655	.
Derived AJCC Stage Group 6th Edition			
Stage I (ref)		.	<.0001
Stage II vs Stage I	0.880 (0.70, 1.11)	0.2769	.
Stage III vs Stage I	0.695 (0.58, 0.83)	<.0001	.
Stage IVA vs Stage I	0.455 (0.38, 0.55)	<.0001	.
Initial Treatment			
Radiation (ref)		.	<.0001
Chemotherapy vs Radiation	0.625 (0.50, 0.78)	<.0001	.
Chemotherapy and Radiation vs Radiation	0.827 (0.69, 1.00)	0.0464	.
Chemotherapy and Surgery vs Radiation	1.337 (1.04, 1.72)	0.0223	.
Chemotherapy, Surgery and Radiation vs Radiation	0.969 (0.72, 1.31)	0.8356	.
Surgery vs Radiation	1.093 (0.90, 1.33)	0.3676	.
Surgery and Radiation vs Radiation	1.259 (0.83, 1.92)	0.2843	.
Diagnostic Imaging Category			
Any PET (ref)		.	0.0002
CT/CTA Alone vs Any PET	0.673 (0.56, 0.81)	<.0001	.
No related imaging vs Any PET	1.178 (0.64, 2.18)	0.6019	.
Histologic Subtype of NSCLC			
Adenocarcinoma (ref)		.	0.0183
Adenosquamous vs Adenocarcinoma	1.065 (0.72, 1.57)	0.7528	.
Large cell carcinoma vs Adenocarcinoma	0.920 (0.62, 1.35)	0.6718	.
Neuroendocrine vs Adenocarcinoma	0.576 (0.36, 0.91)	0.0187	.
Squamous cell carcinoma vs Adenocarcinoma	1.176 (1.02, 1.35)	0.0212	.
Other/Not-specified vs Adenocarcinoma	1.148 (0.95, 1.39)	0.1537	.

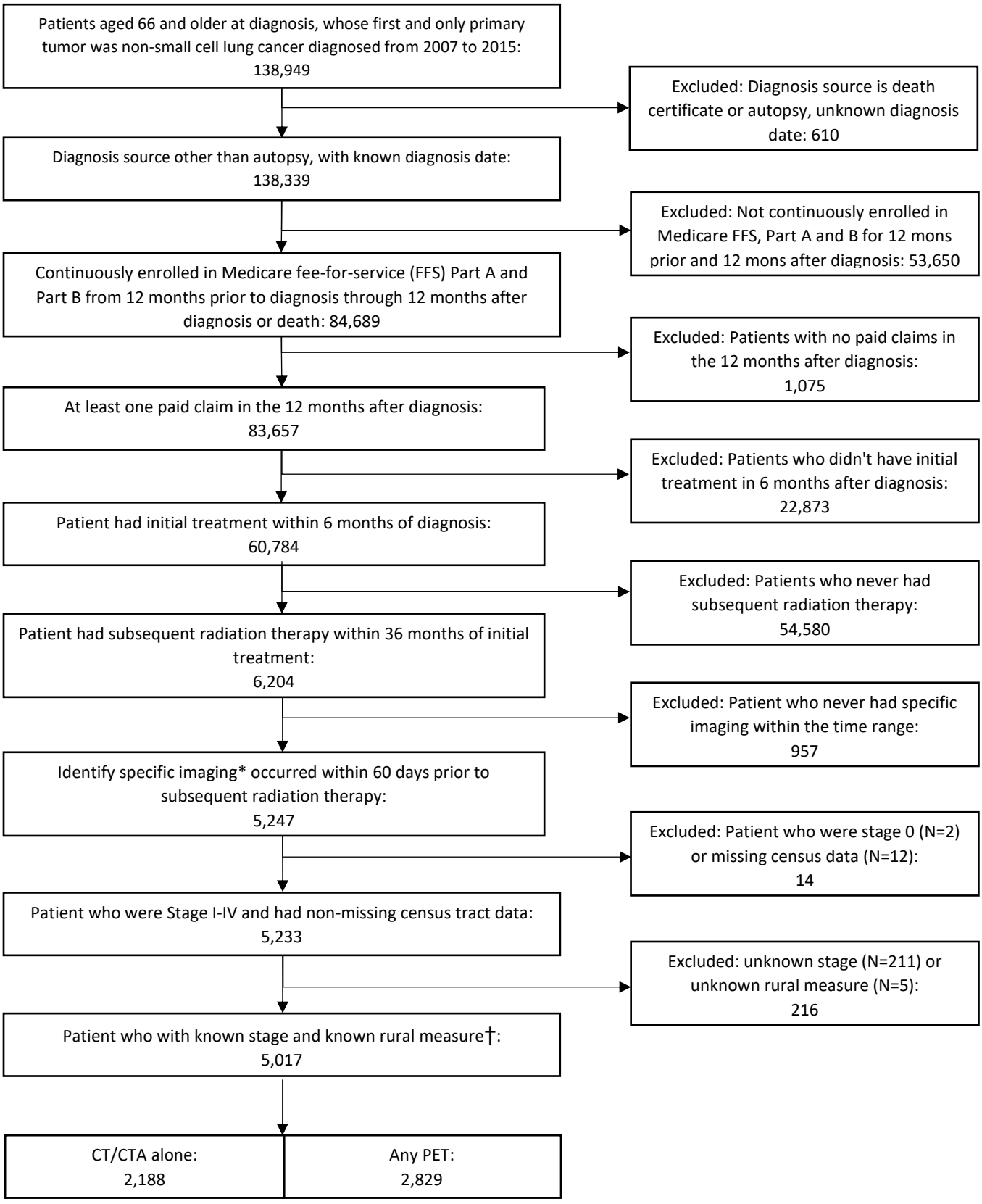
Table 3: Multivariate Analysis of Survival at 3-year Follow Up.

