Cost Variation and Savings Opportunities in the Oncology Care Model

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ABSTRACT

OBJECTIVES: This study seeks to identify service categories that present the greatest opportunities to reduce spending in oncology care episodes, as defined by the CMS Oncology Care Model (OCM). Regional variation in spending for similar patients is often interpreted as evidence that resources can be saved, because higher-spending regions could achieve savings by behaving more like their lower-spending counterparts.

STUDY DESIGN: We used Surveillance, Epidemiology, and End Results Medicare data from 2006-2013 for this retrospective observational cohort study. Analysis focused on patients with non–small cell lung cancer, advanced (stage III or IV) breast cancer, renal cell carcinoma, multiple myeloma, or chronic myeloid leukemia.

METHODS: Episodes were identified for patients with the 5 included cancers, following the episode definition used in the OCM. We estimated standardized episode-level spending for a standard patient across subcategories of care for each hospital referral region (HRR) defined by the Dartmouth Atlas. The contribution of each subcategory to interregional variation in total spending reflects that subcategory's potential to yield savings.

RESULTS: Chemotherapy and acute inpatient hospital care tended to be the highest contributors to interregional variation. Imaging, nonchemotherapy Part B drugs, physician evaluation and management services, and diagnostics were negligible contributors to interregional variation for all 5 cancers.

CONCLUSIONS: Chemotherapy and inpatient hospital care offer the most potential to reduce spending within OCM-defined episodes. Other sources of savings differ by type of cancer. Assuming patient outcomes are not compromised, low-spending HRRs may be models for lowering cost in cancer care.

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Both public and private payers have targeted cancer care as a prime source of healthcare savings. The testing of new payment models, such as the Oncology Care Model (OCM) by CMS and the Episode Payment Program demonstration by UnitedHealthcare, present 2 cases in point.[1-3] Programs like these attempt to generate savings by changing provider incentives, without setting rules regarding how such savings should be achieved. The goal is to give providers the discretion to deliver high-quality, high-value care individualized for each patient. These incentives will have even greater impact if they are coupled with information that can help providers seek out and eliminate low-value care. To that end, the goal of our study was to identify the categories of cancer care that offered the greatest potential opportunities for savings within a treatment episode.

We explored this issue using tools drawn from the established literature on geographic variations in healthcare.[4] When the cost of treating similar patients varies widely across geographic regions, efficiencies can be achieved by having high-spending regions emulate low-spending ones.[5] The crux of the research problem is to define the concept of patient "similarity" and measure variation across regions that results from practice styles alone and not from variation in patient health.

Our study addresses that issue by considering patient and episode characteristics within an analysis that identifies the subcategories of spending (eg, chemotherapy, acute hospital inpatient care, imaging) most responsible for the interregional variation in total spending. Our particular focus was on spending per cancer care episode using the OCM's definition of "episode," because under the OCM, practices have a financial incentive to reduce total Medicare spending on their patients within these OCM-defined episodes.[1] We examine interregional variation in spending per OCM-defined episode for 5 cancer types, representing a mix of solid and hematologic cancers that differ in prevalence and level of treatment innovation.

To reduce spending in OCM episodes, subcategories of spending that contribute most to interregional variation in standardized spending per episode may be the lowest-hanging fruit. An important caution, however, is that assessing the impact of differences

in spending on patient outcomes is beyond the scope of the current study. Our goal is to flag for providers and health systems those categories of spending that contribute the most to differences in practice styles across regions. These categories ought to be viewed as the highest priorities for careful decision making about how to reach the appropriate trade-off between spending and outcomes.

TAKEAWAY POINTS

Innovative payment models, such as the Oncology Care Model (OCM), aim to encourage lower-cost and higher-quality care. An unanswered question is which service categories present the greatest potential to reduce costs within the OCM.

- Retrospective cohort analysis determined which service categories contributed the most to apparent practice style differences within OCM-defined episodes.
- Chemotherapy was the largest contributor, followed by hospital inpatient care, to inter-regional variation in spending for some types of cancer studied.
- Chemotherapy and hospital inpatient care may merit the most scrutiny when seeking to reduce spending within OCM-defined episodes, but potential effects on patient outcomes must also be considered.

METHODS

Data

We used data from the Surveillance, Epidemiology, and End Results Medicare (SEER-Medicare) database for 2006-2013. SEER-Medicare links data from the SEER program of the National Cancer Institute, which contains information from 18 cancer registries, with Medicare claims files. SEER-Medicare covers approximately 28% of the US population distributed geographically throughout the country. Our cost analysis included 2007 through 2013. The year 2006 was included for creating the Charlson Comorbidity Index (CCI) score of comorbidities for each episode, based on the patient's prior-year claims. We excluded patients who spent time in Medicare Advantage (MA) because of incomplete treatment information and because MA patients were excluded from the OCM. The study was determined to be exempt from institutional review board oversight.

The patient cohort includes those with a new diagnosis of 1 of the 5 selected tumors between January 1, 2007, and December 31, 2011. Patients were required to be covered by Medicare parts A, B, and D from 12 months prior to the diagnosis through the end of data or date of death and to be treated with at least 1 chemotherapy drug in an outpatient setting that would trigger an episode within the OCM, including Part D chemotherapy claims. This restriction was chosen to allow us to define an episode in the same way as the OCM.

Cancers Included

We identified a cohort of patients with 1 of the following 5 tumor types as the primary cancer: non–small cell lung cancer (NSCLC), advanced (stage III or IV) breast cancer (BC), renal cell carcinoma (RCC), multiple myeloma (MM), and chronic myeloid leukemia (CML). These tumor types were chosen to provide variety in prevalence in the population 65 years and older, ensure a mix of solid and hematological tumors, and offer variation in treatment patterns, innovation, and resource mix.

Episode Definition

Episodes were defined as they are in the OCM. Either infusion or injection of outpatient chemotherapy or the filling of a prescription for Part D–covered chemotherapy triggered an episode. The OCM defines chemotherapy in a broad sense and includes antineoplastic drug therapies generally; for example, monoclonal antibody therapies.[6] Likewise, we use the term *chemotherapy* in the same broad sense as the OCM. Following the OCM definition, the episode ended either 6 months later or at death. As delineated in the OCM, subsequent episodes for the same patient were allowed and began at first use of qualifying chemotherapy following the end of the previous episode.

Standardization of Claim Amounts

We converted every Medicare claim to a standardized amount to eliminate the effects of payment rate differentials across regions. We further adjusted claims for changes in Medicare prices over time, including the effects of the federal budget sequester beginning in April 2013. Our final measures of standardized spending are in 2013 (presequester) dollars. Because of these standardization steps, when we detect higher spending, it is due to greater utilization or greater use of higher-cost goods and services. For details on our sample and standardization methods, see the eMethods section in the **eAppendix** (available at **ajmc.com**).

Subcategories of Spending

We assigned every claim to 1 of 13 service subcategories following the definitions of Brooks et al,[7] who designed the categories to be mutually exclusive and cancer-relevant. We modified the categories to incorporate Part D claims by adding Part D chemotherapy claims to the chemotherapy subcategory and by creating an additional subcategory for nonchemotherapy Part D (drug) claims. For every episode, we calculated both total spending and spending by subcategory.

Geographic Regions

We used the hospital referral regions (HRRs) defined in the Dartmouth Atlas of Health Care for our geographic regions in this study.[8] The region for an episode was the patient's HRR of residence. The HRRs were developed by the Dartmouth Atlas of Health Care to define regional healthcare markets based on referral patterns for tertiary care. They have been widely used to define geographic markets for studies of variation in use of medical services. Within the Medicare program, beneficiaries receive more than 80% of their care in their residence HRR.[9]

TABLE 1. Summary Statistics of Study Population

	Cancer Type				
	NSCLC	BC	RCC	MM	CML
Disease-level					
Total number of 6-month episodes	25,697	16,039	2711	7246	2163
Total number of patients	14,380	3593	1224	2218	466
Number of included HRRs with ≥20 episodes in each HRR	112	102	69	91	64
Patient-level					
Age at diagnosis, years, mean (SD)	72.4 (8.1)	73.0 (10.6)	73.1 (8.8)	74.7 (8.3)	72.6 (11.2)
CCI score at first episode, mean (SD)	1.5 (1.4)	1.0 (1.3)	1.7 (1.7)	1.4 (1.6)	1.5 (1.7)
Sex, male, n (%)	7157 (49.8)	Excluded	681 (55.6)	1017 (45.9)	237 (50.9)
Stage at diagnosis, n (%)					
Stage I	2299 (17.1)	N/A	426 (36.9)	N/A	N/A
Stage II	855 (6.3)	N/A	70 (6.1)	N/A	N/A
Stage III	4309 (32.0)	2342 (65.2)	176 (15.2)	N/A	N/A
Stage IV	6017 (44.6)	1467 (34.8)	484 (41.9)	N/A	N/A
Entitled to Medicare through disability, n (%)	3487 (24.2)	836 (23.3)	266 (21.7)	346 (15.6)	124 (26.6)
Medicaid eligible, n (%)	5565 (38.7)	1467 (40.8)	518 (42.3)	737 (33.2)	186 (39.9)

BC indicates advanced (stages III and IV) breast cancer; CCI, Charlson Comorbidity Index; CML, chronic myeloid leukemia; HRR, hospital referral region; MM, multiple myeloma; N/A, not applicable; NSCLC, non–small cell lung cancer; RCC, renal cell carcinoma.

