Redistribution of Health Care Costs after the Adoption of Positron Emission Tomography among Medicare Beneficiaries with Non–Small-Cell Lung Cancer, 1998–2005

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Introduction: Treatment patterns and cost implications of increased positron emission tomography imaging use since Medicare approval in 1998 are not well understood. We examined rates of surgery, radiotherapy, and chemotherapy and inpatient and total health care costs between 1998 and 2005 among Medicare beneficiaries with non–small-cell lung cancer.

Methods: Patients in this retrospective cohort study were 51,374 Medicare beneficiaries diagnosed with non–small-cell lung cancer between 1996 and 2005. The main outcome measures were receipt of surgical resection, radiotherapy, and chemotherapy and inpatient and total health care costs within 1 year of diagnosis.

Results: Between 1996–1997 and 2004–2005, the proportion of patients undergoing surgical resection decreased from 29% to 25%, the proportion receiving radiation therapy decreased from 49% to 43%, and inpatient costs decreased from $28,900 to $26,900. The proportion of patients receiving chemotherapy increased from 25% to 40% and total costs increased from $47,300 to $52,200 ($p < 0.001$ for all comparisons). Changes in use and costs remained after adjustment for shifting demographic characteristics during the study period.

Conclusions: Adoption of positron emission tomography between 1998 and 2005 was accompanied by decreases in rates of surgery and radiotherapy and in short-term inpatient costs among Medicare beneficiaries with non–small-cell lung cancer, although there was an increase in chemotherapy and overall costs.

Key Words: Carcinoma, Non–small-cell lung cancer, Health care costs, Positron emission tomography.

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Positron emission tomography (PET) is an advanced imaging modality used in the clinical diagnosis, staging, and follow-up of non–small-cell lung cancer (NSCLC). Randomized controlled trials of PET use in initial staging of NSCLC have suggested that PET can detect occult metastatic disease and avoid futile resection.[1–3] Epidemiologic studies suggest that PET is associated with upstaging of NSCLC in clinical practice.[4,5] The presumption that appropriate detection of occult metastatic disease should reduce futile rates of localized tumor control and associated health care costs has been examined in a single randomized controlled trial[6] and remains an open question at the population level. Whether increased PET use among Medicare beneficiaries with NSCLC has affected rates of localized control or its associated costs remains an important policy question.

In this study, we examined rates of local surgical resection, radiotherapy, and chemotherapy and inpatient and total health care costs among Medicare beneficiaries with NSCLC. Specifically, we tested the hypotheses that, between 1998 and 2005, the Medicare population with NSCLC experienced reductions in the use of surgical resection and radiotherapy and in short-term inpatient surgery costs and overall health care costs.

PATIENTS AND METHODS

Data Source

Data are from the Surveillance Epidemiology and End Results (SEER)-Medicare linked data. SEER-Medicare is a collaborative effort between the National Cancer Institute and the Centers for Medicare & Medicaid Services that links routinely collected population-based data from cancer registries across the United States to Medicare administrative data and health care claims.[7] The SEER data include demographic and incident cancer characteristics, including grade and stage, for approximately 25% of the U.S. population with cancer. Medicare provides health insurance for 97% of people 65 years and older in the United States, and the data reflect health care services used and comorbid conditions. SEER-Medicare data have been used previously to examine factors that affect the quality of care for patients with cancer, including sociodemographic characteristics, physician and hospital characteristics, surgery, chemotherapy, radiation, comorbid conditions,

complications, screening, relapse, and costs.[8–18] The Office of Human Research Ethics at the University of North Carolina at Chapel Hill approved this study.

Study Population

We analyzed SEER-Medicare data from the 12 SEER registries that were active from 1996 onward. We included all patients from these registries who had a diagnosis of cancer of the lung and bronchus with microscopically confirmed NSCLC histology between 1996 and 2005, were 66 years or older at the time of the diagnosis, and had Medicare Part A and Part B coverage without participating in a health maintenance organization or in Medicare Part C during the year before and after diagnosis or until death. We excluded patients for whom a diagnosis was determined at autopsy or death or who had another diagnosis of malignancy in the year before the NSCLC diagnosis. To help ensure full acquisition of cancer-related claims, we also required that patients have a primary diagnosis of lung cancer (*International Classification of Diseases, Ninth Revision, Clinical Modification* 162.2–162.9 or 231.2) on an inpatient, outpatient, or carrier-based Medicare claim within 2 months of the SEER diagnosis.