	Overall Survival				Cancer-Specific Survival		
Characteristics	**HR (LCL-UCL)**	**P-value**	**Global p-value**		**HR (LCL-UCL)**	**P-value**	**Global p-value**
Age Category							
66 to 69 (ref)			0.0066				0.0079
70 to 74	0.988 (0.90, 1.08)	0.7992	.		0.940 (0.85, 1.04)	0.2436	.
75 and Older	1.115 (1.02, 1.22)	0.0157	.		1.089 (0.99, 1.20)	0.0901	.
Sex							
Male (ref)			0.0012				0.0008
Female	0.886 (0.82, 0.95)	0.0012	.		0.869 (0.80, 0.94)	0.0008	.
Facility Types							
NCI Center (ref)			0.0174				0.0191
Other/No Hospital	1.151 (1.02, 1.30)	0.0205	.		1.164 (1.02, 1.33)	0.0280	.
Teaching Hospital	1.050 (0.93, 1.18)	0.4213	.		1.047 (0.91, 1.20)	0.5064	.
Derived AJCC Stage Group 6th Edition							
Stage I (ref)			<.0001				<.0001
Stage II	1.906 (1.62, 2.25)	<.0001	.		1.920 (1.59, 2.31)	<.0001	.
Stage III	2.057 (1.67, 2.54)	<.0001	.		2.135 (1.70, 2.69)	<.0001	.
Stage IVA	2.810 (2.11, 3.74)	<.0001	.		2.846 (2.08, 3.89)	<.0001	.
Initial Treatment							
Radiation (ref)			<.0001				<.0001
Chemotherapy	0.681 (0.58, 0.80)	<.0001	.		0.696 (0.58, 0.83)	<.0001	.
Chemotherapy and Radiation	0.533 (0.42, 0.67)	<.0001	.		0.537 (0.42, 0.69)	<.0001	.
Chemotherapy and Surgery	0.278 (0.20, 0.38)	<.0001	.		0.272 (0.19, 0.38)	<.0001	.
Chemotherapy, Surgery, and Radiation	0.337 (0.23, 0.49)	<.0001	.		0.330 (0.22, 0.50)	<.0001	.
Surgery	0.673 (0.59, 0.76)	<.0001	.		0.675 (0.58, 0.78)	<.0001	.
Surgery and Radiation	0.466 (0.34, 0.63)	<.0001	.		0.415 (0.29, 0.59)	<.0001	.
Histologic Subtype of NSCLC							
Adenocarcinoma (ref)			<.0001				0.0005
Adenosquamous	1.471 (1.17, 1.85)	0.0010	.		1.392 (1.07, 1.81)	0.0138	.
Large cell carcinoma	1.416 (1.11, 1.81)	0.0059	.		1.315 (1.00, 1.72)	0.0470	.
Neuroendocrine	1.375 (1.02, 1.85)	0.0342	.		1.455 (1.05, 2.01)	0.0232	.
Squamous cell carcinoma	1.719 (1.40,2.11)	<.0001	.		1.644 (1.32, 2.05)	<.0001	.
Other/Not-specified	1.728 (1.34,2.23)	<.0001	.		1.687 (1.28, 2.22)	0.0002	.
Diagnostic Imaging Category							
Any PET (ref)			<.0001				0.0001
CT/CTA Alone	2.089 (1.55, 2.81)	<.0001	.		1.986 (1.45, 2.73)	<.0001	.
No related imaging	0.438 (0.27, 0.72)	0.0011	.		0.448 (0.26, 0.77)	0.0039	.
Imaging Category Before Subsequent Radiation Therapy							
Any PET (ref)			<.0001				<.0001
CT/CTA Alone	1.417 (1.32, 1.52)	<.0001	.		1.430 (1.32, 1.55)	<.0001	



Graphical Abstract

Supplemental Figure 1: Exclusion Flow Chart



Abbreviations: CT, Computerized tomography imaging; PET, Positron emission tomography imaging; HS, High school; NCI, National Cancer Institute; AJCC, American Joint Committee on Cancer.