Statistical Methods

We created a measure of standardized spending per episode for each HRR for each cancer. Due to the potential for inaccurate inferences owing to sampling variation in HRRs with few episodes, we required at least 20 episodes for an HRR to be included in the analysis for a particular cancer. To adjust for patient and episode characteristics, we estimated a generalized linear model with a gamma distribution and log-link, with spending per episode as the dependent variable. The regression included the following covariates: patient age and age squared; CCI score and CCI score squared; number of prior episodes; indicators for male (except for the BC sample, which was restricted to female) patients, Medicaid eligibility, Medicare entitlement through disability, stage at diagnosis (except for the hematologic cancers, for which SEER staging does not apply), and death during the episode; and indicator variables for each HRR.

The estimates obtained from the regression were used to create a measure of standardized spending for each HRR by using the coefficient for the HRR's indicator variable along with a standardized set of values for the covariates and their corresponding coefficient estimates. The standardization was defined at mean values of the covariates over the entire sample for the respective cancer types.

For each subcategory of spending, we used the same procedure to create a measure of standardized spending per episode for that subcategory for each HRR. Following the method of Newhouse and Garber, and using NSCLC as an example, we created a series of figures to graphically illustrate the variation in total standardized spending per episode across HRRs and to show the contribution of the respective subcategories to that interregional variation.[10]

Next, for each cancer, we developed a simple statistic that measured the contribution of each subcategory to the interregional variation in total spending per episode. The statistic, S_c, is defined as

$$S_c = \frac{[e_1 - e_{2c}]}{e_1} = 1 - \frac{e_{2c}}{e_1}$$

where e_1 is the explained sum of squares from a multivariable least squares regression of HRR standardized total spending per episode on standardized spending of each of the 15 subcategories of spending; e_{2c} is the explained sum of squares from a multivariable least squares regression of HRR standardized total spending per episode on spending of each subcategory except for the category (c) in question. (Within each HRR, we summed standardized subcategory spending per episode over all subcategories to arrive at standardized total spending per episode.) To the extent that the interregional variation in subcategory c contributes to the interregional variation in total spending, e_{2c} will be small relative to e_1 and the statistic S_c will be relatively large. It stands to reason that if dropping a single subcategory from the regression of total spending on the subcategories results in a large loss of explanatory power, then that subcategory must be important in explaining the variation in total spending.

RESULTS

Table 1 presents summary statistics describing our data set and patient population. The numbers of episodes and patients, and the number of included HRRs that met our criterion of at least 20 episodes, reflect the differences in incidence of the 5 cancer types. Patients with BC had the lowest comorbidity index, on average, whereas patients with RCC had the highest comorbidity measure.

Table 2 shows summary statistics for spending per episode and the distribution of spending across subcategories of services. The least expensive episodes, on average, occurred for BC ($20,887) and the most expensive for MM ($52,489). Chemotherapy was the largest category of spending across all cancer types, ranging from 25.9% of total spending for BC to 67.8% for CML.

The **Figure** illustrates the contribution of selected subcategories to the variation in total spending per episode across regions for NSCLC, from lowest to highest spending region in terms of standardized

spending per OCM-defined episode (see **eAppendix Figure** for additional detail). For economy of presentation, we developed the statistics shown in **Table 3** to summarize the contribution of each subcategory to the interregional variation in total spending for each cancer type. Because we have standardized for differences in Medicare prices (payment rates) and for observable patient and episode characteristics, differences in our reported measure of standardized spending represent differences in utilization for a patient with the same, "average," characteristics.

The first panel of the Figure depicts the differences across HRRs in total standardized spending per episode for NSCLC. The interquartile range is $7281. The ratio of spending at the 80th to the 20th percentile is 1.3.

Chemotherapy was the largest contributor to the interregional variation in total spending, as shown by the general size and progression of bars in the Figure, which correspond to the relatively high value of the contribution statistic (0.2896) in Table 3. Acute hospital care, which includes both facility and inpatient physician services components, was also a large contributor. Notably, imaging contributed little to the interregional differences, as illustrated by the roughly flat overall trend of the bars in the Figure, which translates to the low value for imaging (0.0178) in Table 3.

Table 3 displays the contribution to interregional variation for the 5 respective cancers and for all spending subcategories. The memorandum lines provide 2 measures of the size of the variation in total standardized spending across regions.

Chemotherapy spending was the largest contributor to interregional variation in total episode spending across regions for 4 of the 5 cancers, and especially for RCC and MM. Spending on acute hospital care was the next largest contributor for NSCLC and MM but was less important for RCC and CML. The category of "unspecified outpatient hospital and other Part B" spending was the second largest contributor to variation for RCC and CML. That category consists primarily of facility charges for outpatient hospital use.

Nonchemotherapy Part D (drug) spending was a substantial contributor to interregional spending variation for advanced BC. Radiation

TABLE 2. Summary of Spending Per OCM-Defined Episode and Percentage of Spending by Service Category of the Study Population (unadjusted for patient characteristics)[a]

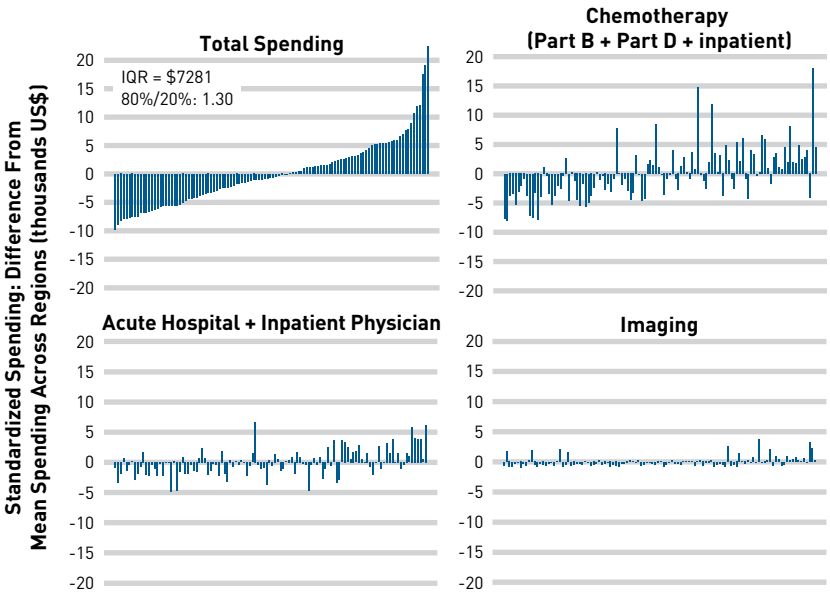
	NSCLC	BC	RCC	MM	CML
Mean total spending per episode (2013 US$)	$39,544	$20,887	$33,553	$52,489	$40,452
Acute hospital + inpatient physician	21.5%	16.0%	18.0%	13.2%	12.7%
Chemotherapy (inpatient + Part B + Part D)	31.2%	25.9%	45.3%	60.7%	67.8%
Diagnostics	1.1%	1.5%	1.0%	1.6%	1.5%
Durable medical equipment	0.9%	0.9%	0.7%	0.4%	0.5%
Home health aid	1.8%	2.4%	1.7%	1.2%	0.9%
Hospice	3.4%	2.1%	2.7%	0.7%	0.6%
Imaging	5.2%	4.8%	3.7%	1.3%	0.9%
Other MEDPAR hospital and facilities	0.6%	0.5%	0.5%	0.3%	0.2%
Other Part D (excludes chemotherapy)	3.8%	7.3%	5.0%	3.4%	4.9%
Outpatient physician E&M	3.2%	4.5%	3.1%	2.5%	2.3%
Outpatient procedures	9.4%	12.3%	6.6%	6.9%	4.2%
Part B medication (excludes chemotherapy)	1.4%	2.0%	0.6%	0.5%	0.2%
Postacute facility	2.6%	4.0%	2.7%	2.1%	1.4%
Radiation therapy	5.0%	5.7%	1.6%	0.5%	0.1%
Unclassified hospital outpatient and other Part B services[b]	9.0%	10.0%	6.0%	4.9%	2.0%

BC indicates advanced (stages III and IV) breast cancer; CCI, Charlson Comorbidity Index; CML, chronic myeloid leukemia; E&M, evaluation and management; MEDPAR, Medicare Provider Analysis and Review; MM, multiple myeloma; NSCLC, non–small cell lung cancer; OCM, Oncology Care Model; RCC, renal cell carcinoma.

[a]The spending totals were adjusted for Medicare payment rate differentials and do not reflect further adjustments for patient characteristics.

[b]This category consists, on average, of about 63% outpatient hospital facility charges and 37% other Part B services, such as vision, hearing, and ambulance costs.

FIGURE. Variation in Standardized Episode Spending Across Geographic Regions: Total and by Selected Service Subcategory for NSCLC[a]



IQR indicates interquartile range; NSCLC, non–small cell lung cancer.

[a]IQR shows the difference in standardized spending per episode between the 75th and 25th percentiles of the distribution in 2013 US$. The 80%:20% shows the ratio of standardized spending per episode of the 80th to the 20th percentile of the distribution.

