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ARTICLE

Regional Variation in Spending and Survival for Older Adults With Advanced Cancer

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Background Medicare spending varies substantially across the United States. We evaluated the association between mean regional spending and survival in advanced cancer.

Methods We identified 116 523 subjects with advanced cancer from 2002 to 2007, using Surveillance, Epidemiology and End Results (SEER)–Medicare linked data. Subjects were aged 65 years and older with non–small cell lung, colon, breast, prostate, or pancreas cancer. Of these subjects, 61 083 had incident advanced-stage cancer (incident cohort) and 98 935 had death from cancer (decedent cohort); 37% of subjects were included in both cohorts. Subjects were linked to one of 80 hospital referral regions within SEER areas. We estimated mean regional spending in both cohorts. We assessed the primary outcome, survival, in the incident cohort; the exposure measure was the quintile of regional spending in the decedent cohort. Survival in quintiles 2 through 5 was compared with that in quintile 1 (lowest spending quintile) using Cox regression models.

Results From quintile 1 to 5, mean regional spending increased by 32% and 41% in the incident and decedent cohorts (incident cohort: $28 854 to $37 971; decedent cohort: $27 446 to $38 630). The association between spending and survival varied by cancer site and quintile; hazard ratios ranged from 0.92 (95% confidence interval [CI] = 0.82 to 1.04, pancreas cancer quintile 5) to 1.24 (95% CI = 1.11 to 1.39, breast cancer quintile 3). In most cases, differences in survival between quintile 1 and quintiles 2 through 5 were not statistically significant.

Conclusion There is substantial regional variation in Medicare spending for advanced cancer, yet no consistent association between mean regional spending and survival.

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The last 2 decades have seen sustained reductions in cancer incidence and mortality in the United States, primarily because of reductions in smoking and improved detection and treatment of early-stage cancers (1,2). Improvements in outcomes for patients with advanced cancer have been limited; most new advanced cancer therapies provide survival gains of weeks to months, and many are associated with high costs (3,4).

Spending for cancer care comprises approximately 10% of Medicare payments (5), and US outlays for cancer care will reach $157 billion annually by 2020 (6). Phase-of-care costs are highest for patients with advanced-stage cancer (7,8). Although developing life-prolonging therapies for advanced cancer remains the primary goal of therapeutic research, improving the value of medical spending for advanced cancer is increasingly recognized as a priority (9–11).

Analysis of regional variation in medical spending can be used to assess value in health-care delivery. Studies of regional variation have demonstrated large area-level differences in general medical spending (12,13); however greater area-level spending has not been consistently associated with better patient outcomes (14–16). The policy and practice implications of regional variation in medical spending remain uncertain, however, as the value of increased spending varies across clinical settings and interventions.

We sought to better understand the association between medical spending and survival in patients with advanced cancer. Our study used the Surveillance, Epidemiology and End Results (SEER)–Medicare linked data, providing us with extensive clinical information about patients with advanced cancer, including cancer stage. We hypothesized that area-level spending was not associated with overall survival.

Methods

Data Sources

SEER data record incident cancer cases from 17 affiliated cancer registries, covering approximately 28% of the US population (17). Clinical information includes details of cancer site, stage, and histology. The Medicare files document use of health-care services by patients enrolled in fee-for-service Medicare. The SEER–Medicare linkage included patients with diagnoses of invasive cancer before

December 31, 2007, and Medicare claims through December 31, 2009. The study was deemed exempt from review by the institutional review board at the Dana-Farber Harvard Cancer Center.

Study Subjects

All subjects were Medicare beneficiaries aged 65 years and older who had been diagnosed with one of five cancers (non–small cell lung cancer [NSCLC], colorectal, pancreas, breast, and prostate cancer). These five cancer sites account for the majority of newly diagnosed cancer cases and cancer deaths in the United States (1).

We assembled two analytic cohorts: subjects in the incident cohort had a diagnosis of advanced-stage cancer from 2002 to 2007, and subjects in the decedent cohort died from cancer between 2002 and 2007. Patients with atypical histologies (eg, neuroendocrine tumors) were excluded. Advanced stage was defined as the American Joint Committee on Cancer (version 6) stages at which therapeutic interventions are generally palliative, including stage IV for all cancer sites, as well as stage IIIB for NSCLC and stage III for pancreas cancer. Because SEER data do not identify cancer progression, all subjects in the incident cohort had advanced-stage cancer at the time of diagnosis. In the decedent cohort, death from cancer was determined using the SEER cause-specific death classification (18). Qualifying patients could be included in both cohorts. Medicare spending was estimated, and mean regional spending was calculated in both cohorts. Survival, the primary outcome, was assessed in the incident cohort.

We estimated spending in two cohorts because the attributes of the cohorts are complementary. Subjects in the incident cohort are prospectively identified and have a shared expected prognosis ("look-forward" approach); however time from diagnosis until death is variable. For subjects in the decedent cohort, spending is calculated over an identical amount of time before death ("look-back" approach). Because decedent cohorts are only retrospectively identifiable, their use in research has been criticized (19). However, illness trajectory in many advanced cancers is highly homogeneous, and resource use at the end of life has important clinical and policy implications. Our study design allows for a comparison of spending variation in overlapping "look-forward" and "look-back" cohorts.

Estimation of Medicare Spending

We used Medicare claims to estimate total Medicare spending over a 6-month observation period in both cohorts. Claims files included inpatient, outpatient, physician, home health, durable medical equipment, and hospice files. The observation period for claims in the incident cohort was from diagnosis until 6 months after diagnosis; for subjects who died less than 6 months after diagnosis, spending estimates are from the time of diagnosis until the time of death. The observation period in the decedent cohort was the 6 months before death, regardless of the date of diagnosis.

