

Scientific Article

Palliative radiation and fractionation in medicare patients with incurable non-small cell lung cancer

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Abstract

Purpose: Palliative radiation therapy (RT) can improve quality of life but also incurs time and financial costs. The aim of this study was to evaluate factors associated with use and intensity of palliative RT for incurable non-small cell lung cancer (NSCLC).

Methods and materials: This was a retrospective analysis of Medicare's Surveillance, Epidemiology and End Results data. We identified patients who were diagnosed with incurable (American Joint Committee on Cancer 6th edition stage IIIB with malignant effusion or stage IV) NSCLC between 2004 and 2011. Univariable and multivariable logistic regressions were used to identify factors associated with the receipt of palliative RT and the use of >10 fractions during the first course of radiation. Among patients who were treated with radiation, freestanding versus hospital-based center information was collected on the basis of the location of the RT delivery claim.

Results: Among 55,258 patients with incurable NSCLC, 38% (21,053 patients) received palliative RT during the first year after diagnosis. Among patients who received RT, 56% (11,717 patients) received >10 fractions. On multivariable analysis, factors associated with greater RT use included younger age group (overall $P < .01$), lower modified Charlson comorbidity score (overall $P < .01$), female sex (odds ratio [OR]: 1.1; $P < .01$), marital status (OR: 1.1; $P < .01$), and chemotherapy use (OR: 3.6; $P < .01$). Predictors for >10 fractions were chemotherapy use (OR: 1.7; $P < .01$) and treatment at a freestanding versus hospital-based facility (58% vs 43%; OR: 1.7; $P < .01$).

Conclusions: More than a third of patients diagnosed with incurable lung cancer receive palliative RT and 56% received >10 fractions. The use of RT varied by region and patient characteristics, and patients treated at freestanding RT centers were more likely to receive >10 fractions. Further research into factors that influence treatment decisions including potential financial incentives may contribute to the high value and strategic utilization of palliative RT.

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Introduction

Nearly half of patients who present with non-small cell lung cancer (NSCLC) have incurable disease at the time of diagnosis and harbor a 5-year survival of <5%.¹ The goals

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of care focus primarily on the prolongation of survival and palliation of symptoms rather than curing.^{2,3} Palliative radiation therapy (RT) is frequently employed in patients with incurable NSCLC, and the most common radiation treatment sites are the brain, thorax, and bone.⁴ Despite its ability to stabilize or improve symptoms,³ prior studies have shown significant variations in the use of palliative RT that ranged from 31% to 66% in patients with incurable disease.⁴⁻¹⁰ Even in instances when palliative RT is employed, RT fractionation schemes vary and are not always well-supported by randomized data.^{4,11,12}

Over the past decade, there have been several significant clinical developments with the potential to influence the use of palliative RT including new radiation technologies such as stereotactic radiosurgery and stereotactic body radiation therapy. New biologically targeted therapies also can alter the timing and need for conventional palliative RT. Prior studies^{4,8,13} that investigated RT receipt among patients with incurable NSCLC largely included only patients diagnosed prior to adoption of these new treatment advances. Even less is known about the factors that influence the number of radiation fractions used in patients with incurable NSCLC. On the basis of the results of multiple trials that showed no difference in pain control between single fraction and longer radiation courses for patients with bone metastases,¹⁴⁻¹⁸ the American Society for Radiation Oncology Choosing Wisely Campaign recommended against the routine use of extended fractionation schemes (>10 fractions) for palliation of bone metastases.¹⁹ Additionally, although 1 meta-analysis found that higher dose schedules (30 Gy per ≥ 10 fraction-equivalent) were associated with small improvements in symptom control and survival at the cost of increased short-term side effects,^{20,21} the general consensus is that shorter courses should be considered for patients with a poor prognosis or performance status.^{18,21} Because the use of extended RT courses is associated with increased cost of care and inconvenient for patients with a significant disease burden and limited life expectancy,^{22,23} understanding the factors that influence their use is critical.