*: Please see Appendix B Coding Manual for all imaging codes we used in the analysis. Noted that codes of CT/CTA imaging are for chest, Abdomen, and abdomen & pelvis.

†: Rurality classification is based on US Department of Agriculture's Rural Urban Commuting Area Codes version 2010.

Supplemental Table 1: Coding Manual List

Histology Codes:

Non-small cell lung cancer: 8015, 8050, 8140, 8141, 8143-8145, 8147, 8190, 8201, 8211, 8250-8255, 8260, 8290, 8310, 8320, 8323, 8333, 8401, 8440, 8470, 8471, 8480, 8481, 8490, 8503, 8507, 8550, 8570-8572, 8574, 8576, 8051, 8052, 8070, 8076, 8078, 8083, 8084, 8090, 8094, 8120, 8123, 8012-8014, 8021, 8034, 8082, 8003, 8004, 8022, 8030-8033, 8035, 8200, 8240, 8241, 8243-8246, 8249, 8430, 8525, 8560, 8562, 8575, 8046.

Initial treatment – Chemotherapy Codes:

ICD-9 Diagnosis: V58.1, V58.11, V58.12.

ICD-9 Procedure: 0010, 9925, 9928, 9929, 0015, 1770.

ICD-10 Diagnosis: Z511, Z5111, Z5112.

ICD-10 Procedure:

3E06003, 3E06303, 3E04003, 3E04303, 3E0S303, 3E05003, 3E05303, 3E03003, 3E03303, 3E0R303, 3E0J30M, 3E0J70M, 3E0J80M, 3E0A30M, 3E0V30M, 3E0600M, 3E0630M, 3E0400M, 3E0430M, 3E0Q30M, 3E0Q70M, 3E0BX0M, 3E0B30M, 3E0B70M, 3E0S30M, 3E0CX0M, 3E0C30M, 3E0C70M, 3E0P30M, 3E0P70M, 3E0P80M, 3E0K30M, 3E0K70M, 3E0K80M, 3E0U30M, 3E0H30M, 3E0H70M, 3E0H80M, 3E0W30M, 3E0N30M, 3E0N70M, 3E0N80M, 3E0DX0M, 3E0D30M, 3E0D70M, 3E0230M, 3E09X0M, 3E0930M, 3E0970M, 3E0Y30M, 3E0Y70M, 3E0500M, 3E0530M 3E0300M, 3E0330M, 3E0M30M, 3E0M70M, 3E0L30M, 3E0L70M, 3E0E30M, 3E0E70M 3E0E80M, 3E0F30M, 3E0F70M, 3E0F80M, 3E00X0M 3E0R30M, 3E0130M, 3E0G30M, 3E0G70M, 3E0G80M, 3E06005, 3E06305, 3E04005, 3E04305, 3E0BX05, 3E0B305, 3E0B705, 3E0S305, 3E0CX05, 3E0C305, 3E0C705, 3E0U305, 3E0DX05, 3E0D305, 3E0D705, 3E09X05, 3E09305, 3E09705, 3E05005, 3E05305, 3E03005, 3E03305, 3E0R305, 3E0600P, 3E0630P, 3E0400P, 3E0430P, 3E0500P, 3E0530P, 3E0300P, 3E0330P, XW04351, XW03351.

HCPCS:

96400-96549, J8999-J9999, 0519F, 4180F, A9522, A9600, A9604, A9605, C1084, C1086, C1166, C1167, C1178, C8953, C8954, C8955, C9004, C9012, C9027, C9110, C9131, C9205, C9207, C9213, C9214, C9215, C9216, C9230, C9235, C9237, C9257, C9262, C9265, C9272, C9284, C9287, C9297, C9414, C9415, C9416, C9417, C9418, C9419, C9420, C9421, C9422, C9423, C9424, C9425, C9426, C9427, C9429, C9431, C9432, C9433, C9434, C9437, C9438, C9440, C9480, G0355, G0356, G0357, G0358, G0359, G0360, G0361, G0362, G8372, G8373, G8374, G8381, G9021, G9022, G9023, G9024, G9025, G9026, G9027, G9028, G9029, G9030, G9031, G9032, J0128, J0129, J0178, J0202, J0207, J0340, J0490, J0594, J0640, J0641, J0894, J0897, J0900, J1050, J1051, J1060, J1070, J1080, J1090, J1190, J1457, J1620, J1675, J1826, J1930, J1950, J2320, J2321, J2322, J2323, J2352, J2353, J2354, J2430, J2675, J3120, J3130, J3140, J3150, J3262, J3315, J7150, J7527, J8510, J8520 J8521, J8530, J8560, J8561, J8562, J8565, J8600, J8610, J8700, J8705, Q0083, Q0084, Q0085,

Q2017, Q2020, Q2024, Q2043, Q2044, Q2046, Q2048, Q2049, Q2050, Q4079, S0087, S0088, S0108, S0115, S0116, S0146, S0156, S0165, S0170, S0172, S0175, S0176, S0177, S0178, S0179 S0182, S0187, S2107, S5019, S5020, S9329, S9330, S9331, 36640, 61517, 81350, 83520.

