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RESEARCH BRIEF

Dartmouth Atlas Area-Level Estimates of End-of-Life Expenditures: How Well Do They Reflect Expenditures for Prospectively Identified Advanced Lung Cancer Patients?

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Objective. Assess validity of the retrospective Dartmouth hospital referral region (HRR) end-of-life spending measures by comparing with health care expenditures from diagnosis to death for prospectively identified advanced lung cancer patients.

Data/Setting/Design. We calculated health care spending from diagnosis (2003–2005) to death or through 2011 for 885 patients aged ≥ 65 years with advanced lung cancer using Medicare claims. We assessed the association between Dartmouth HRR-level spending in the last 2 years of life and patient-level spending using linear regression with random HRR effects, adjusting for patient characteristics.

Findings. For each \$1 increase in the Dartmouth metric, spending for our cohort increased by \$0.74 ($p < .001$). The Dartmouth spending variable explained 93.4 percent of the HRR-level variance in observed spending.

Conclusions. HRR-level spending estimates for deceased patient cohorts reflect area-level care intensity for prospectively identified advanced lung cancer patients.

Key Words. Variation, health care expenditures, lung cancer

Evidence from the Dartmouth Atlas of Health Care researchers and others demonstrates substantial area-level variation in intensity of care and health care spending at the end of life across the United States for patients with chronic illnesses (Wennberg and Cooper 1999; Fisher et al. 2003; Wennberg et al. 2004) and cancer specifically (Goodman et al. 2010; Morden et al. 2012). Examining variation in spending among cohorts of patients in the last 6 months, or the last 2 years, of life can account for patient-level differences in

health status and risk of death as, by definition, all patients will die within the time window. Areas with high spending in end-of-life cohorts use more inpatient care, diagnostic tests, and specialty visits, even for patients not at the end of life, and these differences in utilization do not seem to reflect differences in underlying illness (Welch et al. 1993; Fisher et al. 2003; Song et al. 2010). However, because these measures rely on retrospective cohorts of patients who have died, this method has been criticized because physicians may not know with a high degree of certainty which patients will die when prospectively making decisions to provide care that drives spending (Bach, Schrag, and Begg 2004; Bach 2010). A prospective study is needed to validate the retrospective Dartmouth assessment of health care spending and, thereby, indicate the generalizability of this commonly used measure.

In this research brief, we used data from the Cancer Care Outcomes Research and Surveillance (CanCORS) study linked with Medicare claims to assess prospectively the intensity of care delivered to patients who were diagnosed with advanced lung cancer. We assessed the association of the Dartmouth area-level measures of end-of-life (EOL) spending with total health care expenditures from diagnosis until death for prospectively identified patients with advanced lung cancer who were followed up for up to 9 years.

METHODS

Data

The CanCORS study is a multiregional study examining care delivered to patients diagnosed with lung or colorectal cancer between 2003 and 2005

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(Ayanian et al. 2004). Patients were prospectively enrolled from population-based sites (eight counties in Northern California, Los Angeles County, the state of Iowa, the state of Alabama, and 22 counties in North Carolina) or health care system-based sites (5 health maintenance organizations and 15 Veterans Affairs Medical Centers). Patients (or their surrogates if they were deceased or too ill) were surveyed by telephone approximately 3–6 months after diagnosis. Patients alive at the baseline survey (or their surrogate if they were deceased) were surveyed again 12 months after diagnosis. A final survey was conducted in 2011–2012 (6–9 years after initial enrollment).

We linked survey data from CanCORS with Medicare enrollment data (including date of death) and claims data (inpatient, outpatient, physician/supplier, hospice, home health, and durable medical equipment claims) from 2003 through the end of 2011. We obtained patients' Social Security number (SSN), date of birth, and gender from participating sites. Initial matches were based on SSN or SSN+date of birth+sex if there was more than one matching SSN (some women receive benefits through their spouses, SSN). We refined matches using previously developed criteria (Fleming et al. 1992) and required cases to agree on sex (if known) and two of the three date of birth elements. We achieved a match rate of 89.3 percent in CanCORS patients aged ≥ 65 at the time of diagnosis, similar to that of the NCI's SEER-Medicare program (Potosky et al. 1993).

We obtained publicly available data on area-level spending by hospital referral region (HRR) at the end of life for patients with serious chronic illness from the Dartmouth Atlas (Dartmouth Atlas of Health Care 2014). Specifically, we used data on total Medicare expenditures (excluding Part D spending) in the last 2 years of life for fee-for-service beneficiaries with serious chronic illnesses who died during 2003–2007 (reflecting the time window for the publicly available data that corresponded to the time period during which most deaths in our cohort occurred). The Dartmouth Atlas defined serious chronic illness based on nonsurgical hospitalizations for cancer, congestive heart failure, chronic pulmonary disease, dementia, coronary artery disease, peripheral artery disease, diabetes with end-organ damage, chronic renal failure, or severe chronic liver disease.