The goal of our study was to elucidate palliative RT practice patterns and identify patient and health care service factors associated with the use of palliative RT and extended fractionation (>10 fractions) among patients with incurable NSCLC.

Methods and materials

Sources of data

We used data from the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) cancer registries linked to Medicare claims data. The SEER database consists of tumor registries across the United States and provides a near representative sample of approximately 28% of the U.S. population.²⁴ SEER registries include data on patient demographics, cancer site, stage, histology, and dates of diagnosis and death. SEER data for patients diagnosed between January 1, 2004 and December 31, 2011 were linked to inpatient and outpatient Medicare claims data through December 31, 2012.²⁴

Study cohort

Our cohort included Medicare-enrolled patients age >65 years diagnosed with incurable lung cancer (defined as stage IIIB with malignant effusion [wet IIIB] or stage IV NSCLC [American Joint Committee on Cancer 6th Edition]) between 2004 and 2011 in a SEER surveillance area. NSCLC had to be pathologically confirmed and diagnosed prior to death as the first cancer diagnosis. Subjects were continuously enrolled in Medicare Parts A and B and not in a health maintenance organization from the time of diagnosis to death. Patients with a prior history of cancer who were enrolled in Medicare due to end stage renal disease or cancer that was diagnosed at the time of an autopsy were excluded (Fig 1).

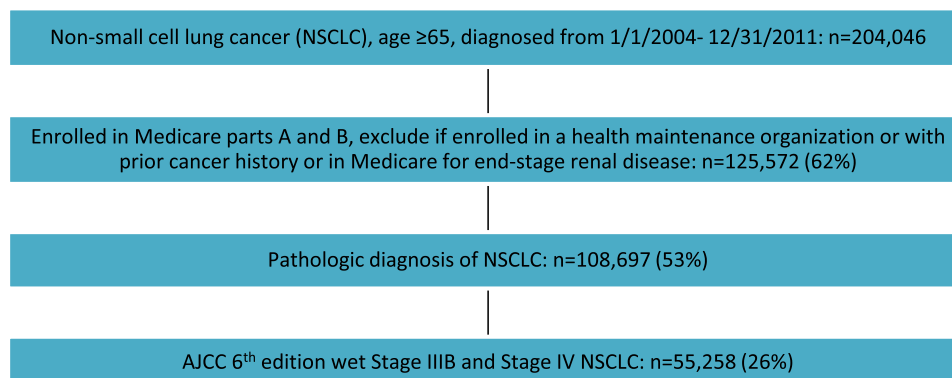


Figure 1 Flowchart of cohort selection. NSCLC, non-small cell lung cancer.

Definition of outcomes variables

We identified patients who had at least 1 Medicare claim for radiation delivery for conventional RT (2-dimensional, 3-dimensional, or intensity modulated RT [IMRT]) or stereotactic radiation surgery and stereotactic body RT within 1 year of diagnosis. Conventional palliative RT was defined as external beam 2-dimensional, 3-dimensional, or IMRT on the basis of the common procedural terminology (CPT) or Healthcare Common Procedure Coding System (HCPCS) codes 77401-77416, 77418, 0073T, and G0174 (Table A1). Stereotactic RT was defined separately from conventional palliative RT and based on CPT/HCPCS codes 77371-77373, G0173, G0243, G0251, G0339, and G0340.

Among the patients who received conventional palliative RT, we determined whether the RT delivery code had an associated International Classification of Diseases 9th Revision (ICD-9) diagnosis code of brain metastases (198.3), bone metastases (198.5), or other (nonbrain, nonbone). Patients with multiple ICD-9 codes were first assigned to brain metastases, then bone, then lung or other sites (nonbrain, nonbone). Fractionation by associated ICD-9 code was calculated. Furthermore, among patients who received conventional palliative RT, we also calculated the number of RT fractions delivered during the first course of treatment on the basis of the number of RT delivery codes for conventional RT. RT courses were considered separate if there was more than a 14-day break between treatment deliveries. Extended fractionation for this study was defined as >10 fractions, which corresponds to about 2 weeks of daily treatment.