Initial treatment – Radiation therapy Codes:

ICD-9 Diagnoses: V58.0, V66.1, V67.1, E8732, E8792

ICD-9 Procedures: 922, 9221-9229, 923, 9231-9233, 9239, 9241

ICD-10 Diagnoses: Z510

ICD-10 Procedures: D0%, D7%, D8%, D9%, DB%, DD%, DF%, DG%, DH%, DM%

HCPCS: 0073T, 0082T, 0182T, 0190T, 0197T, 19296, 19297, 19298, 20555, 20660, 31463, 32553, 41019, 49411, 49412, 52250, 55859, 55860, 55875, 55876, 55920, 57155, 57156, 58346, 61720, 61735, 61770, 61781, 61782, 61783, 61793, 61795—61800, 63620, 63621, 73670, 76950, 76965, 77370—77373, 77380, 77381, 77385, 77386, 77387, 77399, 77400—77418, 77421, 77422, 77423, 77470, 77520, 77522, 77523, 77525, 77750, 77761, 77762, 77763, 77776— 77799, 77781–77787, 79005, 79030, 79035, 79100, 79101, 79200, 79300, 79400, 79403, 79420, 79440, 79445, 79999, G0173, G0174, G0178, G0243, G0251, G0256, G0273, G0274, G0339, G0340, G0458, G6003—G6016, C1350, C2632, C9714, C9715,C9726, C9728, S2270, S8049.

Revenue Center Codes: 0330, 0333.

Initial treatment – Surgery for lung specific:

ICD-9 Procedures: 3201, 3209, 321, 3220, 3221, 3222, 3223, 3224, 3225, 3226, 3227, 3228, 3229, 3230, 3239, 3241, 3249, 3250, 3259, 329, 3401, 4029.

ICD-10 Procedures:

0B53%, 0B54%, 0B55%, 0B56%, 0B57%, 0B58%, 0B59%, 0B5B%, 0BB3%, 0BB4%, 0BB5%, 0B5K%, 0B5L%, 0B5M%, 0BB6%, 0BB7%, 0BB8%, 0BB9%, 0BBB%, 0BBK%, 0BBL%, 0BBM%, 0BT3%, 0BT4%, 0BT5%, 0BT6%, 0BT7%, 0BT8%, 0BT9%, 0BTB%, 0BTC%, 0BTD%, 0BTF%, 0BTG%, 0BTH%, 0BTJ%, 0BTK%, 0BTL%, 0BTM%, 0BQK%, 0BQL%, 0BQM%, 0BBC4ZZ, 0BBD4ZZ, 0BBF4ZZ, 0BBG4ZZ, 0BBH4ZZ, 0BBJ4ZZ, 0BBK4ZZ, 0BBL4ZZ, 01B30ZZ, 01BL0ZZ, 0PB10ZZ, 0PB20ZZ, 0W9800Z, 0W980ZZ, 0W9830Z, 0W983Z, 0W9840Z, 0W984ZZ, 0WP80JZ, 0WP83JZ, 0WP84JZ, 07B70ZZ, 07B73ZZ, 07B74ZZ.

HCPCS: 32480, 32482, 32486, 32663, 32520, 32503, 32504, 32522, 32525, 32484, 32500, 32657, 32440, 32442, 32445, 32488, 38746, 32310, 32320, 32656.

Subsequent treatment – Radiation therapy Codes:

HCPCS:

77301, 77334, 77338, 77370, 77373, 77380, 77381, 77385, 77386, 77387, 77399, 77408, 77410, 77412, 77413, 77417, 77418, 77421, 77423, 77520, 77522, 77523, 77525, 0073T, 0082T, 0083T, 0197T, C9715, G0173, G0174, G0178, G0243, G0251, G0339, G0340, G6008, G6012, G6015, G6016.

Imaging codes:

CT & CTA Codes:

Abdomen:

ICD-9 Procedures: 8801.

ICD-10 Procedures: BW2000Z, BW200ZZ, BW2010Z, BW201ZZ, BW20Y0Z, BW20YZZ, BW20ZZZ.

HCPCS: 74177, 74160, 74176, 74150, 74178, 74170.

Chest:

CT: 71260, 71250, 71270; CTA: 71275.

Abdomen & Pelvis:

CTA: 74174, 74175.

PET Codes:

PET alone: 78811, 78812, 78813.