Study Variables

The primary study outcomes were surgical resection, receipt of radiotherapy, and inpatient health care costs within 1 year of the SEER diagnosis. Additional treatment and cost variables included receipt of chemotherapy, use of PET, and overall health care costs. We obtained treatment and health care costs from claims data from 2 months before through 12 months after the month of the NSCLC diagnosis in the SEER data. We identified receipt of each treatment modality using previously defined sets of Healthcare Common Procedure Coding System codes and *International Classification of Diseases, Ninth Revision, Clinical Modification* codes (Supplemental Table, Supplementary Digital Content 1, http://links.lww.com/JTO/AXX).[19,20] We identified surgical procedures using claims for lung resection from inpatient, outpatient, or carrier claims files.[19] We identified receipt of chemotherapy using claims from outpatient, carrier, and durable medical equipment claims files.[20] We used outpatient and carrier claims data to identify receipt of radiation therapy.[20] We also used outpatient and carrier claims from 2 months before through 4 months after the SEER diagnosis to identify use of PET to coincide with the 4-month follow-up period used by SEER to provide cancer stage.[21] Medicare payment information was available in each claim file; we summed line-item payments (from home health, hospice, and outpatient files), total claim payment amounts (from carrier and durable medical equipment files), or total reimbursement plus total daily per diem charges (from inpatient files) and adjusted all payments to 2008 dollars using the health care component of the Consumer Price Index.

We obtained all remaining variables from the SEER Patient Entitlement and Diagnosis Summary File. We extrapolated SEER cancer stage to the American Joint Committee on Cancer third edition staging system to provide a common staging system throughout the study period.[5] Survival at 2 years was obtained from the SEER-based death date. Demographic variables included age, sex, race, ethnicity, marital status, and local census tract characteristics (i.e., metropolitan urban or rural status, percentage not finishing high school, percentage below the poverty line, and percentage of black race).

Statistical Analysis

We defined discrete cohorts to represent the pre-PET period (1996–1997), the initial PET period (2000–2001), and the late PET period (2004–2005). We compared demographic and treatment characteristics using chi-square tests for categorical variables and Kruskal-Wallis nonparametric tests for continuous variables. We used multivariable logistic regression models (logit) to examine the use of surgical resection, radiation therapy, and chemotherapy over time using 1996–1997 as the reference period and modeling subsequent years as categorical variables.

We analyzed health care costs using multivariable ordinary least squares regression models of total Medicare payments in the inpatient, non-inpatient, and total claims files between 1996 and 2005. We modeled Medicare payments as logged costs to adjust for left-skewed cost data and to avoid nonnormally distributed error terms. We calculated relative percentage differences in costs as described by Kennedy.[22]

All regression models controlled for disease stage and demographic characteristics. In order for all observations to use sociodemographic variables from the 2000 census, we used 1996 as the earliest year in the regression analyses. Patient SEER registry was included as a control variable in all regressions to mitigate the effects of regional differences in treatment practices and costs.[7]

We performed sensitivity analysis of cost regressions by analyzing short-term costs (within 4 mo of diagnosis) to provide a more direct surrogate for initial surgical costs. All results were considered significant at p less than 0.05. We used SAS version 9.2 (SAS Institute, Cary, NC) for all analyses.

RESULTS

Of the 159,201 Medicare beneficiaries diagnosed with cancer of the lung and bronchus by SEER between 1996 and 2005, 58,575 met the eligibility criteria for the analysis (Supplemental Figure, Supplementary Digital Content 1, http://links.lww.com/JTO/AXX). Later NSCLC cohorts had a larger percentage of patients who were older than 80 years, were women, had more than 1 comorbid condition, and were not married (Table 1; all $p < 0.001$).