All spending estimates are from the perspective of the Medicare program and are based on Medicare reimbursement variables in claims files. Estimates do not include patient copayments or coinsurance. Disproportionate share and indirect medical education payments were subtracted from inpatient reimbursements. To adjust for inflation we used the Hospital Input Price Index for part A expenditures and the Medicare Economic Index for part B expenditures (20). All spending is expressed in 2009 US dollars.

Geographic and Demographic Adjustment of Medicare Spending

To compare Medicare spending between regions with distinct geographic and demographic characteristics, we performed geographic and demographic adjustments of all spending estimates. Medicare payment policies explicitly recognize geographic variation in spending power by varying payments to health-care providers based on local differences in prevailing wages (21). Our geographic adjustment effectively reverses the Medicare payment adjustments, approximating a geographically normalized payment. We used the capital geographic adjustment factor to adjust part A expenditures and the geographic practice cost indices to adjust part B expenditures (20). The geographic adjustment factor and geographic practice cost indices are calculated by the Department of Health and Human Services for applicable administrative regions (22). Geographic adjusters were assigned based on the location of care delivery.

We adapted the method of the Dartmouth Atlas of Health Care in performing demographic adjustment of spending (12). Each patient was assigned to a demographic cell defined by cancer site, age (65–69, 70–74, 75–79, or 80 years and older), race (black vs nonblack), sex, and stage (for NSCLC only). We then used estimates of mean spending in each cell to adjust spending for all subjects to that of a demographically standardized subject. Demographic adjustments were performed separately for the incident and decedent cohorts.

Exposure Measure

The exposure measure for our survival analysis was the mean regional 6-month spending for advanced cancer stratified by quintile, as measured in the decedent cohort. We used the decedent cohort spending quintiles as the exposure measure to minimize endogeneity bias, where variable observation time leads to systematic error in spending estimation. We calculated a distinct set of spending quintiles in the incident cohort to evaluate the consistency of mean regional spending over the two cost observation periods.

We used hospital referral regions (HRRs) as the regions of interest. HRRs are geographic areas defined by the Dartmouth Atlas of Health Care to describe regional patterns of referral for tertiary care (23). Three hundred six HRRs are defined in the United States, and 95 HRRs overlap with SEER areas. Using a restricted variable from the SEER data (zip code of residence), we identified 80 HRRs in SEER areas contributing 100 or more eligible subjects with incident advanced cancer from 2002 to 2007; we included subjects living in these 80 HRRs in our study.

For each HRR, we first calculated mean spending by cancer site. We then calculated a composite measure of mean regional advanced cancer spending for all five cancer sites. The composite measure is a rescaled and weighted mean of spending across the five cancer sites; details are reported in the Supplementary Methods (available online). We then rank-ordered the 80 HRRs by the composite measure and divided them into quintiles. Quintiles represent similar numbers of subjects, resulting in varying numbers of HRRs per quintile.

Baseline Characteristics

Baseline characteristics of study subjects, including age at diagnosis, sex, race/ethnicity, marital status, urban residency, comorbidity, area median education, and area median income, are reported in Table 1. The Deyo (24) and Klabunde (25) adaptations of the Charlson (26) comorbidity index were used to measure severity of comorbid diseases, with modification to exclude cancer diagnoses. We applied this method to Medicare inpatient, outpatient, and physician claims during the 12-month period before the cost observation period. For patients who did not have 12 months of claims data available (3.3%), we used all available data to assign a comorbidity score.

Outcomes

We measured overall survival in the incident cohort for each of the five cancer sites. Survival was measured from the time of advanced cancer diagnosis until death from any cause, as reported in the Medicare enrollment file. Patients surviving until December 31, 2009, were censored. Additional outcomes included the use of nine specific health-care services and seven end-of-life quality measures (27,28); these data were extracted from Medicare claims using summary data fields, Healthcare Common Procedure Coding System codes, and International Classification of Diseases, Ninth Edition procedure codes (see Supplementary Methods, available online, for details).

Table 1. Characteristics of older adults with advanced cancer by cohort and spending quintile*