Definition of explanatory variables

Demographic variables including age, sex, race, and marital status were obtained from the SEER data and categorized as shown in Table 1. Patients were categorized in income quartiles on the basis of the median household income in the ZIP code of residence. A modified Charlson comorbidity index was determined using Deyo's implementation of the Charlson score applied to both inpatient and outpatient claims over the 12 months prior to the diagnosis month as suggested by Klabunde.^{25,26} Treatment factors included use of any hospice service or chemotherapy during the first year after diagnosis. Patients who had any claims in the SEER-Medicare Hospice file²⁴ were categorized as having received hospice services. Receipt of chemotherapy was defined by the CPT/HCPCS codes listed in Table A1.

The health service characteristics included urban residence, SEER region, and density of radiation oncology providers. Urban residence was obtained from the SEER data. SEER registries were grouped geographically into the following regions: West (San Francisco, San Jose, Los Angeles, Greater California, Hawaii, New Mexico, Seattle,

and Utah), Midwest (Detroit and Iowa), South (Atlanta, rural Georgia, Kentucky, Louisiana, and Oklahoma), and Northeast (Connecticut and New Jersey). On the basis of the 2011 state and county data, the Center for Medicare and Medicaid Services (CMS) Area Resource File²⁷ was utilized to ascertain the density of radiation oncologists, which was defined as the number of radiation oncologists (per 100,000 population) who practiced within each patient's county of residence. The density of radiation oncologists was reported by top, middle, and bottom tertiles, which corresponded to ≥ 1.5 , 1 to 1.5, or < 1 radiation oncologist per 100,000 population.

Among patients who were treated with palliative radiation, freestanding versus hospital-based center information was collected. Patients were assigned as receiving RT in a hospital-associated outpatient clinic if the RT delivery claims were only present in the SEER-Medicare outpatient data file.²⁴ Patients who received RT in a freestanding RT center were assigned if the RT delivery claim was only in the SEER-Medicare carrier claims file.²⁴ Patients who had RT delivery claims in both the outpatient and carrier files were categorized as having received RT at a freestanding center.

Statistical methods

χ^2 tests were used to compare categorical baseline demographic and clinical characteristics between patients treated with conventional palliative RT and those who were not. Univariable and multivariable fixed-effects logistic regressions were used to identify patient, treatment and health care system factors associated with receipt of RT and number of treatment fractions received with a correction for clustering at the county level. All variables that were included in the univariable analysis were included in the multivariable analysis. SAS software version 9.4 (SAS Institute, Cary, NC) was used for the analyses.

Results

Among the 55,258 patients diagnosed with incurable NSCLC, the median age was 76 years, 53% were male, and 84% were white. The remaining characteristics of the patient cohort are described in Table 1.

Use of radiation therapy in patients with incurable non-small cell lung cancer

Overall, 38% (21,053 patients) received conventional palliative RT within 1 year of diagnosis. Among these patients, 3% received a single fraction and 56% received >10 fractions for their first course. Use of conventional RT trended downward from 40% in 2004 to 35% in 2011 (χ^2 trend test

Table 1 Baseline characteristics among patients with incurable non-small cell lung cancer (2004-2011)