As shown in Table 2, between 1996–1997 and 2004–2005, decreasing proportions of patients underwent surgical resection (29.1% versus 24.7%; $p < 0.001$) and radiation (49.4% versus 42.9%; $p < 0.001$). By contrast, the proportion of patients receiving chemotherapy increased significantly from 25.1% to 40.4% ($p < 0.001$). During the same period, total costs per patient increased from $47,300 to $52,200 ($p < 0.001$). Increasing costs were entirely driven by non-inpatient costs ($18,400 versus $25,300; $p < 0.001$). Inpatient costs in the year after diagnosis decreased by $2200 per patient by 2000–2001 ($p < 0.001$). The overall proportion of patients undergoing surgical resection or radiation began to decrease by 2000, whereas chemotherapy use increased

TABLE 1. Demographic Characteristics of the Study Population by Cohort

Characteristic	Pre-PET Cohort, 1996–1997 (*n* = 9638)	Initial PET Cohort, 2000–2001 (*n* = 9551)	Post-PET Cohort, 2004–2005 (*n* = 11,814)	*p*
Age >80 yr, *n* (%)	1624 (16.9)	2006 (21.0)	2837 (24.0)	<0.001
Male, *n* (%)	5332 (55.3)	5140 (53.8)	6064 (51.3)	<0.001
Black race, *n* (%)	763 (7.9)	786 (8.2)	964 (8.2)	0.70
Comorbid conditions, *n* (%)				<0.001
0	5532 (57.4)	4988 (52.2)	5751 (48.7)	
1	2568 (26.6)	2726 (28.5)	3456 (29.3)	
≥2	1538 (16.0)	1837 (19.2)	2607 (22.1)	
Census tract characteristics (highest quartile)				
Did not complete high school	2026 (26.1)	2070 (25.5)	2399 (22.8)	<0.001
Below poverty line	2005 (25.8)	2007 (24.7)	2423 (23.1)	<0.001
Percent black	2019 (26.0)	1995 (24.6)	2437 (23.2)	<0.001
Married, *n* (%)	5385 (55.9)	5064 (53.0)	6108 (51.7)	<0.001
Metropolitan, *n* (%)	8294 (86.1)	8179 (85.6)	10,165 (86.0)	0.63
U.S. geographic region				<0.001
Midwest	3377 (35.0)	3314 (34.7)	3822 (32.4)	
Northeast	1479 (15.4)	1374 (14.4)	1796 (15.2)	
South	678 (7.0)	649 (6.8)	777 (6.6)	
West	4104 (42.6)	4214 (44.1)	5419 (45.9)	

PET, positron emission tomography.

throughout the study period (Figure 1). Inpatient surgery costs decreased between 1998 and 2003, whereas nonsurgical inpatient costs remained stable over the study period and total costs increased steadily between 2000 and 2004 (Figure 2). The average cost of chemotherapy and radiation therapy combined constituted a relatively small and stable cost over the course of the study.

After adjustment for shifting patient demographic characteristics, and using 1996–1997 as the reference, the odds of undergoing surgical resection or radiation therapy decreased

TABLE 2. Outcomes, Treatments, and Costs by Cohort

Characteristic	Pre-PET Cohort, 1996–1997 (*n* = 9638)	Initial PET Cohort, 2000–2001 (*n* = 9551)	Post-PET Cohort, 2004–2005 (*n* = 11,814)	*p*
Any PET scan, *n* (%)	23 (0.2)	1674 (17.5)	6314 (53.5)	<0.001
Distance to PET facility < 40 miles, *n* (%)	—	4511 (47.2)	6075 (51.4)	<0.001
Disease stage, *n* (%)				<0.001
Localized disease (stage I–IIIA)	3173 (32.9)	3031 (31.7)	4342 (36.8)	
Advanced disease (stage IIIB–IV)	4303 (44.7)	4907 (51.4)	6212 (52.6)	
Unstaged	2162 (22.4)	1613 (16.9)	1260 (10.7)	
Overall 2-year survival, *n* (%)	2766 (28.7)	2730 (28.6)	3529 (29.9)	0.07
Treatment, *n* (%)				
Any resection	2803 (29.1)	2529 (26.5)	2913 (24.7)	<0.001
Any radiation	4765 (49.4)	4685 (49.1)	5066 (42.9)	<0.001
Any chemotherapy	2423 (25.1)	3257 (34.1)	4771 (40.4)	<0.001
No treatment	7519 (22.0)	7393 (22.6)	8895 (24.7)	<0.001
Costs, mean, $[a]				
Inpatient	28,924	26,749	26,944	<0.001
Non-inpatient	18,411	20,329	25,266	<0.001
PET[a]	0	308	741	<0.001
Total	47,335	47,079	52,209	<0.001

[a]PET costs are a subset of non-inpatient costs. All costs are expressed in 2008 U.S. dollars.
PET, positron emission tomography.