	Incident cohort						Decedent cohort					
Characteristics	**No.**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**No.**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
Cancer site												
All	61 083	100	100	100	100	100	98 935	100	100	100	100	100
NSCLC	35 680	57.5	59.8	60.0	59.3	55.6	47 961	45.0	49.1	51.7	49.1	47.1
Colorectal	9778	15.9	15.5	16.0	16.4	16.1	21 983	23.0	21.2	21.7	22.4	23.0
Pancreas	6910	11.8	10.8	10.2	11.5	12.3	10 864	10.8	11.0	9.9	11.3	12.1
Breast	3316	4.8	4.7	5.4	5.8	6.3	9187	10.0	8.9	8.9	9.4	9.3
Prostate	5399	10.0	9.3	8.4	7.1	9.7	8940	11.3	9.8	7.8	7.8	8.6
Age, y												
65–69	14 269	22.7	23.2	25.9	22.2	22.9	20 371	20.1	19.8	22.8	20.2	20.2
70–74	14 971	24.3	24.6	25.1	24.4	24.2	23 332	24.0	23.5	24.3	23.8	22.3
75–79	14 630	24.0	24.2	24.2	24.5	22.9	23 844	24.1	24.2	23.3	24.7	24.2
≥80	17 201	29.0	28.0	24.8	28.9	30.0	31 376	31.8	32.5	29.6	31.3	33.4
Sex												
Female	28 542	44.5	46.8	45.1	49.7	47.3	49 104	48.1	48.7	49.5	51.2	50.7
Male	32 541	55.5	53.2	54.9	50.3	52.7	49 831	51.9	51.3	50.5	48.8	49.3
Race/ethnicity												
White†	50 411	81.7	87.6	86.3	80.2	77.7	82 639	83.0	91.1	86.9	80.7	75.1
Black†	6252	3.3	4.9	12.2	18.1	11.7	9715	4.2	2.9	10.3	17.3	14.5
Other	4200	15.0	7.4	1.5	1.8	10.6	6581	12.8	6.0	2.8	2.0	10.3
Marital status												
Married	31 361	54.0	51.0	52.9	48.4	50.6	48 672	51.7	51.9	48.5	46.6	47.3
Not married	29 722	46.0	49.0	47.1	51.6	49.4	50 263	48.3	48.1	51.5	53.4	52.7
Metropolitan residency												
Yes	51 873	81.8	88.9	70.0	93.2	89.9	83 511	78.0	79.7	78.6	93.8	91.8
No	9 210	18.2	11.1	30.0	6.8	10.1	15 424	22.0	20.3	21.4	6.2	8.2
Modified Charlson comorbidity score‡												
0	34 519	59.4	57.7	57.0	53.9	54.9	60 190	65.9	63.4	59.8	56.8	58.4
1	15 147	24.2	24.9	24.8	24.8	25.3	21 980	20.7	21.5	22.9	23.3	22.6
≥2 or	11 417	16.4	17.4	18.2	21.3	19.8	16 765	13.3	15.1	17.3	19.9	18.9
Median income (Census tract)§												
1 (lowest)	12 214	13.3	16.0	28.9	21.4	20.2	19 777	13.0	15.4	26.2	21.6	23.6
2	12 217	19.4	21.7	23.2	18.5	17.5	19 780	21.6	22.6	18.9	20.7	16.0
3	12 212	20.0	24.1	19.8	20.6	15.8	19 776	21.4	23.3	16.5	21.1	17.3
4	12 216	23.3	21.5	16.0	19.5	19.7	19 781	22.9	20.7	16.6	20.5	19.4
5 (highest)	12 216	24.0	16.6	12.1	19.9	26.8	19 777	21.2	17.9	21.6	16.1	23.6
College educated (Census tract)												
1 (lowest)	12 221	12.1	18.2	26.5	25.1	17.9	19 781	10.6	14.6	27.8	25.8	20.9
2	12 218	19.4	20.1	23.5	20.2	17.0	19 768	22.0	20.1	18.9	22.3	16.6
3	12 200	22.5	22.2	17.1	20.0	18.1	19 790	22.4	23.6	14.9	20.7	18.2
4	12 227	24.2	21.7	17.5	15.8	21.3	19 777	24.6	22.0	15.8	17.0	20.7
5 (highest)	12 210	21.9	17.8	15.4	18.9	25.6	19 776	20.3	19.7	22.5	14.1	23.6

* All numbers are column percentages unless otherwise specified. NSCLC = non–small cell lung cancer; Q = spending quintile.

† Non-Hispanic.

‡ Charlson comorbidity score (26) modified using Deyo adaptation (24) with exclusion of cancer diagnoses. Applied to Medicare claims data as described by Klabunde et al (25).

§ Zip-code level data used where Census tract data not available.

Statistical Analysis

We calculated mean spending and 95% confidence intervals (CIs) for each cohort and quintile of regional advanced cancer spending by cancer site and overall. Overall mean spending is mean spending adjusted for cancer site case mix. To characterize use of specific health-care services, we calculated per capita service use for each spending quintile. The significance of use differences across quintiles was assessed with a trend test.

Overall survival in the incident cohort was assessed for each cancer site. We used multivariable Cox proportional hazards models to calculate hazard ratios (HRs) comparing survival for subjects in quintile 1 (lowest spending) with that for subjects in quintiles 2 through 5. The survival models included variables for age, sex, race, stage, and comorbidity. Models were adjusted for clustering of outcomes by HRRs. The proportional hazards assumption was satisfied using the Schoenfeld residuals method. SAS software, version 9.2 (SAS Institute Inc, Cary, NC) was used for all analyses. Statistical significance was set at P less than .05, and all tests were two-tailed.

Results

The incident cohort included 61 083 subjects with newly diagnosed advanced-stage cancer; all subjects had stage IV cancer with the following exceptions: 31% of subjects with NSCLC had stage IIIB cancer, and 15% of subjects with pancreas cancer had stage III cancer. The decedent cohort included 98 935 subjects with death from cancer. Details of cohort selection are shown in Figure 1. Subjects were assigned to quintiles of advanced cancer spending based on mean 6-month spending within the HRR of residence. Details of the demographic composition of cohorts are shown in Table 1.

Mean 6-month advanced cancer spending was $33 727 in the incident cohort and $33 099 in the decedent cohort. From quintile 1 to quintile 5, mean overall spending increased by 32% in the incident cohort and by 41% in the decedent cohort (incident cohort: $28 854 to $37 971; decedent cohort: $27 446 to $38 630). Mean spending by quintile is shown graphically in Figure 2. Sensitivity analysis of spending estimates was performed using a regression model to adjust for individual-level differences in income, education, metropolitan residence, and marital status; adjustment for these variables did not substantially affect estimates of spending variation. Quintile assignments were insensitive to alternative weighting schemes for calculating the composite spending measure.

The composite measures of mean regional spending calculated from the incident and decedent cohorts were strongly correlated (r = 0.889; P <.001). Strong correlation persisted in a sensitivity analysis where the 37% of subjects eligible for both cohorts were excluded from the decedent cohort. The spending quintile assignments for HRRs derived from the decedent cohort are shown in a map in Supplementary Figure 1 (available online); low-spending regions were predominantly located in the Midwest and West, whereas high-spending regions were clustered in central New Jersey, Southern California, and Louisiana.