	N	%
Demographic		
Age at time of diagnosis (years)		
65-69	13,904	25%
70-74	13,904	25%
75-79	12,773	23%
>80	14,677	27%
Sex		
Female	25,966	47%
Male	29,292	53%
Race		
White	47,359	86%
Black	4,993	9%
Asian/Pacific Islander	2,654	5%
Other	252	1%
Marital status		
Not married	27,840	50%
Married	27,418	50%
Diagnosis year		
2004-2005	15,165	27%
2006-2007	14,413	26%
2008-2009	13,234	24%
2010-2011	12,446	23%
Median income quartile (percentile)*		
≤25 th	13,549	25%
25 th -50 th	13,547	25%
50 th -75 th	13,589	25%
>75 th	13,598	25%
Clinical and treatment		
Modified Charlson comorbidity score[†]		
0	28,449	51%
1	14,211	26%
2	6,129	11%
>3	6,469	12%
Radiation treatment[‡]		
No	33,506	62%
Yes	20,435	38%
Chemotherapy[‡]		
No	31,812	58%
Yes	23,446	42%
Hospice services[‡]		
No	28,926	52%
Yes	26,332	48%
Regional and health care services		
SEER region		
Northeast	10,300	19%
South	15,798	28%
Midwest	7,544	14%
West	21,616	39%
Living in urban area		
No	6,537	12%
Yes	48,721	88%
Radiation oncologist density[§]		
Lowest tertile	18,230	33%
Middle tertile	20,054	36%
Highest tertile	16,968	31%

SEER, Surveillance, Epidemiology and End Results.

* By ZIP code.

† Measured using the Klabunde modification.

‡ Within 1 year of diagnosis.

§ Number of radiation oncologists (per 100,000 population) practicing within each patient's county of residence, divided into top (>1.5), middle (1-1.5), and bottom (<1) tertiles.

$P < .01$) but the use of stereotactic RT increased from 0.8% in 2004 to 5% in 2011 (χ^2 trend test $P < .01$; Fig 2).

Among patients who received conventional palliative RT, 26% of courses were associated with a brain metastasis, 18% with bone metastases, and 57% with lung or other diagnosis codes. Among patients who received radiation associated with brain or bone metastasis diagnosis codes, >50% received ≤10 fractions (Table 2). Among those who received radiation associated with lung or other metastases, close to two-thirds received >10 fractions and 35% received >20 fractions.

Predictors of conventional palliative radiation therapy receipt

On multivariable analysis, demographic factors associated with use of conventional palliative RT included marital status (married vs unmarried; 42% vs 35%; $P < .01$), younger age group (48% vs 43% vs 37% vs 27% for age groups 65-69, 70-75, 76-80, and 80+ years; overall $P < .01$), and female sex (38% vs 39%; $P < .01$). Clinical and treatment factors that were associated with the receipt of RT were a lower modified Charlson comorbidity score (42% vs 38% vs 34% vs 29% for modified Charlson 0, 1, 2, and 3+, respectively; overall $P < .01$) and receipt of chemotherapy (57% vs 25%; $P < .01$).

In terms of regional and health service factors associated with the use of RT, patients in the West were less likely to receive RT relative to patients in the Northeast, Midwest, or South of the United States (36% vs 39% vs 40% vs 41%; overall $P < .01$). There appeared no clear trend in the percentage of patients who received RT between patients living in counties with low, middle, and high densities of radiation oncologists (39% vs 37% vs 40% for lowest, middle, and top tertiles). Race, urban residence, median census income quartile, and use of hospice services were not significant predictors of RT receipt. Table 3 lists the univariable and multivariable predictors of conventional RT use.

Predictors of receipt of extended fractionation (>10 fractions)

None of the demographic factors (sex, marital status, race, year of diagnosis, and median ZIP code income) in our model was associated with the use of extended fractionation RT on multivariable analysis and there was no consistent age-related trend. The receipt of chemotherapy in the year after diagnosis (54% vs 39%; $P < .01$) was associated with use of extended fractionation but the modified Charlson comorbidity score was not a significant predictor of extended fractionation.

With regard to health system factors, radiation oncologist density, urban residence, and SEER region were not significant predictors of receiving extended fractionation.