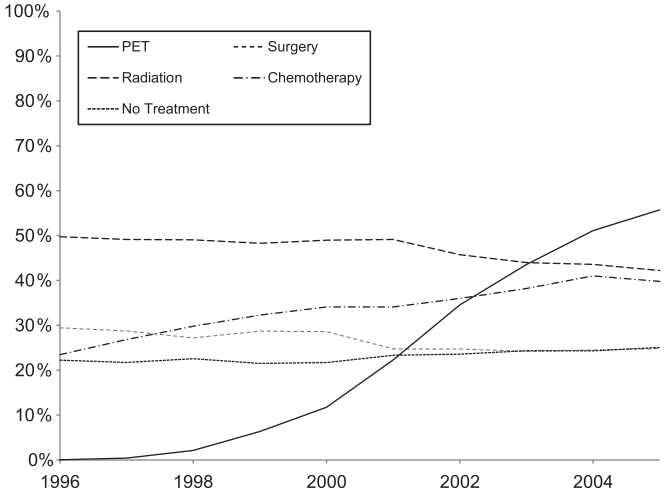

FIGURE 1. Treatment patterns among Medicare beneficiaries with non–small-cell lung cancer, 1996–2005. PET, positron emission tomography.

and the odds of receiving chemotherapy increased between 2001 and 2005 (Table 3). Surgical resection was more likely among patients who had localized disease or were married and was less likely among older patients, men, patients from census tracts with lower levels of education, and patients with advanced disease or multiple comorbid conditions. Both radiation therapy and chemotherapy were more likely among patients with advanced disease and were less likely among patients older than 80 years (all $p < 0.001$).

Total non-inpatient and overall mean costs per patient increased between 1996–1997 and 2005. After adjustment for shifting demographic characteristics and using 1996–1997 as the pre-PET baseline, 12-month inpatient costs in the year after diagnosis did not change significantly, but the coefficients for years 2000, 2001, and 2004 suggested a trend toward decreasing inpatient costs (Table 4). Sensitivity analyses of inpatient costs, in which we limited the cost analysis to the 4 months after diagnosis, showed a significant 12% decrease in inpatient costs. Total health care costs increased by 10% by 2005, driven entirely by increases in non-inpatient costs. Localized disease, black race, and comorbidity increased both inpatient and overall health care costs.

In sensitivity analyses, the presence of localized disease was more strongly associated with inpatient costs within 4 months than at 12 months. Overall costs and non-inpatient cost estimates were unaffected by analyses using a 4-month versus 12-month cost window.

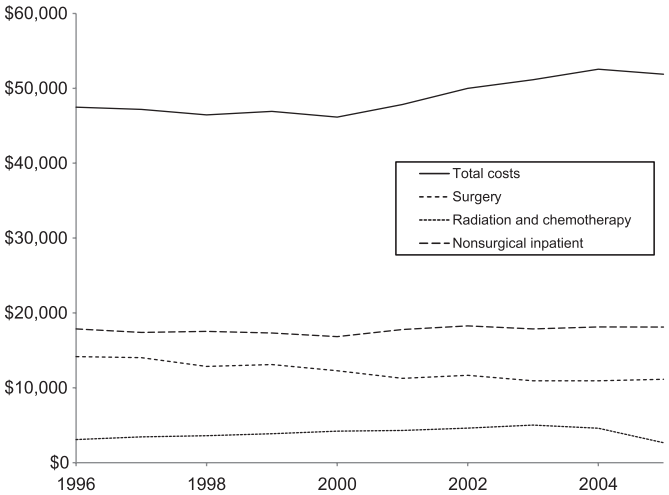

FIGURE 2. Mean treatment costs among Medicare beneficiaries with non–small-cell lung cancer, 1996–2005.