We evaluated overall survival among subjects in the incident cohort from time of advanced cancer diagnosis until death. The median survival was 4.8 months for NSCLC, 7.6 months for colorectal cancer, 3.4 months for pancreas cancer, 15.8 months for breast cancer, and 36.5 months for prostate cancer. Kaplan–Meier curves of overall survival by cancer site and quintile are shown in Figure 3, and adjusted hazard ratios for death are shown in Figure 4. The unadjusted analysis showed no consistent survival trend by spending quintile for any cancer site. In the adjusted survival analysis, no quintile strata for any cancer site showed a survival improvement compared with quintile 1. The lowest hazard ratio was seen in quintile 5 subjects with pancreas cancer; however, this was not statistically significantly different from the reference (HR = 0.92, 95% CI = 0.82 to 1.04; P =.19). Quintiles 3 and 4 demonstrated statistically significant decreases in survival compared with quintile 1 for breast and prostate cancer; the largest survival decrement was seen in quintile 3 subjects with breast cancer (HR = 1.24, 95% CI = 1.11 to 1.39; P <.001). Overall, there was no consistent association between advanced cancer spending and survival outcomes.

To identify drivers of differences in mean regional spending, we calculated the use of specific health services by quintile. Because increased medical spending has been considered a proxy for aggressiveness of care, we also used previously reported metrics (27) to characterize the aggressiveness of end-of-life cancer care. Subjects in high-spending regions were more likely to be hospitalized and admitted to the intensive care unit and consistently received more aggressive end-of-life care than subjects in low-spending regions. Results are shown in Table 2.

Discussion

We chose to pursue our study in subjects with advanced cancer because this population has high treatment costs (8) and, within each cancer site, a well-characterized prognosis. Effective interventions to prolong survival in this population are limited. For these reasons, regional variation in the intensity of medical care is likely to be attributable to health system rather than patient or disease-specific factors.

Despite substantial regional variation in advanced cancer spending, we found no consistent association between spending and advanced cancer survival. In the unadjusted survival analysis, Kaplan–Meier curves for spending quintiles were entirely overlapping for NSCLC, colorectal, and pancreas cancer. Separation of survival curves in breast and prostate cancer did not show a dose–response relationship to spending. In the adjusted survival analysis, increased spending compared with the lowest spending regions (quintile 1) was not associated with a statistically significant improvement in survival for any cancer site. Modest survival decrements were seen in patients with breast and prostate cancer in quintiles 3 and 4. Overall, point estimates for survival differences were small in magnitude and were unlikely to be clinically meaningful.

Previous research has examined the association between regional variation in general medical spending and survival with disparate results (14–16,29–32). A number of studies of hospital-level spending have found a positive association between increased spending and survival; however, these reports have focused on mortality from acute illness in surgical and hospitalized patients

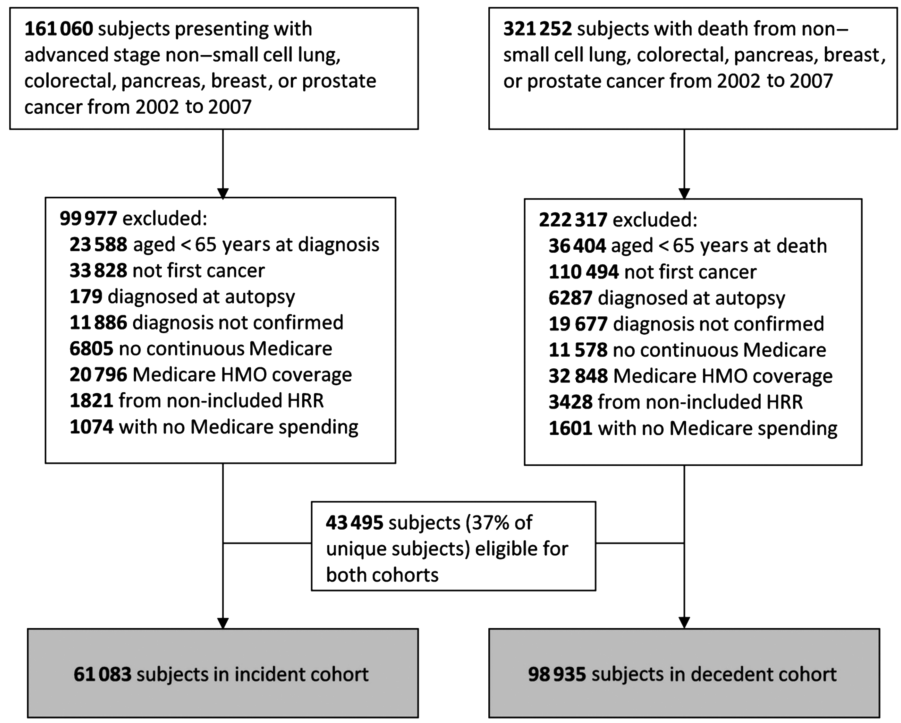

Figure 1. Assembly of study cohorts. Exclusion criteria were applied sequentially as listed in the figure. HMO = health maintenance organization; HRR = hospital referral region.