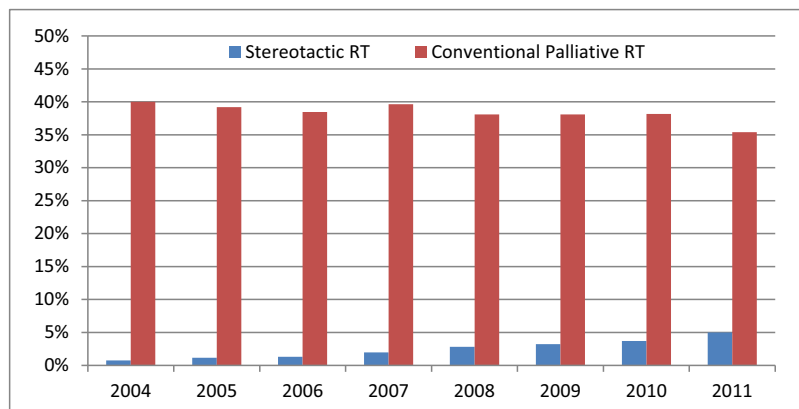


Figure 2 Percent of patients with incurable non-small cell lung cancer who received conventional and stereotactic radiation therapy by year of diagnosis.

Table 2 Number of palliative radiation therapy fractions by site of metastases

	1 fraction	2-5 fractions	6-10 fractions	11-15 fractions	16-20 fractions	>20 fractions
Brain	132 (2%)	623 (12%)	2042 (38%)	1767 (33%)	458 (8%)	393 (7%)
Bone	152 (4%)	595 (16%)	1400 (38%)	968 (26%)	340 (9%)	262 (7%)
Lung and other	298 (3%)	1364 (11%)	2730 (23%)	2234 (19%)	1104 (9%)	4191 (35%)

However, we found that patients treated at freestanding RT facilities were more likely to receive extended fractionation compared with those treated at hospital-based facilities (58% vs 44%; $P < 0.01$). Table 4 lists the univariable and multivariable predictors of extended fractionation.

Discussion

This study characterizes the delivery of RT among patients diagnosed with incurable NSCLC including factors that influenced the use of conventional palliative RT and choice of extended RT fractionation in the year after diagnosis. Although we observed decreases in the use of conventional palliative RT between 2004 and 2011, this was offset by a synchronous increase in the utilization of stereotactic RT.

A combination of patient and treatment factors were associated with the use of conventional RT. Younger age, female sex, lower modified Charlson comorbidity score, marital status, and chemotherapy use were associated with greater conventional RT use, which is consistent with prior studies.^{8,9} Chemotherapy receipt may be a surrogate for a preference for higher intensity of care and patients fit enough to receive chemotherapy may also have a higher chance of receiving RT.

More than 50% of patients with incurable NSCLC received >10 fractions of palliative RT including 42% who received RT associated with a bone metastasis diagnosis code despite national guidelines that suggest shorter

courses.¹⁹ This is consistent with findings from other studies²⁸⁻³⁰ and suggests that there may be opportunities to streamline or consolidate care by implementing programs to evaluate whether and when shorter courses of radiation are appropriate.

Furthermore, a proportion of patients in our study likely received palliative radiation directed to the chest. Prior studies suggest that approximately 20% of patients with metastatic lung cancer receive palliative chest RT.^{4,31} Although several RCTs failed to find a statistically significant benefit to prolonged courses of RT to the chest,^{20,32-34} an exploratory meta-analysis suggested that more aggressive radiation schedules (greater than 30 Gy/10 fractions) was associated with modest improvements in survival,²¹ though with greater acute side effects. In our cohort, 22% of patients received radiation associated with a nonmetastatic diagnosis code, many of whom likely received RT directed to the chest. In this group, approximately 28% of patients received >10 fractions and 9% received >15 fractions. Many patients who received >10 fractions may also have good overall performance or were treated more aggressively for oligometastatic disease.