TABLE 3. Contribution of Subcategory in Explaining the Variation in Total Spending per OCM-Defined Episode Across Regions

	NSCLC	BC	RCC	MM	CML
Acute hospital + inpatient physician	0.1016	0.0579	0.0296	0.0892	0.0347
Chemotherapy (Part B + Part D + inpatient)	0.2896	0.1386	0.4883	0.6672	0.2543
Diagnostics	0.0005	0.0004	0.0002	0.0012	0.0004
Durable medical equipment	0.0007	0.0014	0.0004	0.0044	0.0033
Home health aid	0.0044	0.0130	0.0025	0.0053	0.0038
Hospice	0.0147	[a]	[a]	[a]	[a]
Imaging	0.0178	0.0026	0.0006	0.0007	0.0002
Other MEDPAR hospital and facilities	0.0182	[a]	[a]	[a]	[a]
Other Part D (excludes chemotherapy)	0.0077	0.2093	0.0030	0.0174	0.0059
Outpatient physician E&M	0.0012	0.0017	0.0005	0.0102	0.0010
Outpatient procedures	0.0309	0.0265	0.0078	0.0247	0.0091
Part B medication (excludes chemotherapy)	0.0040	0.0059	0.0015	0.0011	0.0002
Postacute facility	0.0101	0.0187	[a]	0.0602	[a]
Radiation therapy	0.0083	0.0101	0.0401	0.0009	0.0672
Unclassified hospital outpatient and other Part B services[b]	0.0518	0.0566	0.0566	0.0616	0.0710
Memorandum					
IQR of total spending per episode[c]	$7281	$5368	$10,251	$9320	$10,966
80%:20% of total spending per episode[c]	1.30	1.41	1.47	1.25	1.42

BC indicates advanced (stages III and IV) breast cancer; CCI, Charlson Comorbidity Index; CML, chronic myeloid leukemia; E&M, evaluation and management; IQR, interquartile range; MEDPAR, Medicare Provider Analysis and Review; MM, multiple myeloma; NSCLC, non–small cell lung cancer; OCM, Oncology Care Model; RCC, renal cell carcinoma.

[a]Estimates were omitted due to few non-zero values that did not allow for reliable estimation.

[b]This category consists, on average, of about 63% outpatient hospital facility charges and 37% other Part B services such as vision, hearing, and ambulance.

[c]IQR shows the difference in standardized spending per episode between the 75th and 25th percentiles of the distribution in 2013 US$. The 80%:20% shows the ratio of standardized spending per episode of the 80th to the 20th percentile of the distribution.

therapy was a larger contributor to interregional cost variation than inpatient care for both RCC and CML, but it played an insignificant role for other cancer types studied.

Imaging, nonchemotherapy Part B drugs, physician evaluation and management services, and diagnostics were among the negligible contributors (defined here as <0.02) to the interregional variation in total spending.

DISCUSSION

Our summary statistics in Table 2 are consistent with the findings of Rocque et al, who found in a sample of Southeastern US cancer centers that chemotherapy is the highest spending category, followed by inpatient hospital care.[11]

Consistent with a Dartmouth interpretation, the subcategories with higher values in Table 3 may be the most fruitful in yielding savings, given apparent differences in practice styles or professional opinion about appropriate total spending. A higher value in Table 3 indicates a greater contribution of that subcategory to the variation across regions in total standardized spending within OCM-defined episodes.

The OCM definition of an episode appears to play an important role in explaining the high contribution of chemotherapy spending listed in Table 3. Because the OCM defines an episode as the 6-month period commencing with chemotherapy, OCM-defined episodes are necessarily "chemo-centric." Our results might appear to contradict those of Brooks et al,[7] who concluded that inpatient care was a more substantial driver of interregional variation than chemotherapy, but that difference likely occurs because the OCM episodes of care begin at a conceptually different index date. Although both episodes last 6 months, those in the Brooks study began at cancer diagnosis, whereas in the OCM, episodes commence with chemotherapy treatment. In a different analysis, Wang et al concluded that radiotherapy was the largest driver of regional cost differences for prostate cancer, but this study also used an episode definition (2 months prior to 12 months after diagnosis) different from that of the OCM.[12]

Although less substantial than the contribution of chemotherapy spending, the importance of acute inpatient hospital care is not surprising, given the earlier finding of Brooks et al.[7] Consistent with their conclusions, our results suggest that use of inpatient care has a substantial effect on real spending differences across areas. Our results are consistent with the longstanding view that avoiding admissions can reduce cost, but as demonstrated by our results for RCC and CML, acute inpatient hospital care is not a uniformly strong contributor for all cancers. Importantly, the study by Brooks et al does not contradict our findings in that it does not include RCC or CML.

Outpatient procedures, especially in a hospital outpatient setting, are probably more likely sources for potential savings than suggested by the "outpatient procedures" line in Table 3. This is because the category "unclassified hospital outpatient and other Part B services" may capture some of the hospital outpatient facility charges that are coupled with the utilization of outpatient procedures. The latter category contributes more to total spending variation for all 5 cancer types and comprises mainly unspecified hospital outpatient facility charges, which may be incurred for performing outpatient procedures.

The potential spending reductions on nonchemotherapy Part D drugs for advanced BC and on radiation therapy for RCC and CML may be less promising than they appear in Table 3. Unlike other contributors to variation, these particular results hinged on single high-spending HRRs. Removal of the single highest spending HRR for other Part D drugs in BC changed the contribution statistic from 0.209 to 0.013, consistent with the negligible contribution seen for other cancers. Removal of the single highest spending HRR for

radiation therapy reduced the contribution from 0.040 to 0.015 for RCC and from 0.067 to 0.019 for CML, suggesting that interregional differences of opinion on appropriate use of radiation therapy in RCC and CML play a limited role in total spending variation. Perhaps a review of utilization in these subcategories is appropriate, but only single HRRs in the sample are the reason for review.

Just as noteworthy as items that appear to be fruitful targets for cost cutting are subcategories that are unimportant contributors to interregional total spending variation. Although imaging and nonchemotherapy Part B drugs are suggested as areas for savings in the literature,[13] those subcategories were negligible contributors to interregional variation in spending within OCM-defined episodes.

Although a subcategory can be a nontrivial fraction of overall spending (Table 2), it may be a negligible contributor to interregional variation in total spending. For example, for NSCLC and advanced BC, Table 3 indicates that radiation therapy is not a substantial contributor to interregional differences in total episode spending despite accounting for 5% or more of total spending (Table 2). This suggests that radiation therapy is not a fruitful target for OCM savings for those cancer types because lower spending on radiation therapy is not the reason that low total spending regions have low spending.

Limitations

Importantly, this analysis does not include patient outcomes data. Thus, we cannot determine if differences in utilization of particular services across regions result in differences in important outcomes.

Additional questions for future research exist but remain beyond the scope of this study. When more data are available to compare OCM-participating and nonparticipating practices, researchers can further evaluate the OCM's effectiveness, but they will need to take into consideration the fact that participation is voluntary. In addition, if sufficient data were available from MA plans, it would be interesting to compare MA plans with both OCM-participating and nonparticipating fee-for-service practices. Another potential evaluation is a more broadly targeted alternative payment model than the OCM—for example, one that considers episodes not necessarily confined to chemotherapeutic treatments. Finally, as more treatment innovations occur, our findings may need to be revisited.

CONCLUSIONS

We took a Dartmouth-style approach to identify opportunities to reduce costs within OCM-defined episodes by quantifying how different subcategories of care contribute to observed differences in standardized total episode spending across regions. Given these results, while also recognizing that higher spending does not necessarily imply less efficiency if outcomes are better, OCM-participating practices may wish to evaluate their treatment styles within the high-priority categories identified here. ■

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Authorship Information: Concept and design (JB, CZ, DL); acquisition of data (JB, AS); analysis and interpretation of data (JB, AS, CZ, DL); drafting of the manuscript (JB, AS, CZ); critical revision of the manuscript for important intellectual content (JB, AS, CZ, DL); statistical analysis (JB, AS); obtaining funding (JB, CZ); and supervision (JB, CZ, DL).

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Contents of Supplementary Material:

eMethods. Sample and Standardization Methods

Data

We used data from the Surveillance, Epidemiology and End Results Medicare (SEER-Medicare) database 2014 linkage. The SEER-Medicare data reflect the linkage of two large population-based sources of data that provide detailed information for Medicare beneficiaries with a cancer diagnosis between 1973 and 2011. The SEER program of the National Cancer Institute (NCI) has routinely collected information on cancer diagnosis date, site, histology, stage, initial stage, survival, socioeconomic and demographic characteristics among cancer patients through its population-based cancer registries since 1973. The registries capture all incident cases except for non-melanoma skin cancer and in situ cervical cancer. SEER currently covers approximately 28 percent of the U.S. population from 18 registries. Medicare is a federally funded program that provides health insurance to the elderly (age ≥ 65), patients with end-stage renal disease, and some disabled. Of the elderly persons eligible for the benefit, 97% are enrolled in the program.