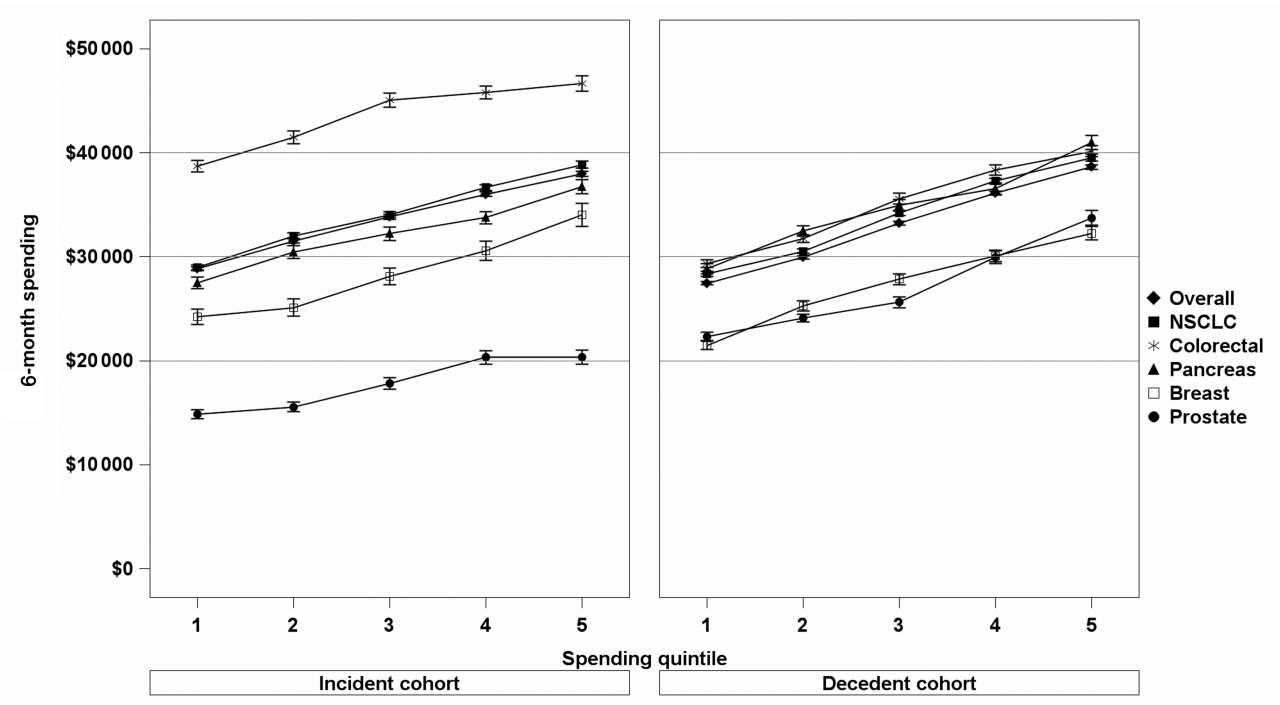

Figure 2. Mean 6-month spending for advanced cancer by quintile of regional spending. The **left panel** shows mean spending in the incident cohort stratified by incident cohort spending quintiles. The **right panel** shows mean spending in the decedent cohort, stratified by decedent cohort spending quintiles. Error bars represent 95% confidence intervals. NSCLC, non–small cell lung cancer.

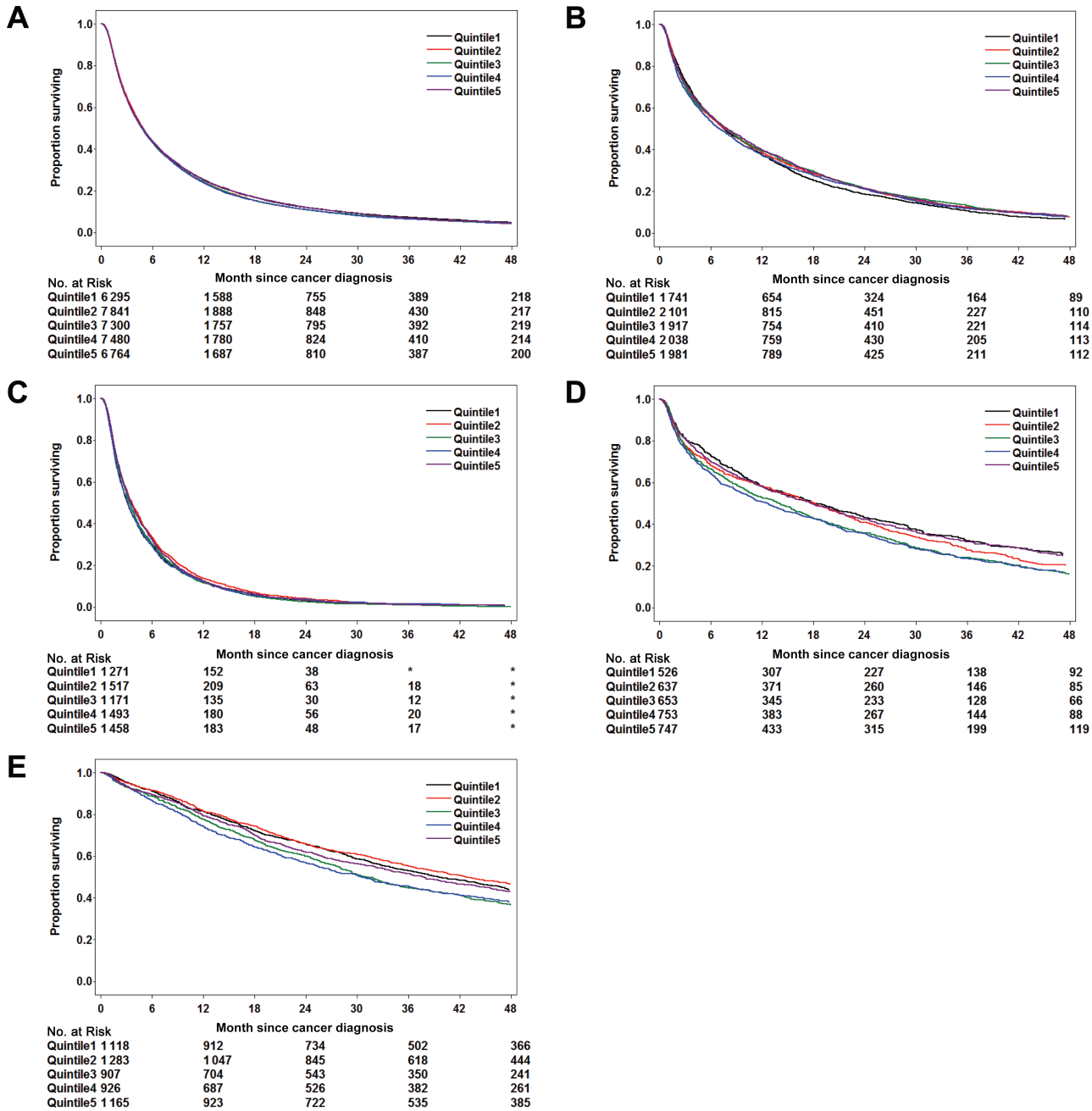

Figure 3. Unadjusted survival by cancer site and spending quintile. **A–E**) Kaplan–Meier plots of overall survival by cancer type stratified by spending quintile. **A**) Non–small cell lung cancer. **B**) Colorectal cancer. **C**) Pancreas cancer. **D**) Breast cancer. **E**) Prostate cancer.