We found that many of the patient factors such as sex, comorbidity, and marital status, which predicted a patient receiving conventional RT, did not influence the choice of fractionation scheme. Once the decision to deliver palliative RT is made, other factors appear to influence the fractionation schedule. Patients who received any chemotherapy and those treated at a freestanding RT facility were respectively 1.79 and 1.74 times more likely to receive >10

Table 3 Predictors of receipt of RT among patients with incurable non-small cell lung cancer

Predictors	RT Yes	RT No	Univariable			Multivariable		
			OR	95% CI	P-value	OR	95% CI	P-value
Demographic								
Age at time of diagnosis (years)								
65-69	48%	52%	ref		< .01	ref		< .01
70-74	43%	57%	0.82	0.79-0.86		0.88	0.84-0.93	
75-79	37%	63%	0.64	0.61-0.67		0.74	0.70-0.79	
>80	27%	73%	0.41	0.39-0.43		0.60	0.56-0.64	
Sex								
Female	38%	62%	ref		.54	ref		< .01
Male	39%	61%	1.01	0.98-1.05		0.93	0.89-0.97	
Race								
White	39%	61%	ref		< .01	ref		.12
Black	36%	64%	0.89	0.84-0.94		0.93	0.87-1.00	
Asian/Pacific Islander	35%	65%	0.84	0.78-0.92		1.02	0.90-1.14	
Other	32%	68%	0.74	0.57-0.97		0.78	0.58-1.07	
Marital status								
Not married	35%	65%	ref		< .01	ref		< .01
Married	42%	58%	1.38	1.34-1.43		1.15	1.10-1.20	
Diagnosis year								
2004-2005	40%	60%	ref		< .01	ref		.03
2006-2007	39%	61%	0.98	0.93-1.02		1.02	0.97-1.07	
2008-2009	38%	62%	0.94	0.89-0.98		0.97	0.91-1.04	
2010-2011	37%	63%	0.89	0.85-0.93		0.92	0.87-0.98	
Median income quartile (percentile)*								
≤25th	38%	62%	ref		.06	ref		.90
25 th to 50 th	38%	62%	1.04	0.99-1.09		1.00	0.93-1.07	
50 th -75 th	39%	61%	1.08	1.00-1.10		1.00	0.93-1.07	
>75 th	39%	61%	1.07	1.02-1.12		1.02	0.95-1.10	
Clinical and treatment								
Modified Charlson comorbidity score[†]								
0	42%	58%	ref		< .01	ref		< .01
1	38%	62%	0.88	0.85-0.92		0.91	0.87-0.95	
2	34%	66%	0.73	0.69-0.77		0.81	0.75-0.88	
3 +	29%	71%	0.58	0.55-0.61		0.69	0.64-0.74	
Chemotherapy[‡]								
No	25%	75%	ref		< .01	ref		< .01
Yes	57%	43%	3.98	3.84-4.13		3.57	3.42-3.72	
Hospice services[‡]								
No	41%	59%	ref		< .01	ref		.23
Yes	36%	64%	0.83	0.80-0.86		1.02	0.98-1.07	
Regional and health care services								
SEER region								
Northeast	39%	61%	ref		< .01	ref		< .01
South	41%	59%	1.12	1.07-1.18		1.14	1.04-1.24	
Midwest	40%	60%	1.06	1.00-1.13		1.08	1.00-1.18	
West	36%	64%	0.89	0.85-0.94		0.91	0.83-0.99	
Living in urban area								
No	40%	60%	ref		< .01	ref		.41
Yes	38%	62%	0.92	0.88-0.97		0.97	0.89-1.05	
Radiation oncology county density[§]								
Lowest tertile	39%	61%	ref		< .01	ref		< .01
Middle tertile	37%	63%	0.95	0.91-0.99		1.14	1.05-1.23	
Highest tertile	40%	60%	1.04	0.99-1.08		1.14	1.05-1.22	

CI, confidence interval; OR, odds ratio; ref, reference group; RT, radiation therapy; SEER, Surveillance, Epidemiology and End Results.