The Medicare claim files contain longitudinal, billed claims including information on disease diagnosis and services received. Medicare files are further divided into the Medicare provider analysis and review (MEDPAR) file which includes short and long hospital stay as well as skilled nursing facilities (SNF), carrier (physician), outpatient, hospice, home health agency (HHA), durable medical equipment (DME), and part D pharmacy (PDE) files. SEER and Medicare databases were linked by the NCI in collaboration with the SEER registries and the Centers for Medicare and Medicaid Services (CMS) based on the unique patient identification number. All cancer registry patients who were diagnosed in 1973 – 2011 and eligible for the Medicare benefit in 1991-2012 were linked to the Medicare databases. The longitudinal treatment-related data from Medicare files allow for the cancer patients to be followed during the study period from Medicare enrollment to death or December 31, 2013, the most recent year when the Medicare files were linked to the SEER registries. The Medicare data also include date of death, obtained from the Social Security Administration, which allows for reliable measurement of death information.

The Patient Entitlement and Diagnosis Summary File (PEDSF) provides cancer-related information used for cohort selection and variable selection. We used the PEDSF file for diagnoses between 2007 and 2011, and linked Medicare Claims (MEDPAR, Carrier, Outpatient, Home Health, Hospice, DME from 2006-2013 and Part D Claims from 2007-2013). (The 2006 data was used to calculate an index of co-morbidities during the previous year, with our main analysis beginning in 2007.)

Geographic region of the patient was defined as the hospital referral region (HRR) of the patient's residence. The HRRs are geographic regions developed by the Dartmouth Atlas of Health Care to define regional health care markets based on referral patterns for tertiary care. The HRRs have been widely used to define geographic markets for use in studies of the variation in use of medical services. Within the Medicare program it has been found that beneficiaries receive over 80% of their care in their residence HRR.[1] This study used unencrypted residence zip code (a restricted variable that requires an additional approval process) to allow for a crosswalk between residence zip codes and HRRs.

Study Population including cancer codes used to identify included patients

We identified a cohort of patients diagnosed with one of the following tumor types as the first or only cancer: breast cancer (BC), renal cell carcinoma (RCC), multiple myeloma (MM), chronic myeloid leukemia (CML), and non-small cell lung cancer (NSCLC). These tumor types were chosen based on the incidence and prevalence in the 65+ population, to ensure a mix of solid and hematological tumor types, and to offer variation in treatment patterns, innovation, and resource mix. Recoded ICD-O-3 codes were used to identify patients with these five tumor types (BC: 26000, RCC: 29020, MM: 34000, CML: 35022, NSCLC: 22030). RCC and NSCLC populations were further refined using histology codes (RCC: 8260, 8310, 8312, 8316, 8317, 8318, 8319, 8320, 8510, 8959. NSCLC: 8012, 8013, 8014, 8022, 8031, 8032, 8033, 8046, 8052, 8070, 8071, 8072, 8073, 8082, 8083, 8084, 8123, 8140, 8250, 8251, 8252, 8253, 8254, 8255, 8260, 8310, 8333, 8430, 8470, 8480, 8481, 8490, 8550, 8560, 8972, 8980).

The patient cohort includes any patient in the SEER-Medicare data newly diagnosed with one of the five selected tumors between January 1, 2007 and December 31, 2011. For breast cancer, we ultimately included only patients diagnosed with stage 3 or 4 because of the amount of heterogeneity that may exist in both disease and treatment course between early stage and late stage BC patients. Patients were required to be covered by Medicare Parts A, B and D from 12 months prior to the diagnosis through the end of data or up to the date of death. They were also required to be treated with at least one OCM eligible chemotherapy drug in an outpatient setting (including part D chemotherapy claims). (This restriction was chosen to allow us to define an episode in the same way as CMS's Oncology Care Model (OCM).)
Patients enrolled in a Medicare Advantage plan any time after 12 months prior to their cancer diagnosis were excluded since SEER-Medicare does not include full treatment information on these patients. Patients whose reporting source was death certificate or autopsy were also excluded since death certificate and autopsy are considered unreliable sources for abstraction of cancer cases. Patients who have end-stage renal disease or whose SEER and Medicare death dates differed by more than 3 months were also excluded. (Note that patients with end-stage renal disease or on Medicare Advantage are also excluded from the OCM.[2])

Definition of episode (codes for initiation of chemo)

Each episode was defined as a period of six months (180 days) following the start of an oncology drug therapy in an outpatient setting (i.e., covered by part B or part D). Oncology drug therapies were identified using NDC and HCPCS codes in the Part D, DME, Outpatient, and Carrier claims files. These codes were vetted by two experts, a hematologist-oncologist and an experienced medical coder. Patients could have multiple episodes (i.e. the first six months of care starts from the first initiation of oncology drug treatment following diagnosis as the first episode, the second episode starts at the first outpatient oncology drug therapy not in the first episode, and so on). This was continued through the end of the data or their death -- a final episode could be less than 6 months. All episodes that contained or followed a claim for dialysis were excluded from the analysis.

Spending

Using the Medicare claims, we calculated the base cost for each claim. The way of doing this differed by claim type. Outpatient and carrier costs were the sum of payment amount, part B deductible, part B coinsurance and the blood deductible liability coinsurance amounts. Costs for extra short inpatient hospital stays accompanied by a transfer to another hospital, SNF or IRF were calculated as:

$$\{2*(\text{Daily Base Amount})_{\text{Unadjusted}}+(\text{LOS}-1)*(\text{Daily Base Amount})_{\text{Unadjusted}}\}*\text{DRG}_{\text{Weight}}+(\text{Outlier Payment})$$

where weights and geometric mean LOS values were available from CMS by claim year and diagnosis related group. The cost of all other inpatient hospitalizations was calculated as:

$$(\text{Standard Base Amount})_{\text{Unadjusted}}*\text{DRG}_{\text{Weight}}+(\text{Outlier Payment})$$

(These methods for obtaining a standardized spending amount for inpatient claims follow Schousboe (2014).)[3]

All other MEDPAR claims were the sum of coinsurance amount, reimbursement amount, and blood deductible amount. Hospice and HHA costs were the payment amount. DME costs were the sum of the payment amount and the beneficiary payment amount. Part D costs were based on the gross drug costs. All episodes that contained a claim with a nonzero payment from a primary payer other than Medicare were excluded.

Standardization for Differential Payment Rates within Medicare

Because we fundamentally care about differences in utilization, we adjusted spending for the different prices that Medicare pays for the same services in different regions. For each claim, we adjusted the spending value to a standardized amount so that the same service will be priced at the same dollar value regardless of region or price markups received by particular providers, such as the indirect medical education adjustments or disproportionate share adjustment received by certain hospitals for inpatient care, or adjustments to payment rates to reflect varying wage rates or input costs across different regions.

The standardization method varied based on claim type. For inpatient hospitalization, our way of calculating costs (explained above) required no additional adjustment since it was only based on LOS and DRG. Part B drug claims did not need to be adjusted because of uniform payment nationwide. All other Part A and Part B claims were assigned to a cost-adjustment category to match up with tables developed by CMS to adjust for payment differences at the county level (categories are: long term care hospital, SNF, HHA, Hospice, Federally qualified health center/rural health center, Hospital outpatient, Ambulatory surgery center, E+M, Procedures, Imaging, DME, Tests, general outpatient, and ambulance).[4] The base costs were multiplied by the CMS ratio of standardized to actual cost for the appropriate cost category, FIPS county, and claim year. If the value of the actual or standardized amount was zero or missing for the county, we used the state average. Part D claims were not adjusted because drugs are commodities with negotiations occurring over pricing between competing drug plans and manufacturers.

Because our spending data covers several years and Medicare fee schedules increase year-to-year, we also corrected for changes in prices over time. All claims were set to 2013 dollars. Inpatient

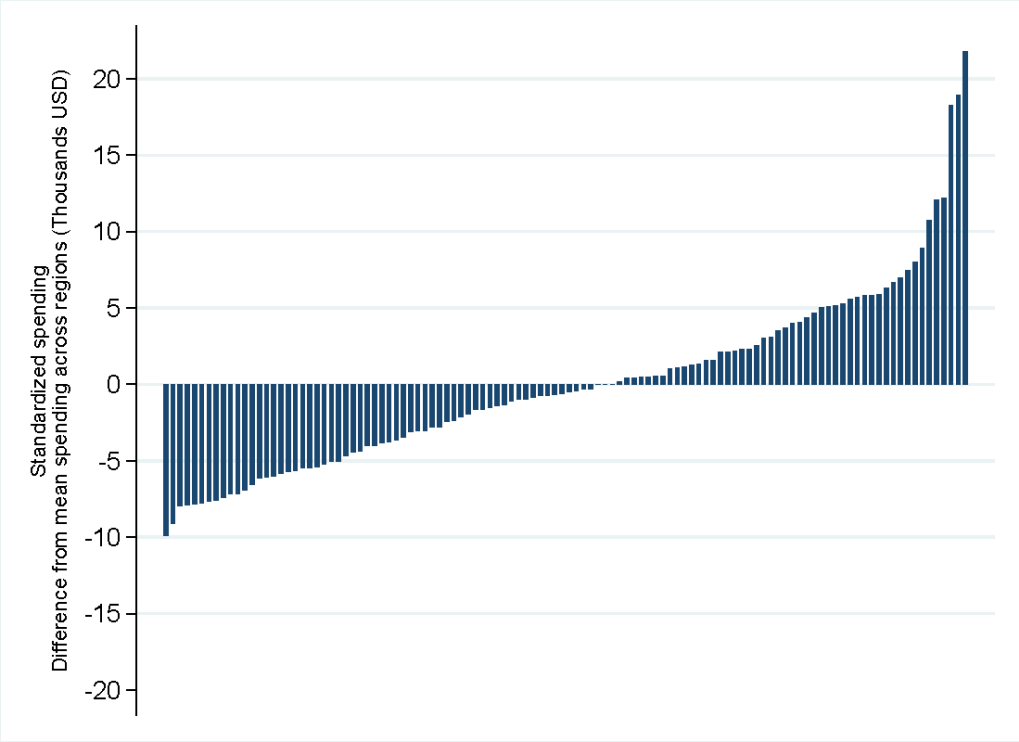
hospitalization claims were adjusted based on the standardized base amount. All hospital outpatient and ambulatory claims were adjusted based on the standard OPPS conversion factor for that calendar year. Physician services, E+M, Procedure and Imaging claims were adjusted based on Hanh (2014).[5] SNF, HHA, Hospice, LTC, Inpatient Psychiatric and Inpatient Rehab, were adjusted based on the appropriate CMS MarketBasket data. The payment amount for outpatient, carrier, HHA, hospice and DME claims on or after April 1, 2013 were adjusted to account for sequester. Part D drugs were adjusted using the CPI for prescription drugs and Part B drugs were adjusted using the PPI for pharmaceutical preparations. Clinical labs were adjusted based on the CPI for medical care services. Ambulance services were adjusted based on the CMS Ambulance Fee Schedule. DME claims were adjusted based on the MEI.