(29–32). Of three previous area-level studies of spending and survival in chronic disease populations, none showed a consistent association between spending and survival (14–16). Our study adds to this knowledge base, studying a patient population that accounts for approximately half of US cancer deaths and confirming that any association between area-level spending and survival is weak or nonexistent.

The degree of spending variation we report for subjects with advanced cancer is consistent with prior studies of regional variation in medical spending (12,13). This variation persisted regardless of whether spending was measured in the 6 months after advanced cancer diagnosis ("look-forward") or in the 6 months before death ("look-backward"), and patterns of spending variation were consistent across the five cancer sites studied.

Our analysis identified differences in the use of inpatient hospital services as a key driver of regional variation in spending for advanced cancer. Subjects living in high-spending regions were substantially more likely to be hospitalized and to receive intensive care. In contrast, we found little or no difference between high- and low-spending regions in use of chemotherapy or other outpatient services. Among decedents, there was an inverse association between spending and regional rates of hospice use, corroborating

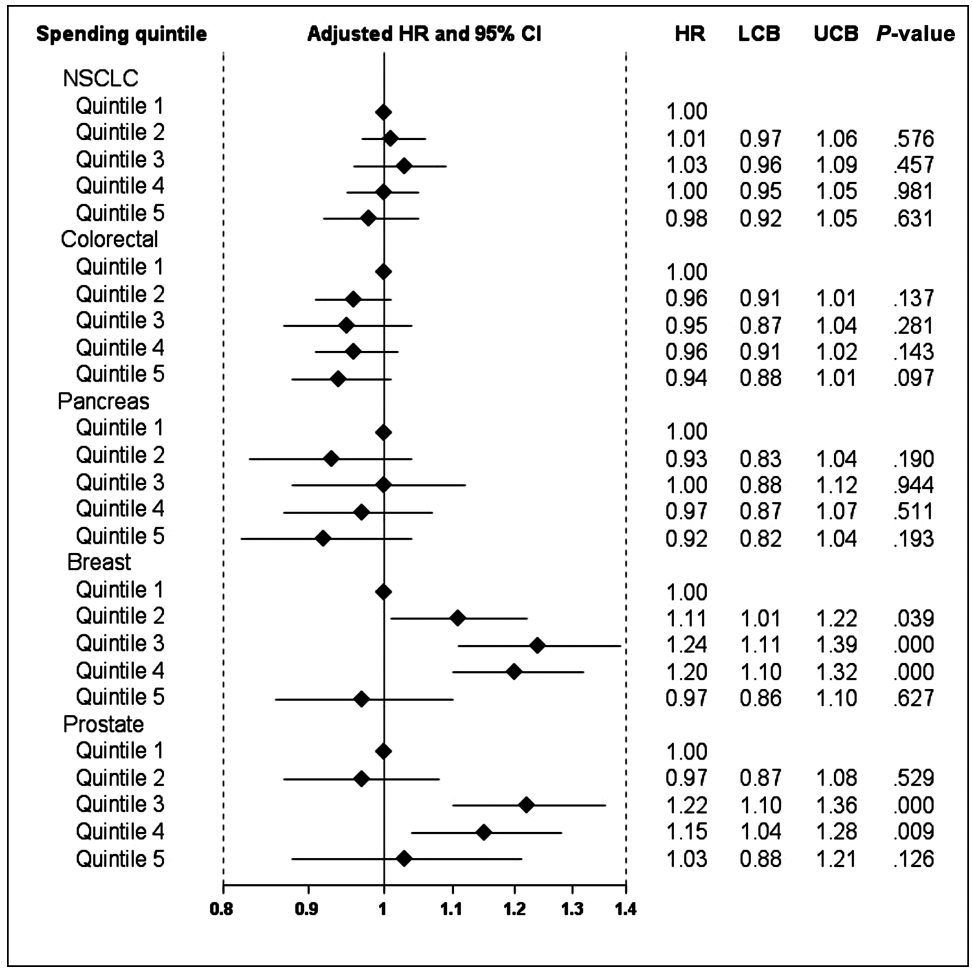

Figure 4. Adjusted survival by cancer site and spending quintile. Hazard ratios (HRs) are shown for quintiles 2 through 5 in comparison with quintile 1 (reference). Hazard ratios are adjusted for age, race, sex, and comorbidity. Error bars represent 95% confidence intervals for hazard ratio estimates. LCB = lower confidence bound; NSCLC = non–small cell lung cancer; UCB, upper confidence bound.

previous findings that end-of-life costs are lower for patients enrolled in hospice care (33–35). This result is provocative in the context of mounting evidence for the quality-of-life and possible survival benefits associated with hospice and palliative care (36,37).

A strength that distinguishes our study from prior reports is the use of two well-defined cohorts identified from linked registry and claims data. We measured survival in the clinically relevant population of subjects with advanced-stage cancer (stage is a critical determinant of outcome that is not identifiable in unlinked claims data). Additionally, we estimated spending specific to our population of interest rather than using external data sources to categorize the intensity of medical spending. This approach makes our analysis more sensitive to specific variation in patterns of cancer care, as opposed to the patterns of general end-of-life care that are measured by the Dartmouth Atlas end-of-life expenditure index (12). Nevertheless, our study confirms that geographic patterns of spending in advanced cancer are similar to those observed in general Medicare spending.