DISCUSSION

After controlling for shifting demographic characteristics, we found that Medicare beneficiaries with NSCLC were less likely after the adoption PET to undergo surgery or radiation therapy and had lower mean inpatient costs between 1998 and 2005. However, during the same period, the use of chemotherapy and non-inpatient expenditures increased rapidly, more than offsetting potential savings in inpatient expenditures.

Estimates from 2003 through 2005 suggest a relatively stable reduction of 12% in inpatient expenditures, which in 2004–2005 would have amounted to an approximately $3200 reduction per patient. During the same period, increased non-inpatient costs counteracted any net cost savings. Interpretation of cost redistribution may be complicated by other changes in oncology practice that occurred during the study period, including a global shift of cancer care from inpatient to outpatient settings[23] and evolving guidelines supporting increased chemotherapy use in patients with NSCLC.[24] We observed a consistent increase in chemotherapy use before, during, and after the study period that did not appear temporally correlated with PET adoption. Alternatively, the observed decrease in surgical and associated inpatient costs could be due, in part, to a growing proportion of patients with multiple comorbid conditions in later cohort years who might be denied a surgical procedure for medical reasons unrelated to cancer. However, we did not observe a concomitant substitution or increase in radiation therapy, typically used in medically inoperable patients, which would argue against an increase in comorbidity as the sole explanation for our findings.

It has been largely accepted that PET may reduce futile thoracotomies that might otherwise occur when a patient who presents with occult metastatic disease undergoes local, definitive treatment for incurable disease.[1] It should be noted, however, that PET scans can also result in false-positive results and could potentially cause cancellation of surgical resection for some patients. Because of appropriate, selective PET administration among patients with early-stage, less aggressive disease, demonstrating a direct association of PET with reduced thoracotomy and radiotherapy rates is difficult using a nonexperimental approach. Nonetheless, our study provides supporting evidence that PET-induced stage migration may have reduced rates of futile thoracotomy and radiation, accompanied by a decrease in subsequent inpatient health care costs.

Alternative explanations for decreasing surgery rates include changes in general oncology practice patterns unrelated to PET use,[23] changing guidelines,[24] and evidence suggesting the benefit of chemotherapy, and improvements

TABLE 3. Regression Analysis of Receiving Any Resection, Radiation, or Chemotherapy between 1996 and 2005 (n = 43,695)