eAppendix Figure. Contributions of Subcategories to Total Spending Variation for NSCLC

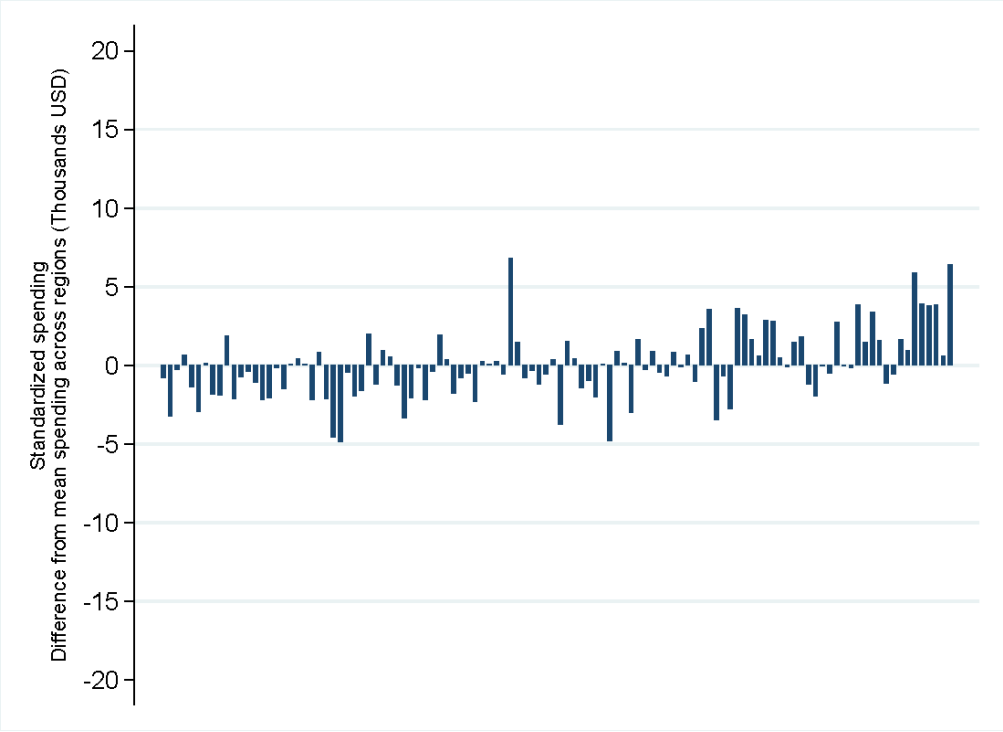
Because of space considerations, figure 1 in the text displays only 3 subcategories of spending and illustrates their contribution to total spending variation. Variation from the lowest to highest HRR in terms of total standardized spending per episode is shown below followed by standardized spending per episode for the respective subcategories of service types (Figures A1-16). Note the correspondence between these figures and the entries in Table 3 of the text. The summary statistics in table 3 capture the material that can be seen in these figures. Service subcategories that contribute more to the left to right variation in the total spending figure show higher numbers in table 3.

eAppendix Figure. Variation in standardized episode spending across geographic regions: Total and by service subcategory for NSCLC

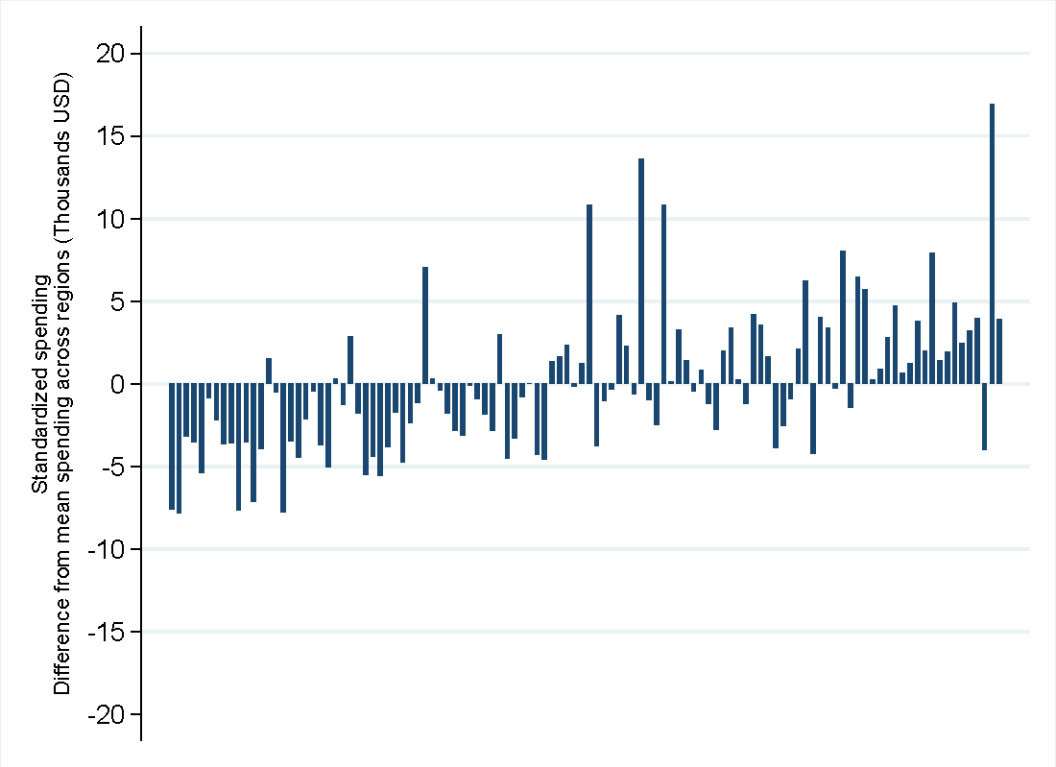
Panel 1: Average total spending per episode (2013 USD)



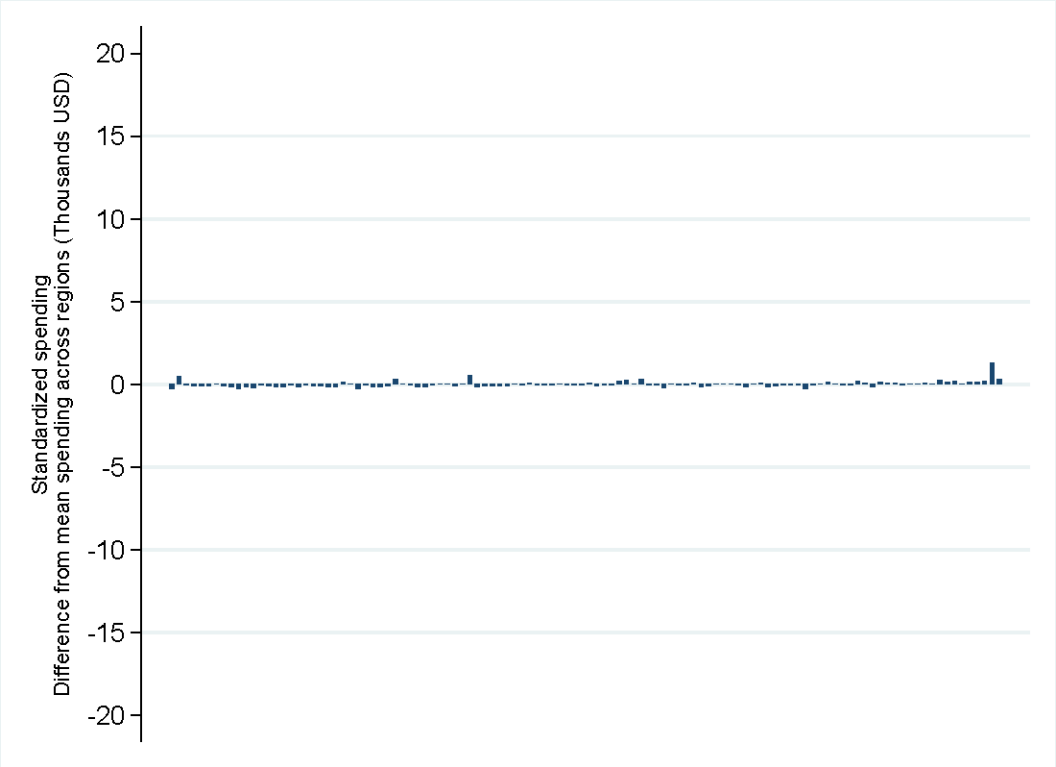
Panel 2: Acute hospital + inpatient physician