PET/CT: 78815, 78814, 78816.

Supplemental Table 2: Characteristics by imaging modality before subsequent radiation therapy of NSCLC patients

Characteristic	Total	CT/CTA Alone*	Any PET	p-value†
All Patients	**5,017**	**2,188**	**2,829**	**.**
Age at Diagnosis				
66 to 69	1,287 (25.7)	585 (26.7)	702 (24.8)	0.2567
70 to 74	1,579 (31.5)	670 (30.6)	909 (32.1)	.
75 and Older	2,151 (42.9)	933 (42.6)	1,218 (43.1)	.
Race/Ethnicity Category				
White NH	4,223 (84.2)	1,786 (81.6)	2,437 (86.1)	<.0001
Black NH	337 (6.7)	183 (8.4)	154 (5.4)	.
Hispanic	179 (3.6)	80 (3.7)	99 (3.5)	.
Other/Unknown	278 (5.5)	139 (6.4)	139 (4.9)	.
Marital Status Category				
Non-Married	2,122 (42.3)	931 (42.6)	1,191 (42.1)	0.7487
Married or Partnered	2,895 (57.7)	1,257 (57.4)	1,638 (57.9)	.
Patient Region at Diagnosis				
East	1,061 (21.1)	493 (22.5)	568 (20.1)	0.0215
Midwest	617 (12.3)	285 (13.0)	332 (11.7)	.
South	1,510 (30.1)	618 (28.2)	892 (31.5)	.
West	1,829 (36.5)	792 (36.2)	1,037 (36.7)	.
Census Tract Rurality Category (RUCA)‡				
Urban Commuting Area	4,397 (87.6)	1,934 (88.4)	2,463 (87.1)	0.1562
Not Urban Commuting Area	620 (12.4)	254 (11.6)	366 (12.9)	.
Census Tract Poverty Level§				
Less than Median	2,695 (53.7)	1,185 (54.2)	1,510 (53.4)	0.5811
Median or Higher	2,322 (46.3)	1,003 (45.8)	1,319 (46.6)	.
Census Tract % HS Education Or Less‖				
Less than Median	2,617 (52.2)	1,149 (52.5)	1,468 (51.9)	0.6615
Median or Higher	2,400 (47.8)	1,039 (47.5)	1,361 (48.1)	.
Charlson Comorbidity Index Category¶				
0	1,818 (36.2)	826 (37.8)	992 (35.1)	0.0610
1	1,603 (32.0)	701 (32.0)	902 (31.9)	.
2 or more	1,596 (31.8)	661 (30.2)	935 (33.1)	.
Facility Types				
NCI Center	605 (12.1)	296 (13.5)	309 (10.9)	0.0179
Teaching Hospital	2,021 (40.3)	873 (39.9)	1,148 (40.6)	.
Other/No Hospital	2,391 (47.7)	1,019 (46.6)	1,372 (48.5)	.
Derived AJCC Stage Group 6th Edition#				
Stage I	1,597 (31.8)	518 (23.7)	1,079 (38.1)	<.0001
Stage II	472 (9.4)	160 (7.3)	312 (11.0)	.
Stage III	1,511 (30.1)	675 (30.9)	836 (29.6)	.
Stage IVA	1,437 (28.6)	835 (38.2)	602 (21.3)	.
Initial Treatment				

Radiation	943 (18.8)	385 (17.6)	558 (19.7)	<.0001
Surgery	1,217 (24.3)	421 (19.2)	796 (28.1)	.
Chemotherapy	659 (13.1)	402 (18.4)	257 (9.1)	.
Surgery and Radiation	112 (2.2)	39 (1.8)	73 (2.6)	.
Chemotherapy and Radiation	1,348 (26.9)	676 (30.9)	672 (23.8)	.
Chemotherapy and Surgery	488 (9.7)	158 (7.2)	330 (11.7)	.
Chemotherapy, Surgery and Radiation	250 (5.0)	107 (4.9)	143 (5.1)	.
Diagnostic Imaging Category**				
CT/CTA Alone	531 (10.6)	285 (13.0)	246 (8.7)	<.0001
Any PET	4,440 (88.5)	1,885 (86.2)	2,555 (90.3)	.
No related imaging	46 (0.9)	18 (0.8)	28 (1.0)	.
Histologic Subtype of NSCLC***				
Adenocarcinoma	2,546 (50.7)	1,157 (52.9)	1,389 (49.1)	<.0001
Adenosquamous	120 (2.4)	47 (2.1)	73 (2.6)	.
Large cell carcinoma	117 (2.3)	54 (2.5)	63 (2.2)	.
Neuroendocrine	89 (1.8)	57 (2.6)	32 (1.1)	.
Squamous cell carcinoma	1,542 (30.7)	601 (27.5)	941 (33.3)	.
Other/Not-specified	603 (12.0)	272 (12.4)	331 (11.7)	.