	OR (95% CI)		
Characteristic	**Any Resection**	**Any Radiation**	**Any Chemotherapy**
Year of diagnosis			
1996/1997	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
1998	0.93 (0.84–1.04)	0.97 (0.85–1.11)	1.30 (1.19–1.43)[a]
1999	1.04 (0.91–1.18)	0.95 (0.86–1.05)	1.52 (1.34–1.72)[a]
2000	0.98 (0.88–1.10)	0.96 (0.90–1.03)	1.68 (1.58–1.79)[a]
2001	0.87 (0.79–0.96)	0.97 (0.92–1.03)	1.72 (1.59–1.87)[a]
2002	0.86 (0.76–0.97)	0.85 (0.79–0.93)[a]	1.89 (1.75–2.04)[a]
2003	0.83 (0.74–0.93)	0.81 (0.77–0.85)[a]	2.08 (1.94–2.23)[a]
2004	0.72 (0.63–0.81)[a]	0.81 (0.73–0.89)[a]	2.52 (2.35–2.70)[a]
2005	0.75 (0.67–0.84)[a]	0.76 (0.69–0.84)[a]	2.39 (2.21–2.57)[a]
Localized disease	7.14 (5.75–8.88)[a]	0.73 (0.68–0.79)[a]	0.54 (0.49–0.61)[a]
Advanced disease	0.30 (0.24–0.37)[a]	1.40 (1.29–1.51)[a]	1.21 (1.09–1.34)[a]
PET facility >40 miles away	1.09 (0.97–1.23)	1.02 (0.96–1.08)	1.02 (0.93–1.12)
Age > 80 yr	0.44 (0.40–0.47)[a]	0.76 (0.72–0.81)[a]	0.34 (0.32–0.36)[a]
Black race	0.68 (0.59–0.77)[a]	1.12 (1.04–1.21)	0.96 (0.88–1.05)
Comorbid conditions			
1	0.90 (0.82–0.99)	0.94 (0.89–0.99)	0.87 (0.84–0.91)[a]
>1	0.71 (0.65–0.77)[a]	0.88 (0.85–0.91)[a]	0.61 (0.57–0.67)[a]
Census tract–level percentage of population with less than high school education			
Quartile 2	0.79 (0.72–0.88)[a]	1.02 (0.99–1.06)	0.97 (0.94–1.00)
Quartile 3	0.72 (0.61–0.86)[a]	1.02 (0.95–1.09)	0.95 (0.89–1.02)
Quartile 4	0.63 (0.51–0.78)[a]	1.02 (0.96–1.09)	0.91 (0.8–1.03)
Census tract–level percentage of population below poverty level			
Quartile 2	1.05 (0.96–1.15)	0.96 (0.92–1.01)	0.97 (0.92–1.02)
Quartile 3	1.08 (0.96–1.22)	0.92 (0.88–0.96)[a]	0.89 (0.83–0.96)
Quartile 4	1.03 (0.87–1.20)	0.95 (0.90–1.01)	0.84 (0.72–0.98)
Census tract–level percentage of population of black race			
Quartile 2	1.01 (0.95–1.08)	1.01 (0.96–1.06)	0.98 (0.92–1.03)
Quartile 3	0.96 (0.87–1.07)	1.02 (0.97–1.07)	0.99 (0.93–1.07)
Quartile 4	1.06 (1.00–1.12)	0.95 (0.88–1.02)	0.87 (0.81–0.94)[a]
Male sex	0.74 (0.7–0.78)[a]	1.14 (1.11–1.17)[a]	1.15 (1.11–1.20)[a]
Married	1.39 (1.31–1.47)[a]	1.10 (1.06–1.14)[a]	1.40 (1.34–1.46)[a]
Metropolitan area	0.99 (0.92–1.06)	1.01 (0.93–1.09)	0.88 (0.78–0.99)

[a] $p < 0.001$.
CI, confidence interval; OR, odds ratio; PET, positron emission tomography.

in management of side effects. Alternatively, the use of higher-resolution computed tomographic scans or mediastinoscopy, increased appreciation of surgical morbidity in patients with advanced disease, or an aging and sicker population may have shifted the risks and benefits, actual or perceived, of local versus systemic treatment during the study period. In theory, a reduction in futile thoracotomy could lead to an inadvertent increase in the use of chemotherapy. Making this scenario less likely is the observation that chemotherapy rates increased before PET adoption. Nonetheless, the potential for PET to shift care from thoracotomy to chemotherapy has not previously been appreciated within small randomized trials and represents an important consideration when evaluating the overall effect of PET use on health care expenditures.

Our study has several limitations. First, we were only able to identify PET scans reimbursed by Medicare. To minimize missed claims, we limited all analyses to Medicare beneficiaries who were likely to have complete claims data. Second, the SEER registry overrepresents patients who are nonwhite, live in areas with less poverty, and live in urban areas, which may limit the generalizability of the findings.[7] In addition, changes in treatment patterns and costs between SEER registries may vary. To help mitigate these differences, we included registry as a control variable in all regression analyses. Third, Medicare claims include intravenous chemotherapy and oral equivalents, but not chemotherapy or supportive medications filled as outpatient prescription. Oral chemotherapy can pose a substantial cost to patients and outside insurers, and our analysis likely underestimates the

TABLE 4. Regression Analysis of Inpatient and Total Costs between 1996 and 2005 (n = 43 695)