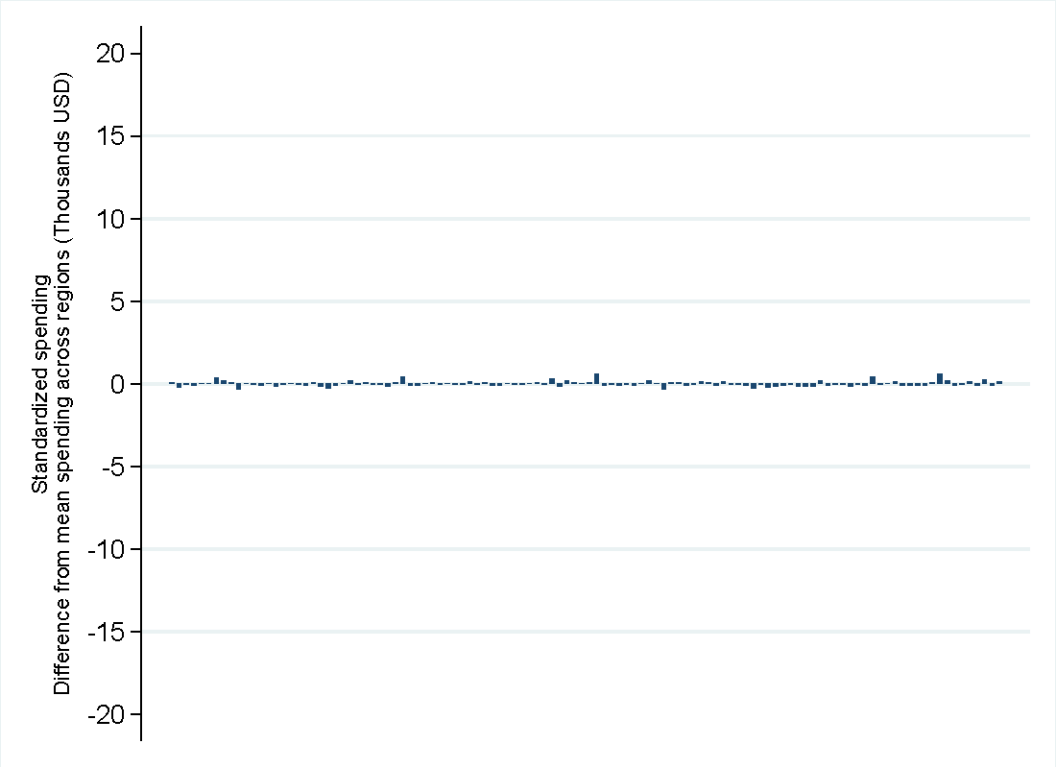
Panel 3: Chemotherapy (inpatient + Part B + Part D)



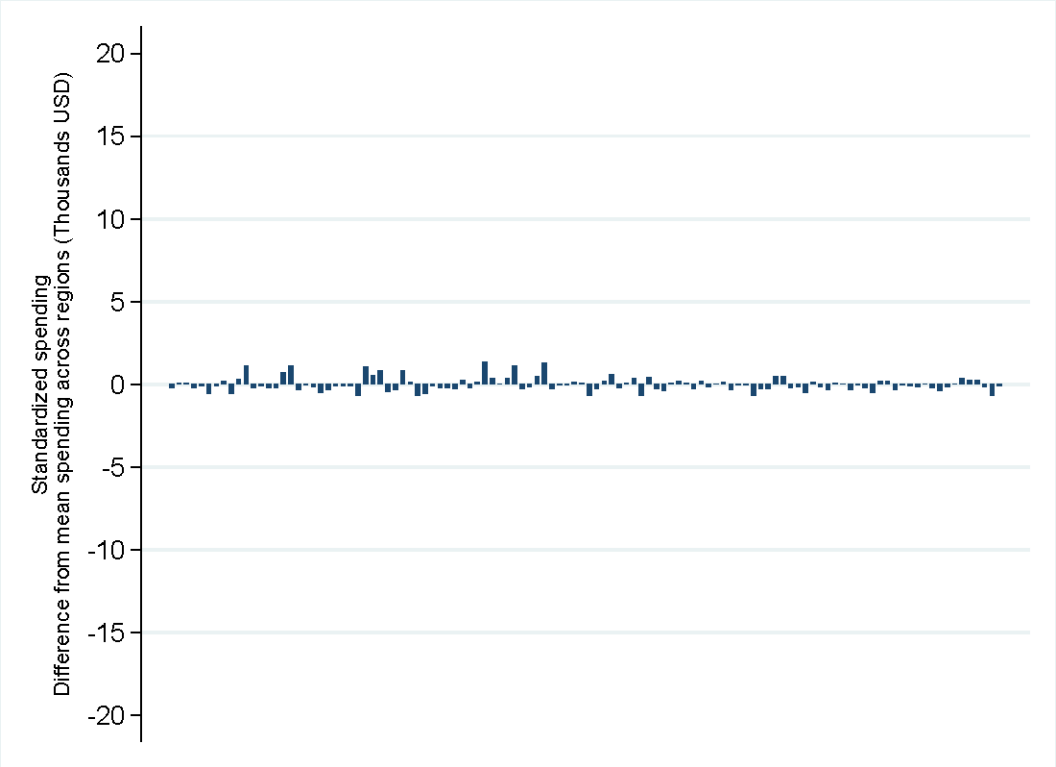
Panel 4: Diagnostics



Panel 5: Durable Medical Equipment (DME)