Note: Data presented as No. (Column %), highlighted significance level of $p < 0.05$ in red.

Abbreviations: CT, Computerized tomography imaging; PET, Positron emission tomography imaging; HS, High school; NCI, National Cancer Institute; AJCC, American Joint Committee on Cancer.

*: Sites of CT/CTA alone are abdomen, chest and abdomen & pelvis. Definition by codes: 8801(ICD-9 Procedures); BW2000Z, BW200ZZ, BW2010Z, BW201ZZ, BW20Y0Z, BW20YZZ, BW20ZZZ (ICD-10 Procedures); and 71260, 71250, 71270, 71275, 74150, 74160, 74170, 74174, 74175, 74176, 74177, 74178 (HCPCS).

†: P-value is comparing patients who had CT/CTA alone and those who received any PET.

‡: Rurality classification is based on US Department of Agriculture's Rural Urban Commuting Area Codes version 2010.

§: Census Tract variable from American Community Survey (ACS) 5-Year data Income and Poverty for Poverty Status (using 100% level) in the past 12 months.

‖: Census Tract variable from American Community Survey (ACS) 5-Year Data Educational Attainment for the population 25 Years and over.

¶: This is the NCI Comorbidity Index with 16 conditions included. Here we used the macros provided by NCI to define the comorbidity index category, more detailed introduction can be found in this website: https://healthcaredelivery.cancer.gov/seermedicare/considerations/comorbidity.html

#: Staging by AJCC 6th Edition.

**: The diagnostic imaging category is the same as the outcome imaging category before subsequent radiation therapy. Sites of CT/CTA alone are abdomen, chest and abdomen & pelvis. Those who had no related imaging can be without any imaging (CT/CTA scans or PET) or with other site-specific imaging not in the CT/CTA along list.

***: Histologic subtype of NSCLC is based on https://www.cancer.org/cancer/lung-cancer/about/what-is.html.

Supplemental Table 3: Logistic regression predicting whether patients received PET or not

Characteristics	OR (95% CI)	p-value	Global p-value
Year of Diagnosis			
2007 (ref)		.	0.0518
2008 vs 2007	1.028 (0.81, 1.30)	0.8203	.
2009 vs 2007	1.175 (0.93, 1.49)	0.1852	.
2010 vs 2007	1.164 (0.92, 1.48)	0.2116	.
2011 vs 2007	1.373 (1.08, 1.75)	0.0098	.
2012 vs 2007	1.393 (1.09, 1.78)	0.0077	.
2013 vs 2007	1.056 (0.83, 1.34)	0.6528	.
2014 vs 2007	1.150 (0.90, 1.47)	0.2597	.
2015 vs 2007	1.336 (1.01, 1.77)	0.0423	.
Age Category			
66 to 69 (ref)		.	0.2254
70 to 74 vs 66 to 69	1.106 (0.95, 1.29)	0.2001	.
75 and Older vs 66 to 69	0.985 (0.85, 1.14)	0.8422	.
Sex			
Male (ref)		.	0.6872
Female vs Male	1.026 (0.91, 1.16)	0.6872	.
Race/Ethnicity Category			
White NH (ref))		.	0.0044
Black NH vs White NH	0.688 (0.54, 0.88)	0.0023	.
Hispanic vs White NH	0.958 (0.70, 1.32)	0.7944	.
Other/Unknown vs White NH	0.752 (0.58, 0.98)	0.0336	.
Marital Status Category			
Married or Partnered (ref)		.	0.9247
Non-Married vs Married or Partnered	0.994 (0.88, 1.13)	0.9247	.
Patient Region at Diagnosis			
West (ref)		.	0.0374
East vs West	0.799 (0.67, 0.95)	0.0111	.
Midwest vs West	0.856 (0.70, 1.05)	0.1390	.
South vs West	0.996 (0.85, 1.17)	0.9655	.
Census Tract Rurality Category (RUCA)			
Urban Commuting Area (ref)		.	0.7894
Not Urban Commuting Area vs Urban Commuting Area	1.026 (0.85, 1.24)	0.7894	.
Census Tract Poverty Level			
Less than Median (ref)		.	0.9059
Median or Higher vs Less than Median	1.009 (0.87, 1.17)	0.9059	.
Census Tract % HS Education Or Less			
Less than Median (ref)		.	0.9761
Median or Higher vs Less than Median	1.002 (0.87, 1.16)	0.9761	.
Charlson Comorbidity Index Category			
0 (ref)		.	0.4290
1 vs 0	0.916 (0.79, 1.06)	0.2279	.