	Relative Change in Percentage of Costs		
Characteristic	**Inpatient Costs at 1 Year (95% CI)[a]**	**Inpatient Costs at 4 Months (95% CI)[a]**	**Total Costs at 1 Year (95% CI)[a]**
Year of diagnosis			
1996/1997	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
1998	0.99 (0.92–1.06)	0.97 (0.92–1.02)	1.00 (0.94–1.06)
1999	1.00 (0.94–1.07)	0.98 (0.93–1.04)	1.02 (0.96–1.08)
2000	0.92 (0.87–0.97)	0.90 (0.87–0.93)[b]	0.97 (0.93–1.02)
2001	0.93 (0.89–0.97)	0.90 (0.87–0.93)[b]	1.02 (0.98–1.06)
2002	0.99 (0.92–1.07)	0.96 (0.89–1.02)	1.09 (1.03–1.15)
2003	0.93 (0.86–1.00)	0.88 (0.84–0.91)[b]	1.09 (1.02–1.17)
2004	0.92 (0.87–0.98)	0.85 (0.81–0.89)[b]	1.11 (1.06–1.17)[b]
2005	0.94 (0.88–1.00)	0.88 (0.84–0.93)[b]	1.10 (1.05–1.15)[b]
Localized disease	1.32 (1.28–1.37)[b]	1.46 (1.41–1.50)[b]	1.14 (1.13–1.15)[b]
Advanced disease	1.03 (0.96–1.10)	1.15 (1.05–1.25)	1.00 (0.97–1.04)
PET facility > 40 miles away	1.00 (0.95–1.04)	1.01 (0.98–1.04)	1.00 (0.97–1.03)
Age > 80 yr	0.84 (0.81–0.87)[b]	0.88 (0.85–0.91)[b]	0.81 (0.79–0.83)[b]
Black race	1.16 (1.11–1.20)[b]	1.11 (1.09–1.13)[b]	1.10 (1.08–1.12)[b]
Comorbid conditions			
1	1.10 (1.08–1.12)[b]	1.09 (1.06–1.11)[b]	1.07 (1.05–1.10)[b]
>1	1.31 (1.26–1.36)[b]	1.28 (1.24–1.33)[b]	1.21 (1.15–1.27)[b]
Census tract–level percentage of population with less than high school education			
Quartile 2	1.01 (0.97–1.05)	1.00 (0.98–1.02)	1.00 (0.97–1.02)
Quartile 3	1.02 (0.98–1.06)	1.02 (0.98–1.07)	1.00 (0.96–1.03)
Quartile 4	1.04 (1.01–1.08)	1.06 (1.02–1.10)	1.00 (0.98–1.03)
Census tract–level percentage of population below poverty level			
Quartile 2	1.01 (0.98–1.04)	1.00 (0.97–1.03)	1.00 (0.99–1.02)
Quartile 3	1.02 (0.99–1.06)	1.00 (0.98–1.02)	1.01 (0.98–1.04)
Quartile 4	1.11 (1.03–1.20)	1.10 (1.02–1.18)	1.07 (0.98–1.16)
Census tract–level percentage of population of black race			
Quartile 2	1.01 (0.97–1.05)	1.00 (0.95–1.05)	1.00 (0.97–1.02)
Quartile 3	1.02 (0.96–1.08)	1.02 (0.96–1.09)	1.01 (0.97–1.04)
Quartile 4	1.00 (0.94–1.06)	1.01 (0.96–1.07)	0.98 (0.94–1.03)
Male sex	1.04 (1.01–1.07)	1.03 (1.00–1.06)	1.02 (1.00–1.04)
Married	0.96 (0.93–1.00)	0.94 (0.91–0.97)[b]	1.02 (0.99–1.05)
Metropolitan area	1.09 (0.99–1.19)	1.06 (0.97–1.16)	1.04 (0.99–1.08)

[a]Relative percentage change in costs = $\text{Exp}(\beta - \frac{1}{2}\sigma_{\beta}^2) - 1$ (per Kennedy[22]).
[b]$p < 0.001$.
CI, confidence interval; PET, positron emission tomography.

overall costs of oral chemotherapy and nonchemotherapy prescriptions for patients with cancer.

In conclusion, surgical resection, radiotherapy, and corresponding inpatient costs decreased among Medicare with NSCLS after the widespread adoption of PET. Consistent with previous research, this study suggests that PET has played a role in the upstaging of early-stage NSCLC and a corresponding reduction in futile attempts at local control of occult metastatic disease. The ability of PET to affect patient management, health care resource use, and costs remain important areas of ongoing research that may change as new treatments become available.

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