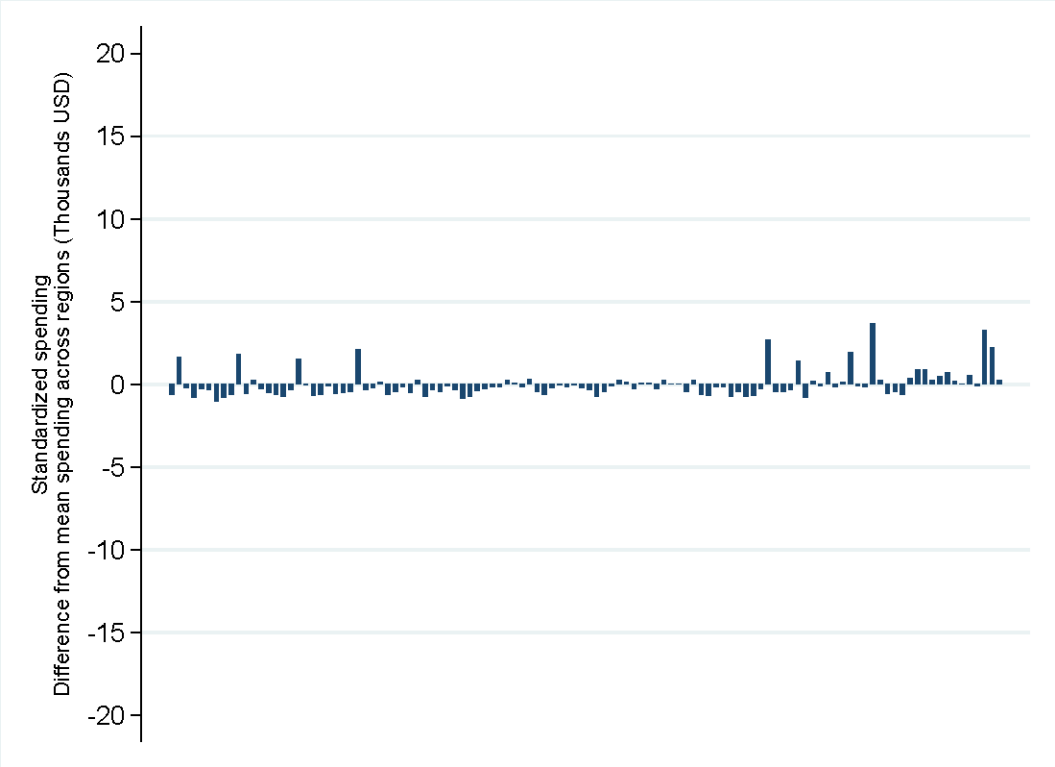


Panel 6: Home Health Aid



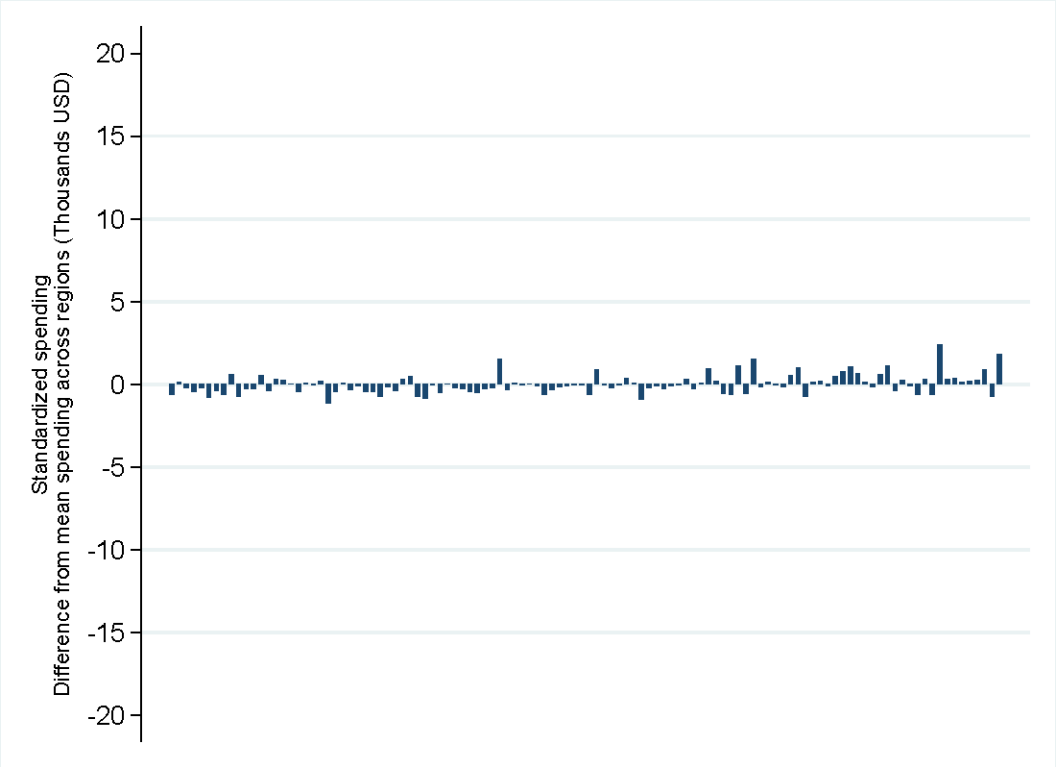
Panel 7: Hospice

Panel 8: Imaging

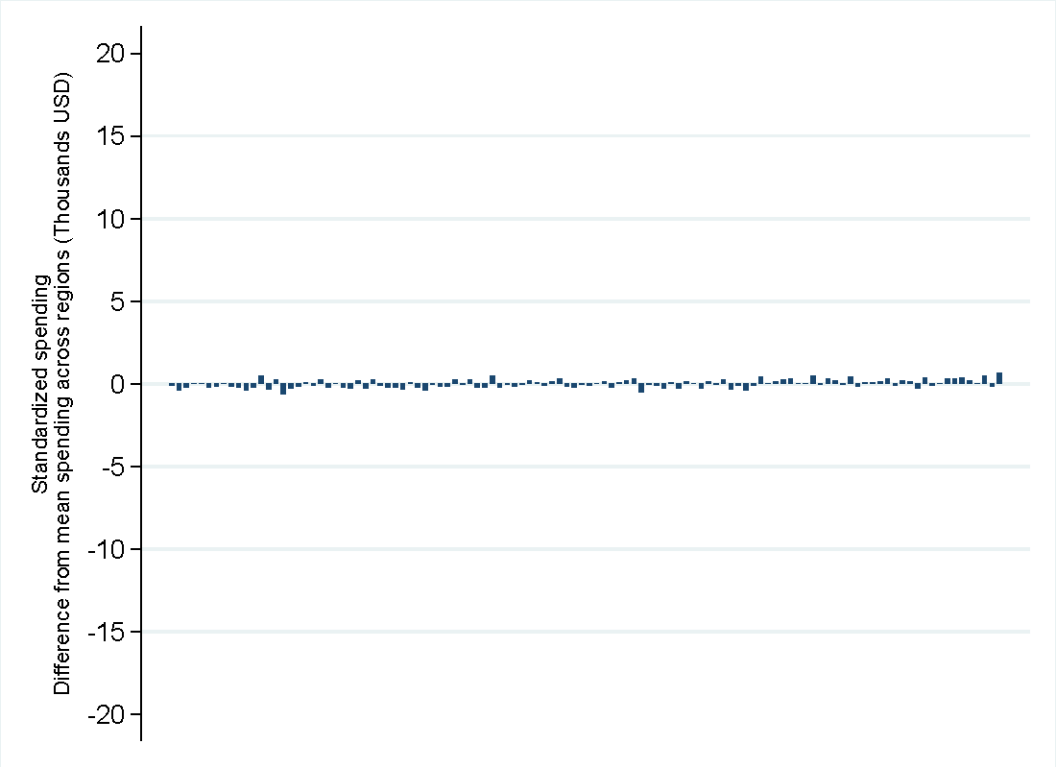


Panel 9: Other MEDPAR hospital and facilities

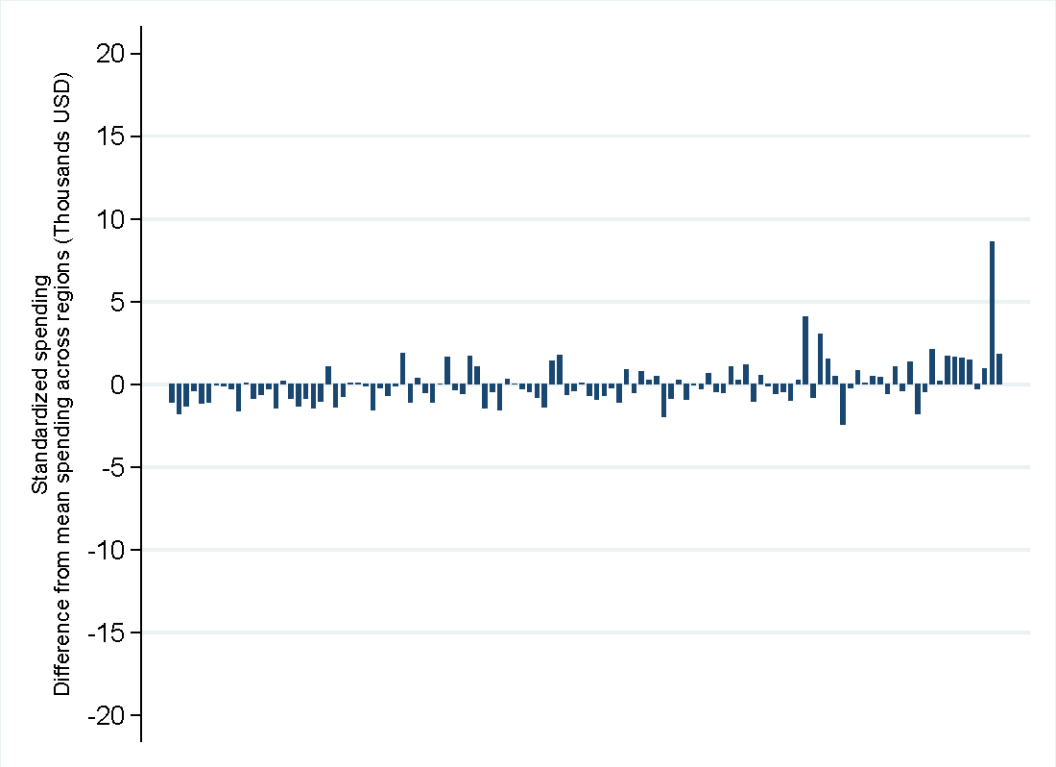
Panel 10: Other Part D (excludes chemo)