Patient Cohort

We identified patients diagnosed in 2003–2005 with stage IIIB or IV non-small cell lung cancer or extensive stage small cell lung cancer or patients who

were diagnosed with earlier stage disease who recurred with metastatic disease by 2011 (ascertained via follow-up survey or medical record abstraction in 2011–2012). We restricted our cohort to patients who were at least 65 years of age, enrolled in fee-for service Medicare, and diagnosed in one of the population-based CanCORS sites that enrolled lung cancer patients (Northern California, Los Angeles County, Iowa, Alabama). Among 885 patients, 860 had died by the end of 2011. We assigned each patient to an HRR based on the zip code of residence at the time of cancer diagnosis.

Variables

Intensity of Care Delivered. To measure intensity of health care delivered, we calculated Medicare expenditures on health care services (Fisher et al. 2003) from the time of cancer diagnosis through death, based on previously described methods (Warren et al. 2002, 2008; Yabroff et al. 2008, 2009). In brief, Medicare expenditures were obtained by summing Medicare reimbursements itemized on claims irrespective of whether they were directly related to the lung cancer diagnosis; patient cost-sharing was not included. To derive spending estimates, we summed Medicare expenditures for inpatient/skilled nursing facility care, outpatient care (including office visits, procedures, and drugs administered in the outpatient setting), physician and supplier fees, durable medical equipment, home health, and hospice care similar to the area-level estimates calculated by the Dartmouth Atlas (which also do not include Part D expenditures). We calculated expenditures from time of diagnosis until death.

Dartmouth Spending Measure. We used HRR-level data on the average total Medicare expenditures per decedent in the last 2 years of life for patients with serious chronic illnesses who died during 2003–2007. These data were not price-adjusted because price-adjusted data are not publicly available. However, other data suggest that HRR-level variations in spending are driven primarily by utilization and not prices (Gottlieb et al. 2010). In exploratory analyses to assess whether our lack of price adjustment would influence our results, we examined the correlation between the Dartmouth area spending variable and Dartmouth measures of utilization among their seriously ill cohort. We found high levels of correlation of the spending measure with utilization, including hospitalizations in the last 30 days of life (correlation coefficient .59), intensive care unit days per decedent (.75), physician visits per

decedent (.83), visits with at least 10 different physicians (.72), and use of life-sustaining treatments (.75) (all $p < .001$).

Control Variables. Control variables ascertained from the baseline CanCORS survey included self-reported sex, race/ethnicity, marital status, education, and income. We also adjusted for age at diagnosis, obtained from cancer registries and categorized as 65–69, 70–74, 75–79, 80–84, and ≥ 85 years. Finally, we adjusted for the number of days from the date of their initial cancer diagnosis until death (or the end of 2011).

Analyses

We used mixed effects linear regression with random HRR effects to assess the association between Dartmouth HRR-level spending (independent variable) and patient-level spending in our CanCORS advanced disease lung cancer cohort (dependent variable), adjusting for patient age, race/ethnicity, marital status, education, income, and time from diagnosis until death/end of follow-up. We estimated the increase in spending in our lung cancer cohort associated with each \$1 increase in the Dartmouth spending measure. We used the estimated variance of the HRR random effects to estimate the standard deviation in spending across HRRs. We repeated the models without the Dartmouth spending variable to assess the proportion of the HRR-level variance explained by the Dartmouth spending variable. We used multiple imputation to account for missing data, which were infrequent (15 patients missing education, 12 missing stage at diagnosis, 177 missing income) (He et al. 2010).

In sensitivity analyses, we repeated analyses among the 860 patients who died by the end of 2011. We also conducted analyses among patients who were diagnosed with or recurred with metastatic colorectal cancer (253 patients who died and 33 patients who were alive at the end of 2011). The colorectal cancer cohort lived in 24 HRRs; this cohort did not include any patients from Iowa, and instead had patients living in North Carolina. Results were similar, although small sample sizes limited our ability to estimate all models and are not presented. We also conducted sensitivity analyses using generalized linear models with a gamma distribution to address the skewed distribution of the spending data; results were similar, although some models did not converge. All analyses were conducted using SAS statistical software, version 9.4 (Carey, NC, USA).

RESULTS

Characteristics of the 885 patients in our cohort are included in Table 1. The patients had a mean age of 74.3; 56.8 percent were men; 79.1 percent had stage IIb or IV disease at diagnosis, and the remaining recurred with advanced disease after the initial diagnosis of earlier stage lung cancer; and 16.9 percent were nonwhite. The median time from diagnosis until death (or end of 2011 for the 25 patients who did not die) was 7.6 months (range = 0 days to 8.5 years; interquartile range = 2.5–18.9 months). The 885 patients lived in 34 HRRs (mean [standard deviation] N per HRR = 26.0 [37.1], range = 1–162). Average spending from diagnosis to death (or through 2011) was \$59,231.20 (standard deviation = \$62,865.63).