Our study is limited by the observational design. Our analysis assumes that covariables are uniformly recorded; however, previous research has shown that comorbid conditions are more likely to be recorded in high-spending regions, leading to relative overadjustment for comorbidity in these regions (38). Additionally, we were unable to measure patient preferences and quality of life, which are important patient-centered mediators of cancer care. Although end-of-life care preferences do not appear to vary regionally in the United States (39), racial/ethnic differences in end-of-life care preferences have been documented (40).

Despite substantial regional variation in Medicare spending for advanced cancer, we did not find a consistent or clinically meaningful association between spending and survival. Increased spending is associated with more frequent and longer hospital visits, more intensive care, and decreased rates of hospice use. The identification of inpatient hospitalization as a key driver of regional variation in advanced cancer spending is an important finding at a time when much attention on the cost of cancer care has been focused on the cost of chemotherapy. Our findings suggest that health-care providers should be incentivized to develop strategies aimed at reducing potentially avoidable hospitalizations and increasing timely access to palliative care for patients with advanced cancer—goals that are consistent with patient-centered care.

Table 2. Mean per capita use of selected health-care services, by quintile of advanced cancer spending*

Variable	Cohort	Q1	Q2	Q3	Q4	Q5	P_{trend}	Q5 to Q1 ratio
Incident cohort, use in 6 mo after diagnosis								
Hospital admissions	1.4	1.2	1.2	1.4	1.5	1.5	<.001	1.30
Hospital days	10.4	8.2	8.8	10.0	12.1	12.8	<.001	1.56
ICU days	1.7	1.4	1.4	1.5	1.9	2.4	<.001	1.73
SNF days	0.21	0.11	0.13	0.25	0.28	0.28	<.001	2.55
Physician office visits	10.5	10.2	11.0	9.8	9.9	11.5	<.001	1.13
Chest CT scans	1.6	1.5	1.5	1.7	1.7	1.7	<.001	1.11
PET scans	0.45	0.47	0.41	0.46	0.45	0.48	<.001	1.02
Peg-GCSF doses	0.17	0.15	0.16	0.15	0.21	0.19	.009	1.27
Receipt of any chemo, %	34.4	31.6	37	34.8	33.6	35.3	.001	1.12
Decedent cohort, use in last 6 mo of life								
Hospital admissions	1.5	1.3	1.3	1.5	1.7	1.8	<.001	1.40
Hospital days	11.5	8.5	8.7	11.5	13.8	15.2	<.001	1.78
ICU days	2.0	1.3	1.4	1.9	2.4	2.9	<.001	2.19
SNF days	0.27	0.19	0.19	0.23	0.39	0.33	<.001	1.74
Physician office visits	9.6	9.3	9.8	9.4	9.3	10.3	<.001	1.11
Chest CT scans	1.3	1.1	1.2	1.3	1.4	1.3	<.001	1.13
PET scans	0.21	0.20	0.19	0.23	0.21	0.22	<.001	1.10
Peg-GCSF doses	0.07	0.06	0.07	0.07	0.08	0.08	.72	1.33
Receipt of any chemo, %	43.8	41.9	44.4	43.6	45.3	43.4	.16	1.04
Decedent cohort, use in last mo of life								
>1 ED visit, %	40.3	35.3	37.6	41.7	45.5	41.2	<.001	1.17
>1 hospitalization, %	26.7	20.9	22.5	28	30.7	31.1	<.001	1.49
ICU admission, %	18.7	14.8	15.2	19.3	21.5	22.9	<.001	1.55
Inpatient death, %	16.0	12.6	13.2	16.8	17.2	20.1	<.001	1.60
Late chemotherapy†, %	17.0	14.0	17.4	18.3	17.5	17.3	<.001	1.24
≥ 3 days hospice, %	39.7	43.3	44.1	40.2	37.5	33.4	<.001	0.77
Any hospice, %	60.2	61.4	63.2	60.2	61.8	53.8	<.001	0.88

* Results are adjusted for age, sex, race and cancer site case mix. Chemo = chemotherapy; CT = computed tomography; ED = emergency department; ICU = intensive care unit. Q = spending quintile; Peg-GCSF = pegylated granulocyte colony stimulating factor; PET = positron emission tomography; SNF = sub-acute nursing facility.

† Receipt of chemotherapy in last 14 days of life.