* By ZIP code.

† Measured using the Klabunde modification.

‡ Within 1 year of diagnosis.

§ Number of radiation oncologists (per 100,000 population) practicing within each patient's county of residence, divided into top (>1.5), middle (1-1.5), and bottom (<1) tertiles.

Table 4 Predictors of receipt of >10 fractions of RT among patients who received conventional RT

Predictors			Univariable			Multivariable		
	>10 fractions	≤10 fractions	OR	95% CI	P-value	OR	95% CI	P-value
Demographic								
Age at time of diagnosis (years)								
65-69	50%	50%	ref		< .01			.02
70-74	49%	51%	0.97	0.90-1.04		1.02	0.95-1.10	
75-79	47%	53%	0.89	0.83-0.96		0.98	0.91-1.06	
>80	47%	53%	0.89	0.82-0.96		1.13	1.04-1.23	
Sex								
Female	48%	52%	ref		.70			.63
Male	49%	51%	1.01	0.96-1.07		0.99	0.93-1.05	
Race								
White	49%	51%	ref		.04			.16
Black	46%	54%	0.88	0.80-0.97		0.92	0.81-1.04	
Asian/Pacific Islander	48%	52%	0.93	0.82-1.06		0.97	0.66-1.44	
Other	48%	52%	1.25	0.81-1.93		1.51	1.00-2.30	
Marital status								
Not married	47%	53%	ref		< .01			.46
Married	49%	51%	1.10	1.04-1.16		1.02	0.97-1.08	
Diagnosis year								
2004-2005	48%	52%	ref		.65			.68
2006-2007	48%	52%	1.00	0.93-1.08		1.03	0.97-1.10	
2008-2009	48%	52%	1.02	0.94-1.10		1.02	0.94-1.10	
2010-2011	49%	51%	1.05	0.97-1.13		1.05	0.96-1.14	
Median income quartile (percentile)*								
≤25th	49%	51%	ref		.11			.23
25 th -50 th	49%	51%	1.02	0.94-1.10		1.07	0.94-1.21	
50 th -75 th	47%	53%	0.93	0.87-1.01		0.96	0.85-1.09	
>75th	48%	52%	0.96	0.89-1.03		1.03	0.91-1.17	
Clinical and treatment								
Modified Charlson comorbidity score[†]								
0	49%	51%	ref		.30			.57
1	49%	51%	1.00	0.94-1.07		1.00	0.93-1.08	
2	47%	53%	0.94	0.86-1.04		0.95	0.85-1.07	
3 +	47%	53%	0.93	0.84-1.02		0.95	0.87-1.04	
Chemotherapy[‡]								
No	39%	61%	ref		< .01			< .01
Yes	54%	46%	1.79	1.69-1.89		1.74	1.61-1.88	
Hospice services[‡]								
No	52%	48%	ref		< .01			< .01
Yes	44%	56%	0.73	0.69-0.77		0.77	0.73-0.82	
Regional and health care services								
SEER region								
Northeast	43%	57%	ref		.09			.07
South	50%	50%	1.34	1.24-1.45		1.19	1.02-1.39	
Midwest	49%	51%	1.27	1.15-1.39		1.23	1.04-1.46	
West	49%	51%	1.29	1.19-1.39		1.13	0.97-1.33	
Living in urban area								
No	50%	50%	ref		.09			.40
Yes	48%	52%	0.93	0.86-1.01		1.06	0.93-1.20	
Radiation oncologist density[§]								
Lowest tertile	50%	50%	ref		< .01			.63
Middle tertile	47%	53%	0.90	0.84-0.96		0.96	0.85-1.09	
Highest tertile	48%	52%	0.92	0.86-0.99		1.01	0.90-1.13	
RT facility type								
Hospital-based	44%	56%	ref		< .01			< .01
Freestanding	58%	43%	1.74	1.65-1.84		1.74	1.60-1.89	

CI, confidence interval; OR, odds ratio; ref, reference group; RT, radiation therapy; SEER, Surveillance, Epidemiology and End Results.