2 or more vs 0	0.988 (0.85, 1.14)	0.8738	.
Derived AJCC Stage Group 6th Edition			
Stage I (ref)		.	<.0001
Stage II vs Stage I	0.880 (0.70, 1.11)	0.2769	.
Stage III vs Stage I	0.695 (0.58, 0.83)	<.0001	.
Stage IVA vs Stage I	0.455 (0.38, 0.55)	<.0001	.
Facility Types			
NCI Center (ref)		.	0.3908
Other/No Hospital vs NCI Center	1.111 (0.91, 1.35)	0.2906	.
Teaching Hospital vs NCI Center	1.144 (0.94, 1.39)	0.1705	.
Initial Treatment			
Radiation (ref)		.	<.0001
Chemotherapy vs Radiation	0.625 (0.50, 0.78)	<.0001	.
Chemotherapy and Radiation vs Radiation	0.827 (0.69, 1.00)	0.0464	.
Chemotherapy and Surgery vs Radiation	1.337 (1.04, 1.72)	0.0223	.
Chemotherapy, Surgery and Radiation vs Radiation	0.969 (0.72, 1.31)	0.8356	.
Surgery vs Radiation	1.093 (0.90, 1.33)	0.3676	.
Surgery and Radiation vs Radiation	1.259 (0.83, 1.92)	0.2843	.
Diagnostic Imaging Category			
Any PET (ref)		.	0.0002
CT/CTA Alone vs Any PET	0.673 (0.56, 0.81)	<.0001	.
No related imaging vs Any PET	1.178 (0.64, 2.18)	0.6019	.
Histologic Subtype of NSCLC			
Adenocarcinoma (ref)		.	0.0183
Adenosquamous vs Adenocarcinoma	1.065 (0.72, 1.57)	0.7528	.
Large cell carcinoma vs Adenocarcinoma	0.920 (0.62, 1.35)	0.6718	.
Neuroendocrine vs Adenocarcinoma	0.576 (0.36, 0.91)	0.0187	.
Squamous cell carcinoma vs Adenocarcinoma	1.176 (1.02, 1.35)	0.0212	.
Other/Not-specified vs Adenocarcinoma	1.148 (0.95, 1.39)	0.1537	.

Note: Data presented as odds ratio and 95% confident interval, highlighted level-specific p-values and global (class-level) p-values in red at 0.05 level.

Abbreviations: OR, odds ratio; CI, confidence interval; HS, High school; NCI, National Cancer Institute; AJCC, American Joint Committee on Cancer; NSCLC, Non-Small Cell Lung Cancer.

Supplemental Table 4: Multivariate Analysis of Survival at 3-year Follow Up. Left: Overall Survival; Right: Cancer-Specific Survival

	Overall Survival				Cancer-Specific Survival		
Characteristics	**HR (LCL-UCL)**	**P-value**	**Global p-value**		**HR (LCL-UCL)**	**P-value**	**Global p-value**
Year of Diagnosis							
2007 (ref)			<.0001				0.0024
2008	0.955 (0.83, 1.10)	0.5186	.		0.970 (0.84,1.12)	0.6759	.
2009	0.893 (0.78, 1.03)	0.1162	.		0.922 (0.80,1.07)	0.2698	.
2010	0.878 (0.76, 1.01)	0.0719	.		0.875 (0.76,1.01)	0.0746	.
2011	0.793 (0.69, 0.91)	0.0015	.		0.783 (0.67,0.91)	0.0013	.
2012	0.888 (0.77, 1.03)	0.1062	.		0.885 (0.76,1.03)	0.1116	.
2013	0.767 (0.66, 0.89)	0.0003	.		0.749 (0.64,0.88)	0.0003	.
2014	0.967 (0.84, 1.12)	0.6513	.		0.792 (0.65,0.97)	0.0246	.
2015	1.641 (1.39, 1.94)	<.0001	.		0.578 (0.27,1.23)	0.1555	.
Age Category							
66 to 69 (ref)			0.0066				0.0079
70 to 74	0.988 (0.90, 1.08)	0.7992	.		0.940 (0.85, 1.04)	0.2436	.
75 and Older	1.115 (1.02, 1.22)	0.0157	.		1.089 (0.99, 1.20)	0.0901	.
Sex							
Male (ref)			0.0012				0.0008
Female	0.886 (0.82, 0.95)	0.0012	.		0.869 (0.80, 0.94)	0.0008	.
Race/Ethnicity Category							
White NH (ref)			0.0912				0.0638
Black NH	0.942 (0.82, 1.08)	0.4048	.		0.931 (0.80, 1.09)	0.3743	.
Hispanic	0.904 (0.75, 1.10)	0.3068	.		0.867 (0.69, 1.08)	0.2046	.
Other/Unknown	0.823 (0.70, 0.97)	0.0195	.		0.799 (0.67, 0.96)	0.0162	.
Marital Status Category							
Married or Partnered (ref)			0.0940				0.0672
Non-Married	1.065 (0.99, 1.15)	0.0940	.		1.081 (0.99, 1.17)	0.0672	.
Patient Region at Diagnosis							
West (ref)			0.2749				0.3012
East	1.008 (0.91, 1.12)	0.8754	.		0.971 (0.86, 1.09)	0.6202	.
Midwest	1.093 (0.97, 1.24)	0.1519	.		1.063 (0.93, 1.22)	0.3827	.
South	0.970 (0.88, 1.07)	0.5315	.		0.939 (0.84, 1.05)	0.2584	.
Charlson Comorbidity Index Category							
0 (ref)			0.0354				0.4237
1	1.004 (0.92, 1.09)	0.9317	.		1.009 (0.92, 1.11)	0.8547	.
2 or more	1.107 (1.01, 1.21)	0.0220	.		1.064 (0.96, 1.17)	0.2197	.
Census Tract Rurality Category (RUCA)							
Urban Commuting Area (ref)			0.7804				0.8201
Not Urban Commuting Area	1.016 (0.91, 1.13)	0.7804	.		1.014 (0.90, 1.15)	0.8201	.
Census Tract Poverty Level							
Less than Median (ref)			0.0775				0.0568