References

1. Siegel R, Naishadham D, Jemal A. Cancer statistics, 2012. *CA Cancer J Clin*. 2012;62(1):10–29.
2. Jemal A, Ward E, Thun M. Declining death rates reflect progress against cancer. *PLoS One*. 2010;5(3):e9584.
3. Sandler A, Gray R, Perry MC, et al. Paclitaxel-carboplatin alone or with bevacizumab for non-small-cell lung cancer. *N Engl J Med*. 2006;355(24):2542–2550.
4. Kantoff PW, Higano CS, Shore ND, et al. Sipuleucel-T immunotherapy for castration-resistant prostate cancer. *N Engl J Med*. 2010;363(5):411–422.
5. Potetz L, DeWilde LF. *Cancer and Medicare: A Chartbook*. Washington, DC: American Cancer Society Cancer Action Network; 2009.
6. Mariotto AB, Yabroff KR, Shao Y, Feuer EJ, Brown ML. Projections of the cost of cancer care in the United States: 2010–2020. *J Natl Cancer Inst*. 2011;103(2):117–128.
7. Riley GF, Potosky AL, Lubitz JD, Kessler LG. Medicare payments from diagnosis to death for elderly cancer patients by stage at diagnosis. *Med Care*. 1995;33(8):828–841.
8. Yabroff KR, Lamont EB, Mariotto A, et al. Cost of care for elderly cancer patients in the United States. *J Natl Cancer Inst*. 2008;100(9):630–641.
9. Schnipper LE, Smith TJ, Raghavan D, et al. American Society of Clinical Oncology identifies five key opportunities to improve care and reduce costs: the top five list for oncology. *J Clin Oncol*. 2012;30(14):1715–1724.
10. Elkin EB, Bach PB. Cancer's next frontier: addressing high and increasing costs. *JAMA*. 2010;303(11):1086–1087.
11. Smith TJ, Hillner BE. Bending the cost curve in cancer care. *N Engl J Med*. 2011;364(21):2060–2065.
12. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ, Lucas FL, Pinder EL. The implications of regional variations in Medicare spending. Part 1: the content, quality, and accessibility of care. *Ann Intern Med*. 2003;138(4):273–287.
13. Zuckerman S, Waidmann T, Berenson R, Hadley J. Clarifying sources of geographic differences in Medicare spending. *N Engl J Med*. 2010;363(1):54–62.
14. Fisher ES, Wennberg DE, Stukel TA, Gottlieb DJ, Lucas FL, Pinder EL. The implications of regional variations in Medicare spending. Part 2: health outcomes and satisfaction with care. *Ann Intern Med*. 2003;138(4):288–298.
15. Landrum MB, Meara ER, Chandra A, Guadagnoli E, Keating NL. Is spending more always wasteful? The appropriateness of care and outcomes among colorectal cancer patients. *Health Aff (Millwood)*. 2008;27(1):159–168.
16. Skinner JS, Staiger DO, Fisher ES. Is technological change in medicine always worth it? The case of acute myocardial infarction. *Health Aff (Millwood)*. 2006;25(2):w34–w47.
17. National Cancer Institute. *Surveillance, Epidemiology and End Results*. http://seer.cancer.gov/about/overview.html. Accessed May 2, 2012.
18. National Cancer Institute. *SEER Cause-Specific Death Classification*. http://seer.cancer.gov/causespecific/. Accessed July 29, 2012.
19. Bach PB, Schrag D, Begg CB. Resurrecting treatment histories of dead patients: a study design that should be laid to rest. *JAMA*. 2004;292(22):2765–2770.
20. Brown ML, Riley GF, Schussler N, Etzioni R. Estimating health care costs related to cancer treatment from SEER–Medicare data. *Med Care*. 2002;40(8 Suppl):IV104–IV117.
21. Medicare Payment Advisory Commision. *Medicare Background: Payment Basics*. http://www.medpac.gov/payment_basics.cfm. Accessed May 21, 2012.
22. Federal Register: Daily Journal of the United States Government. https://www.federalregister.gov/articles/search?conditions[term]=wage+index. Accessed February 11, 2013.
23. Wennberg JE, Cooper MM. The Dartmouth Atlas of Health Care. Chicago, IL: American Hospital Publishing; 1996.

24. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol*. 1992;45(6):613–619.
25. Klabunde CN, Potosky AL, Legler JM, Warren JL. Development of a comorbidity index using physician claims data. *J Clin Epidemiol*. 2000;53(12):1258–1267.
26. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40(5):373–383.
27. Earle CC, Landrum MB, Souza JM, Neville BA, Weeks JC, Ayanian JZ. Aggressiveness of cancer care near the end of life: is it a quality-of-care issue? *J Clin Oncol*. 2008;26(23):3860–3866.
28. National Quality Forum. *NQF-Endorsed Standards*. www.qualityforum.org/measures_list.aspx. Accessed July 31, 2012.
29. Barnato AE, Chang CC, Farrell MH, Lave JR, Roberts MS, Angus DC. Is survival better at hospitals with higher "end-of-life" treatment intensity? *Med Care*. 2010;48(2):125–132.
30. Silber JH, Kaestner R, Even-Shoshan O, Wang Y, Bressler LJ. Aggressive treatment style and surgical outcomes. *Health Serv Res*. 2010;45(6 Pt 2):1872–1892.
31. Romley JA, Jena AB, Goldman DP. Hospital spending and inpatient mortality: evidence from California: an observational study. *Ann Intern Med*. 2011;154(3):160–167.
32. Stukel TA, Fisher ES, Alter DA, et al. Association of hospital spending intensity with mortality and readmission rates in Ontario hospitals. *JAMA*. 2012;307(10):1037–1045.
33. Brumley R, Enguidanos S, Jamison P, et al. Increased satisfaction with care and lower costs: results of a randomized trial of in-home palliative care. *J Am Geriatr Soc*. 2007;55(7):993–1000.
34. Gade G, Venohr I, Conner D, et al. Impact of an inpatient palliative care team: a randomized control trial. *J Palliat Med*. 2008;11(2):180–190.
35. Morrison RS, Dietrich J, Ladwig S, et al. Palliative care consultation teams cut hospital costs for Medicaid beneficiaries. *Health Aff (Millwood)*. 2011;30(3):454–463.
36. Saito AM, Landrum MB, Neville BA, Ayanian JZ, Weeks JC, Earle CC. Hospice care and survival among elderly patients with lung cancer. *J Palliat Med*. 2011;14(8):929–939.
37. Temel JS, Greer JA, Muzikansky A, et al. Early palliative care for patients with metastatic non-small-cell lung cancer. *N Engl J Med*. 2010;363(8):733–742.
38. Song Y, Skinner J, Bynum J, Sutherland J, Wennberg JE, Fisher ES. Regional variations in diagnostic practices. *N Engl J Med*. 2010;363(1):45–53.
39. Barnato AE, Herndon MB, Anthony DL, et al. Are regional variations in end-of-life care intensity explained by patient preferences?: a study of the US Medicare population. *Med Care*. 2007;45(5):386–393.
40. Barnato AE, Anthony DL, Skinner J, Gallagher PM, Fisher ES. Racial and ethnic differences in preferences for end-of-life treatment. *J Gen Intern Med*. 2009;24(6):695–701.

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Notes

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