* By ZIP code.

† Measured using the Klabunde modification.

‡ Within 1 year of diagnosis.

§ Number of radiation oncologists (per 100,000 population) practicing within each patient's county of residence, divided into top (>1.5), middle (1-1.5), and bottom (<1) tertiles.

fractions. Although unobserved differences in patient characteristics or preferences could account for some of this variation, differences in reimbursement of radiation or ownership structure by facility type may also be contributing factors. Prior studies have shown that radiation oncologists are overwhelmingly likely to recommend treatment once a patient is referred to them,³⁵ which suggests that practice type may be more likely to influence decisions about radiation intensity than decisions about whether to treat.

Previous work has shown a nearly two-fold differential in the reimbursement for IMRT between freestanding centers versus hospital-based outpatient clinics.³⁶ Although the reimbursement gap has decreased over time, another study has shown more a rapid adoption of IMRT at freestanding versus hospital-based centers.³⁷ Additionally, Mitchell et al. reported a 29% increase in the use of IMRT for patients with prostate cancer among physician-owned practices compared with nonphysician-owned practices³⁸ but data on practice ownership by freestanding versus hospital-based facility type are not readily available.

Further research is needed to determine the relative impact of financial incentives on the choice of treatment schema and develop effective strategies to properly align incentives. One possible solution may be the implementation of bundled payments that are piloted currently by the CMS and other insurers in close collaboration with providers and hospitals.³⁹ Even though the American Society for Radiation Oncology Choosing Wisely campaign's initial recommendations were released in 2013, data in support of these recommendations existed well before then. Furthermore, our data can serve as a baseline from which to evaluate the impact of the campaign.

Our study has several limitations. First, SEER-Medicare data are observational and lack the clinical granularity needed to identify radiation specifics including radiation treatment fields and doses. In addition, RT delivered in the inpatient setting is not captured in claims data.⁴⁰ SEER-Medicare data also do not directly provide information on treatment site but we expect that radiation that is administered to patients with incurable disease would be palliative in intent.

In our patient cohort, patients possibly received RT to the primary or a metastatic site. Although we attempted to glean potential treatment site by determining the associated ICD-9 code with the radiation delivery claim, diagnosis codes do not necessarily indicate the site of treatment and physicians may bill according to the primary rather than the secondary diagnosis code even when treating a metastatic site. Furthermore, we do not have information on symptom burden or performance status, which may influence decisions about palliative RT and the delivery of long or short courses of treatment.

Second, our analysis is limited to fee-for-service Medicare-insured patients who lived in SEER regions; therefore, the study results may not be generalizable to all patients with incurable NSCLC. However, since a majority of the

lung cancer diagnoses occurred in patients age >65 years and more than 95% of Americans age >65 years are covered by Medicare, our cohort's experiences are likely to represent typical patterns of care for NSCLC. In addition, the SEER-Medicare population has been shown to be reasonably representative of the general U.S. adult population.^{41,42} Finally, although we controlled for available demographic and clinical characteristics in our models, the possibility of additional confounding from other patient characteristics exists.

Conclusions

Our study characterizes the use of RT for patients with incurable NSCLC and identifies factors associated with the use of conventional palliative RT and extended fractionation. Although there are potential clinical scenarios when extended fractionation may be warranted, in most palliative settings, radiation treatments can safely and effectively be given in ≤ 10 fractions. Further research into the underlying factors, including potential financial incentive, that shape treatment decisions will allow for development of effective policies aimed at improving access and efficient administration of RT in an era when high-value care for patients is the focus.

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Supplementary data

Supplementary material for this article (<https://doi.org/10.1016/j.adro.2018.04.005>) can be found at www.practicalradonc.org.

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