Results of the random effects models demonstrated that the Dartmouth spending variable was strongly associated with spending among our lung

Table 1: Characteristics of Individuals in the CanCORS Advanced Lung Cancer Cohort at the Time of Cancer Diagnosis

<i>Characteristic</i>	<i>N (%)</i>
Age at diagnosis in years (SD)	74.3 (6.2)
Sex	
Male	503 (57)
Female	382 (43)
Race/ethnicity	
White	734 (83)
Black	57 (6)
Hispanic	42 (5)
Asian	27 (3)
Other	25 (3)
Marital status	
Unmarried	368 (42)
Married	517 (58)
Education	
Less than high school	236 (27)
High school graduate/GED	499 (57)
College graduate	135 (16)
Annual income	
<\$20,000	274 (31)
\$20,000–<\$40,000	250 (29)
\$40,000–<\$60,000	104 (12)
\$60,000+	80 (9)
Unknown	177 (20)
Time from diagnosis until death in months, median (IQ range)	7.6 (2.5–18.9)

Table 2: Association of Dartmouth Spending Variable with Spending in Prospective Cohort of Advanced Lung Cancer Patients

Model with Dartmouth spending variable	
Increase in spending for each \$1 in Dartmouth spending measure	\$0.74 ($p < .001$)
Variance across HRRs	\$7,130,805
Standard deviation in spending across HRRs	\$2,670
Model without Dartmouth spending variable	
Variance across HRRs	\$108,200,000
Standard deviation in spending across HRRs	\$10,402
% of HRR-level variance explained by Dartmouth spending variable	93.4%

HRR, hospital referral region.

cancer cohort (Table 2); for each \$1 increase in the Dartmouth variable, spending for our cohort increased by \$0.74 ($p < .001$). The residual standard deviation in spending across HRRs after accounting for Dartmouth measures and individual characteristics was \$2,670. Inclusion of the Dartmouth spending variable in the model (compared with a model that did not include the Dartmouth spending variable) demonstrated that the Dartmouth spending variable explained 93.4 percent of the HRR-level variance in observed spending in our lung cancer cohort (Table 2). Full model results are included in the Appendix.

Results were generally similar in analyses restricted to the 860 patients who died by the end of 2011 (data not shown).

DISCUSSION

We assessed Medicare spending for prospectively identified patients with advanced lung cancer and compared these data with the retrospective Dartmouth area-level measures of EOL spending. We found that HRR-level spending from diagnosis until death for lung cancer patients was highly correlated with the Dartmouth measure of spending in the last 2 years of life, with an increase of \$.74 in spending in our cohort for each \$1 increase in spending in the Dartmouth measure. Moreover, the Dartmouth spending measure explained 93.4 percent of the HRR-level variance in observed spending for patients in our lung cancer cohort. These findings provide reassurance that the Dartmouth retrospectively ascertained measures of intensity of care at the end of life reflect area-level care patterns more broadly than only care before death among decedents.

The Dartmouth Atlas estimates of Medicare spending at the end of life are based on Medicare expenditures for cohorts of patients with chronic illnesses who have died. The finding that some regions have higher spending than others suggests differences in area-level medical culture and raises the possibility that interventions targeting higher spending areas could be a strategy to control health care costs. However, because the Dartmouth Atlas estimates are derived from retrospectively aggregating Medicare claims of decedents, it is not possible to ascertain whether physicians actually recognized that individuals were expected to die. An alternative explanation for area-level variation Medicare spending at the end of life is that observed differences stem from differences in rates of unexpected acute episodes of illness among patients whose deaths were not anticipated by their physicians. Our finding that HRR-level spending in a prospectively ascertained cohort of lung cancer patients was quite similar to HRR-level spending using the Dartmouth Atlas decedent cohort supports the view that area-level spending at the end of life reflects area-specific medical culture and practice patterns. Further research should examine the specific types of care that vary by area-level spending. Some evidence suggests that these areas are not only providing more wasteful care but are also providing more guideline-recommended care (Landrum et al. 2008), suggesting that controlling health care spending growth while improving or maintaining quality will require more nuanced strategies than simply delivering less care in high-spending areas.

Our findings should be interpreted in light of some limitations. First, neither the Dartmouth spending measures nor our measures were price-adjusted and some of the correlation between Dartmouth measures and those obtained in the CanCORS cohorts may be driven by geographic variation in Medicare payments, not necessarily intensity of care. However, we also demonstrated high correlation of these measures with utilization of care. In addition, although the cohort encompasses diverse regions across the United States, our cohort represented only 34 of the 306 HRRs in the United States. Finally, we focused on only lung cancer patients, most of whom died during our follow-up period within a relatively short period of time. It was reassuring that patterns appeared similar for our colorectal cohort, although small sample sizes limited our ability to estimate all models for patients with colorectal cancer.

In conclusion, these findings suggest that HRR-level estimates of area-level spending and intensity of care that are calculated based on cohorts of seriously ill patients who died can serve as a good proxy for intensity of care for prospectively identified lung cancer patients. Because HRR-level estimates are publicly available, they can serve as a feasible tool for other researchers

and policy makers to approximate high utilization of services among similar patients.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.

Appendix SA2. Full Model Results.