Median or Higher	1.080 (0.99, 1.18)	0.0775	.		1.099 (1.00, 1.21)	0.0568	.
Census Tract % HS Education Or Less							
Less than Median (ref)			0.4948				0.5456
Median or Higher	1.030 (0.95, 1.12)	0.4948	.		1.030 (0.94, 1.13)	0.5456	.
Facility Types							
NCI Center (ref)			0.0174				0.0191
Other/No Hospital	1.151 (1.02, 1.30)	0.0205	.		1.164 (1.02, 1.33)	0.0280	.
Teaching Hospital	1.050 (0.93, 1.18)	0.4213	.		1.047 (0.91, 1.20)	0.5064	.
Derived AJCC Stage Group 6th Edition							
Stage I (ref)			<.0001				<.0001
Stage II	1.906 (1.62, 2.25)	<.0001	.		1.920 (1.59, 2.31)	<.0001	.
Stage III	2.057 (1.67, 2.54)	<.0001	.		2.135 (1.70, 2.69)	<.0001	.
Stage IVA	2.810 (2.11, 3.74)	<.0001	.		2.846 (2.08, 3.89)	<.0001	.
Initial Treatment							
Radiation (ref)			<.0001				<.0001
Chemotherapy	0.681 (0.58, 0.80)	<.0001	.		0.696 (0.58, 0.83)	<.0001	.
Chemotherapy and Radiation	0.533 (0.42, 0.67)	<.0001	.		0.537 (0.42, 0.69)	<.0001	.
Chemotherapy and Surgery	0.278 (0.20, 0.38)	<.0001	.		0.272 (0.19, 0.38)	<.0001	.
Chemotherapy, Surgery, and Radiation	0.337 (0.23, 0.49)	<.0001	.		0.330 (0.22, 0.50)	<.0001	.
Surgery	0.673 (0.59, 0.76)	<.0001	.		0.675 (0.58, 0.78)	<.0001	.
Surgery and Radiation	0.466 (0.34, 0.63)	<.0001	.		0.415 (0.29, 0.59)	<.0001	.
Histologic Subtype of NSCLC							
Adenocarcinoma (ref)			<.0001				0.0005
Adenosquamous	1.471 (1.17, 1.85)	0.0010	.		1.392 (1.07, 1.81)	0.0138	.
Large cell carcinoma	1.416 (1.11, 1.81)	0.0059	.		1.315 (1.00, 1.72)	0.0470	.
Neuroendocrine	1.375 (1.02, 1.85)	0.0342	.		1.455 (1.05, 2.01)	0.0232	.
Squamous cell carcinoma	1.719 (1.40,2.11)	<.0001	.		1.644 (1.32, 2.05)	<.0001	.
Other/Not-specified	1.728 (1.34,2.23)	<.0001	.		1.687 (1.28, 2.22)	0.0002	.
Diagnostic Imaging Category							
Any PET (ref)			<.0001				0.0001
CT/CTA Alone	2.089 (1.55, 2.81)	<.0001	.		1.986 (1.45, 2.73)	<.0001	.
No related imaging	0.438 (0.27, 0.72)	0.0011	.		0.448 (0.26, 0.77)	0.0039	.
Imaging Category Before Subsequent Radiation Therapy							
Any PET (ref)			<.0001				<.0001
CT/CTA Alone	1.417 (1.32, 1.52)	<.0001	.		1.430 (1.32, 1.55)	<.0001	

Note: Data presented as hazard ratio and lower and upper control limit at 95% level, highlighted level-specific p-values and global (class-level) p-values in red at 0.05 level.

Abbreviations: HR, hazard ratio; LCL, lower control limit; UCL, upper control limit. HS, High school; NCI, National Cancer Institute; AJCC, American Joint Committee on Cancer.