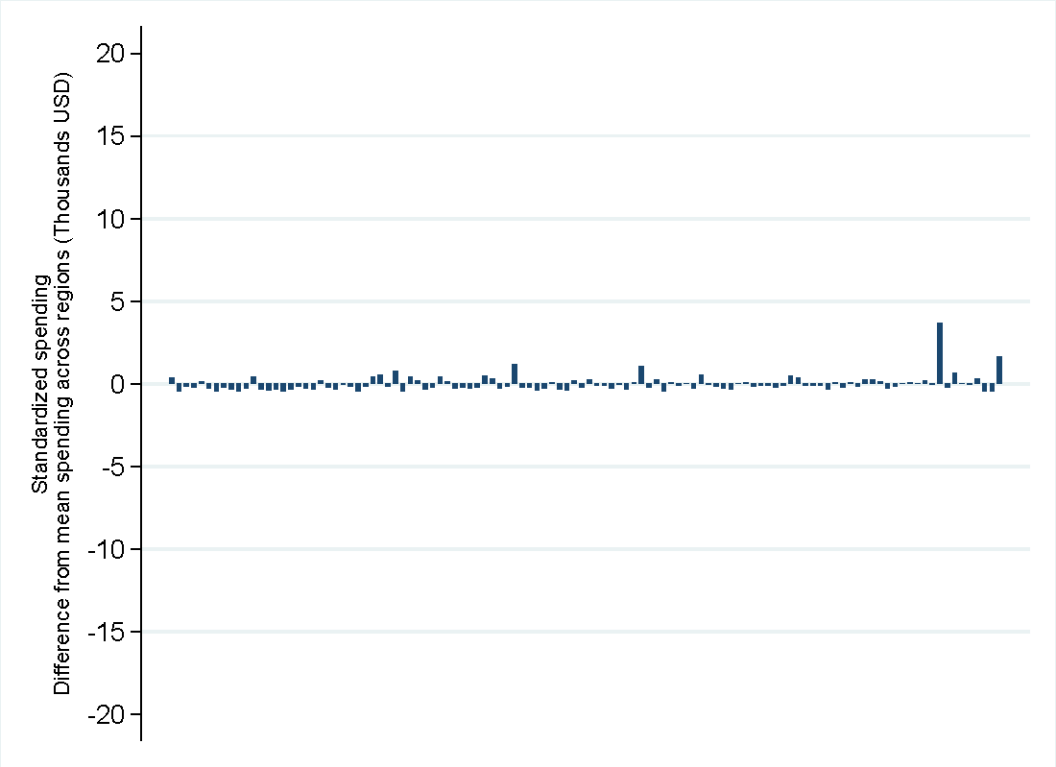
Panel 11: Outpatient physician E&M



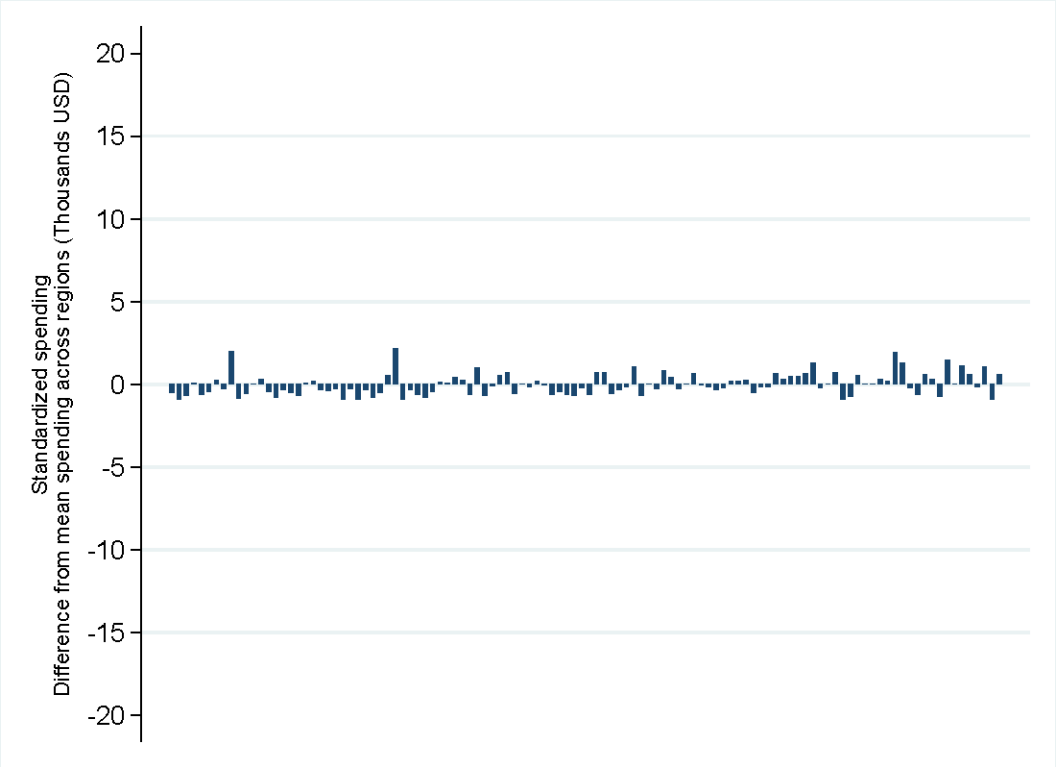
Panel 12: Outpatient procedures



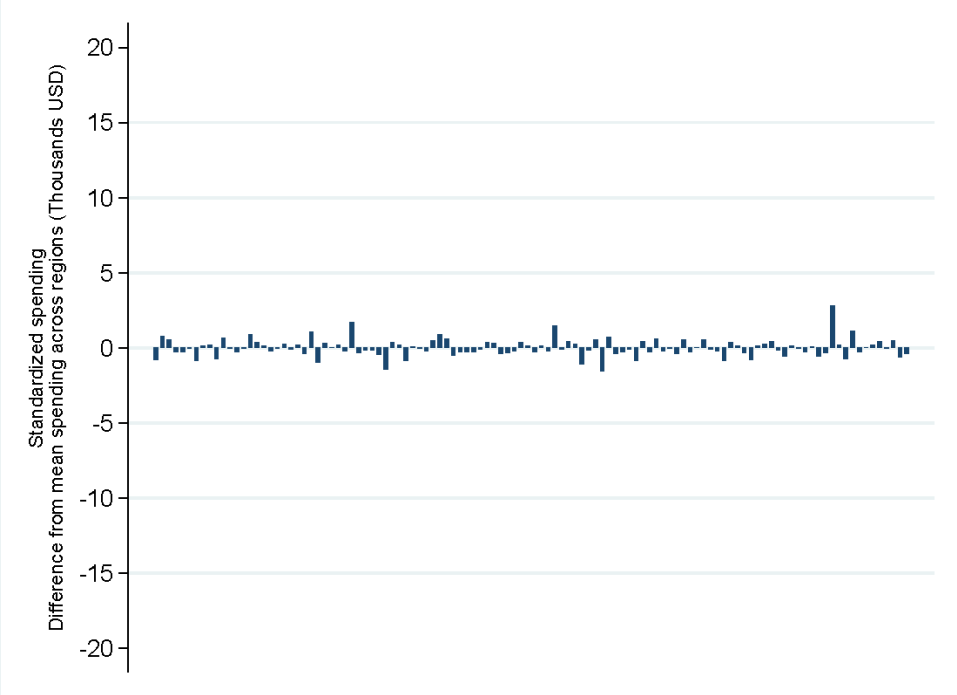
Panel 13: Part B medication (excludes chemo)



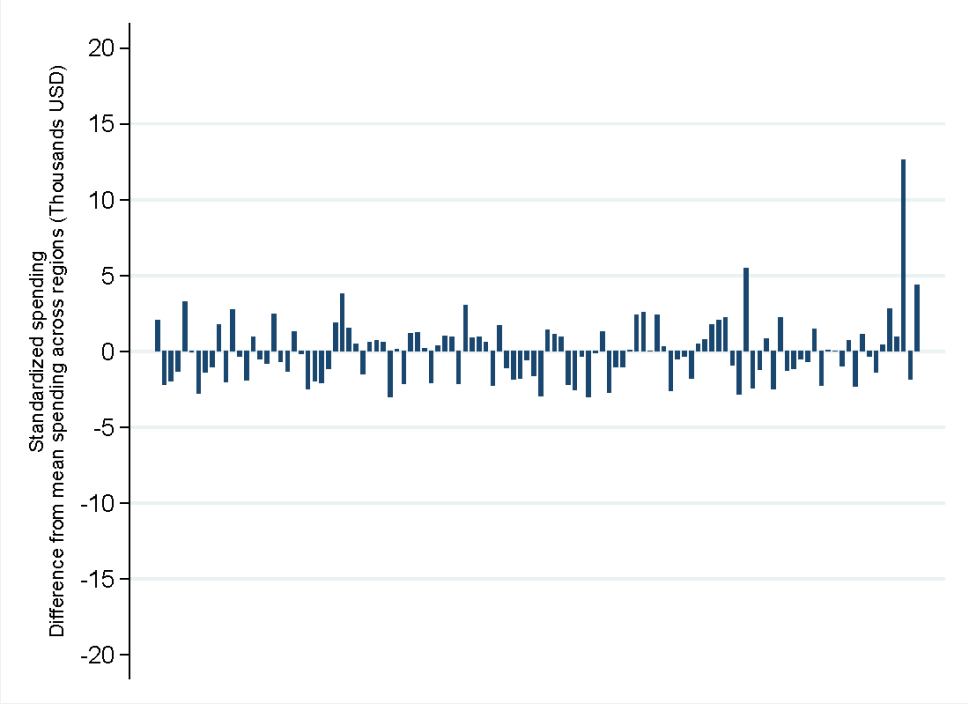
Panel 14: Post-acute facility



Panel 15: Radiation therapy



Panel 16: Unclassified hospital outpatient and other Part B services†



†This category consists on average about 63% outpatient hospital facility charges and 37% other Part B services such as vision, hearing, and ambulance.

References

1. Center for Medicare & Medicaid Services. *Medicare Data for the Geographic Variation Public Use File: A Methodological Overview*. 2017 [cited 2017 May 5]; Available from: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/Medicare-Geographic-Variation/Downloads/Geo_Var_PUF_Methods_Paper.pdf.
2. Center for Medicare & Medicaid Innovation *OCM Performance-Based Payment Methodology (Version 1.1). Prepared by RTI International and Actuarial Research Corporation.* . 2016.
3. Schousboe, J.T., et al., *Estimation of Standardized Hospital Costs from Medicare Claims That Reflect Resource Requirements for Care: Impact for Cohort Studies Linked to Medicare Claims.* Health Services Research, 2014. **49**(3): p. 929-949.
4. Center for Medicare & Medicaid Services. *Medicare Geographic Variation Public Use File*. 2017 [cited 2017 May 5]; Available from: https://www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/medicare-geographic-variation/gv_puf.html.
5. Hanh, J., *Medicare Physician Payment Updates and the Sustainable Growth Rate (SGR) System*. 2014, Congressional Research Service: Washington, DC.